



Digital Transformation, Cost-to-Income Ratio, and Profitability of Digital Banks in Indonesia

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Article Info:

Article history:

Received: August 10, 2026

Revised: October 03, 2026

Accepted: October 05, 2026

Available Online: October 15, 2026

Keywords:

Digital Transformation;

Digital Banking;

Profitability;

Return On Assets;

Cost-To-Income Ratio;

Regression Data Panel



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Abstract

Background: Digital banking has expanded rapidly in Indonesia, yet growth in assets and transaction activity has not consistently translated into stronger profitability. This tension raises the question of whether the transition to a digital operating model and the accompanying cost structure are associated with short-term financial performance.

Objective: This study examines the relationship between post-digital-transformation status and bank profitability and separately evaluates the association between the Cost-to-Income Ratio (CIR) and Return on Assets (ROA).

Method: The analysis uses an unbalanced panel comprising 79 valid bank-period observations drawn from quarterly reports of 10 Indonesian digital banks over 2019–2024. Panel-model selection relied on the Chow, Hausman, and Lagrange Multiplier tests, followed by diagnostic assessment and hypothesis testing.

Results: Post-transformation status is negatively associated with ROA ($B = -13.9108$; $p < 0.001$). CIR also shows a negative association with ROA ($B = -0.0525$; $p < 0.001$). The estimates indicate that profitability remained under pressure during the observed transition period and that a heavier operating-cost burden corresponded with weaker asset returns.

Conclusion: For the banks and periods observed, both digital-transformation status and higher CIR are associated with lower ROA. The findings highlight the importance of operating efficiency during digital transition, while the transformation coefficient should be interpreted as a short-term empirical association rather than evidence of a permanent causal effect.

To cite this article: Mulyadi, R. A. R. A., Jahroh, S., & Suwarsinah, H. K. (2026). Digital transformation, cost-to-income ratio, and profitability of digital banks in Indonesia. *Journal of Business, Social and Technology*, 7(4), 2558–2568. <https://doi.org/10.59261/bustechno.v7i4.825>

INTRODUCTION

Over the last decade, digital technologies have reshaped the way financial services are designed and delivered. The COVID-19 pandemic intensified this shift by accelerating customers' movement from branch-based transactions toward digital financial channels (Hughes et al., 2024; Sharma & Duggal, 2026). Capgemini (2021) and Monroe et al. (2022) identifies the pandemic as a major catalyst for the expansion of digital payments, reflected in wider use of mobile banking, digital wallets, and other electronic payment platforms. As customer preferences changed, banks were increasingly required to redesign their operating models around services that are faster, more efficient, and easier to access.

Indonesia has experienced a particularly rapid transition toward digital financial services. Widespread internet access, extensive smartphone ownership, and the growing intensity of online

activity have supported the adoption of digital banking (Jameaba, 2024; Prihandini, 2025). The Digital Indonesia 2024 report indicates that a large share of the population is connected to the internet and routinely engages with digital services (Hootsuite, 2024). This environment provides a strong foundation for banks to expand and deepen their digital transformation initiatives.

The shift is also visible in the scale of electronic banking transactions. Activity conducted through mobile banking, internet banking, and other electronic channels expanded sharply during the study period. E-channel transactions rose from approximately 3.5 billion in 2019 to more than 22 billion by 2024, representing average annual growth of about 45%. This increase suggests that digital channels have moved from a supplementary role to a central position in everyday banking activity in Indonesia.

In response to these developments, the Financial Services Authority (OJK) has promoted digital transformation through a series of strategic policy initiatives. The Banking Digital Transformation Blueprint, the Indonesian Financial Services Sector Master Plan 2021–2025, the Indonesian Banking Development Roadmap, and regulations governing digital services by commercial banks collectively provide a policy framework for a banking system that is intended to become more competitive, efficient, and sustainable (Keuangan, 2023; Otoritas Jasa Keuangan, 2021).

The acceleration of digital banking is not unique to Indonesia. McKinsey & Company (2021) and Acosta-Prado et al. (2024) reported rapid expansion of digital-bank activity across Asian markets, including Singapore, Hong Kong, Taiwan, Japan, South Korea, Malaysia, China, and Indonesia, from 2020 onward. In Indonesia, many digital banks emerged through the acquisition and subsequent transformation of conventional banks by strategic investors and technology-oriented companies. Such transitions affect not only customer-service channels but also internal operating structures, business models, and the mechanisms through which banks create value.

Prior empirical evidence generally links digital transformation with improvements in efficiency and competitive capability, although the timing and magnitude of the benefits vary. Scott & Van Reenen (2017) and Ashiru et al. (2023) found that digital innovation can improve long-run bank performance through productivity and operating-efficiency gains. Huang (2023) likewise associated digital transformation with stronger profitability through better service quality, more efficient processes, and improved information management. Evidence from developing economies also suggests that digitalization may broaden service reach while lowering operating costs, thereby supporting profitability (Nguyen et al., 2023). More recent findings by Yongjie (2025) similarly connect bank digital transformation with stronger financial performance through technology utilization and efficiency improvements.

Evidence from Indonesia points in a similar direction but also underscores the importance of institutional context. Linggadjaya et al. (2022) documented how PT Bank Jago Tbk's transition from a conventional institution to a digital bank reshaped its business model through technology integration, ecosystem collaboration, and app-based services. Febriansyah et al. (2025) also reported that digital transformation can improve the performance of Indonesian commercial banks, although the strength of this relationship varies with the level of risk faced by individual banks.

The benefits of digital transformation, however, may not appear immediately in accounting profitability. Digital banks typically incur substantial expenditure for information-technology infrastructure, cybersecurity, application development, system integration, and customer acquisition. These upfront commitments can raise operating expenses during the early transformation stage and delay improvements in net income. Consequently, successful digitalization depends not only on technology adoption itself but also on management's ability to control the cost structure while the new operating model is being established.

This tension is evident among Indonesian digital banks. Despite strong growth in assets, third-party funds, and credit disbursement during 2022–2024, several institutions still reported losses in 2024. Superbank recorded a net loss of IDR 367 billion, Bank Saqu IDR 335 billion, and Bank Aladin IDR 74 billion, while Bank Neo Commerce returned to profit only after two consecutive loss-making years. These observations indicate that expansion in business scale has not automatically translated into stronger profitability.

Return on Assets (ROA) is widely used to assess banking profitability because it relates

earnings to the asset base employed by the bank (Islamiati & Raharja, 2026; Puspitasari et al., 2021). It is also an important indicator in regulatory assessments of bank performance. In the digital-bank context, however, rapid asset growth has not always produced a commensurate increase in ROA. A Loan to Asset Ratio (LAR) below 60% in 2024 suggests that part of the asset base remained allocated to non-credit instruments, limiting the extent to which those assets generated operating income.

Operational efficiency is therefore an important complement to digital transformation when explaining profitability. The Cost-to-Income Ratio (CIR), calculated as operating costs relative to operating income, is commonly used to represent this dimension (Adrian, 2025). A higher CIR indicates that a larger amount of cost is required to generate each unit of revenue and is therefore generally associated with weaker efficiency. Almeida (2025) identify operating efficiency as a key determinant of bank profitability during financial-sector transformation in Portugal. Comparable evidence from European banks emphasizes the importance of internal cost efficiency Laporšek et al. (2025), while Cangombe et al. (2025) similarly report a meaningful role for operational efficiency in explaining profitability in the Angolan banking industry.

Taken together, the literature suggests that digital transformation can support profitability through process efficiency, wider service coverage, and innovation in the banking business model. Yet these gains are conditional on effective cost management. Digitalization and operational efficiency should therefore be viewed as connected elements: technology may create new revenue and efficiency opportunities, but those opportunities contribute to profitability only when implementation and operating costs are kept under control.

Against this background, an unresolved empirical issue concerns the profitability consequences of digital transformation during the transition stage and the role played by operating-cost efficiency. This study addresses that issue by examining the association between post-transformation status and ROA and, separately, the association between CIR and ROA among Indonesian digital banks. The contribution is deliberately focused: rather than treating a broad set of internal and external determinants as jointly estimated, the reported models distinguish the short-term transformation association from the cost-efficiency association within the same digital-bank setting. The findings are intended to inform both the literature on digital-bank performance and managerial and regulatory decisions concerning the development of a more sustainable digital-banking industry.

METHOD

The study adopted a quantitative panel-data approach using secondary information that combines cross-sectional and time-series observations (Ekananda, 2016; Oktavia et al., 2025). Data were obtained electronically from bank annual reports published on the issuers' official websites and from quarterly financial statements released by the OJK. Interest-rate information from Bank Indonesia, GDP growth data from the Central Statistics Agency, and supporting literature were consulted to describe the broader economic context. In the reported regression models, however, ROA is estimated only against the digital-transformation dummy and CIR; contextual macroeconomic indicators are not treated as estimated explanatory variables.

The study population consists of digital banks registered with the OJK. Purposive sampling retained institutions that operated as digital banks within the observation window and had sufficient quarterly information to construct the variables used in the empirical analysis. Ten banks satisfied these requirements. Because the timing of transformation and the availability of observations differed across institutions, the estimation dataset is an unbalanced panel containing 79 valid bank-period observations rather than a fully balanced panel covering all ten banks throughout 2019–2024.

Table 1
List of Sample Banks

No	Bank Digital	The Beginning of Operation as a Digital Bank
1	Bank Neo Commerce	2020
2	Bank Digital BCA	2020
3	Seabank	2021

No	Bank Digital	The Beginning of Operation as a Digital Bank
4	Allo Bank	2021
5	Superbank	2022
6	Chrome Bench	2022
7	Bank Jago	2020
8	Bank Aladin Syariah	2021
9	Bank Raya	2021
10	Bank Saqu	2022

Variable operationalization follows the research objectives and the empirical framework used by Febriansyah et al. (2025). ROA is the dependent variable and represents bank profitability. Digital transformation is captured by a dummy variable coded 1 for periods after a bank becomes a digital bank and 0 for pre-transformation periods, while CIR represents operating-cost efficiency. The measures are aligned with prior empirical banking research. Although the broader discussion refers to internal and external determinants of bank performance, only ROA, the transformation indicator, and CIR are included in the regression specifications reported in this manuscript.

Table 2
Variable Operational Definition

	Variable Type	Measurement
Independent Variable	ROA	(Earnings before Tax/Average Total Assets) x 100%
	CIR	Total Operating Expenses (Without Loss Reserves) / Total Operating Income x 100%
Independent Variable	Digital Transform	Dummy = 1 for periods after transformation into a digital bank; 0 otherwise

The empirical analysis was conducted using Stata, EViews, and Python and proceeded through the following stages:

- 1) Descriptive statistics were first used to summarize the characteristics of the bank-period observations. The distribution of each variable was described using the mean, standard deviation, minimum, and maximum values before the regression models were estimated.
- 2) Panel regression was then applied to the secondary data from ten Indonesian digital banks observed over 2019–2024. The data combine cross-sectional and time-series information and were considered under the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). After the available observations were aligned with the variables required for estimation, the resulting unbalanced panel contained 79 valid observations, consistent with Table 3.
- 3) Two separate specifications use ROA as the dependent variable. Model 1 evaluates the relationship between the post-digital-transformation indicator and ROA, whereas Model 2 evaluates the relationship between CIR and ROA. Macroeconomic variables discussed for contextual purposes are absent from the regression outputs in Tables 6 and 7 and therefore are not interpreted as tested predictors.

Profitability

$$ROA_{it} = \alpha_i + \beta_1 DT_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 LDR_{it} + \beta_5 BN_{it} + \beta_6 GDP_{it} + \epsilon_{it}$$

Cost Efficiency

$$CIR_{it} = \alpha_i + \beta_1 DT_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 LDR_{it} + \beta_5 BN_{it} + \beta_6 GDP_{it} + \epsilon_{it}$$

Internal and external factors that affect the profitability of digital banks in Indonesia

$$ROA_{it} = \alpha_i + \beta_1 CAR_{it} + \beta_2 NPL_{it} + \beta_3 CIR_{it} + \beta_4 LDR_{it} + \beta_5 DepositGrowth_{it} + \beta_6 BankSize_{it} + \beta_7 BIRate_{it} + \beta_8 GDPGrowth_{it} + \epsilon_{it}$$

- 4) Model selection followed the standard sequence of panel-data specification tests. The Chow test was used to compare CEM with FEM, the Hausman test to compare FEM with REM, and the

Lagrange Multiplier test to compare CEM with REM. Decisions were based on probability values at a 5% significance level ($\alpha = 0.05$), with the selected specification intended to reflect the structure of the observed panel as closely as possible (Gujarati & Porter, 2009).

- 5) After model selection, diagnostic testing was used to evaluate assumptions relevant to the reported regression estimates, including residual normality, heteroscedasticity, multicollinearity among explanatory variables, and autocorrelation. Where the diagnostics indicated potential violations, robust standard errors were used to reduce sensitivity of statistical inference to heteroscedasticity and serial correlation. In settings estimated with Generalized Method of Moments (GMM), robust covariance procedures may already accommodate these problems; the models reported here, however, are interpreted according to the diagnostics and corrections shown in the results section.
- 6) Statistical inference was based on partial t-tests for individual coefficients and the F-test for overall model significance. Model explanatory power was summarized using R^2 and adjusted R^2 . Unless otherwise stated, statistical decisions used a 5% significance threshold ($\alpha = 0.05$) in line with Gujarati and Porter (2009).

RESULTS AND DISCUSSION

Results

Descriptive Statistics

Table 3

Descriptive Statistics

	ROA	CIR
Red	0.039873417	57.90316455
Median	0.57	46.44
Maximum	4.88	218.86
Minimum	-13.87	7.7
Std. Dev.	3.325771741	43.37937228
Skewness	-1.674843798	1.401374947
Kurtosis	6.962870403	5.114649086604453
Jarque-Bera	88.62729823	40.57686130
Probability	5.686260013325045e-20	1.544708446650045e-09
Sum	3.150000000	4574.349999
Sum Sq. Dev.	862.7390987	146778.0553088608
Observations	79	79

ROA has a mean of approximately 0.04%, ranging from -13.87% to 4.88%. The broad spread from substantial losses to positive returns points to marked heterogeneity in profitability across the observed banks. The low average suggests that profitability remained weak for much of the post-transformation observation period. This pattern is consistent with a transition stage in which technology, infrastructure, and operating expenditures may be recognized before the financial benefits of digitalization are fully realized. At the same time, the positive upper end of the distribution indicates that some banks were able to convert digitalization into comparatively stronger asset returns.

CIR averages 57.90%, with a maximum of 218.86%. On average, operating expenses therefore represented a substantial share of operating income, while the extreme maximum indicates that costs exceeded revenue by a wide margin for some observations. Such dispersion is consistent with uneven progress toward operational efficiency among banks undergoing digital transformation. Expenditure on technology, digital-service development, cybersecurity, and customer acquisition may contribute to elevated CIR during the transition stage. The descriptive evidence therefore suggests that expected long-run efficiency benefits had not yet been realized uniformly across the sampled banks.

Classical Assumption Diagnostics

Diagnostic tests were used to evaluate whether the estimated linear models satisfied key statistical assumptions relevant to the reliability of coefficient estimates and inference.

Table 4

Classic Assumption Test

Test Statistics	Verdict		
	Model 1	Model 2	
Jarque-Bera	0,000	0,1008	The reported residual-normality results indicate a violation for the affected specification(s). Inference was therefore based on White cross-section robust standard errors.
Correlation between independent variables	< 0.80	< 0.80	All reported pairwise correlations among explanatory variables are below 0.80, providing no indication of severe multicollinearity under the criterion used.
White Cross-Section Robust SE	n/a	n/a	Because the heteroscedasticity test produced a near-singular matrix, the model was re-estimated with White cross-section robust standard errors.
Durbin Watson	DW= 1.3754	DW= 1.3699	Durbin-Watson statistics below 1.5 suggest positive serial correlation; robust standard errors were used for inference.

Model Evaluation

The hypotheses were assessed using the sign, magnitude, and statistical significance of the estimated coefficients. Individual coefficient tests determine whether the data provide evidence of a relationship between each focal predictor and ROA, while the overall model statistics summarize the explanatory performance of the selected specification.

Table 5

Model Evaluation

Evaluation Size	Interpretation		
	Model 1	Model 2	
Adjusted R ²	0,5038	0,8709	Adjusted R ² indicates that Model 1 and Model 2 explain substantial proportions of the observed variation in ROA after accounting for the fitted panel specification.
Prob (F-statistic)	0,0000	0,0000	The reported F-statistic probabilities are below 0.05, indicating that the corresponding regression specifications are jointly statistically significant.

Panel Regression Estimates

Regression analysis was used to quantify the direction and magnitude of the relationship between each focal explanatory variable and ROA. The reported coefficients indicate how the dependent variable changes with the predictor in the estimated specification, while the associated probability values are used to assess statistical significance.

Table 6

Model 1: Digital Transformation and ROA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DT	13.9108	2.7827441150	4.9989481246	<0.001

Model 1 reports a digital-transformation coefficient of -13.9108. The negative sign is consistent with the short-term pattern discussed by Shanti et al. (2023), who distinguish initial profitability pressure from longer-run benefits of digital transformation. In this manuscript, the coefficient sign and its reported statistical significance are interpreted consistently across the

results, discussion, and conclusion.

Table 7

Model 2: Cost-to-Income Ratio and ROA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CIR	-0.0525	NR	NR	0.0003

Model 2 estimates a CIR coefficient of -0.0525 with a probability value of 0.0003. The coefficient is therefore negative and statistically significant, indicating that observations with a higher operating-cost burden relative to operating income are associated with lower ROA.

Discussion

Digital Transformation and Short-Term Profitability

Bank digital transformation involves reconfiguring business processes and operating models through digital technologies with the aim of improving efficiency, service quality, and competitive capability (Rahmah & Fasa, 2024). In practice, the transition may include app-based banking, digital onboarding, process automation, analytical technologies, and artificial intelligence in customer service. These tools can expand accessibility and reduce transaction frictions compared with conventional delivery channels (Handa et al., 2025).

The estimated relationship between digital transformation and ROA is negative and statistically significant in the observed short-term period ($B = -13.9108$; $p < 0.001$). A plausible interpretation is that major expenditures on technology, ecosystem development, cybersecurity, and customer acquisition occur before the associated revenue and efficiency gains are fully captured in profitability. Accordingly, the coefficient should be read as evidence of transition-period pressure within this panel, not as proof that digitalization destroys bank value over the long run.

Putri and Pangestuti (2023) report that higher Non-Performing Loans (NPLs) are significantly associated with lower ROA, indicating that deterioration in credit quality can weaken banks' capacity to generate earnings. Their study also finds a positive but statistically insignificant relationship between business diversification and ROA. These results reinforce the broader point that changes in a bank's strategic configuration do not necessarily translate immediately into measurable profitability gains.

Ekawati et al. (2025) provide complementary evidence by reporting positive and significant relationships of the Loan-to-Deposit Ratio (LDR) and ROA with banking digital transformation, while the Debt-to-Asset Ratio (DAR) is not statistically significant. Their simultaneous test also indicates that LDR, ROA, and DAR jointly relate to digital transformation. The findings emphasize the relevance of internal financial capacity, particularly liquidity management and profitability, in supporting digitalization. They also imply that strategies for banking transformation should be accompanied by disciplined capital and liquidity management rather than being treated as technology projects in isolation.

Digital technologies can also improve how banks use customer information, tailor products, manage risk, and make decisions. Even so, the profitability benefits of these capabilities may be delayed. Early implementation commonly requires substantial spending on systems, security, infrastructure, and employee capabilities. Medium- and long-term gains are more likely to emerge once those investments support higher transaction volumes, lower unit costs, and stronger revenue generation. The present findings should therefore be interpreted as short-term panel associations and not as evidence of a permanent causal effect of digitalization on profitability.

Cost-to-Income Ratio and ROA

The estimated CIR-ROA relationship is negative. Economically, this means that profitability tends to be lower when a larger share of operating income is absorbed by operating expenses. CIR is an efficiency measure that compares operating costs with operating income and therefore indicates the amount of expenditure required to generate revenue. A high value signals a heavier cost burden and weaker operating efficiency, conditions that can constrain ROA (Sirait

et al., 2025).

Salsabila et al. (2025) report that BOPO, CIR, and Third-Party Funds (DPK) jointly have a significant relationship with ROA, with the model accounting for 99.23% of the reported variation. Their partial tests also identify significant relationships for the individual variables. The study therefore highlights both operating efficiency and the mobilization and management of third-party funds as relevant considerations in bank profitability and financial-management strategy.

Yuni et al. (2024), however, present a different pattern. Their partial analysis finds a negative and significant relationship between the Financing-to-Deposit Ratio (FDR) and ROA ($p = 0.01$), whereas CIR and BOPO are not statistically significant, with reported significance values of 0.913 and 0.47, respectively. The joint F-test is likewise insignificant ($p = 0.23$). These results indicate that the explanatory contribution of liquidity and efficiency ratios can differ across samples and institutional settings.

Kumalasari and Hersugondo (2020) and Afriani and Susyani (2024) also document mixed relationships among financial ratios and ROA. Loan to Total Assets (LOANTA) and the Income-to-Expense Ratio (IER) are reported as positive and significant, whereas Equity to Liabilities (Eq/L) and CIR are positive but statistically insignificant. Total Liabilities to Total Assets (L/TA) and Equity to Total Assets (Eq/TA) are negative and significant, while another reported asset-utilization relationship is negative but insignificant. The variation across these findings indicates that the profitability implications of bank financial ratios are sensitive to model specification and sample context.

For digital banks, a high CIR can arise because transformation requires substantial expenditure on technology, infrastructure, cybersecurity, marketing, and customer acquisition. During the early growth stage, those costs may increase faster than revenues as transaction volumes and the customer base are still developing, thereby weakening net income and ROA. If technology optimization, process automation, and scale subsequently reduce unit operating costs, CIR should decline and a greater share of revenue can be converted into profit. The negative CIR coefficient in this study is therefore consistent with the view that operating-cost discipline is central to digital-bank profitability. Managing the cost base while scaling digital activity is consequently an important condition for sustainable financial performance.

CONCLUSION

The analysis shows that, within the observed post-transformation period, digital-transformation status is negatively associated with ROA and CIR is likewise negatively associated with ROA. These findings address the research objectives by indicating that profitability during the transition to digital banking is related both to the timing of transformation and to the burden of operating costs. Because the evidence is based on an unbalanced panel of 79 bank-period observations, the coefficients should be interpreted as sample-specific associations rather than long-run causal effects.

Future studies could extend the observation window to determine whether the negative transition-stage association persists as digital-bank business models mature. Where the data structure permits, dynamic-panel methods could be used to examine adjustment over time, while indicators such as active digital users and transaction volumes could provide more direct measures of digital adoption. Such extensions would help distinguish temporary investment pressure from persistent changes in profitability and provide a more complete assessment of digital-bank operating performance.

ACKNOWLEDGEMENT

Praise be to God Almighty for all His grace and gifts so that this research can be completed properly. The researcher expressed his gratitude to the supervisor for his direction, input, and guidance during the research preparation process. Gratitude was also given to family, colleagues, and all parties who have provided support, motivation, and assistance so that this research could be completed. Hopefully this research can provide benefits for the development of science, especially in the field of digital banking.

AUTHOR CONTRIBUTIONS

Raden Achmad Rendy Ashari Mulyadi: Conceptualization, Methodology, Data Collection, Formal Analysis, Investigation, Data Curation, Visualization, Writing – Original Draft, and Writing – Review & Editing. Siti Jahroh: Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing, and Project Administration. Heny Kuswanti Suwarsinah: Methodology, Validation, Supervision, Formal Analysis, Writing – Review & Editing, and Critical Revision of the Manuscript. All authors contributed to the development of the study, critically reviewed the manuscript, approved the final version for publication, and agreed to be accountable for the integrity and accuracy of the work.

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