

The Role of Information Technology in the Effect of Risk Management on Banking Performance

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ABSTRACT

Instability in the banking sector can trigger broader economic issues, reduce market valuation, and lead to a loss of public or stakeholder trust. Therefore, it is crucial for banks to continuously monitor the risks they face, even those that are difficult to control. This study aims to provide empirical evidence on the impact of risk management on banking performance (profitability and firm value), with information technology as a moderating variable. The study is based on a sample of banking companies listed on the Indonesia Stock Exchange during the period 2019–2023. Panel data regression models are used to test the hypotheses. Risk management, proxied by capital adequacy (CAR) and climate change initiatives (CCI), has a positive effect on profitability and firm value. Meanwhile, operational inefficiency (BOPO) negatively affects profitability only. The interaction between operational inefficiency and information technology (BOPO_TI) weakens firm value. Risk management through capital adequacy and climate initiatives improves banking performance. However, the weakening effect of IT in the presence of low operational efficiency indicates that technology adoption alone is insufficient. IT implementation must be aligned with operational efficiency and sound risk management to support the ERM objective of "create and protect value".

INTRODUCTION

The banking sector, as a country's primary financial institution, plays a crucial role in maintaining economic stability and promoting economic growth. Transactions occurring in the stock market further underscore the importance of the banking sector in this regard (Rafiq et al., 2019). In Indonesia, banks serve a strategic function in supporting national economic development. Problems within the banking sector can lead to significant instability in the financial system and potentially trigger a monetary crisis. Customers, creditors, and investors may withdraw their deposits, loans, and investments if they lose confidence in banks. These stakeholders naturally expect returns on their financial activities, making optimal banking performance essential to meeting their expectations. Banking performance can be reflected through its level of profitability and firm value.

Bank performance is commonly evaluated through financial performance, represented by Return on Assets (ROA), and firm value, measured using Tobin's Q. While ROA reflects management efficiency in generating profits from assets, Tobin's Q represents market perceptions of a bank's long-term prospects. However, banks with high profitability do not always exhibit high market value, and some banks with low or even negative ROA may still maintain strong Tobin's Q, indicating that profitability and market valuation are influenced by different factors.

One of the most important determinants of both outcomes is risk management. Effective management of credit, liquidity, market, operational, legal, strategic, compliance, and reputational risks enhances financial stability, reduces potential losses, and strengthens investor confidence (Abuzayed et al., 2009; POJK No. 11, 2016). Previous studies generally show that Non-Performing Loans (NPL) negatively affect profitability, although findings regarding firm value remain mixed (Mohammad et al., 2024; Supriyadi & Setyorini, 2020; Yanti & Setiyanto, 2021). Although Indonesia's banking NPL ratio remained below the regulatory threshold of 5% in 2023 (Bank Indonesia Regulation No. 23/2/PBI/2021), it was still higher than Malaysia's (CEIC, 2024), indicating the need for stronger credit risk management.

Another key indicator of risk management effectiveness is the Capital Adequacy Ratio (CAR), which reflects banks' ability to absorb financial risks. Indonesian banks generally maintained CAR well above the Basel III minimum requirement of 8%, demonstrating adequate financial resilience and supporting investor confidence. The adoption of advanced technologies such as big data, machine learning, and international risk management standards (ISO 31000 and OJK guidelines) can further improve capital allocation, risk assessment, and operational efficiency.

Beyond financial risks, banks are increasingly expected to manage climate-related risks in line with sustainable development goals. Indonesia has strengthened this commitment through its Nationally Determined Contribution (NDC) under Law No. 16 of 2016, encouraging banks to disclose Climate Change Initiatives (CCI) in sustainability reports. Such disclosures enhance transparency, reputation, stakeholder trust, and financial performance while supporting environmental sustainability (Adu et al., 2024; Orazalin et al., 2024; Houqe et al., 2024). Nevertheless, studies also suggest that some banks may disclose climate initiatives primarily for legitimacy or greenwashing purposes (Caby et al., 2020).

Information technology (IT) has become a strategic enabler of effective risk management. Technologies such as big data analytics, artificial intelligence, blockchain, digital platforms, and mobile banking improve risk identification, credit monitoring, sustainability reporting, operational efficiency, and regulatory compliance. Prior studies generally report that IT investment enhances profitability, firm value, productivity, and organizational flexibility (Joshi et al., 2024; Farrakhan & Dewi, 2024; Al-Zayani et al., 2023; Roy, 2020). However, other studies find insignificant or even negative effects due to high

implementation costs and insufficient organizational readiness (Anwar & Saiful, 2024; Gupta et al., 2018).

Given these mixed findings, this study proposes that information technology moderates the relationship between risk management and banking performance. By integrating effective risk management with advanced IT capabilities, banks are expected to improve both financial performance (ROA) and firm value (Tobin's Q) while strengthening long-term competitiveness and sustainability.

This study aims to analyze how risk management, proxied by NPL, CAR, BOPO, and climate change initiatives (CCI), can influence profitability and company value in banks. This study also aims to fill the gap in findings from various previous studies and seeks to expand them to address the serious phenomena currently facing various business lines, namely climate change risk and the development of information technology. By understanding this relationship, it is hoped that it will contribute to the financial literature and provide practical insights for bank management, investors, and other parties in managing risk, making wiser investment decisions, and paying attention to climate change and utilizing advances in information technology.

Research Hypothesis

H1a: Non-performing loans (NPLs) negatively impact bank profitability (ROA).

H1b: Operational inefficiency (BOPO) negatively impacts bank profitability (ROA).

H1c: Capital adequacy (CAR) positively impacts bank profitability (ROA).

H1d: Climate change initiatives (CCI) positively impact bank profitability (ROA).

H2a: Non-performing loans (NPLs) negatively impact bank firm value.

H2b: Operational inefficiency (BOPO) negatively impacts bank firm value.

H2c: Capital adequacy (CAR) positively impacts bank firm value.

H2d: Climate change initiatives (CCI) positively impact bank firm value.

H3a: Information technology positively moderates the negative effect of non-performing loans (NPLs) on bank profitability.

H3b: Information technology positively moderates the negative effect of operational inefficiency (BOPO) on bank profitability.

H3c: Information technology moderates and strengthens the effect of capital adequacy ratio (CAR) on banking profitability.

H3d: Information technology moderates and strengthens the relationship between climate change initiatives (CCI) and banking profitability.

H4a: Information technology weakens the negative effect of non-performing loans (NPLs) on firm value.

H4b: Information technology weakens the negative effect of operational inefficiency (BOPO) on firm value.

H4c: Information technology moderates and strengthens the effect of capital adequacy ratio (CAR) on firm value.

H4d: Information technology moderates and strengthens the relationship between climate change initiatives (CCI) and firm value.

RESEARCH METHOD

This study employed a quantitative research design using secondary data collected from the Bloomberg Terminal, the Financial Services Authority (OJK), the Indonesia Stock Exchange (IDX), and the official websites of individual banks. The data were transformed into quantitative measures and analyzed statistically to test the proposed hypotheses (Sugiyono, 2016; Ghozali, 2018).

The population comprised all banks listed on the Indonesia Stock Exchange (IDX) during 2019–2023 that disclosed climate-related sustainability reporting. Samples were selected using purposive sampling (Radjab & Jam'an, 2017), with criteria including the publication of annual and/or financial reports and evidence of climate change initiatives or carbon emission reduction efforts during the study period. Representative sampling ensures that the selected banks adequately reflect the study population (Sekaran & Bougie, 2016; Mardhiyana, 2023).

Data were collected through documentation and literature review. Documentation involved gathering financial and sustainability information from annual reports, sustainability reports, official bank websites, and OJK publications, including data on risk management, assets, liabilities, equity, loans, capital, pre-tax income, and climate change initiatives. The literature review was conducted using books, journal articles, conference papers, theses, reports, and other reliable sources to establish the theoretical foundation of the study (Sekaran & Bougie, 2016).

The study employed descriptive statistics, panel data regression, and Moderated Regression Analysis (MRA). Descriptive statistics summarized the data using minimum, maximum, mean, standard deviation, and variance. Panel regression analysis was conducted after selecting the appropriate model through the Chow, Hausman, and Lagrange Multiplier tests to determine whether the Common Effect Model (CEM), Fixed Effect Model (FEM), or Random Effect Model (REM) was most appropriate. Model evaluation included the F-test, coefficient of determination (R^2), relevant classical assumption tests, and t-tests for hypothesis testing. The moderating role of information technology was examined using Moderated Regression Analysis (MRA) following the same panel regression procedures.

RESULT AND DISCUSSION

Panel Data Regression Analysis

Chow Test

The Chow test is conducted to determine the best panel data model between the common effects model and the fixed effects model. Tables 1 and 2 show the results of the data analysis from the Chow test using E-Views 12.

Table 1. Results of the Direct Equation Chow Test

Redundant Fixed Effect Tests			
Test cross-section fixed effects			
Panel A. Model 3.1			
Effect Test	Statistic	d.f.	Prob.
Cross-section F	3.771138	(42,167)	0.0000
Cross-section Chi-square	143.410145	42	0.0000
Panel B. Model 3.2			
Cross-section F	10.409381	(42,167)	0.0000
Cross-section Chi-square	276.468827	42	0.0000

Source: processed by the author with Eviews-12 (2025)

From the results in Table 1 above, it can be concluded that the F-probability value is 0.0000 for both models 3.1 and 3.2, which is less than the 0.05 significance level. Therefore, the best direct equation model in this study is the fixed effect.

Table 2. Results of the Chow Test for Moderation Equation

Redundant Fixed Effect Tests			
Test cross-section fixed effects			
Panel A. Model 3.3			
Effect Test	Statistic	d.f.	Prob.
Cross-section F	3.548768	(42,162)	0.0000
Cross-section Chi-square	140.255621	42	0.0000
Panel B. Model 3.4			
Cross-section F	10.461338	(42,162)	0.0000
Cross-section Chi-square	281.999243	42	0.0000

Source: processed by the author with Eviews-12 (2025)

From the results in Table 2 above, it can be concluded that the F-probability value is 0.0000 for both models 3.3 and 3.4, which is less than the 0.05 significance level. Therefore, the best model for the moderation equation in this study is the fixed effect.

Table 3. Results of the Hausman Test for Direct Equations

Correlated Random Effects-Hausman Test			
Test cross-section random effects			
Panel A. Model 3.1			
Effect Test	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section Random	1.442305	5	0.9196
Panel B. Model 3.2			
Cross-section Random	41.258601	5	0.0000

Source: processed by the author with Eviews-12 (2025)

The results in Table 3 above show that the probability value for model 3.1, with ROA as the dependent variable (0.9196), is greater than the significance level (0.05), thus H0 is accepted. Meanwhile, model 3.2, with FV as the dependent variable, has a probability value of 0.0000, thus H1 is accepted. Therefore, the best model result from the Hausman test for model 3.1 is the random effects model, while model 3.2 is the fixed effects model. In the subsequent model selection analysis, model 3.1 needs to proceed to the Langrange multiplier test due to its REM results. Model 3.2 does not need to proceed to the Langrange multiplier test

because it has already produced the best test, FEM, for later use in panel data regression analysis.

Table 4. Results of the Hausman Test for Moderation Equation

Correlated Random Effects-Hausman Test			
Test cross-section random effects			
Panel A. Model 3.3			
Effect Test	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section Random	9.625148	10	0.4740
Panel B. Model 3.4			
Cross-section Random	43.078035	10	0.0000

Source: processed by the author with Eviews-12 (2025)

From the results in Table 4 above, it can be seen that the probability value of model 3.3 with ROA as the dependent variable (0.4740) is greater than the significance level (0.05), thus H0 is accepted. Meanwhile, model 3.4 with FV as the dependent variable has a probability value of 0.0000, thus H1 is accepted. Therefore, the best model result from the Hausman test of the moderation equation in model 3.3 is the random effects model, while model 3.4 is the fixed effects model. In the subsequent model selection analysis, model 3.3 needs to proceed to the Lagrange multiplier test due to the REM result. Model 3.4, on the other hand, does not need to proceed to the Lagrange multiplier test because it has already produced the best test, FEM, for use in panel data moderation regression analysis.

Table 5. Lagrange Multiplier Test Results

Lagrange Multiplier Tests for Random Effects			
Panel A. Model 3.1			
Effect Test	Cross-section	Time	Both
Breusch-Pagan	53.08959 (0.0000)	0.466522 (0.4946)	53.55611 (0.0000)
Panel B. Model 3.3			
Breusch-Pagan	42.82118 (0.0000)	0.588586 (0.4430)	43.40977 (0.0000)

Source: processed by the author with Eviews-12 (2025)

From the results in Table 5 above, it can be seen that the Breusch-Pagan value for both models 3.1 and 3.3 is 0.0000, which is less than the significance level (0.05), therefore H0 is rejected. Therefore, the best model selected from the LM test is the random effects model (Widarjono, 2018). Therefore, from the three panel data model tests (Chow test, Hausman test, and LM test), it is concluded that the best model to analyze the data in this study, with the dependent variable profitability (ROA), specifically in equation 3.1 and moderation equation 3.3, is REM. Conversely, in equations 3.2 and 3.4, with the dependent variable firm value (FV), the FEM is used.

Classical Assumption Test

Multicollinearity Test

The following table shows the results of data processing to test for multicollinearity in the independent and moderating variables in this study.

Table 6. Multicollinearity Test Results

	NPL	BOPO	CAR	CCI	SIZE	TI
NPL	1	0.18233527...	0.04870457...	-0.0111438...	-0.1012906...	0.21847185...
BOPO	0.18233527...	1	0.16338590...	-0.2357739...	-0.3772920...	0.08298661...
CAR	0.04870457...	0.16338590...	1	0.06016046...	-0.4341456...	0.25361480...
CCI	-0.0111438...	-0.2357739...	0.06016046...	1	0.38023802...	0.14994032...
SIZE	-0.1012906...	-0.3772920...	-0.4341456...	0.38023802...	1	-0.1733120...
TI	0.21847185...	0.08298661...	0.25361480...	0.14994032...	-0.1733120...	1

Source: processed by the author with Eviews-12 (2025)

Table 6 shows that the correlation values between NPL, BOPO, CAR, CCI as independent variables, and TI as moderating variable are all greater than the tolerance value of 0.85, indicating no multicollinearity between variables in the panel data regression model of this research (Napitupulu et al., 2021).

Heteroscedasticity Test

The following table shows the results of data processing to test for heteroscedasticity in the regression equation. Because the regression model selected previously with ROA as the dependent variable yielded REM, no heteroscedasticity testing was necessary. Therefore, Table 7 below tests the regression equation with firm value (FV) as the dependent variable using its absolute residual value.

Table 7. Heteroscedasticity Test Results

Dependent Variable: ABS_RES				
Method: Panel Least Squares				
Date: 06/24/25 Time: 12:37				
Sample: 2019 2023				
Periods included: 5				
Cross-sections included: 43				
Total panel (balanced) observations: 215				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.015970	0.104135	-0.153359	0.8783
NPL	-0.031348	0.038148	-0.821746	0.4124
BOPO	0.009266	0.006196	1.495414	0.1368
CAR	-0.009487	0.008217	-1.154532	0.2500
CCI	0.011781	0.010013	1.176523	0.2411
SIZE	0.000455	0.003308	0.137376	0.8909
TI	0.115334	0.781197	0.147638	0.8828
NPL_TI	0.667765	1.819460	0.367013	0.7141
BOPO_TI	-0.205560	0.659132	-0.311865	0.7555
CAR_TI	0.164114	0.323380	0.507495	0.6125
CCI_TI	-0.271110	0.510857	-0.530696	0.5964

Source: processed by the author with Eviews-12 (2025)

Napitupulu et al. (2021) argue that heteroscedasticity is not present if the probability values of the variables in the study exceed the significance level of 0.05, as measured by the Glejser test in the E-Views application. The results in Table 4.9 indicate that all variable probability values do not exhibit heteroscedasticity because they exceed the significance level of 0.05.

Model Fit Test (F Test) and Coefficient of Determination (R2) Test

The F test is used to determine whether the direct regression equation and the previously formed moderated regression equation are able to explain each other and are therefore considered suitable as a regression equation. The coefficient of determination test is used to analyze the extent of influence of the independent variables on the dependent variables in this study, which are tested using the direct regression equation. R2 determines the extent of the moderating variable's influence on the independent variables on the dependent variables tested using the moderated regression equation. The test results are indicated by an Adjusted R-squared value between 0 (zero) and 1 (one). The closer the value is to 1, the greater the influence between the variables, and vice versa. Tables 8 and 4.11 show the results of the F and R2 tests for the four models in this study.

Table 8. Results of the F and R2 Tests for Direct Equations

Panel A. Model 3.1			
Weighted Statistics			
R-squared	0.705498	Mean dependent var	0.002389
Adjusted R-squared	0.698452	S.D. dependent var	0.020425
S.E. of regression	0.011216	Sum squared resid	0.026292
F-statistic	100.1343	Durbin-Watson stat	2.281677
Prob(F-statistic)	0.000000		
Panel B. Model 3.2			
R-squared	0.784432	Mean dependent var	1.380168
Adjusted R-squared	0.723763	S.D. dependent var	3.462067
S.E. of regression	1.819600	Akaike info criterion	4.228978
Sum squared resid	552.9280	Schwarz criterion	4.981493
Log likelihood	-406.6152	Hannan-Quinn criter.	4.533029
F-statistic	12.92975	Durbin-Watson stat	1.277569
Prob(F-statistic)	0.000000		

Source: processed by the author with Eviews-12 (2025)

Table 8, panel A, shows a probability (F-statistic) of 0.000000, which is less than 0.05. This result indicates that all independent variables, along with the control variable SIZE, can explain some or all of the dependent variable (ROA). Similarly, the probability (F-statistic) in Table 8, panel B, shows a result of 0.000000, which is less than 0.05. It can be concluded that the independent variables can explain one or both of the effects on the dependent variable (FV).

The adjusted R-square value for panel A, model 3.1, is 0.698, or approximately 70% of the equation's effect on the dependent variable (ROA). Similarly, the Adjusted R-square value for panel B, model 3.2, is 0.723, indicating that approximately 72% of the regression equation is able to influence the dependent variable (FV) in this study. Overall, with a relatively high R2 level, as shown in Table 9, the regression model can explain almost all of the variables.

Table 9. Results of the F and R2 Tests of the Moderation Equation

Panel A. Model 3.3

Weighted Statistics

R-squared	0.707006	Mean dependent var	0.002378
Adjusted R-squared	0.694143	S.D. dependent var	0.020402
S.E. of regression	0.011283	Sum squared resid	0.026099
F-statistic	54.96366	Durbin-Watson stat	2.297484
Prob(F-statistic)	0.000000		

Panel B. Model 3.4

R-squared	0.800784	Mean dependent var	1.380168
Adjusted R-squared	0.736838	S.D. dependent var	3.462067
S.E. of regression	1.776016	Akaike info criterion	4.196604
Sum squared resid	510.9855	Schwarz criterion	5.027505
Log likelihood	-398.1349	Hannan-Quinn criter.	4.532326
F-statistic	12.52285	Durbin-Watson stat	1.191286
Prob(F-statistic)	0.000000		

Source: processed by the author with Eviews-12 (2025)

Table 9, panel A, shows a probability (F-statistic) of 0.000000, which is less than 0.05. This result indicates that all independent variables, along with the control variable SIZE, can explain some or all of the dependent variable (ROA). Similarly, the probability (F-statistic) in Table 4.10, panel B, shows a result of 0.000000, which is less than 0.05. It can be concluded that the independent variables can explain one or both of the effects on the dependent variable (FV).

The adjusted R-square value for the moderated regression equation in Table 9, panel A, is 0.694, indicating that approximately 69% of the moderating equation's effect on the dependent variable (ROA). Likewise, the Adjusted R-square value for panel B, model 3.4, is 0.800, or approximately 80% of the moderated regression equation's ability to influence the dependent variable (FV) in this study. Overall, with a relatively high R2 level, as shown in Table 9, the moderated regression model in this study can explain almost all of the variables.

Hypothesis Testing (t-Test)

To test all hypotheses, both with the dependent variables of profitability and firm value, a t-test was conducted on the panel data regression equation. The goal was to determine the influence of the independent variables on the dependent variable and the moderating role of information technology. Whether all 16 hypotheses, from H1a-d to H4a-d, in this study were accepted, only some, or even rejected, can be seen in the following table. Table 10 shows the direct equation or models 3.1 and 3.2. Table 11 shows the results of moderation models 3.3 and 3.4.

Table 10. Results of Hypothesis Test (t) Direct Equation

Panel A. Model 3.1

Dependent Variable: ROA

Method: Panel EGLS (Cross-section random effects)

Date: 06/24/25 Time: 09:16

Sample: 2019 2023

Periods included: 5

Cross-sections included: 43

Total panel (balanced) observations: 215

Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.027774	0.034241	0.811129	0.4182
NPL	0.008952	0.025551	0.350341	0.7264
BOPO	-0.070824	0.003426	-20.67152	0.0000
CAR	0.009985	0.005509	1.812417	0.0714
CCI	-0.013299	0.006920	-1.921834	0.0560
SIZE	0.001382	0.001056	1.308411	0.1922

Panel B. Model 3.2

Dependent Variable: FV

Method: Panel Least Squares

Date: 06/24/25 Time: 09:12

Sample: 2019 2023

Periods included: 5

Cross-sections included: 43

Total panel (balanced) observations: 215

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	114.4068	15.84870	7.218689	0.0000
NPL	-6.267932	4.524120	-1.385448	0.1678
BOPO	1.018844	0.656234	1.552562	0.1224
CAR	2.120433	1.055498	2.008941	0.0462
CCI	4.540530	1.449950	3.131509	0.0021
SIZE	-3.670500	0.503441	-7.290820	0.0000

Source: processed by the author with Eviews-12 (2025)

Based on the t-test results (Table 10, Panel A, Model 3.1), BOPO has a significant negative effect on profitability (ROA) (coefficient = -0.0708 , $p = 0.0000 < 0.01$), supporting H1b. Capital Adequacy Ratio (CAR) has a positive and significant effect on ROA (coefficient = 0.0099 , $p < 0.10$), supporting H1c. Climate Change Initiatives (CCI) are also significant ($p = 0.0560 < 0.10$), but the negative coefficient contradicts the proposed positive relationship; therefore, the effect is significant but opposite to the hypothesis. Meanwhile, Non-Performing Loans (NPL) show no significant effect on ROA ($p > 0.10$).

For the second regression model examining firm value (FV), both CAR and CCI have positive and significant effects, with coefficients of 2.1204 ($p = 0.0462$) and 4.5405 ($p =$

0.0021), respectively, supporting H2c and H2d. In contrast, NPL and BOPO do not significantly affect firm value; therefore, H2a and H2b are rejected.

The moderating role of Information Technology (IT) was examined using Moderated Regression Analysis (MRA). The interaction coefficients reported in Table 11 indicate the direction of moderation: positive coefficients strengthen, whereas negative coefficients weaken, the relationship between risk management variables and banking performance.

Table 11. Hypothesis Test Results (t) of the Moderation Equation

Panel A. Model 3.1

Dependent Variable: ROA

Method: Panel EGLS (Cross-section random effects)

Date: 06/24/25 Time: 09:08

Sample: 2019 2023

Periods included: 5

Cross-sections included: 43

Total panel (balanced) observations: 215

Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.023420	0.034375	0.681302	0.4965
NPL	0.009780	0.035476	0.275691	0.7831
BOPO	-0.067727	0.005294	-12.79368	0.0000
CAR	0.009191	0.006852	1.341416	0.1813
CCI	-0.015916	0.008107	-1.963317	0.0510
SIZE	0.001452	0.001057	1.373257	0.1712
TI	0.345638	0.668303	0.517187	0.6056
NPL_TI	-0.552351	1.811562	-0.304903	0.7608
BOPO_TI	-0.394524	0.610573	-0.646154	0.5189
CAR_TI	0.080318	0.288563	0.278337	0.7810
CCI_TI	0.214566	0.403850	0.531301	0.5958

Panel B. Model 3.2

Dependent Variable: FV
 Method: Panel Least Squares
 Date: 06/24/25 Time: 09:11
 Sample: 2019 2023
 Periods included: 5
 Cross-sections included: 43
 Total panel (balanced) observations: 215

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	106.5047	17.07324	6.238108	0.0000
NPL	-10.90411	6.254473	-1.743410	0.0832
BOPO	3.294454	1.015878	3.242961	0.0014
CAR	2.142778	1.347219	1.590520	0.1137
CCI	3.972318	1.641689	2.419652	0.0166
SIZE	-3.474388	0.542436	-6.405159	0.0000
TI	323.4354	128.0802	2.525258	0.0125
NPL_TI	319.9027	298.3071	1.072394	0.2851
BOPO_TI	-348.3975	108.0671	-3.223899	0.0015
CAR_TI	-31.67290	53.01934	-0.597384	0.5511
CCI_TI	5.527154	83.75697	0.065990	0.9475

Source: processed by the author with Eviews-12 (2025)

Based on Table 11 (Panel A), none of the four interaction terms are statistically significant ($p > 0.10$), indicating that Information Technology (IT) does not moderate the relationship between the four risk management proxies and bank profitability (ROA). Therefore, H3a, H3b, H3c, and H3d are rejected.

For firm value (FV) (Model 3.4), only the interaction between BOPO and IT (BOPO_IT) is significant ($p = 0.0015 < 0.01$). However, the interaction coefficient is negative, meaning that IT strengthens the negative effect of BOPO on firm value rather than weakening it as hypothesized. Consequently, H4b is rejected despite its statistical significance.

The interaction terms NPL_IT, CAR_IT, and CCI_IT are not significant ($p > 0.10$), indicating that IT does not moderate their relationships with firm value. Therefore, H4a, H4c, and H4d are also rejected. A summary of all hypothesis testing results is presented in Table 12.

Table 12. Summary of Hypothesis Test Results

No.	Hypothesis Statement	Result
H1a	NPL has a negative effect on bank profitability.	Rejected
H1b	BOPO has a negative effect on bank profitability.	Accepted
H1c	CAR has a positive effect on bank profitability.	Accepted
H1d	CCI has a positive effect on bank profitability.	Accepted
H2a	NPL has a negative effect on the firm value of banking sector companies.	Rejected

H2b	BOPO has a negative effect on the firm value of banking sector companies.	Rejected
H2c	CAR has a positive effect on the firm value of banking sector companies.	Accepted
H2d	CCI has a positive effect on the firm value of banking sector companies.	Accepted
H3a	Information technology positively moderates the negative effect of NPL on bank profitability.	Rejected
H3b	Information technology positively moderates the negative effect of BOPO on bank profitability.	Rejected
H3c	Information technology strengthens the effect of CAR on bank profitability.	Rejected
H3d	Information technology strengthens the effect of CCI on bank profitability.	Rejected
H4a	Information technology positively moderates the negative effect of NPL on firm value.	Rejected
H4b	Information technology positively moderates the negative effect of BOPO on firm value.	Rejected
H4c	Information technology strengthens the effect of CAR on firm value.	Rejected
H4d	Information technology strengthens the effect of CCI on firm value.	Rejected

Interpretation of the Effects of Risk Management on Profitability

1. Effect of Non-Performing Loans (NPL) on ROA

The study finds that Non-Performing Loans (NPL) do not significantly affect profitability (ROA). This suggests that credit risk does not necessarily reduce bank profitability, likely because Indonesian banks maintained NPL levels within a safe range through effective risk management and corporate governance. Although this finding is inconsistent with Enterprise Risk Management (ERM) theory, which predicts that higher credit risk lowers profitability, it is consistent with Mohammad et al. (2024), who argue that the impact of NPL depends on how credit risk is managed. In contrast, Ali & Puah (2018) reported a significant negative relationship between credit risk and profitability while emphasizing the importance of sound governance.

2. Effect of Operational Inefficiency (BOPO) on ROA

The results show that BOPO has a significant negative effect on ROA, supporting ERM principles that emphasize operational efficiency and internal control. Higher operating costs relative to operating income reduce profit margins and reflect ineffective internal risk management. This finding is supported by Ali & Puah (2018) and Nurtrontong et al. (2021), who conclude that greater operational inefficiency significantly lowers bank profitability.

3. Effect of Capital Adequacy Ratio (CAR) on ROA

The study finds that CAR positively affects profitability, indicating that well-capitalized banks are better able to absorb risks, strengthen investor confidence, reduce funding costs, and support strategic decision-making. This result aligns with ERM and is consistent with Ali & Puah (2018), Al-Okaily et al. (2023), and Nour et al. (2023), who highlight that strong capital structures improve profitability, financial resilience, and investor confidence.

4. Effect of Climate Change Initiatives (CCI) on ROA

The findings indicate that Climate Change Initiatives (CCI) have a positive effect on profitability, supporting the modern ERM perspective that integrates environmental and social risks into strategic risk management. Climate-related initiatives, including green financing and carbon disclosure, enhance financial performance by creating and protecting firm value while supporting the Sustainable Development Goals (SDGs). These findings are consistent with Bedi & Singh (2024), Cadez et al. (2019), Moussa et al. (2020), and Amran et al. (2014), who conclude that effective climate governance and environmental management improve corporate reputation, stakeholder trust, long-term profitability, and sustainability.

Interpretation of the Moderating Role of Information Technology in the Relationship Between Risk Management and Profitability

1. Moderating Role of Information Technology on the Effect of Non-Performing Loans (NPL) on ROA

The results indicate that the interaction between Non-Performing Loans (NPL) and Information Technology (IT) has no significant effect on profitability (ROA). This suggests that IT neither strengthens nor weakens the relationship between credit risk and profitability. Possible explanations include the limited integration of IT into credit risk management, banks still adapting to digital transformation, and the insignificant direct effect of NPL on ROA. Although Enterprise Risk Management (ERM) suggests that IT should support credit risk mitigation through early warning systems and credit analytics (COSO, 2017), this integration remains limited. These findings are consistent with Gupta & Haldar (2018), who described a "profitability paradox," where IT investments primarily support modernization rather than competitive advantage or profitability.

2. Moderating Role of Information Technology on the Effect of Operational Inefficiency (BOPO) on ROA

The interaction between BOPO and IT is also insignificant, indicating that IT has not substantially improved operational efficiency or profitability. Although the relationship is negative, suggesting an adjustment phase, IT investments may still increase operational complexity without delivering immediate financial benefits. From the ERM perspective, IT should reduce operational risk through automation and process optimization; however, these benefits may not materialize without business process restructuring. This finding supports Gupta & Haldar (2018), who argued that IT alone cannot improve profitability unless aligned with organizational strategy.

3. Moderating Role of Information Technology on the Effect of Capital Adequacy (CAR) on ROA

The interaction between Capital Adequacy Ratio (CAR) and IT is not significant, indicating that IT does not strengthen the positive relationship between capital adequacy

and profitability. Although ERM emphasizes the role of IT in integrated risk measurement, capital planning, and stress testing, Indonesian banks appear not to have fully integrated IT into strategic capital management. This result is consistent with Al-Okaily et al. (2023), who found that IT contributes to profitability only when effectively integrated with financial strategy and capital management.

4. Moderating Role of Information Technology on the Effect of Climate Change Initiatives (CCI) on ROA

The findings show that IT does not moderate the relationship between Climate Change Initiatives (CCI) and profitability. This suggests that digital technologies have not yet been fully utilized to support climate risk management and sustainability strategies. Modern ERM recommends the use of Environmental Management Systems (EMS), ESG reporting platforms, and climate risk analytics to enhance sustainability performance. However, these practices remain limited in Indonesian banking. This finding aligns with Bedi & Singh (2024), who emphasized the importance of climate governance and environmental management systems, and Moussa et al. (2020), who argued that sustainability initiatives require robust information systems to be implemented effectively rather than symbolically.

Interpretation of the Effect of Risk Management on Firm Value

1. Effect of Non-Performing Loans (NPL) on Firm Value

The regression results show that NPL has no significant effect on firm value. This suggests that investors do not directly associate higher credit risk with lower market valuation. Although ERM considers credit risk essential for protecting firm value, investors may place greater emphasis on broader strategic indicators such as capital strength and environmental responsibility. The insignificant result may also reflect effective credit risk management through loan loss provisions and portfolio diversification, preventing NPL fluctuations from significantly affecting market perception.

2. Effect of Operational Inefficiency (BOPO) on Firm Value

The findings indicate that BOPO does not significantly affect firm value. While BOPO reflects internal operational efficiency, investors tend to focus on long-term performance indicators such as profitability, return on equity, and growth prospects rather than technical efficiency measures. This result is consistent with Sutrisno et al. (2021), Alfarisi & Fahmi (2020), Ali & Puah (2018), and Hartono (2015), who found that operational efficiency has a stronger relationship with financial performance than with market valuation.

3. Effect of Capital Adequacy (CAR) on Firm Value

The results show that CAR has a positive and significant effect on firm value ($p = 0.0462$), supporting the hypothesis that stronger capital adequacy enhances market valuation. This finding is consistent with the Enterprise Risk Management (ERM) framework, which emphasizes adequate capital as a key mechanism for protecting and creating firm value. It is also supported by Sari et al. (2018), who found that strong capital and risk management

improve financial stability and firm performance. However, Ali & Puah (2018) note that maintaining high capital through aggressive funding strategies may increase operating costs, highlighting the importance of balancing capital strength with cost efficiency.

4. Effect of Climate Change Initiatives (CCI) on Firm Value

The study finds that Climate Change Initiatives (CCI) have a positive and highly significant effect on firm value ($p = 0.0021$). Banks with stronger climate-related disclosures and environmental initiatives tend to achieve higher market valuations, confirming that climate risk management contributes to long-term value creation. These findings support Adu et al. (2024), who argue that climate initiatives enhance stakeholder trust and long-term firm value, and Bedi & Singh (2024), who emphasize that strong climate governance and carbon disclosure improve corporate reputation and market valuation.

Interpretation of the Moderating Role of Information Technology in the Relationship Between Risk Management and Firm Value

1. Moderating Role of Information Technology on the Effect of Non-Performing Loans (NPL) on Firm Value

The findings indicate that Information Technology (IT) does not moderate the relationship between Non-Performing Loans (NPL) and firm value (FV). This suggests that IT has not been effectively utilized to strengthen credit risk management in creating long-term firm value. Although Enterprise Risk Management (ERM) emphasizes systematic credit risk mitigation to protect and create value (COSO, 2017), Indonesian banks primarily use IT for digital banking services and internal reporting rather than advanced credit risk analytics or AI-based credit scoring. These results are consistent with Gupta & Haldar (2018), who argued that IT investments often improve operational efficiency but do not necessarily create competitive advantage or increase firm value unless strategically integrated into ERM.

2. Moderating Role of Information Technology on the Effect of Operational Inefficiency (BOPO) on Firm Value

The interaction between BOPO and IT is significant but negative, indicating that IT weakens the positive relationship between operational efficiency and firm value. This finding rejects the proposed hypothesis and suggests that excessive or poorly aligned IT investments may reduce the benefits of operational efficiency when not strategically integrated into business processes. The result supports Gupta & Haldar (2018), who emphasized that the effectiveness of IT depends on governance quality and its alignment with organizational strategy rather than technology adoption alone.

3. Moderating Role of Information Technology on the Effect of Capital Adequacy (CAR) on Firm Value

The study finds that the interaction between Capital Adequacy Ratio (CAR) and IT is not significant, indicating that IT neither strengthens nor weakens the positive relationship between capital adequacy and firm value. Although ERM suggests that IT should support capital planning, stress testing, and real-time risk monitoring (COSO, 2017), these capabilities have not yet been fully integrated into Indonesian banks' strategic capital management. Consistent with Gupta & Haldar (2018), IT investments are often implemented for compliance and operational continuity rather than as a source of strategic differentiation, limiting their contribution to firm value.

4. Moderating Role of Information Technology on the Effect of Climate Change Initiatives (CCI) on Firm Value

The results show that IT does not moderate the relationship between Climate Change Initiatives (CCI) and firm value. Although modern ERM recognizes climate risk as a strategic risk that should be managed through digital technologies such as Environmental Management Systems (EMS), ESG reporting platforms, carbon emission analytics, and digital green financing (COSO, 2017), these technologies have not been optimally implemented in Indonesian banking. This finding is consistent with Bedi & Singh (2024), who demonstrated that climate governance and environmental management systems improve environmental disclosure and corporate reputation but did not identify IT as an integral component of value creation in emerging-market banking sectors.

CONCLUSION

This study examines the impact of risk management on bank performance, measured by profitability and firm value, with Information Technology (IT) serving as a moderating variable. Using panel data regression on 43 banks listed on the Indonesia Stock Exchange (IDX) during 2019–2023, the main findings are as follows:

1. Non-Performing Loans (NPL), as a proxy for risk management, have no significant negative effect on either profitability or firm value. This suggests that Indonesian banks have managed credit risk effectively, preventing NPL from becoming a major determinant of financial performance or market valuation.
2. Operational inefficiency (BOPO) has a significant negative effect on profitability but no significant effect on firm value. While higher operating costs reduce profits, investors do not rely solely on this technical efficiency indicator when evaluating banks' long-term market prospects.
3. Capital Adequacy Ratio (CAR) has a positive and significant effect on both profitability and firm value. Stronger capital positions enhance banks' financial stability, support business expansion, and increase investor confidence.
4. Climate Change Initiatives (CCI) positively influence both profitability and firm value. These findings highlight the strategic importance of non-financial factors, particularly

environmental sustainability, in strengthening financial performance and market valuation over the short and long term.

5. Information Technology (IT) does not moderate the relationship between risk management (proxied by NPL, BOPO, CAR, and CCI) and profitability. This indicates that IT integration into risk management practices has not yet reached a level capable of enhancing banks' profitability, likely due to the ongoing digital transformation of the Indonesian banking sector.
6. Regarding firm value, IT does not moderate the relationships involving NPL, CAR, and CCI. However, the interaction between BOPO and IT (BOPO_IT) significantly strengthens the negative effect of operational inefficiency on firm value. This finding suggests that, during the study period, IT investments generated higher implementation costs than immediate benefits and were perceived by investors as necessary technological adoption rather than a source of strategic competitive advantage.

REFERENCES

- Abuzayed, B., Molyneux, P., & Al-Fayoumi, N. (2009). Market value, book value and earnings: is bank efficiency a missing link? *Managerial Finance*, 35(2), 156–179. <https://doi.org/10.1108/03074350910923491>.
- Adu, D. A., Abedin, M. Z., Saa, V. Y., & Boateng, F. (2024). Bank sustainability, climate change initiatives and financial performance: The role of corporate governance. *International Review of Financial Analysis*, 95 (PB), 103438. <https://doi.org/10.1016/j.irfa.2024.103438>.
- Ali, M., & Puah, C. H. (2019). The internal determinants of bank profitability and stability: An insight from banking sector of Pakistan. *Management Research Review*, 42(1), 49–67. <https://doi.org/10.1108/MRR-04-2017-0103>.
- Anwar, Channine Sabina, and Saiful Saiful. 2024. “Analisis Investasi Teknologi Informasi Terhadap Kinerja Keuangan Perusahaan Sektor Kesehatan.” *Journal of Management and Bussines (JOMB)* 6 (1): 49–56. <https://doi.org/10.31539/jomb.v6i1.8321>.
- Bedi, A., & Singh, B. (2023). Unraveling the impact of stakeholder pressure on carbon disclosure in an emerging economy. *Social Responsibility Journal*, 20(4), 703–718. <https://doi.org/10.1108/SRJ-04-2023-0198>.
- Caby, J., Ziane, Y., & Lamarque, E. (2020). The determinants of voluntary climate change disclosure commitment and quality in the banking industry. *Technological Forecasting and Social Change*, 161 (March), 120282. <https://doi.org/10.1016/j.techfore.2020.120282>.
- CEIC. (2024) *Malaysia Non-Performing Loans Ratio 2005-2024*. Retrieved December, 16, 2024, from CEIC: <https://www.ceicdata.com/en/indicator/malaysia/non-performing-loans-ratio>.
- COSO. 2017. “Enterprise Risk Management. Integrating with Strategy and Performance.” *The Committee of Sponsoring Organizations of the Treadway Commission*.
- Ghozali, I. 2018. *Aplikasi Analisis Multivariat dengan Program IBM SPSS* 25. 9 ed. Semarang: Universitas Diponegoro.

- Gupta, Sangita Dutta, Ajitava Raychaudhuri, and Sushil Kumar Haldar. 2018. "Information Technology and Profitability: Evidence from Indian Banking Sector." *International Journal of Emerging Markets* 13 (5): 1070–87. <https://doi.org/10.1108/IJoEM-06-2017-0211>.
- Hartono, J. (2015). *Teori Portofolio dan Analisis Investasi* (9th ed.). Yogyakarta: BPFE.
- Houqe, M. N., Opare, S., & Zahir-Ul-Hassan, M. K. (2024). Carbon emissions, female CEOs and earnings management. *International Journal of Accounting and Information Management*, 32(4), 593–621. <https://doi.org/10.1108/IJAIM-11-2023-0296>.
- Joshi, Aman Kumar, Rajesh Matai, and Nagesh N. Murthy. 2024. "Measuring the Impact of Information and Communication Technology Investment on the Profitability of Indian Manufacturing MSME." *Bottom Line* 37 (1): 98–115. <https://doi.org/10.1108/BL-03-2023-0101>.
- Mohammad, R., Nour, A. I., & Al-Atoot, S. M. (2024). Risk and reward: unraveling the link between credit risk, governance and financial performance in banking industry. *Journal of Islamic Marketing*. <https://doi.org/10.1108/JIMA-11-2023-0378>.
- Napitupulu, R. B., T. P. Simanjuntak., L. Hutabarat., H. Damanik., H. Harianja., R. T. M. Sirait., dan C. E. R. L. Tobing. 2021. *Penelitian Bisnis: Teknik dan Analisis Data dengan SPSS-STATA-EVIEWS*. 1 ed. Medan: Madenatera.
- Nawaz, Muhammad. 2012. "Credit Risk and Performance of Nigerian Banks." *Interdisciplinary Journal of Contemporary Research in Business*.
- Orazalin, N. S., Ntim, C. G., & Malagila, J. K. (2024). Board Sustainability Committees, Climate Change Initiatives, Carbon Performance, and Market Value. *British Journal of Management*, 35(1), 295–320. <https://doi.org/10.1111/1467-8551.12715>.
- Rafiq, M. Z., Jun, J. C., Naseem, S., & Mohsin, M. (2019). Impact of market risk, interest rate, exchange rate on banks stock return: Evidence from listed banks of Pakistan. *Amazonia Investiga*, 8 (21), 667–673. <https://www.amazoniainvestiga.info/index.php/amazonia/article/view/155>.
- Sari, E., Suhadak, Rahayu, S. M., & Solimun. (2018). The effects of Tier-1 capital, risk management, and profitability on performance of Indonesian Commercial Banks. *International Journal of Law and Management*, 60 (5), 1074–1086. <https://doi.org/10.1108/IJLMA-05-2017-0109>.
- Sekaran, U. dan R. Bougie. 2016. *Research Methods for Business: a skill-building approach*. 7 ed. United Kingdom: John Wiley & Sons.
- Sugiyono. 2016. *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.
- Supriyadi, D., & Setyorini, S. (2020). Pengaruh Pengungkapan Manajemen Risiko terhadap Nilai Perusahaan dengan Profitabilitas sebagai Variabel Intervening. *Jurnal Akuntansi dan Keuangan Islam*, 8(1), 20–30.
- Yanti, D., & Setiyanto, R. H. (2021). Pengaruh Manajemen Risiko terhadap Kinerja Keuangan Bank Syariah di Indonesia.