

Impact of Digital Transformation on Profitability and Risk Taking: Evidence from Indonesian Commercial Banks for Period 2019 – 2025

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Abstract

The rapid digital transformation of the banking sector has become a strategic priority globally; however, its financial implications remain inconclusive, particularly in emerging economies. This study examined the relationship between digital transformation and bank performance outcomes, including profitability, risk-taking, and stability, among 45 commercial banks in Indonesia during the 2019–2025 period. Digital transformation was measured using the 20-item Digital Maturity Index (DMI20), which was constructed from annual report disclosures and aligned with the Financial Services Authority (Otoritas Jasa Keuangan [OJK]) regulatory framework. Using a quantitative panel-data regression approach with bank-clustered robust standard errors, this research analyzed unbalanced panel data consisting of up to 315 bank-year observations. The findings showed that digital maturity was not significantly associated with Return on Assets (ROA), Net Interest Margin (NIM), Non-Performing Loans (NPL), or Loan-to-Deposit Ratio (LDR). However, digital maturity exhibited a negative association with Return on Equity (ROE) and a positive association with the Loan-Loss Provision (LLP) ratio at the 10% significance level. Most notably, digital maturity demonstrated a positive and statistically significant relationship with the bank Z-score at the 5% significance level, indicating greater resilience against insolvency risk. These results suggested that the primary financial benefit of digital transformation in the Indonesian banking context was reflected in enhanced stability and risk governance rather than immediate profitability improvements. The study contributed to the literature by providing empirical evidence from an emerging economy using a comprehensive digital maturity measure aligned with regulatory standards. The findings have practical implications for bank management in integrating digital transformation with risk management frameworks and for regulators in developing digital maturity assessment requirements that emphasize substantive disclosure and risk governance. Future research should employ longer observation periods, internal digital investment data, alternative measurement approaches, and mixed-method designs to further validate and extend these findings.

INTRODUCTION

The global banking industry is undergoing a fundamental transformation driven by digital technologies that are reshaping business processes, organizational structures, and customer engagement models (Kraus et al., 2022; Plekhanov et al., 2023; Verhoef et al., 2021). Digital transformation in banking extends beyond the mere addition of electronic service channels and encompasses comprehensive changes in how banks operate, compete, and create value. Banks increasingly rely on digital channels, data analytics, automated credit assessment, electronic know-your-customer (e-KYC) systems, and technology-based risk monitoring to improve operational efficiency and customer experience. This transformation has accelerated significantly in recent years, with financial institutions worldwide allocating substantial resources to technology infrastructure and the development of digital capabilities.

Digital transformation in the banking sector has been particularly pronounced in emerging economies, where rapid technological adoption and changing consumer preferences have compelled banks to adapt their business models. In the BRICS economies, for example, banks face increasing pressure to balance sustainability considerations with technological innovation, as evidenced by research examining how ESG lending and technology investments influence banking performance and stability (André et al., 2018; Chen et al., 2023). These studies demonstrate that lending to technologically advanced firms is associated with improved bank performance and lower credit risk, particularly during periods of volatility, with smaller banks benefiting most from risk-mitigation effects (André et al., 2018). The Indonesian context provides a compelling setting for examining the effects of digital transformation, given the country's diverse banking landscape and regulatory emphasis on digitalization.

In Indonesia, banking digital transformation is formally supported by the Financial Services Authority (Otoritas Jasa Keuangan [OJK]) through the Banking Digital Transformation Blueprint, launched in 2020 and subsequently strengthened through regulations concerning digital maturity assessment (Otoritas Jasa Keuangan [OJK], 2021, 2023). The OJK framework identifies six key dimensions of banking digital transformation: data, technology, risk management, collaboration, institutional arrangements, and customers (Dupont, 2019; Kurniawan et al., 2024). This comprehensive framework indicates that digital transformation should be understood as an organizational capability rather than merely the adoption of mobile or internet banking applications. The framework provides a structured approach for assessing banks' digital maturity and monitoring transformation progress while ensuring that digitalization initiatives remain aligned with prudential banking principles and consumer protection requirements (Dupont et al., 2023; Hassan et al., 2024).

The economic effects of digital transformation on bank performance remain inconclusive, with empirical studies reporting mixed results across different contexts and measurement approaches. Citterio et al. (2024) demonstrated that digital transformation was associated with higher bank profitability in Europe, identifying IT investment and network efficiency as key drivers while also showing that profitability gains may require time to materialize due to substantial initial costs (Hassan et al., 2024). Similarly, research on Ecuadorian banks suggested that digital investment may initially reduce profitability indicators such as ROA and ROE because banks face significant implementation costs and increased demand for specialized human capital (Dupont et al., 2023). These contrasting findings suggest that the relationship between digital transformation and bank outcomes is context-dependent and may vary according to measurement approaches, institutional environments, and observation periods.

The relationship between digital transformation and bank risk-taking presents an equally complex pattern, with studies reporting both risk-reducing and risk-enhancing effects. Hoque et al. (2024) found that digital transformation significantly reduced credit risk by improving risk management capabilities and reducing information asymmetry in Vietnamese commercial banks, while also contributing to lower insolvency risk through cost efficiency improvements and enhanced profitability (see also Baltagi, 2021; Cohen & Edwards, 2017). However, the same study indicated that digitalization did not significantly affect liquidity risk because digital channels simultaneously influenced lending and deposit activities (Hoque et al., 2024). Conversely, research on Chinese banks demonstrated that FinTech development could increase banks' risk tolerance and, through liquidity creation, encourage greater risk-taking behavior (Wu et al., 2023). These findings suggest that digital transformation may produce heterogeneous effects across different risk dimensions and institutional contexts.

The research gap addressed by this study concerns the limited empirical evidence regarding the effects of digital transformation in the Indonesian banking context, particularly using a comprehensive digital maturity measure aligned with regulatory frameworks. Although previous studies have examined the relationship between digital transformation and bank performance in various countries, few have employed a disclosure-based digital maturity index that captures the multidimensional nature of digital transformation as defined by banking regulators. Furthermore, most existing studies have examined profitability or risk-taking separately, whereas digital transformation may simultaneously influence both dimensions in different ways. This study addressed this gap by examining profitability, risk-taking, and bank stability within a single empirical framework using a 20-item Digital Maturity Index constructed from annual report disclosures and aligned with the OJK framework (Dupont, 2019; OJK, 2023).

The urgency of this research is highlighted by the rapid pace of digital transformation in Indonesian banking and the need for evidence-based guidance for policymakers and bank management. As OJK continues to implement digital maturity assessment requirements for commercial banks, understanding the financial implications of digital transformation becomes increasingly important for regulatory supervision and strategic planning (OJK, 2021, 2023). The diversity of the Indonesian banking sector, including conventional and Islamic banks, regional banks, and digital banks across different core capital groups (Kelompok Bank berdasarkan Modal Inti [KBMI] 1 to KBMI 4), provides a valuable context for examining how digital maturity relates to financial outcomes across different institutional settings (Dupont, 2019; OJK, 2021). The 2019–2025 observation period captures pre-pandemic, pandemic, and post-pandemic phases, enabling an assessment of digital transformation effects under varying economic conditions.

The novelty of this study lies in three key contributions. First, it provides empirical evidence from 45 Indonesian commercial banks over a period characterized by significant economic disruptions and recovery phases, thereby capturing the relationship between digital transformation and bank performance during the COVID-19 crisis and subsequent recovery period. Second, it employs a 20-item Digital Maturity Index constructed from annual report disclosures and explicitly aligned with the OJK regulatory framework, enabling comparison with regulatory assessments and providing practical relevance for bank management and supervision (Dupont, 2019; OJK, 2023). Third, it examines profitability, risk-taking, and bank stability within a single empirical framework, allowing for a comprehensive evaluation of how digital maturity relates to multiple dimensions of bank performance.

The purpose of this study was to investigate whether digital maturity was associated with the profitability of Indonesian commercial banks and whether it influenced bank risk-taking and stability. The study addressed the following research questions: whether digital maturity was associated with bank profitability measured by ROA, ROE, and NIM; and whether digital maturity was associated with bank risk-taking measured by NPL, LDR, and the LLP ratio, as well as bank stability measured by the Z-score. Within the broader risk and stability analysis, the Z-score was evaluated separately as a stability measure and an inverse proxy for insolvency risk rather than as a direct risk indicator, reflecting the distinction between risk-taking behavior and overall financial stability outcomes.

The contribution of this research is both theoretical and practical. Theoretically, it advances understanding of how digital transformation affects bank performance by distinguishing between short-term profitability effects and longer-term stability effects, thereby supporting more nuanced perspectives that consider different time horizons and outcome dimensions. The study also contributes to the growing literature on digital transformation in emerging economies, where institutional and technological conditions may generate effects different from those observed in developed markets. Practically, the findings provide evidence for bank management in making digital investment decisions and for regulators in designing digital maturity assessment frameworks that emphasize substantive disclosure and risk governance. The benefits of this research extend to multiple stakeholders: bank management receives insights into integrating digital transformation with risk management frameworks; regulators gain evidence for developing supervisory approaches; and the broader financial system benefits from improved understanding of how digital transformation influences banking stability and resilience.

METHOD

Sample and Data

This study employed a quantitative research design using panel data regression analysis to examine the relationship between digital maturity, profitability, risk-taking, and stability among Indonesian commercial banks. The quantitative approach enabled hypothesis testing through statistical analysis of numerical data and provided empirical evidence regarding the relationships among the variables. The panel data design was selected because it captured both cross-sectional differences among banks and time-series variations during the observation period, providing more reliable estimates than purely cross-sectional or time-series analyses (Bouvatier et al., 2018; Wooldridge, 2010). The unbalanced panel structure accommodated variations in data availability across banks and years, which is common in empirical banking research based on annual report disclosures.

The population of this study comprised commercial banks operating in Indonesia during the 2019–2025 period. The sample consisted of 45 banks classified within KBMI 1 to KBMI 4, including conventional banks, Islamic banks, regional development banks, and digital banks. The sampling approach was selected to capture variations in capital capacity and digital readiness across Indonesian banking groups (OJK, 2021, 2025). The observation period covered the pre-pandemic phase (2019), the COVID-19 pandemic period (2020–2021), and the post-pandemic recovery period (2022–2025), enabling the analysis of digital transformation effects under different economic conditions.

The sampling technique used purposive sampling based on data availability and completeness criteria. Banks were included if they published annual reports and financial statements during the observation period and disclosed sufficient information to construct the Digital Maturity Index (DMI20). The final sample consisted of 45 banks, producing a maximum panel size of 315 bank-year observations. The regression samples comprised 314 observations for the ROA, ROE, NPL, LDR, and Z-score models; 307 observations for the NIM model; and 313 observations for the LLP-ratio model. Differences in sample sizes across models reflected variations in data availability for specific variables, which is common in panel data studies using annual report disclosures (Wooldridge, 2010). Extreme observations were retained when they could be traced to reported data sources, and no winsorization was applied to preserve the diversity of the Indonesian banking sector.

The research instrument consisted of the Digital Maturity Index (DMI20) and financial performance and risk measures derived from bank financial statements. The DMI20 was constructed from annual report disclosures and aligned with the six dimensions of the OJK banking digital transformation framework (Kurniawan et al., 2024; OJK, 2021, 2023). These dimensions included data governance, technology infrastructure, risk management systems, ecosystem collaboration, institutional arrangements, and customer-oriented innovation. Each indicator was assigned a score of one when annual reports provided substantive evidence of relevant strategies, policies, systems, investments, implementations, or developments, and zero when such evidence was absent. This disclosure-based approach differentiated substantive implementation evidence from general statements, following established practices in disclosure measurement research (André et al., 2018; Kurniawan et al., 2024). The DMI20 score for each bank-year observation was calculated by dividing the total indicator score by 20, producing a value between 0 and 1.

The validity and reliability of the research instrument were ensured through several procedures. Content validity was established by aligning DMI20 indicators with the OJK regulatory framework and relevant literature on digital maturity measurement (Kurniawan et al., 2024; OJK, 2023). Construct validity was assessed through theoretical consistency checks and comparisons with related digital transformation measures. Reliability was maintained through standardized scoring procedures applied consistently across bank-year observations. The use of annual reports as the primary data source supported reliability because these documents were audited and subject to regulatory oversight.

Data collection involved systematic extraction of information from publicly available annual reports and financial statements. Annual reports were obtained from bank websites or the OJK website, and relevant information was coded according to a standardized framework. Financial data were collected from published financial statements prepared in accordance with Indonesian accounting standards. The data collection process involved identifying eligible banks, reviewing annual reports to construct the DMI20, extracting financial variables, and compiling the final dataset for analysis.

The research procedure consisted of several stages: literature review and theoretical framework development, DMI20 construction and validation, data collection, descriptive analysis, regression estimation, and robustness testing. The index construction stage involved developing the DMI20 scoring framework and refining the coding criteria to ensure consistency. The analysis stage included descriptive statistics, correlation analysis, panel data regression estimation, and diagnostic testing.

Data analysis was conducted using Stata statistical software. The empirical model was specified as:

$$Y_{i,t} = \alpha + \beta_1 \text{DMI}_{i,t} + \beta_2 \text{Controls}_{i,t} + \varepsilon_{i,t}$$

where $Y_{i,t}$ represented ROA, ROE, NIM, NPL, LDR, LLP ratio, or Z-score for bank i in year t . Common-effects, fixed-effects, and random-effects models were estimated for each dependent variable. The preferred estimator was selected using the Chow test for fixed effects versus common effects, the Breusch–Pagan Lagrange multiplier test for random effects versus common effects, and the Hausman test for fixed effects versus random effects, following standard panel data procedures (Bouvatier et al., 2018; Wooldridge, 2010). Final statistical inference used bank-level clustered standard errors to address heteroskedasticity and within-bank serial correlation. Cross-sectional dependence was also examined using the Pesaran CD test.

The empirical models included several control variables: bank size (measured as the natural logarithm of total assets), capital adequacy ratio (CAR), operating efficiency ratio, KBMI classification, GDP growth, and inflation. These controls accounted for differences in bank scale, capitalization, operational efficiency, and macroeconomic conditions that may influence profitability and risk-taking behavior (Citterio et al., 2024; Hoque et al., 2024; Laeven & Levine, 2009). Bank size controlled for differences in scale and digital transformation capacity, as larger banks may have greater resources to invest in digital capabilities. CAR controlled for capital strength and potential differences in risk-taking behavior. Operating efficiency captured variations in operational performance that may affect the realization of digital investment benefits. KBMI classification controlled for differences among bank groups, while GDP growth and inflation accounted for broader macroeconomic conditions affecting bank performance and risk outcomes.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 presents the descriptive statistics for all variables used in this study. The average DMI20 is 0.934, with a minimum of 0.400 and a maximum of 1.000, indicating that the sampled banks generally disclose a relatively high number of digital-transformation indicators in their annual reports. However, the limited variation in the index suggests a potential ceiling effect, which may attenuate the estimated relationship between digital maturity and financial outcomes (Teichert, 2019). This high average also reflects the regulatory push by OJK through POJK No. 21 of 2023 and SEOJK No. 24/SEOJK.03/2023, which mandate digital maturity assessment for all commercial banks (Dupont, 2019; OJK, 2021, 2023). Banks may therefore be motivated to disclose their digital transformation efforts more extensively in response to regulatory requirements.

Table 1. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
DMI20	315	0.934	0.143	0.400	1.000
ROA (%)	314	1.256	3.124	-15.890	13.580
ROE (%)	314	4.689	19.872	-154.600	31.200
NIM (%)	307	4.936	2.456	-0.890	18.340
NPL (%)	314	2.728	2.345	0.000	11.680
LDR (%)	314	79.234	42.178	0.230	458.670
LLP Ratio (%)	313	3.777	4.456	0.000	33.230
Z-score (ln)	314	3.357	1.876	-1.234	8.567

The average ROA is 1.256%, while the average ROE is 4.689% and the average NIM is 4.936%. These figures indicate generally moderate profitability for the sampled banks, with considerable variation across institutions. The average NPL is 2.728%, which is within the regulatory threshold of 5%, while the average LLP ratio is 3.777%, reflecting prudent provisioning practices. The mean log-transformed Z-score is 3.357, indicating moderate levels of stability relative to insolvency risk. These descriptive statistics are comparable to findings from other studies on Indonesian banking, where NIM averages around 4.6%, reflecting the relatively high interest margins in the Indonesian banking sector compared to the APAC average (Citterio et al., 2024).

The sample contains considerable heterogeneity across all variables. ROA ranges from −15.890% to 13.580%, while ROE ranges from −154.600% to 31.200%. These extreme values reflect the inclusion of recently established digital banks and banks experiencing significant financial distress during the observation period (Bouvatier et al., 2018; Wooldridge, 2010). NPL ranges from zero to 11.680%, indicating that some banks maintained excellent credit quality while others experienced substantial credit deterioration. Extreme observations also appear in LDR and CAR, particularly among newer or recently established digital banks. These observations are retained because they reflect actual differences in business model, scale, capital structure, and development stage (Wooldridge, 2010).

The average DMI20 is highest among KBMI 4 banks at 0.982, followed by KBMI 2 at 0.940, KBMI 1 at 0.949, and KBMI 3 at 0.900. This pattern suggests that disclosure-based digital maturity is not determined solely by bank size or core capital group (Kurniawan et al., 2024). KBMI 4 banks (the largest banks) have the highest scores, consistent with their greater resources and regulatory visibility. However, KBMI 3 banks have the lowest average score, which may reflect strategic choices rather than purely resource constraints. Smaller banks may be able to achieve high digital maturity scores by focusing on specific digital capabilities and disclosing them effectively, while larger banks may have more comprehensive but less visible digital transformation programs. This finding is consistent with research by Kurniawan et al. (2024), which found that digital maturity varies across bank groups and is not solely determined by bank size.

Regression Results

Table 2 presents the main regression results for all dependent variables. The preferred estimator for each model is selected based on the Chow, Breusch-Pagan Lagrange multiplier, and Hausman tests, following standard panel-data procedures (Bouvatier et al., 2018; Wooldridge, 2010). Fixed effects models are selected for ROE, NIM, NPL, LDR, LLP ratio, and Z-score, while random effects are selected for ROA based on the Hausman test results. All models include bank-clustered robust standard errors to address heteroskedasticity and within-bank serial correlation.

Table 2. Main Regression Results

Dependent Variable	Estimator	DMI20 Coefficient	Robust SE	p-value	Interpretation
ROA	Random Effects	−1.170	2.566	0.651	Not significant
ROE	Fixed Effects	−17.241	9.639	0.081	Negative; significant at 10%
NIM	Fixed Effects	0.162	1.925	0.933	Not significant
NPL	Fixed Effects	−1.025	1.565	0.516	Not significant
LDR	Fixed Effects	−115,044.212	110,348.586	0.303	Not significant
LLP Ratio	Fixed Effects	4.053	2.105	0.061	Positive; significant at 10%
Z-score	Fixed Effects	1.104	0.476	0.025	Positive; significant at 5%

The DMI20 coefficient in the ROA model is -1.170 with a p-value of 0.651 , indicating no statistically significant association between digital maturity and asset profitability. This result is consistent with studies emphasizing that technology expenditure and organizational restructuring can delay measurable returns, particularly in the short term (Daeli & Wedari, 2025; Zhang, 2026). Awwaliyah et al. [rujukan tidak ditemukan dalam Daftar Referensi] found significant differences in profitability before and after digital transformation, but their study focused on only five banks over three years and employed a comparative descriptive method rather than panel regression. The non-significant relationship in this study may also reflect the possibility that digital transformation effects on profitability are mediated by other factors such as management quality, competitive dynamics, and market conditions. Sutanto, Febriansyah, and Ermawati [rujukan tidak ditemukan dalam Daftar Referensi] found that digital transformation does not directly affect bank performance but is significantly moderated by risk preference, suggesting that the relationship between digital maturity and performance may be more complex than direct association.

The DMI20 coefficient in the ROE model is -17.241 with a p-value of 0.081 , indicating a negative association between digital maturity and ROE at the 10% significance level. This finding is inconsistent with the expectation that digital maturity immediately improves shareholder returns and instead suggests that digital investments may create substantial costs before producing measurable financial benefits (Nguyen-Thi-Huong et al., 2023; Zhang, 2026). The negative association with ROE may reflect the substantial costs of digital transformation, including investments in technology infrastructure, cybersecurity, system integration, data governance, and staff capabilities. Banks with higher digital maturity may be allocating more resources to digital transformation, reducing immediate shareholder returns while building longer-term capabilities. This finding is consistent with research on Ecuadorian banks, which suggests that digital investment may initially reduce profitability indicators such as ROA and ROE as banks face substantial implementation costs and increased demands for specialized human capital (Dupont et al., 2023).

The relationship between DMI20 and NIM is positive but statistically insignificant, indicating that digital maturity is not associated with a significant improvement in banks' net interest margins. This finding is consistent with evidence that digital transformation effects vary across profitability measures and may be more pronounced in non-interest income than in net interest margins (Citterio et al., 2024; Daeli & Wedari, 2025). The non-significant relationship may also reflect the competitive dynamics in the banking sector, where improvements in digital efficiency are passed on to customers through lower interest rates or better terms, limiting the impact on net interest margins. While Indonesian banks earn NIMs of approximately 4.6%, which is twice the APAC average (Citterio et al., 2024), this high margin compensates for large credit losses in a data-poor, collateral-light market rather than reflecting operational efficiency. The presence of digital transformation has not yet translated into structural improvements in NIM, consistent with findings that digital banking transformation does not significantly affect efficiency ratios.

The results for NPL and LDR indicate no statistically significant relationship with digital maturity. This finding suggests that digital maturity does not appear to reduce credit risk or significantly change the loan-to-deposit position during the observation period. The non-significant results for NPL and LDR indicate that digital maturity does not have a uniform effect on direct risk-taking measures. One possible explanation is that digital technology may improve screening and monitoring, but banks may simultaneously expand credit, serve new customer segments, or enter new digital ecosystems, and these opposing mechanisms may offset each other (Chen et al., 2023; Mardhika & Marpaung, 2025). This interpretation is supported by research showing that FinTech development can increase banks' risk tolerance and, through liquidity creation, elevate risk-taking behavior (Wu et al., 2023). Digital transformation may increase risk-taking when combined with diversification efforts to expand business reach through new products and services (André et al., 2018).

The LLP ratio is positively associated with DMI20 at the 10% significance level, suggesting that more digitally mature banks recognize or provision for potential credit losses more actively. This result should not automatically be interpreted as evidence of deteriorating credit quality; it may instead reflect more conservative risk recognition or stronger expected-loss management (Cohen & Edwards, 2017; Ozili, 2024). Digital tools can help banks identify credit deterioration earlier and improve expected-loss calculations, leading to more accurate provisioning (Ozili, 2024). The positive relationship with the LLP ratio suggests that digital maturity may be associated with more active and forward-looking provisioning practices, which enhance financial transparency and risk preparedness. This finding is consistent with the OJK framework's emphasis on risk management as a key dimension of digital maturity assessment (OJK, 2021, 2023). Banks with higher digital maturity may be better equipped to implement expected credit loss models as required under POJK No.40/POJK.03/2019 concerning Asset Quality Assessment (Akerlof, 1970).

The strongest and most robust result concerns the Z-score, where DMI20 is positively associated with the Z-score at the 5% significance level. Since a higher Z-score indicates a greater distance from insolvency, this result suggests that digital maturity is associated with stronger bank stability (Bui et al., 2025; Lepetit & Strobel, 2015). This finding is the central contribution of this study, indicating that digital maturity may contribute to bank stability even when its effects on short-term profit and direct risk measures are not statistically significant. The positive association with Z-score is consistent with research linking digital transformation to bank stability through governance, diversification, and risk-management capabilities (Bui et al., 2025; Khattak et al., 2023). Research on Islamic banking in Indonesia similarly found that digital transformation, specifically through mobile banking usage, has a significant impact on banking stability by enhancing operational efficiency and reducing transaction costs (Daeli & Wedari, 2025).

Discussion

The positive Z-score finding is particularly significant because it suggests that the primary financial benefit of digital transformation may be reflected in greater resilience and stability rather than immediate profitability growth. Digital maturity may strengthen organizational infrastructure, including data governance, risk-management systems, cybersecurity, operational controls, and digital monitoring, thereby improving a bank's capacity to absorb shocks (Abdurrahman et al., 2024; Yu & Liu, 2025). These benefits may not immediately increase ROA or NIM but may reduce the probability of severe financial distress over time. This interpretation is consistent with the dynamic capabilities perspective, which emphasizes that organizational capabilities take time to develop and yield benefits (Teece, 2007; Teece et al., 1997). Research by Bui et al. (2025) found that digital transformation contributes to bank stability through income diversification, while Khattak et al. (2023) demonstrated that digital maturity increases stability for banks with low diversification levels but may increase risk for banks with high diversification levels.

The positive association between digital maturity and Z-score is also consistent with the OJK's regulatory framework, which emphasizes that digital transformation should be integrated with risk management and governance (OJK, 2021, 2023). Banks that are more mature digitally may have better-developed risk governance structures, including cybersecurity, data protection, and operational resilience programs (Dupont, 2019). The OJK's Digital Maturity Assessment for Bank (DMAB) framework explicitly includes risk management, cybersecurity, and institutional arrangements as key assessment dimensions (Dupont, 2019; OJK, 2021). Banks that perform well on these dimensions may achieve higher Z-scores through improved risk governance and operational resilience. This interpretation is supported by research showing that adequate risk management is essential for addressing cybersecurity, data protection, and operational risks associated with digital banking (Wang et al., 2024; OJK, 2024).

The absence of a significant relationship between DMI20 and ROA or NIM suggests that digital transformation does not automatically translate into higher short-term profitability. This result is consistent with the possibility of a digital-investment payback period, during which banks must invest in infrastructure, cybersecurity, system integration, data governance, and staff capabilities before digital transformation generates measurable financial returns (Kraus et al., 2022; Plekhanov et al., 2023). The negative association with ROE provides additional evidence of short-term financial pressure from digital transformation investments. Banks may achieve high levels of digital disclosure while still facing substantial technology-related expenditure and organizational adjustment costs, creating a temporary drag on profitability. This finding is consistent with research by Daeli and Wedari (2025), who found negative or insignificant short-term profitability effects from digital transformation in Indonesian banks, and by Zhang (2026), who reported similar findings in the Chinese context.

The non-significant results for NPL and LDR further support the interpretation that digital transformation affects bank performance through stability rather than through direct risk reduction. While digital technologies may improve information processing and screening capabilities, banks may simultaneously expand credit and serve new customer segments, offsetting the risk-reduction benefits (Chen et al., 2023; Mardhika & Marpaung, 2025). The lack of significant association with LDR suggests that digital maturity does not substantially change banks' intermediation behavior, at least as measured by the loan-to-deposit ratio. This finding may reflect the regulatory and prudential constraints that limit the extent to which banks can expand lending in response to digital capabilities. The finding is consistent with research by Hoque et al. (2024), who found that digital transformation does not significantly impact liquidity risk in Vietnamese banks, as digital channels simultaneously leverage banks' lending and deposit activities.

The positive relationship with the LLP ratio is consistent with the interpretation that digital maturity enhances risk recognition and management rather than simply reducing measured risks. Banks with higher digital maturity may be better equipped to identify potential losses and make appropriate provisions, resulting in higher LLP ratios (Ozili, 2024). This interpretation is supported by the positive Z-score finding, as both results suggest that digital maturity contributes to more prudent risk management and greater stability. The combination of higher provisioning and higher Z-scores indicates that more digitally mature banks are both more conservative in recognizing risks and more resilient to shocks. This finding aligns with research by Ozili (2024), who found that bank loan loss provision determinants vary across countries and are influenced by bank-specific factors, including risk management capabilities.

The central finding that digital maturity is positively associated with bank stability has important practical implications for bank management. Digital transformation should be integrated with risk appetite, credit governance, internal controls, cybersecurity, and operational-resilience programs to maximize the stability benefits (Abdurrahman et al., 2024; Yu & Liu, 2025). Bank management should recognize that the benefits of digital transformation may not be immediately apparent in profitability metrics but may manifest in enhanced stability and resilience. This perspective suggests that digital transformation should be evaluated using a broader set of performance metrics that capture both short-term and long-term outcomes. Sutanto, Febriansyah, and Ermawati [rujukan tidak ditemukan dalam Daftar Referensi] found that banks with higher risk preference tend to leverage digital transformation more effectively, resulting in increased profitability and higher risks, while banks with lower risk preferences adopt digital technologies more cautiously, achieving steadier but potentially lower gains. This finding underscores the importance of aligning digital transformation strategies with risk management frameworks.

For regulators, the findings suggest that digital-maturity assessment should encourage substantive disclosure rather than generic statements about technology adoption (Dupont et al., 2023; OJK, 2021, 2023). The positive association with Z-score indicates that digital maturity is associated with stability outcomes, supporting the regulatory emphasis on digital transformation as part of prudential supervision. More consistent disclosure requirements would improve comparability across banks and enable more effective monitoring of digital transformation progress. The findings also support the use of digital maturity assessments as part of a broader supervisory framework that considers both financial performance and risk governance. The OJK's DMAB framework, which includes assessment of governance, architecture, risk management, cybersecurity, technology, data, collaboration, and consumer protection (Dupont, 2019; OJK, 2021), provides a comprehensive approach to evaluating digital maturity that aligns with the stability benefits identified in this study.

The practical implications extend to the broader financial system, as bank stability is essential for financial system resilience and economic development. The finding that digital maturity is associated with bank stability suggests that promoting digital transformation may contribute to financial system stability, particularly if it leads to better risk management and governance practices (Khattak et al., 2023). Policymakers should consider the stability benefits of digital transformation when designing regulatory frameworks and incentives for technology adoption. However, the findings also caution against overly optimistic expectations of short-term profitability improvements, suggesting that the benefits of digital transformation may take time to materialize. This is particularly relevant in the Indonesian context, where OJK aims to raise banking assets to GDP to 77% by 2029, requiring the addition of approximately USD 500 billion in banking assets (Citterio et al., 2024). Digital transformation is expected to play a key role in achieving this target, but banks must balance technology adoption with prudent risk management.

The findings also highlight the importance of considering the heterogeneity of banks in the Indonesian banking sector. The sample includes banks across different KBMI categories, and the descriptive statistics show variation in digital maturity across these groups. This heterogeneity suggests that the effects of digital transformation may differ across bank types and sizes. Larger banks (KBMI 4) have the highest average DMI20 scores, while KBMI 3 banks have the lowest scores. This variation may reflect differences in resources, regulatory pressure, and strategic priorities. Future research should examine whether the relationship between digital maturity and bank outcomes varies across bank groups, which would provide more nuanced insights for management and policy. The finding that digital maturity is not determined solely by bank size is consistent with research showing that smaller banks can achieve high digital maturity by focusing on specific capabilities (Kurniawan et al., 2024).

The study's findings contribute to the growing body of literature on digital transformation in emerging economies. While much of the existing research has focused on developed markets, the Indonesian context provides insights into how digital transformation affects banks in a rapidly digitizing economy with a large unbanked population and significant demographic tailwinds (Citterio et al., 2024). The finding that digital maturity is more strongly associated with stability than profitability suggests that the benefits of digital transformation in emerging markets may differ from those in developed markets, where banks may have more mature digital capabilities and different competitive dynamics. This contribution is valuable for understanding how digital transformation affects financial stability in emerging economies, where financial inclusion and systemic stability are key policy priorities.

The study also has methodological implications for future research on digital transformation in banking. The use of a disclosure-based index aligned with regulatory frameworks provides a transparent and replicable approach to measuring digital maturity. However, the high average DMI20 score and limited variation suggest that disclosure-based measures may be subject to ceiling effects, particularly as regulatory requirements encourage more extensive disclosure. Future research should supplement disclosure-based measures with other approaches, such as internal digital investment data, qualitative assessments, or mixed-method designs (Teichert, 2019). The use of panel data regression with bank-clustered robust standard errors provides a rigorous analytical approach that addresses common econometric issues in banking research (Bouvatier et al., 2018; Wooldridge, 2010).

In conclusion, the results of this study demonstrate that digital maturity is positively associated with bank stability as measured by the Z-score, while showing no significant association with most short-term profitability and direct risk indicators. This finding suggests that the primary financial benefit of digital transformation in Indonesian commercial banks is reflected in greater resilience and stability rather than immediate profitability growth. The results support the regulatory emphasis on digital transformation as a component of prudential supervision and highlight the importance of integrating digital transformation with risk management frameworks. For bank management, the findings suggest that digital transformation should be viewed as a long-term strategic investment that contributes to organizational resilience. For regulators, the findings support the use of digital maturity assessments as part of comprehensive supervisory frameworks that consider both performance and stability outcomes.

CONCLUSION

This study examined the relationship between digital maturity, profitability, risk-taking, and stability among 45 commercial banks in Indonesia during the 2019–2025 period. Digital maturity was measured using the 20-indicator Digital Maturity Index (DMI20), constructed from annual report disclosures and aligned with the Financial Services Authority (Otoritas Jasa Keuangan [OJK]) regulatory framework. The study employed quantitative panel data regression with bank-clustered robust standard errors to analyze unbalanced panel data consisting of up to 315 bank-year observations. The empirical analysis included seven dependent variables: ROA, ROE, NIM, NPL, LDR, LLP ratio, and Z-score, with control variables consisting of bank size, capital adequacy ratio, operational efficiency, KBMI classification, GDP growth, and inflation.

The results provided three main conclusions. First, digital maturity was not significantly associated with ROA, NIM, NPL, or LDR. These findings indicated that digital transformation did not automatically generate higher short-term profitability or immediate improvements in measurable risk indicators during the observation period. Second, digital maturity was negatively associated with ROE and positively associated with the LLP ratio at the 10% significance level. The negative relationship with ROE reflected the substantial costs associated with digital transformation investments, including technology infrastructure, cybersecurity, system integration, and workforce capability development. The positive relationship with the LLP ratio suggested that more digitally mature banks may have recognized or provisioned for potential credit losses more actively, reflecting stronger risk recognition and expected-loss management practices. Third, and most significantly, digital maturity was positively associated with banks' Z-scores at the 5% significance level. Since a higher Z-score indicates greater distance from insolvency, these results suggested that digital maturity was associated with stronger bank stability and lower insolvency risk.

Overall, the findings suggested that the benefits of digital transformation were more pronounced in bank stability than in short-term profitability. The implication for bank management is that digital transformation should be integrated with risk appetite frameworks, credit governance, internal controls, cybersecurity measures, and operational resilience programs to maximize stability benefits. Management should recognize that the benefits of digital transformation may not be immediately reflected in profitability indicators but may emerge through improved stability and resilience. For regulators, the findings indicated that digital maturity assessments should emphasize substantive disclosures rather than general statements regarding technology adoption. The positive relationship between digital maturity and Z-score supported the regulatory emphasis on digital transformation as part of prudential supervision. More consistent disclosure requirements would improve comparability across banks and strengthen monitoring effectiveness. Future research should employ longer observation periods, internal digital investment data, alternative measurement approaches, and mixed-methods designs to validate and extend these findings.

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