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Digitalization and Financial Performance of Regional Development Banks: Net Interest Margin as A Mediator

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Keyword:	Abstract
Digital Adoption; Loan to Deposit Ratio; Net Interest Margin; Capital Adequacy Ratio; Financial Performance; Regional Development Banks	Digital transformation has become essential for Regional Development Banks (BPDs); however, its contribution to profitability depends on effective financial intermediation, interest margin management, and sufficient capital strength. This study examines the effects of digital adoption, the loan-to-deposit ratio (LDR), and net interest margin (NIM) on return on assets (ROA), while also testing the moderating role of the capital adequacy ratio (CAR) and the mediating role of NIM. A quantitative explanatory research design was applied to 27 Indonesian BPDs observed from 2021 to 2025, resulting in 135 observations. Data obtained from annual reports, financial reports, and sustainability reports were analyzed using panel-data regression with the Random Effects Model and the Sobel test. The results show that digital adoption negatively affects NIM and ROA, while LDR does not significantly affect either NIM or ROA. NIM negatively affects ROA. CAR positively moderates the relationships between digital adoption and NIM, digital adoption and ROA, and NIM and ROA; however, it does not moderate the effects of LDR on NIM or ROA. Furthermore, NIM does not mediate the effects of digital adoption or LDR on ROA. The study concludes that sustainable BPD performance requires integrated digital capabilities, strong capitalization, operational efficiency, sound asset quality, risk-based pricing strategies, cybersecurity resilience, and effective risk governance to support long-term financial sustainability.

INTRODUCTION

Digital transformation has reshaped how banks deliver services, manage business processes, and perform their intermediation functions. For Regional Development Banks (BPDs), this transformation is strategically important because BPDs are not solely oriented toward profitability; they also serve regional economic development functions by mobilizing public funds and channeling financing to productive sectors (Zunairoh et al., 2023) . The regulatory framework for strengthening BPDs places capital adequacy, governance, risk management, efficiency, human resources, and digital transformation within an interconnected strategic agenda (Peraturan Otoritas Jasa Keuangan Republik Indonesia Nomor 4/POJK.03/2017 Tentang Penilaian Tingkat Kesehatan Bank Umum, 2017) . Accordingly, the success of BPD digital transformation should not be assessed merely by the expansion of digital service channels but by the ability of technology to generate sustainable efficiency and economic value (Meliawati et al., 2025; Sihombing & Nugraha, 2025) .

A sustainability perspective broadens the assessment of banking performance beyond short-term profitability by considering the capacity to create long-term economic value while maintaining resilience, managing risk, and addressing social and governance dimensions (Gleißner & Walkshäusl, 2022a; Riegler, 2023) . Digitalization is relevant to Sustainable Development Goal 9 because it supports innovation and resilient infrastructure. In the banking sector, digitalization can expand service access, strengthen connectivity among communities and micro, small, and medium-sized enterprises, and improve operational efficiency. Nevertheless, digital transformation requires investment in technology, system integration, cybersecurity, and human resource capabilities. Therefore, higher levels of digital adoption do not necessarily translate immediately into increased profitability (Setiawan & Prakoso, 2024a; Shanti et al., 2023).

This issue becomes more significant when viewed through the perspective of financial intermediation. The loan-to-deposit ratio (LDR) reflects the extent to which third-party funds are converted into loans, whereas net interest margin (NIM) reflects a bank's ability to generate net interest income from productive assets. Conceptually, credit expansion may increase interest income; however, its effects on NIM and return on assets (ROA) depend on funding costs, credit quality, pricing strategies, provisioning policies, and operational efficiency. Previous studies have reported inconsistent relationships among LDR, NIM, and profitability (Evadine, 2025; Hasbi et al., 2024; Pramusinta et al., 2022). These findings suggest that higher levels of financial intermediation do not necessarily correspond to greater financial value creation (Damayanti, 2025a; Gleißner & Walkshäusl, 2022b; Jonnardi et al., 2025a) .

The study data indicate substantial heterogeneity in performance among BPDs. During 2021–2025, the average digital adoption score was 6.3851, the average LDR was 84.1511, and the average ROA was 1.9820. This pattern suggests that relatively intensive intermediation and increasingly developed digital services have not automatically been accompanied by higher profitability. In this context, NIM represents an important mechanism to examine because it may explain how digital capabilities and intermediation activities are translated into financial performance.

The capital adequacy ratio (CAR) represents a bank's capacity to absorb risk and support business activities. The Risk-Adjusted Return on Capital (RAROC) perspective emphasizes that returns should be evaluated after accounting for the risks incurred and the capital allocated. Technology adoption, credit expansion, and interest margin management can create value when supported by adequate capital capacity and effective risk management. From the Resource-Based View perspective, capital strength and digital capabilities can be considered internal resources whose benefits depend on an organization's ability to integrate them effectively into business processes (Jonnardi et al., 2025a; Setiawan & Prakoso, 2024b) .

The research gap in this study comprises three main aspects. First, empirical findings regarding the relationship between digitalization and banking performance remain inconsistent. Second, the relationships between LDR, NIM, and financial performance remain contextdependent and do not fully explain the characteristics of BPDs. Third, studies that simultaneously examine NIM as a mediating mechanism and CAR as a moderating factor in the relationships among digital adoption, financial intermediation, and BPD financial performance remain limited. (Damayanti, 2025b) positions NIM as a mediator between technology adoption, financial ratios, and banking performance, whereas (Jonnardi et al., 2025b) examine the relationships among digitalization, sustainable finance, risk management, and profitability. This study extends these research areas by examining Indonesian BPDs through an integrated empirical model incorporating digitalization, financial intermediation, interest margins, and capital capacity.

Based on these research gaps, this study aims to analyze the effects of digital adoption, LDR, and NIM on ROA; examine the moderating role of CAR in the relationships among digital adoption, LDR, NIM, and BPD financial performance; and examine the mediating role of NIM in the effects of digital adoption and LDR on BPD ROA. This study is expected to provide empirical contributions and managerial implications for strengthening digital transformation strategies and supporting the sustainability of BPD financial performance.

METHOD

This study employed a quantitative explanatory design with a causal approach. The population consisted of Regional Development Banks (BPDs) in Indonesia that provided the required information for the 2021–2025 period. The sample included 27 BPDs observed over five years, resulting in 135 observations. Data were obtained from BPD annual reports, financial statements, and sustainability reports.

Digital adoption was measured using an availability index covering eight types of digital services: Automated Teller Machines (ATMs), Electronic Data Capture (EDC), credit/debit cards, SMS banking, internet banking, mobile banking, phone banking, and video banking. Each service was assigned a value of 1 if available and 0 if unavailable, with the total score producing an index ranging from 0 to 8. The loan-to-deposit ratio (LDR) was measured as the ratio of loans to third-party funds. Net interest margin (NIM) represented the bank's ability to generate net interest income from productive assets. The capital adequacy ratio (CAR) was used as an indicator of capital strength, while return on assets (ROA) was used as a measure of financial performance.

Panel-data regression analysis was conducted. Model selection was performed by comparing the Common Effects Model, Fixed Effects Model, and Random Effects Model using model-selection tests. The results indicated that the Random Effects Model (REM) was the most appropriate model. The mediating effect was examined through indirect-effect analysis using the Sobel test. The first model examined the effects of digital adoption (AD), LDR, CAR, and the interaction terms AD×CAR and LDR×CAR on NIM. The second model examined the effects of AD, LDR, NIM, CAR, and the interaction terms AD×CAR, LDR×CAR, and NIM×CAR on ROA.

Model 1

is specified as: $NIM_i = \alpha + \beta_1 AD_i + \beta_2 LDR_i + \beta_3 CAR_i + \beta_4 (AD\times CAR)_i + \beta_5 (LDR\times CAR)_i + \varepsilon_i$.

Model 2

is specified as: $ROA_i = \alpha + \beta_1 AD_i + \beta_2 LDR_i + \beta_3 NIM_i + \beta_4 CAR_i + \beta_5 (AD \times CAR)_i + \beta_6 (LDR \times CAR)_i + \beta_7 (NIM \times CAR)_i + \varepsilon_i$.

RESULT AND DISCUSSION

Random Effect Model Estimation Results

Tabel 1. Random Effect Model Estimation Results

Variable	Model 1: NIM Coef.	Prob.	Model 2: ROA Coef.	Prob.
AD	-1.0841	0.0046	-0.9593	0.0007
LDR	0.0000	0.9980	-0.0156	0.3204
NIM	-	-	-0.5384	0.0066
CAR	-0.2573	0.0172	-0.4418	0.0000
AD×CAR	0.0326	0.0182	0.0351	0.0006
LDR×CAR	0.0004	0.4742	0.0002	0.6505
NIM×CAR	-	-	0.0348	0.0000
R^2	0.1034		0.5044	
Adjusted R^2	0.0686		0.4771	
Prob. F	0.0141		0.0000	

Table 1 indicates that Model 1 explains 10.34% of the variation in NIM, whereas Model 2 explains 50.44% of the variation in ROA. The higher explanatory power of Model 2 indicates that BPD financial performance is more comprehensively explained when digitalization, intermediation, interest margins, capital adequacy, and moderating interactions are considered jointly

Digital Adoption of NIM

Digital adoption has a negative effect on NIM; therefore, H1 is not supported. The coefficient of -1.0841 indicates that an increase in the digital adoption score during the observation period did not directly increase net interest margins. This condition may reflect a transformation phase in which banks continue to incur costs related to system development and maintenance, technology integration, cybersecurity, and human-resource development. Shanti et al. (2023) show that digital transformation requires investment and time before financial benefits can materialize, while Setiawan and Prakoso (2024) demonstrate that digital banking adoption does not necessarily produce improved performance. The finding supports the view that technological availability is not equivalent to value-generating digital capability.

LDR of NIM

LDR has no effect on NIM; therefore, H2 is not supported. This finding indicates that the quantity of credit disbursement alone is insufficient to explain changes in net interest margins. NIM is also influenced by funding costs, pricing, credit quality, provisioning, and the composition of productive assets. The RAROC perspective clarifies that intermediation expansion creates value only when additional lending generates adequate returns after considering risk and capital. The finding is consistent with the view of Pramusinta et al. (2022) and Hasbi et al. (2024) that the relationships among LDR, NIM, risk, and profitability should be interpreted jointly.

Digital Adoption of ROA

Digital adoption has a negative effect on ROA; therefore, H3 is not supported. This result indicates that the expansion of digital channels was not translated into profitability during the 2021–2025 observation period. Technology investment may increase costs before economies of scale are achieved, while the associated revenue benefits may not yet be fully realized. The finding is consistent with Setiawan and Prakoso (2024). From a sustainability perspective, a negative short-term effect does not imply that digital transformation is unsuccessful; digital benefits may emerge through improved access, efficiency, innovation, and financial infrastructure over a longer horizon.

LDR of ROA

LDR has no effect on ROA; therefore, H4 is not supported. This finding indicates that an increase in lending volume does not automatically improve the ability of assets to generate profits. Credit quality, risk-based pricing, funding costs, provisioning, and efficiency determine whether intermediation expansion produces adequate returns. The finding is consistent with (Pramusinta et al., 2022) and (Evadine, 2025) which indicate that LDR is not necessarily a partial determinant of profitability (Ivan Jan Jaya Silaen et al., 2024).

NIM of ROA

NIM has a negative effect on ROA; therefore, H5 is not supported. This result indicates that a higher interest margin does not necessarily reflect better efficiency or earnings quality. NIM may increase because of higher pricing to compensate for risk or because of the characteristics of riskier productive assets. If additional interest income is accompanied by higher non-performing loans, provisioning, funding costs, or operating expenses, an increase in margin may not translate into higher ROA. The finding is consistent with Pramusinta et al. (2022) and (Gunawan & Priyono D, 2025) .

CAR as a Moderator of Digital Adoption and ROA

The AD×CAR interaction has a positive effect on ROA; therefore, H6 is supported. The interaction coefficient of 0.0351 indicates that stronger capital adequacy reduces the negative pressure of digital adoption on ROA. Adequate capital provides BPDs with room to absorb transformation costs, finance technology security, develop human resources, and manage operational risks. From a Resource-Based View perspective, capital functions as a supporting resource that enables digital resources to be converted into more productive capabilities.

CAR as a Moderator of Digital Adoption and NIM

The AD×CAR interaction also has a positive effect on NIM; therefore, H7 is supported. The coefficient of 0.0326 indicates that stronger capital adequacy enhances the ability of BPDs to convert digital investment into interest margins. This finding emphasizes that digital transformation requires more than technological availability; financial capacity is necessary for system integration, analytics development, cybersecurity, and competency enhancement without excessive cost pressure. The result reinforces the role of CAR as a quasi-moderator in the relationship between digital adoption and NIM.

CAR as a Moderator of LDR and NIM/ROA

The LDR×CAR interaction has no effect on either NIM or ROA; therefore, H8 and H9 are not supported. This finding indicates that additional capital does not alter the relationship between intermediation intensity and performance. CAR primarily functions as a capital buffer, whereas the effectiveness of LDR remains determined by credit quality, pricing, funding costs, risk, and efficiency. Thus, stronger capitalization does not automatically make credit expansion generate higher margins or profitability.

CAR as a Moderator of NIM and ROA

The NIM×CAR interaction has a positive effect on ROA; therefore, H10 is supported. This result indicates that the ability of BPDs to convert interest margins into profitability depends on capital strength. Under the RAROC perspective, margins should be assessed after accounting for the risk incurred and capital employed. Stronger CAR provides a buffer to absorb potential losses and sustain intermediation activities. The finding demonstrates that NIM should not be interpreted as a standalone measure of economic value creation.

The Mediating Role of NIM

The results indicate that NIM does not mediate the effects of digital adoption or LDR on ROA. The indirect effect of digital adoption is 0.5838, with a 95% confidence interval from -0.2159 to 1.4971, which includes zero. For the LDR pathway through NIM, the indirect effect is close to zero, with a confidence interval from -0.0183 to 0.0413, which also includes zero. Therefore, H11 and H12 are not supported. This finding is important because it indicates that digitalization does not automatically translate into higher margins, and higher margins do not automatically translate into greater profitability. Value creation in BPDs is more complex and may involve efficiency, asset quality, risk, funding structure, and organizational capabilities beyond the NIM pathway

CONCLUSION

This study demonstrates that digital transformation and financial intermediation did not automatically generate stronger financial performance among Indonesian BPDs. Digital adoption had negative effects on NIM and ROA, LDR had no significant effect on either NIM or ROA, and NIM had a negative effect on ROA. CAR strengthened the relationships between digital adoption and NIM, digital adoption and ROA, and NIM and ROA, but did not moderate the relationships between LDR and NIM or between LDR and ROA. NIM was also not supported as a mediating mechanism between digital adoption or LDR and ROA.

Theoretically, these findings reinforce the perspective that digital resources require adequate organizational capabilities and capital capacity to generate financial value. Practically, BPDs should shift their focus from merely expanding digital channels and credit volume toward developing digital capabilities, improving operational efficiency and asset quality, implementing risk-based pricing strategies, strengthening cybersecurity, and allocating capital based on risk-adjusted returns. Sustainable BPD performance therefore depends not on a single indicator but on the ability to integrate digitalization, intermediation, margins, capital, risk management, and governance within a comprehensive strategic framework.

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