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Digital Transformation of Banking in Improving Efficiency: A Study on Indonesian Digital Banks

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Abstract

This study aims to examine the effect of digital transformation on bank efficiency in Indonesia by considering the Capital Adequacy Ratio (CAR) and inflation as control variables. The growing adoption of digital banking is driven by technological advancements, increasing internet penetration, and changing customer preferences, particularly among millennials and Generation Z, who are more familiar with digital financial services. These developments have encouraged banks to improve operational efficiency through digital transformation, although the benefits may differ between the short and long term. This study employs a quantitative approach using secondary data from five banks during the 2018–2025 period. The data were analyzed using a panel Autoregressive Distributed Lag (ARDL) model to examine the short-term and long-term relationships among the variables. The findings indicate that digital transformation has no significant effect on bank efficiency in the short term but has a positive and significant effect in the long term. CAR has a positive but insignificant effect in both periods, while inflation has a significant negative effect on bank efficiency in the long term. These findings suggest that improvements in banking efficiency through digital transformation take time to materialize, as banks need to adapt their operational processes and optimize digital infrastructure. This study contributes to the banking literature by providing empirical evidence on the different short-term and long-term effects of digital transformation on bank efficiency in Indonesia, with implications for digital investment and operational management.

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INTRODUCTION

Digital transformation has become a reality in various sectors such as manufacturing, transportation, education, healthcare, agriculture, and the financial and banking sectors. In 2021, Indonesia established a long-term digital roadmap aimed at accelerating digital transformation across four strategic sectors: digital infrastructure, digital government, digital economy, and digital society.

The development of the digital economy demands the digitalization of the banking sector, as banking is one element of the financial system that can accelerate digital finance.

The digitalization of Indonesia's banking sector is shaped by three key factors outlined by the Financial Services Authority in its 2021 report: digital opportunities, digital behavior, and digital transactions.

Opportunities arise from the demographic potential of Indonesia's population, which is dominated by tech-savvy millennials; the potential of the digital economy and finance; internet penetration; and the growing number of potential customers in trade activities. Digital behavior includes the ownership and widespread use of smartphones and mobile applications. Digital transactions because they show increasing levels of online commerce (e-commerce), digital

banking transactions, and electronic money transactions as well as a decrease in the number of bank branches. Figure 1 shows that the value of digital banking transactions over the last 8 (eight) years has continued to experience a significant increase. Based on the increase in electronic transaction channels, internet banking and mobile banking represent the largest proportion of digital financial transaction service activity. The significant increase in digital financial transactions has driven the banking industry to introduce innovations to serve the public's digital transaction needs through digital banking. Digital banking is an electronic banking service developed in the digital era by optimizing the use of customer data to serve customers more quickly, easily, and according to their needs, which can be done independently (Dewi & Octrina, 2022).

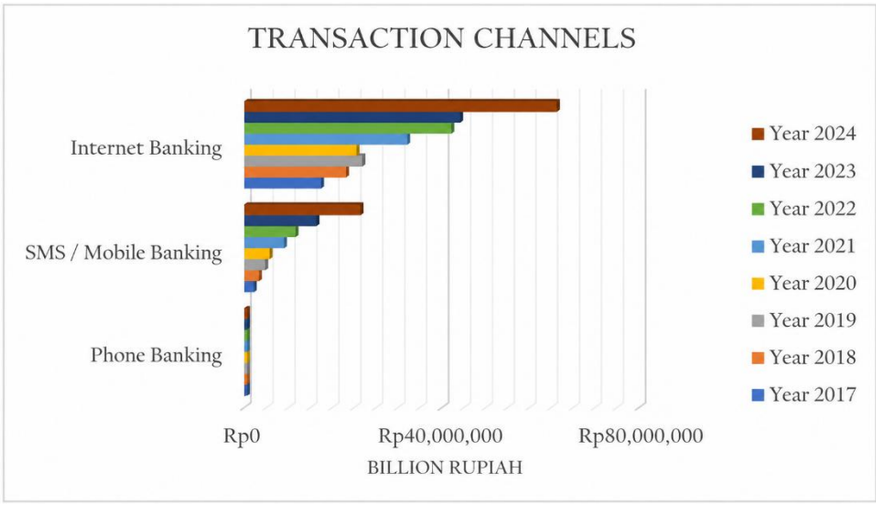


Figure 1. Electronic & Digital Transaction Value

Banks that adopt digital systems are considered to have a positive impact on operational performance. This is because digitalization not only reduces transaction time and manual costs but also plays a role in improving banks' financial performance through greater efficiency, eliminating the need for branch offices and minimizing the use of labor (Indrayani et al., 2025). Moreover, customer satisfaction also increases, as they find it easier to access banking services anytime and anywhere.

Banking digitalization has emerged as a significant force in the banking sector driven by technological advancements and evolving consumer preferences (Kitsios et al., 2021). This is seen as a disruptive innovation from the existence of new technology that can disrupt market competition and can cause the main players to be replaced as industry leaders by innovative newcomers (Bueno et al., 2024).

Digitalization in the banking sector offers numerous benefits. The shift from traditional banking practices to digital banking has impacted efficiency and improved customer experience. This is evident in the trend of digital banking channels offering accessibility and convenience. Digital banking channels are growing in popularity, driven by the expansion of internet network infrastructure, the rise in mobile users, and the integration of innovative technologies such as Artificial Intelligence (AI) and Machine Learning.

This study aims to determine and understand how digital banking operations can influence efficiency by considering other variables as determining factors. Many previous studies have examined efficiency, but generally focused on traditional banking with a dual system. However, this study attempts to examine how the transformation of banking businesses into digital banks can improve their efficiency. In recent years, banking management systems have undergone a digital transformation to achieve inclusion and efficiency.

This is because the banking system is in a technology-intensive business sector. Banks utilize digital technology as an input to produce financial products and services. Another input is talent with high technical skills and relevant knowledge. Digital technology and technological talent in relation to human capital as an element of technological innovation which is also part of digital transformation (Shanti et al., 2024). Therefore, digital transformation is crucial to support efficiency. Furthermore, to boost efficiency, banks also need to consider several other aspects believed to impact their efficiency performance.

According to Widiarti et al. (2015), empirically, it shows that the capital aspect (CAR) is identified as a factor influencing efficiency performance. This is confirmed by Sufian et al. (2016), who found that CAR has a positive influence on bank efficiency performance.

Liquidity is another factor that may influence bank efficiency. A bank is considered sufficiently liquid when it holds adequate cash or other liquid assets to meet its short-term obligations as they fall due and to respond promptly to financing needs. Furthermore, liquidity plays an important role in covering temporary cash flow shortages.

In a study by Sidhu et al. (2023), increasing bank liquidity will improve its efficiency performance. However, after reaching the maximum value, efficiency will decline. Another factor that can influence bank efficiency performance is company size, as measured by total assets. Good asset management by minimizing idle assets is believed to reduce operational costs.

HYPOTHESES DEVELOPMENT

Digital Transformation on Bank Efficiency

Efficiency is part of a company's financial performance, used to assess the success of managing its operational activities. In the banking sector, financial performance can be reflected in the level of efficiency, which indicates a company's ability to operate by maximizing innovative resources. The implementation of digital banking services plays a strategic role in accelerating transaction processes, reducing queues, facilitating customer independent transactions, and increasing operational efficiency by reducing employee workloads (Anugrah & Wahyudi, 2025).

The study conducted by Raihan et al. (2024) found that digital banking is able to increase operational efficiency in regional banks because it is able to reduce costs and increase productivity. This has been empirically proven in research by Abu Al-Haija et al. (2025), which shows that digital transformation of banking is able to increase profitability, operational efficiency, customer satisfaction and market competitiveness in Islamic banks in Indonesian and Malaysia. Combined empirical evidence shows that digitalization not only streamlines operational structures but is also able to expand reach to customers who have not been served by banks, thus strengthening financial inclusion.

Research conducted by McKinsey in 2014 highlighted the potential of digital banking to improve operational efficiency, with estimated gains ranging from 15% to 20%. This aligns with economic theory that technological advances can trigger increases in productivity and efficiency (Adzimatinur et al., 2025).

Our measurement of digital banking transformation uses operational costs for digital transformation features, which include IT infrastructure investment, digital service outsourcing costs, labor costs, and marketing and promotional costs for digital bank branding. Based on these conditions, we develop the following hypothesis

H1: Digital Transformation Has a Positive Impact on Banking Efficiency

The Effect of CAR on Efficiency

Another factor that can influence banking efficiency is the bank's capital level, as measured by the Capital Adequacy Ratio (CAR). Digital banks (neo-banks) in Indonesia have high CARs, exceeding the minimum requirement of 8%. This is because digital banks receive full support from stakeholders in carrying out digital transformation (Shanti et al., 2024). A high level of capital indicates good resilience in absorbing risk. In other words, banks that have good capital will receive lower bankruptcy costs, thereby reducing the cost of funds. Strong capital is crucial for weathering financial crises and increasing customer security, especially during times of macroeconomic instability. A low capital ratio will result in higher leverage and risk (Sufian et al., 2016). Thus a high level of capital indicates good efficiency.

H2: CAR Has a Positive Impact on Banking Efficiency

The Effect Inflation on Efficiency

Inflation as an external factor is believed to be able to influence the company's efficiency performance. The more unstable macro conditions, limited resources and high demand lead to scarcity of production factors, resulting in higher acquisition costs, high operational costs resulting in less efficient company performance. Because this macroeconomic problem factor has a direct impact on banking performance.

H3: Inflation Has a Positive Impact on Banking Efficiency

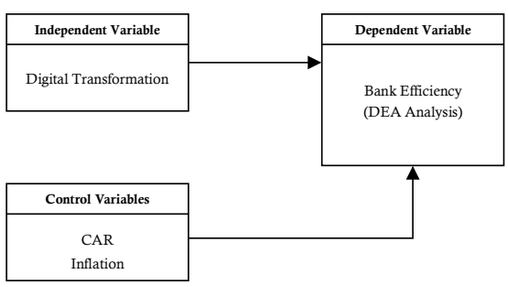


Figure 2. Research Model

METHOD

This quantitative research uses secondary data obtained through publication reports of the Financial Services Authority (OJK). The sample determination was done using purposive sampling with the criteria of digital commercial banks with complete publication of financial reports during the 2018-2025 period. Thus, 5 companies were obtained, consisting of Allo Bank, Bank Jago, Bank Neo, Hi-Bank, and Superbank. This panel data is processed and analyzed using the Autoregressive Distributed Lag regression model (Panel ARDL) using the help of Eviews 13 software. There are several stages, including the first, conducting a data stationarity test to determine the level of stationarity of the data using a unit root test. The ARDL method can be applied when the data stationarity level varies, provided it is at the level or first difference. The equation used in this study is as follows:

$$EF_t = \beta_0 + \beta_1 LDT_t + \beta_2 CAR_t + \beta_3 INF + e_t$$

So the equation in ARDL can be stated as follows:

$$\Delta EF_t = \varphi_0 + \varphi_1 LDT_{t-1} + \varphi_2 CAR_{t-1} + \varphi_3 INF_{t-1} + \sum_{i=1}^{n} \pi_{1i} + \sum_{i=1}^{n} \pi_{2i} + \sum_{i=1}^{n} \pi_{3i} + e_t$$

Information:

EF : Bank efficiency at time t

LDT : Log of digital transformation of bank t

CAR : Capital Adequacy Ratio of bank t

INF : Inflation at time t

Δ : First difference

β : Cointegrating vector

φ : Error correction coefficient

Furthermore, operational variables are measured as in Table 1.

Table 1. Operational Variables

Variable	Description	Measurement
Dependent		
Efficiency	Measuring company performance from the level of operational efficiency measured by non-parametric Data Envelopment Analysis (DEA) intermediation approach.	**Input:** Third-party funds Interest expense Labor expense Fix Asset **Output:** Credit Interest Income Other income
Independent		
Digital Transformation	Intermediation activities that transform the traditional banking business system by maximizing technology and big data functions using operational cost proxies for digital transformation features such as investment in technology infrastructure, digital outsourcing service costs, workforce to promotion and branding as a digital bank.	Operational costs include: Labor cost Marketing and promotion cost Other cost
Control Variable		
Capital Adequacy Ratio	The level of adequacy of bank capital used to cover risks and provide funds for development or to fulfill obligations.	$CAR = \frac{Capital}{ATMR}$
Inflation	Increases in the price of goods/services that can affect operational efficiency	

RESULT AND DISCUSSION

Efficiency is sought based on the DEA method from the combination of input and output of the intermediation approach. The DEA efficiency results show that the average efficiency of all digital banks/neo banks has increased, especially after they transformed from traditional banks to neo banks. This can be seen in the 2019-2021 period, where this period was a transformation process for banks changing their lines and businesses from traditional banks to neo banks or digital banks. During the transformation period, efficiency performance was low, this was due to the large investment costs incurred for IT

infrastructure, digital service costs, IT workforce, management and cultural changes, and marketing costs as promotion for branding the new business model. Digital transformation is certainly driven by increasingly dynamic changes and technical awareness of executives in innovation, especially in banking technology, which is able to have a positive impact on efficiency performance.

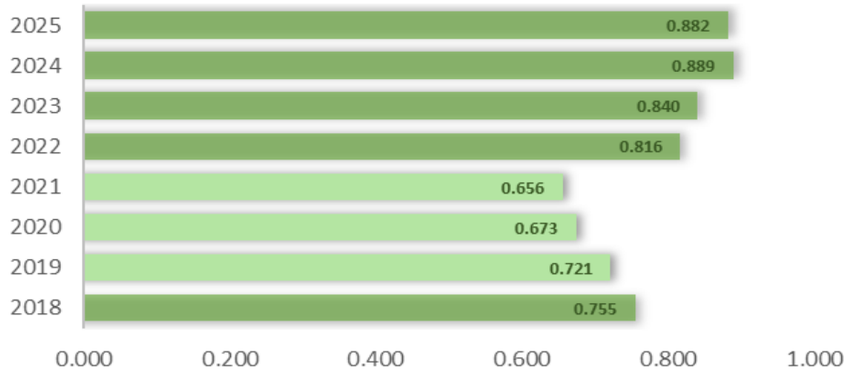


Figure 3. Average Efficiency Score of Digital Banks 2018-2025

As seen in Figure 3, after the transformation period, the efficiency performance of digital banks or neo banks showed increasingly better efficiency performance compared to before they transformed. On a DEA scale of 0 to 1, where 1 means fully efficient, the average score rose from 0.701 before the transformation (2018–2021) to 0.857 after it (2022–2025).

This is in line with Zhu and Jin (2023) in their research on banks listed on the Chinese stock exchange. Furthermore, this study also supports the findings of Kriebel and Debener (2019), who explained that IT investment increases bank efficiency, but there is a time lag to achieve target efficiency. The decline in bank efficiency is in line with the high costs of digital transformation, including large investments in IT infrastructure, costs of technology and digital talent, costs of organizational/management changes, and promotional costs for marketing and branding new business models.

Unit Root Test

The stationarity test aims to ensure that time series data is stationary, meaning it has constant statistical characteristics over time, thus producing valid and well-interpreted results. The following table shows the results of stationarity tests based on LLC and IPS. Because panel data consists of cross-sectional and time-series data, the analysis involves an empirical model by testing the stationarity of each variable.

Table 2. Panel Unit Root Test Results

Variable	LLC	IPS	Order
Efficiency	0.0017***	0.0021***	I(0)
Digital Transformation	0.0000***	0.0000***	I(1)
CAR	0.0000***	0.0000***	I(1)
Inflation	0.0695*	0.0015***	I(0)

Note: Values are probabilities at the level where each variable is stationary (level for I(0), first difference for I(1)). ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2 presents the results of the panel unit root tests using the LLC and IPS methods. Both tests yield consistent conclusions. Efficiency and Inflation are stationary at level, I(0), with Efficiency significant at the 1% level in both tests and Inflation significant at the 10% level (LLC) and the 1% level (IPS). Meanwhile, Digital Transformation and CAR become stationary after first differencing, I(1), at the 1% significance level. Since all variables are integrated of order zero or one, with none at a higher order, the data are suitable for further panel regression analysis.

Cointegration Test

After all panel variables are declared stationary at the level stage and the 1st difference stage, other tests are carried out on the

cointegration test for efficiency as a dependent variable and digital transformation, CAR, inflation as dependent variables. By applying the cointegration test based on Pedroni and Kao. Based on the results of the Pedroni cointegration test, there is no cointegration, in other words, the dependent and independent variables are in a long-term relationship.

Table 3. Cointegration Test Results

Cointegration Test		**Statistic**	**Prob.**
Kao CointegrationTest	ADF	-2.3829	0.0086***
Pedroni CointegrationTest	Panel v-Statistic	-0.6617	0.7459
	Panel rho-Statistic	-0.6102	0.2709
	Panel PP-Statistic	-2.5536	0.0053***
	Panel ADF-Statistic	-2.2386	0.0126**

Significance levels 1% and 5%

The final stage involves using the Pooled Mean Group (PMG) to estimate the ARDL panel regression with the optimum lag selected based on the AIC selection criteria. Table 4 presents the results of the short-term and long-term ARDL panel regressions of digital banking transformation and other explanatory variables in digital banks from 2018 to 2025.

Tabel 4. ARDL Estimation Results (Short Term and Long Term)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Long-Run Equation				
DT	0.23363	0.02800	8.34173	0.0000***
CAR	0.00021	0.00022	0.93002	0.3540
INFLASI	-0.04179	0.01858	-2.24957	0.0261**
C	-0.28392	0.15317	-1.85367	0.0660*
Short-Run Equation				
COINTEQ	-0.4374	0.19509	-2.24238	0.0266**
D(EFFICIENCY(-1))	0.13444	0.17032	0.78932	0.4313
D(DT)	-0.00154	0.06540	-0.02368	0.9811
D(CAR)	0.00015	0.00116	0.13088	0.8961
D(CAR(-1))	6.07E-05	0.00089	0.06809	0.9458
D(INFLATION)	-0.02265	0.01924	-1.17730	0.2412
D(INFLATION(-1))	0.06092	0.03934	1.54858	0.1239
D(INFLATION(-2))	-0.05477	0.03865	-1.41706	0.1588
D(INFLATION(-3))	0.05984	0.05251	1.13959	0.2565

Note: ***, **, and * indicate stationarity at the 1%, 5%, and 10% significance levels, respectively.

Table 4 shows a relationship between the two independent variables, digital transformation and inflation. The cointeq value, as the error correction coefficient, is negative at -0.4374 and significant at the 5% level, implying that all observed variables have a cointegration relationship or long-term equilibrium. This means that the model can be said to be valid in explaining adjustments from the short term to the long term. In other words, efficiency can adjust towards the long term by approximately 43.7% for one period. If a shock or deviation from the long-term efficiency equilibrium occurs, it will be adjusted at a speed of adjustment of approximately 2.29 quarters, or approximately 6-7 months, to return to long-term equilibrium. The significant negative error correction coefficient value also provides evidence of a stable long-term relationship between the predictor and the dependent variable.

In the short term, digital transformation has an insignificant negative value. It is possible that large investments in a short period in various

digital infrastructures could have an impact on reducing bank efficiency. CAR has a positive but insignificant effect, and inflation is insignificant. In the long term, digital transformation will have a positive impact on bank efficiency performance, as seen in the positive coefficient at the 1% level. Other variables, such as CAR, have a positive but insignificant effect, and long-term inflationary economic conditions have a negative effect on bank efficiency. Therefore, it can be concluded that digital transformation can improve bank efficiency after implementing digitalization for a certain period, in line with what is explained in the study (Yang et al., 2018). Other similar studies by He et al. (2025) and Yongjie and Shanyue (2025) provide empirical evidence that digital transformation has a positive impact on long-term banking performance.

DISCUSSION

Based on the results of the methodology used in this study, it shows that the digital transformation from traditional banking to digital banking brings positive changes, especially in improving bank efficiency performance (Shanti et al., 2024; Zhu & Jin, 2023). This is evident from the DEA efficiency value after the transformation into a digital bank, where efficiency is better compared to before the transformation period. The five digital banks consist of Allo Bank formerly Bank Harda International, Bank Jago (formerly Bank Artos Indonesia), Bank Neo (formerly Bank Yudha Bhakti), Hi-Bank formerly (Bank Mayora), and Superbank formerly (Bank Fama Internasional). During the period before the transformation, these banks were small-scale banks or banks with Core Capital Bank Groups (KBMI) 1 and 2 that had limited capital, small market share, limited networks and management performance, poor performance to small digital services compared to KBMI category banks 3 and 4 which have large capital, extensive office networks and management to large market share. The five digital banks transformed after being acquired by technology companies such as Gojek, CT Corp, PT Metamorphosis and emtek group to Singtel (Singapore Telecommunications Limited) (Shanti et al., 2024).

Digital Transformation empirically, based on the results of the ARDL panel test, has a significant positive effect on bank efficiency (He et al., 2025; Zhu & Jin, 2023). In the short term, Transformation has a negative but insignificant effect on bank efficiency. This condition is caused by the large investment costs that companies must incur during the transformation period, such as IT and cloud infrastructure investments, digital application development costs, cybersecurity costs, management and HR changes, maintenance costs, and promotion/marketing costs as digital bank branding (Bueno et al., 2024). In the long term, digital transformation has a positive impact, especially in improving efficient performance. This is seen empirically from the test, which gives a result of 0.2336 with a significant probability level of 1%. In the long term, transformation provides benefits such as a higher business scale by serving millions of customers without having to open many offices, increased competitiveness with fintech, increased productivity, effective and efficient transactions so that these conditions will improve customer experience and result in high product usage, increased customer loyalty, and increased fee-based income, which ultimately directly impacts bank performance in terms of efficiency (Abu Al-Haija et al., 2025; Dewi & Octrina, 2022; Yang et al., 2018; Yongjie & Shanyue, 2025).

Digital transformation is an organization's collective action in adopting disruptive digital technology to achieve its goals and significantly change its performance and efficiency (Kitsios et al., 2021). One reason banks explore digital transformation is to reduce operational costs; another reason is to differentiate themselves (Bueno et al., 2024). This study contributes to the academic field and complements previous studies on the impact of digital transformation on bank efficiency, showing that digital transformation is one of the determinants of bank efficiency (He et al., 2025; Raihan et al., 2024). Digital transformation has a direct and sustainable impact on operational performance, not just financial performance, because efficiency in operational activities and innovation in operational performance are visible (Anugrah & Wahyudi, 2025; Indrayani et al., 2025). Digital technology is a supporting factor in transforming banks into different banks, not only in terms of time and cost efficiency, but also in terms of providing high-quality services to customers with efficient and conducive security guarantees (Filotto et al., 2021).

Another independent variable, CAR, had a positive but not statistically significant effect. Positive parameter estimates indicate that banks with higher CAR ratios tend to exhibit higher levels of efficiency. The CAR variable describes a bank's capital ratio to mitigate the risk of operational losses (Widiarti et al., 2015). A higher CAR value reflects a bank's financial capacity to develop its business, cover the risk of losses, and increase investment in technology (Sufian et al., 2016). The empirical results in this study suggest that the insignificant CAR is another reason why digital banks often face risks related to cyber and operational risks. Therefore, even if digital banks have a high CAR, if the bank faces operational

disruptions or cyber risks, efficiency will remain low. This contrasts with a previous study by Syafrudin et al. (2024), which found that the CAR variable had a significant positive effect on efficiency performance.

Inflation has a negative effect in the long term, with a coefficient value of -0.0417 and significant at the 5% level. In the short term, the negative effect is not significant. This is because the impact of inflation in the short term is not yet felt or is still tolerable, and companies/banks are usually still able to maintain normal operations and reduce costs temporarily. Furthermore, generally, employment contract costs, interest rates, or service fees do not change drastically immediately but rather there is a certain time lag. If inflation persists for a long time and is high, in the long term, its impact begins to depress efficiency (Syafrudin et al., 2024). This will certainly require many spending adjustments, such as increased operational costs (employee salaries, maintenance costs, technology, and electricity). Furthermore, declining purchasing power also contributes to the relatively low demand for services.

CONCLUSION AND RECOMMENDATION

This study examined the effect of digital transformation on the efficiency of digital banks in Indonesia, using DEA to measure efficiency and the panel ARDL model to estimate the effect, with CAR and inflation as control variables. The findings show that digital transformation can improve the efficiency of digital banks. Efficiency scores tended to be lower in the period before the transformation; during the transformation, banks incurred large investment costs to build their digital banks; and after the transformation (2022–2025), efficiency tended to increase. The impact of digital transformation is felt in the long term rather than immediately.

The results indicate a positive effect in the long term, with a time lag of around 6–7 months before the impact is felt (based on quarterly observation data). In the short term, digital transformation has a negative but insignificant effect on efficiency, as the process requires large costs, including IT infrastructure investment, management and cultural changes, technology investment, and promotional costs for branding. This study confirms the findings of previous studies presented in the literature review that digital transformation reduces operational costs and increases customer satisfaction. Among the control variables, CAR has a positive but insignificant effect, while inflation has a significant negative effect in the long term.

Overall, this study verifies that digital transformation can improve operational performance. Increasing efficiency by implementing digital transformation also has the potential to encourage microlending, as microcredit is crucial for supporting business and economic growth. Indonesia, as a developing country, is dominated by Micro, Small, and Medium Enterprises (MSMEs) in the business sector. Digitally integrated services can certainly encourage MSME activity and improve the welfare of low-income communities. The number of digital banks (neobanks) in Indonesia is still limited compared to traditional banks. Some traditional banks are developing their digital banking services through separate business lines. Many academics have studied digital business transformation, but most banks have not fully adopted it due to limited information regarding the adoption of digital transformation and the money used for investment in digital transformation. Therefore, it is important to expand the study of digital transformation not only to improve efficiency but also to its relationship with financial performance and the competition between businesses.

This study has several limitations. The research object is limited to five digital banks/neobanks in Indonesia; future research may include more information from other newcomer neobanks. The determinants of neobank efficiency are limited to three independent variables tested: digital transformation, capital adequacy, and inflation. Many other factors can influence bank efficiency, both specific and macroeconomic. Furthermore, future research could expand the study by adding aspects of competition/market power. This is because digital transformation in banking allows companies to achieve inclusiveness in their products. This condition can create new competition with traditional banks. Furthermore, it can also compare the financial performance of digital banks with traditional banks. Furthermore, future researchers can use other recent statistical tools.

AUTHOR CONTRIBUTIONS

Hadi Satria Ganefi: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, and Project administration.

Arief Surya Lesmana: Supervision, Validation, Resources, Writing – review and editing, and Research coordination.

Dadan Darmawan Muttaqien: Investigation, Data analysis, Validation, Resources, and Writing – review and editing.

FINANCIAL DISCLOSURE

This research was carried out without financial support from external funding agencies or other sponsoring institutions.

CONFLICT OF INTEREST

The authors state that they have no competing interests that may have affected the research, analysis, interpretation of results, or publication of this article.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

The authors declare that generative artificial intelligence was not utilized to generate the article's content, develop its arguments, or establish its conceptual framework.

REFERENCES

Abu Al-Haija, E., Al-Haraizah, A., Lataifeh, A. S., Meqdade, M., & Yousef, N. (2025). The impact of digital banking transformation (DBT) platforms on the profitability and efficiency of Islamic banking. *Journal of Islamic Marketing*, 1080–1100.

Adzimatinur, F., Siti Jahidah, N., & Rois, T. (2025). Digital banking: Catalyst or challenge? Analyzing profitability amidst the COVID-19 pandemic. *Jurnal Dinamika Ekonomi Syariah, 11*(2), 153–166.

Anugrah, A., & Wahyudi Nur, R. (2025). The influence of digital banking and operational efficiency on the service performance of Bank Sulselbar, Antang Branch. *Tax and Economic Insights Journal, 2*, 1–10.

Bueno, L. A., Sigahi, T. F. A. C., Rampasso, I. S., Leal Filho, W., & Anholon, R. (2024). Impacts of digitization on operational efficiency in the banking sector: Thematic analysis and research agenda proposal. International *Journal of Information Management Data Insights, 4*(1), Article 100230.

Dewi, D. D., & Octrina, F. (2022). Pengaruh era digital terhadap kinerja keuangan perbankan BUMN periode 2013–2020. *E-Proceeding of Management, 9*(4), 1773–1780.

Filotto, U., Caratelli, M., & Fornezza, F. (2021). Shaping the digital transformation of the retail banking industry: Empirical evidence from Italy. *European Management Journal, 39*(3), 366–375.

He, S., Jin, Z., Hong, Y., Ma, L., Jiang, Y. E., & Chen, Y. J. (2025). The impact of digital transformation on commercial banks' business performance: An empirical study of 39 listed commercial banks. *SAGE Open, 15*(4), 1–16.

Indrayani, E., Berlian, S., Lestari, R. P., & Purnomo, R. A. (2025). Peran digitalisasi dalam meningkatkan kinerja perbankan di era transformasi teknologi. *PESHUM: Jurnal Pendidikan, Sosial dan Humaniora, 4*(3), 4835–4842.

Kitsios, F., Giatsidis, I., & Kamariotou, M. (2021). Digital transformation and strategy in the banking sector: Evaluating the acceptance rate of e-services. *Journal of Open Innovation: Technology, Market, and Complexity, 7*(3), Article 204.

Kriebel, J., & Debener, J. (2019). The effect of digital transformation on bank performance. *SSRN, 14*(4), 1–34.

Raihan, M., Nasution, M. L. I., & Daulay, A. N. (2024). Analisis dampak perkembangan teknologi AI dalam meningkatkan efisiensi operasional bank syariah (Studi kasus Bank Sumut Kantor Cabang Syariah Medan Ringroad). *Jesya, 7*(2), 2049–2062.

Shanti, R., Siregar, H., Zulbainarni, N., & Tony. (2024). Revolutionizing banking: Neobanks' digital transformation for enhanced efficiency. *Journal of Risk and Financial Management, 17*(5), Article 188.

Sidhu, A. V., Abraham, R., Bhimavarapu, V. M., Kanoujiya, J., & Rastogi, S. (2023). Impact of liquidity on the efficiency of banks in India using panel data analysis. *Journal of Risk and Financial Management, 16*(9), Article 390.

Sufian, F., Kamarudin, F., & Nassir, A. M. (2016). Determinants of efficiency in the Malaysian banking sector: Does bank origins matter? *Intellectual Economics, 10*(1), 38–54.

Syafrudin, O., Satria Ganefi, H., & Surya Lesmana, A. (2024). Determinant efficiency of the banking industry in Indonesia. *Jurnal Riset Ekonomi dan Bisnis, 17*(2), 113–125.

Widiarti, A. W., Siregar, H., & Andati, T. (2015). The determinants of bank's efficiency in Indonesia. *Buletin Ekonomi Moneter dan Perbankan, 18*(2), 129–156.

Yang, S., Li, Z., Ma, Y., & Chen, X. (2018). Does electronic banking really improve bank performance? Evidence in China.

International Journal of Economics and Finance, 10(2), 82.

Yongjie, Z., & Shanyue, J. (2025). The impact of bank digital transformation on the financial performance of commercial banks. *SAGE Open, 15*(3), 1–21.

Zhu, Y., & Jin, S. (2023). How does the digital transformation of banks improve efficiency and environmental, social, and governance performance? *Systems, 11*(7), Article 328.