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Banking in the Digital Era: Charting the Path from Transformation to Performance in Indonesian Banks

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Abstract

Research Originality: This research develops a new digital transformation adoption measure based on the number of products and services provided by a bank.

Research Objectives: This study examines the impact of digital transformation, specifically the adoption of digital services and products, on bank performance in Indonesia.

Research Methods: This study used hand-collected data from commercial bank annual reports to determine their digital transformation adoption and the BankFocus BvD database for the banks' financial data for 2014–2023. This study employed fixed- and random-effects models and the two-step generalized method of moments to address endogeneity.

Empirical Results: Digital transformation positively affects banking performance, and the significant effect is heterogeneous in nonstate-owned commercial and small and medium-sized banks.

Implications: This study provides policymakers and banking executives with insights into the critical role of digital product and service adoption in overcoming the increasing challenges of modern business. The heterogeneity test results suggest that targeted policies and incentives are needed to create a supportive climate for digital transformation.

Keywords:

digital services; digital products; digital adoption; transformation; bank performance

How to Cite:

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INTRODUCTION

As technological advancements advance, digital transformation has become increasingly attractive to various business sectors, including the banking industry. Digital transformation in the global banking sector began at the end of the 20th century, when Internet technology, such as balance checking and fund transfer services, was first used. Digitalization allows banks to offer efficient, fast, and affordable services without relying on physical interaction (Shanti et al., 2023). This development has become increasingly advanced, with many banks worldwide using Internet services to increase their efficiency and clients' convenience (Laukkanen & Lauronen, 2005). For example, Bank of Scotland launched the first online banking service in 1983. Subsequently, Citibank and HSBC integrated digital technology into their services (Gomber et al., 2017). After the 2008 global financial crisis, many banks accelerated their adoption of digital services, including their integration of financial technology (fintech) (Claessens et al., 2018).

Digital transformation is one of the pillars of service innovation, business process redesign, and operational efficiency improvement (Dewasiri et al., 2023). Commercial banks are increasingly adopting digital technologies to meet changing business strategies and deliver fast, high-quality services to customers (Forcadell et al., 2020). The need for digital services became urgent during the COVID-19 pandemic, when restrictions on physical interaction made customers dependent on digital banking services (Setiawan & Prakoso, 2024). A significant spike in digital banking activity was observed during the COVID-19 pandemic, including increases of 54% in mobile banking transactions, 19.56% in the number of mobile banking agents, and 14.56% in the number of mobile banking accounts (Tut, 2023).

In Indonesia, digitalization in the banking sector was triggered by external regulations from the Financial Services Authority (*Peraturan Otoritas Jasa Keuangan* [*POJK*]), namely POJK No. 12/POJK.03/2018, which mandated digital banking transformation as a strategic step to increase the competitiveness of the national financial sector. The regulation encouraged banks to innovate by offering digital services that suit consumer needs while ensuring transaction security and efficiency. Banks' ability to provide safe, fast, and convenient digital services has become one of the factors that can determine their competitiveness and market performance (Siswanti et al., 2024).

Indonesia is one of the developing countries in Southeast Asia with the strongest potential for a digital economy (Kinda & Yan, 2018). Digital transformation in banking is seen as promising by the market. The era of digitalization in the banking sector in Indonesia began in the 2000s, with large banks such as BCA and Bank Mandiri introducing automatic teller machines and Internet banking (Shehadeh et al., 2024). Since 2014, the number of digital banking service users in Indonesia has grown 2.5 times, reaching 32% in 2019 (Barquin et al., 2019). This development was caused by the COVID-19 pandemic, which changed customer–bank interaction patterns.

In addition, the introduction of the Quick Response Code Indonesia Standard by Bank Indonesia in 2019 and the Indonesian Financial Services Sector Master Plan (*Master*

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Plan Sektor Jasa Keuangan Indonesia) 2021–2025 by the Financial Services Authority (*Otoritas Jasa Keuangan* [*OJK*]) accelerated the adoption of bank digitalization (Tribroto et al., 2023). Digital transactions grew by up to 59.3% per year, reaching IDR 17,901.76 trillion in 2021 (Sebayang et al., 2024), thereby demonstrating a positive trend of digital transformation in the Indonesian banking industry.

At the same time, the OJK implemented fintech peer-to-peer lending regulations, namely POJK No. 77/2016, which forced banks to innovate to maintain their market share amid competitive pressures from nonbank institutions (Thuda et al., 2024). Tang (2019) found that fintech peer-to-peer lending can replace traditional banking services, especially in rural areas, and reduce bank loan volumes. In facing the challenges, digital service transformation has become a key strategy for increasing banks' competitiveness and improving their performance (Li et al., 2024). Under pressure from various factors, especially fintech as a new competitor in the digital era, banks have been forced to adopt digitalization across their services and products.

However, previous studies obtained mixed results on the impact of digital service and product transformation on bank performance. Previous research found that digitalization can improve banks' operational efficiency, reduce costs, and increase the noninterest income ratio by expanding their customer base and service offerings (Thuda et al., 2024). The results are supported by other studies, such as Shaikh and Anwar (2023), which obtained similar findings and noted that digitalization can provide superior customer experiences. Banks with high levels of digitalization are considered to have a positive image and can attract customers effectively. Nguyen-Thi-Huong et al. (2023) argued that digital transformation can help save time, improve operational efficiency, and increase customer satisfaction. In addition, digitalization can provide people with easy access to hard-to-reach areas without requiring complex physical infrastructure (Chao et al., 2024).

However, digital transformation can present challenges, such as the high cost of implementing digital technology, which can burden small banks with limited resources (Liu et al., 2024). Xiang and Jiang (2023) stated that digital transformation can degrade bank performance because the costs and resource sacrifices may not yield the expected returns, a phenomenon referred to as the "digital paradox." This phenomenon can be seen in small banks with limited capabilities and resources. Conversely, large banks have advantages in operational resilience and economies of scale, which can well prepare them to benefit from digital transformation (Nguyen et al., 2023), particularly in their long-term investments (Liu et al., 2024). In addition, the situation can be further exacerbated by the dual strategy, as companies face pressure from digitalization and sustainability strategies that can negatively impact their nonfinancial performance (Ardito et al., 2021).

Hence, this research aims to reconfirm and fill the literature gap in the influence of digitalization, specifically digital service and product adoption, on bank performance. Although many previous studies explored the impact of digitalization on bank performance, most used aggregate approaches or third-party indices to measure digital adoption (Chao et al., 2024; Xiang & Jiang, 2023) and conducted text mining

or analysis on annual reports (Nguyen-Thi-Huong et al., 2023; Shen et al., 2025) and focused only on certain technologies, such as digital payments (Alfawareh et al., 2025). Such approaches can overlook key aspects of digital transformation, such as the types of digital products and services offered by banks. Therefore, our first research contribution is a new measure of digital transformation adoption based on the number of products and services offered by a bank. The classification of digital products and services is defined in POJK No. 12/POJK.03/2018, concerning the digital banking transformation in Indonesia. Our second contribution offers a different perspective on the development of banking digitalization in Indonesia. Banking digitalization in Indonesia is inseparable from the competitive environment, driven by intense competition between digital banks and the fintech industry (Van Greuning & Brajovic Bratanovic, 2020), which can force traditional banks to innovate. Thus, the question of whether digital transformation is a profitable investment or merely a fear-of-missing-out factor to stay competitive remains unanswered. As an emerging country, Indonesia faces limited resources and technological infrastructure challenges that can slow its digital adoption (Purnamasari et al., 2025) and make digital transformation expensive and exclusive.

Our third contribution is a heterogeneity test between large and small and medium-sized banks, similar to previous studies (Xiang & Jiang, 2023), and between state-owned and nonstate-owned commercial banks to offer a comprehensive analysis. State-owned banks are considered less efficient than nonstate-owned banks owing to their political and bureaucratic structures (Wu et al., 2023), which can hinder digital adoption in government banks.

METHODS

The research data are from two main sources. First, data on the number of digital products and services are hand-collected from banks' annual reports on their official websites. Second, the banks' financial report data are from the Bankfocus BvD database. The research sample is all the commercial banks in Indonesia (government-owned and private, including Islamic and conventional banks). The observation period is 2014–2023. Winsorization is applied at 1% and 5% to address extreme values. A total of 99 banks and 875 observations are obtained and used for the analysis.

In this study, we set bank performance as the dependent variable and digital transformation as the independent variable. The regression development model is presented as follows:

$$PFM_{it} = \alpha_0 + \beta_1 DTPS_{it} + \beta_2 Cov_t + \varphi CTRL_{it} + \mu_t + \varepsilon_{it} \quad (1)$$

$$PFM_{it} = \alpha_0 + \beta_1 DTPS_{it} + \beta_2 Cov_t + \varphi CTRL_{it} + \varepsilon_{it} + \mu_t + H1/H2 \quad (2)$$

In the model in Equation (1), PFM_{it} represents bank performance, which is measured by ROA as the primary proxy in this study. The other proxies, such as NIM, are used in the robustness tests. $DTPS_{it}$ represents digital transformation services and products, which are measured by two proxies: (Digital_Log) and (Digital_Prop).

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In addition, Cov_t represents the COVID-19 pandemic, which is a dummy and one of the control variables, and $CTRL_{it}$ represents several control variables, namely, bank stability, size, inefficiency, and asset quality. Details of all variables are presented in Table 1. Moreover, μ before the error term is a control for the year fixed effects (FEs). We also test the heterogeneity impact of DTPS on PFM by referring to the model (Xiang & Jiang, 2023) in Equation (2).

We analyze Equations (1) and (2) by using an FEs model. According to the theory used in this study, an FEs model is appropriate because it captures unobserved bank-level characteristics correlated with the independent variable (Wooldridge, 2016). However, we use a random effects (REs) model in the robustness tests to prove the consistency of our results. Research on digitalization and bank performance considered issues related to endogeneity (Xiang & Jiang, 2023). To address such issues, we use a two-step generalized method of moments (GMM) estimation model in the last robustness test section.

Table 1. Research Variables

Abbreviation/Variable	Explanation	Reference(s)
Return on assets (ROA)	Net income divided by total assets as a proxy for bank performance	Nguyen et al. (2023)
Net interest margin (NIM)	Ratio of total interest income minus interest expense to total asset earnings for other bank performance	Nguyen et al. (2023)
Digital product and service proportion (Digital_Prop)	Proportion of bank digital products and services in the total number of bank products and services	Authors
Logarithm of digital products and services (Digital_Log)	Natural logarithm of the number of digital products and services offered by a bank	Authors
COVID-19 pandemic (Covid)	Dummy variable that takes 1 for the COVID-19 pandemic period, and 0 otherwise	Çolak and Öztekin (2021)
Bank stability (LogZ)	Main proxy for bank risk taking, which is the logarithm of the ROA ratio plus the capital adequacy ratio divided by the standard deviation of ROA	Fu et al. (2014); Risfandy et al. (2022)
Bank size (LogTA)	Logarithm of total assets as a proxy for bank size	Meslier et al. (2017)
Efficiency (INEFF)	Ratio of costs to income as a proxy for bank efficiency	Du Toit and Cuba (2018)
Bank asset quality (LLRGL)	Loan loss reserves divided by gross loans are an indicator of the quality of bank assets	Achsanta et al. (2023)

RESULTS AND DISCUSSION

The first analysis is descriptive statistics, which provides a general description of the sample. Table 2 presents descriptive statistics for the bank performance dependent variable, ROA, with a mean of 0.009, indicating that the average asset performance generates very low profits, and a standard deviation of 0.021, ranging from -0.172 to 0.228. The first digital transformation product variable, namely Digital_Prop, has a mean of 0.230, indicating that digital transformation adoption remains low. That is, some banks do not offer digital products or services.

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
ROA	875	0.009	0.021	-0.172	0.228
NIM	866	0.050	0.033	-0.041	0.253
Digital_Prop	875	0.230	0.154	0.000	1.000
Digital_Log	875	2.058	0.869	0.000	4.522
Covid	875	0.218	0.413	0.000	1.000
LogZ	875	1.700	0.481	-0.228	3464
LogTA	875	17.028	1.532	13.403	21.500
INEFF	875	0.652	0.396	0.174	3.451
LLRGL	875	0.029	0.027	0.000	0.195

The second analysis is a correlation matrix to assess the degree of correlation among the variables. The required correlation value to avoid multicollinearity, which may influence the research results, is < 0.6. Our test results in Table 3 do not indicate multicollinearity among the variables at this threshold.

Table 3. Correlation Matrix

	ROA	NIM	Digita~p	Digita~l	Covid	LogZ	LogTA	INEFF	LLRGL
ROA	1.000								
NIM	0.429	1.000							
Digita~p	-0.061	-0.023	1.000						
Digita~l	0.068	0.043	0.460	1.000					
Covid	-0.085	-0.090	0.036	0.061	1.000				
LogZ	0.221	0.273	0.139	-0.149	0.009	1.000			
LogTA	0.208	0.005	-0.083	0.509	0.050	-0.290	1.000		
INEFF	-0.493	-0.265	0.136	-0.025	0.091	-0.105	-0.229	1.000	
LLRGL	-0.245	0.208	0.081	0.110	0.172	0.132	0.168	0.075	1.000

Table 4 displays the results of the regression testing. The two digitalization proxies used in Columns (1) (Digital_Prop) and (2) (Digital_Log) have significant positive results at the 1% and 5% levels. This result means that the higher the level of digital transformation, the better the bank's performance, as measured by ROA. Many reasons

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explain why digitalization will positively drive bank performance, especially in terms of cost savings and reputation. In the context of cost savings, digitalization has enabled banks to operate more efficiently (Nguyen-Thi-Huong et al., 2023). For example, online banking and mobile payment services have low operating and maintenance costs (Carbó-Valverde et al., 2024). Digital transformation can also encourage a broad range of financial services, reduce transaction costs and risks, and increase revenue margins (Chao et al., 2024). At the same time, digitalization can offer superior-quality services (Boufounou et al., 2022), thereby encouraging consumer loyalty and increasing spending. As a result, bank performance will improve with considerable digital transformation. This finding aligns with several previous studies, including Nguyen-Thi-Huong et al. (2023) and Theiri and Hadoussa (2024). Our results are in line with financial intermediation theory, which states that reducing transaction costs and maximizing efficiency are the advantages of digitalization (Siddik et al., 2023).

Table 4. Baseline Regression Results

	FEs	FEs
	(1) ROA	(2) ROA
Digital_Prop	1.926***	
	(3.38)	
Digital_Log		0.004**
		(2.54)
Covid	-0.012***	-0.012***
	(-3.94)	(-4.32)
LogZ	0.021***	0.021***
	(10.20)	(10.89)
LogTA	0.005***	0.005***
	(2.95)	(3.39)
INEFF	-0.020***	-0.021***
	(-10.39)	(-11.55)
LLRGL	-0.196***	-0.209***
	(-6.67)	(-7.43)
Constant	-0.090***	-0.100***
	(-3.14)	(-3.65)
Year effects	YES	YES
Obs.	875	875
No. of banks	99	99
R-sq.	0.301	0.342

The regression in Table 4 uses Equation (1) and the FEs model; in Column (1), the explanatory variable is Digital_Prop; in Column (2), the explanatory variable is Digital_Log; refer to Table 1 for further explanations on each variable; t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

To determine the impact of digital transformation on bank performance, we conduct a heterogeneity test, as shown in Table 5. In the heterogeneity test, we first compare the impact of digitalization on the performance of state-owned commercial banks (state

and regional development banks) with that of nonstate-owned commercial banks (private, foreign, and branch/joint banks). This grouping is based on majority share ownership, similar to Mardinna (2008). Our results show that the significant positive effect of digitalization emerges in the nonstate-owned commercial banks, as shown in Columns (1)–(4) of Table 5. The underlying reason is that nonstate-owned commercial banks tend to be more agile in implementing new technology and responding to customer needs, such as the digitalization of services or products (Yip & Bocken, 2018), compared with state-owned commercial banks, which are slower to adopt new technology owing to their complex bureaucracy, lack information transparency, and low efficiency (Manta et al., 2024; Wu et al., 2023). That is, nonstate-owned commercial banks are more efficient than state-owned commercial banks in responding to the need for digitalization in a market that increasingly requires effectiveness.

Table 5. Heterogeneity Test Between State-owned and Nonstate-owned Commercial Banks and Between Large and Small and Medium-sized Banks

	FEs	FEs	FEs	FEs	FEs	FEs	FEs	FEs
	SOCB	NON-SOCB	SOCB	NON-SOCB	Large	Small and Medium-sized	Large	Small and Medium-sized
	(1) ROA	(2) ROA	(3) ROA	(4) ROA	(5) ROA	(6) ROA	(7) ROA	(8) ROA
Digital_Prop	-0.184	2.083***			0.225	3.608***		
	(-0.42)	(2.97)			(0.53)	(3.63)		
Digital_Log			0.001	0.005**			0.001	0.008***
			(0.51)	(2.31)			(0.94)	(2.84)
Constant	-0.015	-0.098***	-0.017	-0.112***	-0.167***	-0.038	-0.161***	-0.086
	(-0.64)	(-2.79)	(-0.72)	(-3.30)	(-6.29)	(-0.69)	(-6.22)	(-1.61)
Bank control	YES	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	244	631	244	631	475	400	475	400
No. of banks	30	70	30	70	67	56	67	56
R-sq.	0.482	0.311	0.483	0.354	0.408	0.351	0.409	0.402

The regression in Table 5 uses Equation (2) and the FEs model (SOCB is state-owned commercial banks); in Columns (1)–(2) and (5)–(6), the explanatory variable is Digital_Prop; in Columns (3)–(4) and (7)–(6), the explanatory variable is Digital_Log; refer to Table 1 for further explanations on each variable; t-statistics are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Second, we compare the results of large and small banks based on the median value of their total assets, following Shen et al. (2025). The results are displayed in Columns (5)–(8) of Table 6, which show that digitalization significantly impacts only the small and medium-sized banks and prove that the effects of digitalization are highly pronounced for such banks, which are similar to the results of Shen et al. (2025). Digitalization can help small and medium-sized banks reach or acquire consumers who were previously constrained by geographic barriers and narrow the gap with larger banks

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that are economically stronger (Chen et al., 2023). Digitalization has enabled small banks to expand their business scope, innovate, and increase their market share (Shen et al., 2025). This finding refutes the assumption that digitalization is less profitable for small banks owing to their limited resource capabilities (Liu et al., 2024; Nguyen et al., 2023). On the contrary, digitalization has enabled small banks to compete with large banks and gain increased profits.

For the robustness tests, first, we use a REs estimation model as an alternative, and the results are presented in Columns (1)–(2) of Table 6. The two digitalization proxies (i.e., Digital_Prop and Digital_Lag) are consistent with our initial findings at the 1% and 10% levels. Second, though we use robust standard errors clustered at the year level, some studies considered the importance of using macro variable controls, despite the research being conducted in only one country (Chao et al., 2024). Accordingly, we regress Equation (1) by entering two macro variables (i.e., GDP growth and the logarithm of the GDP), with reference to Risfandy et al. (2022). We obtain the data of the two macro variables from the World Development Indicators (WDI) database. Furthermore, we examine the effect of digitalization adoption on bank performance using NIM as an additional proxy. The results are shown in Table 7. Columns (3)–(4) present the robustness with the macro variables, and Columns (5)–(6) exhibit the robustness with NIM. The Digital_Prop and Digital_Log proxies remain robust and significant in their relationships with the macro variables. Meanwhile, the NIM proxy variable results are robust, with Digital _Prop at the 1% significance level and a coefficient of 1.737.

Table 6. Robustness Tests

	REs	REs	FEs	FEs	FEs	FEs
	(1) ROA	(2) ROA	(3) ROA	(4) ROA	(5) NIM	(6) NIM
Digital_Prop	1.272***		1.926***		1.737***	
	(2.76)		(3.38)		(2.67)	
Digital_Log		0.002*		0.004**		0.002
		(1.76)		(2.54)		(1.43)
Constant	-0.063***	-0.059***	0.632***	0.721***	-0.0212	-0.031
	(-5.34)	(-4.46)	(3.33)	(3.78)	(-0.68)	(-0.98)
Bank control	YES	YES	YES	YES	YES	YES
GDPG			-0.002	-0.001		
			(-0.21)	(-0.20)		
LogGDP			-0.026***	-0.026***		
			(-3.37)	(-3.89)		
Year effects	YES	YES	YES	YES	YES	YES
Obs.	875	875	875	875	866	866
No. of banks	99	99	99	99	99	99
R-sq.	0.293	0.338	0.301	0.342	0.296	0.289

The regression in Table 6 uses Equation (1) and the REs or FEs model; in Columns (1), (3), and (5), the explanatory variable is Digital_Prop; in Columns (2), (4), and (6), the explanatory variable is Digital_Log; Columns (1)–(4) present the results of the dependent variable ROA, and Columns (5)–(6) present the results of the dependent variable NIM; refer to Table 1 for further explanations on each variable; t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 7. Robustness Tests with Lagged Independent Variables and Two-step GMM

	FEs	FEs	GMM	GMM
	(1) ROA	(2) ROA	(3) ROA	(4) ROA
L.ROA			0.242***	0.313***
			(40.68)	(41.26)
Lag_Digital_Prop	2.226***			
	(3.42)			
Lag_Digital_Log		0.00475***		
		(3.01)		
Digital_Prop			0.934***	
			(4.00)	
Digital_Log				0.006***
				(6.58)
Constant	-0.123***	-0.162***	-0.029*	0.004
	(-3.76)	(-5.20)	(-1.90)	(0.21)
Bank control	YES	YES	YES	YES
Year effects	YES	YES	YES	YES
Obs.	771	771	766	766
No. of banks	99	99	99	99
R-sq.	0.336	0.352		
Hansen test			0.252	0.124
AR (1) test			0.025	0.002
AR (2) test			0.356	0.512

The regression in Table 7 uses Equation (1) and the FEs or two-step GMM model; in Columns (1)–(2), the explanatory variable is the lagged Digital_Prop and Digital_Log with FEs; Columns (3)–(4) present the results of the two-step GMM testing; refer to Table 1 for further explanations on each variable; t-statistics are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We also control for endogeneity by lagging our two independent variable proxies and conducting a two-step GMM test, as proposed by Blundell and Bond (1998). The test can prevent an inverse effect relationship between digitalization and bank performance. Banks with a high level of digitalization will gain an advantage in improving their performance, and banks with satisfactory performance will be able to carry out digital transformation effectively. The use of lagged independent variables will prevent the current bank performance from affecting the previous year's digitalization level. Previous research also used this method to address endogeneity, as did Risfandy et al. (2022). However, using lagged independent variables will not necessarily eliminate all the endogeneity problems, especially instrument validity-related issues. We do not include instrumental variables that may influence the relationship between digitalization adoption and bank performance in our model, such as the number of mobile phone users in large cities (Chao et al., 2024). We conduct a two-step GMM estimation to address the validity problem, which has an advantage in tackling endogeneity issues. The results of the lagged independent variable and GMM tests are displayed in Table 7. Specifically, Columns (1)–(4) show that the results remain unchanged, compared with the main findings. The GMM diagnostic test also reveals that the Hansen and Arellano-Bond AR (2) tests passed in terms of their validity. The null of no correlation between the instrumental variables

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and the error terms was not rejected, and no second-order autocorrelation exists, as required. The results indicate that our findings are robust after controlling for endogeneity.

CONCLUSION

Digital transformation has become a business trend across the banking industry. Competitor pressure (e.g., fintech) and consumer demands have prompted banks to adopt digitalization on a massive scale. This study seeks to investigate how digital transformation adoption can affect bank performance. Our findings show the significant positive influence of digital transformation adoption on bank performance. Moreover, the effect is heterogeneous across nonstate-owned commercial and small- and medium-sized banks.

This study provides policymakers and banking executives with practical insights into the importance of digital product and service adoption for overcoming the increasing challenges of modern business. Regulators need tailored policies and incentives to foster a supportive environment for digital transformation. Such policies or incentives include providing technology subsidies, tax incentives, or low-cost financing, and creating different digitalization roadmaps based on bank characteristics. Such policies will enable banks to perceive the role of regulators in encouraging or ensuring their positive digital transformation. We recommend that the government strengthen digital infrastructure and financial literacy programs. Furthermore, future research should consider other comprehensive bank performance indicators, such as labor and operational costs.

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