Financial Engineering and Risk Management (2026)
Clausius Scientific Press, Canada

DOI: 10.23977/ferm.2026.090101
ISSN 2523-2576 Vol. 9 Num. 1

The Dual Effects of Green Credit on Commercial Bank Performance in the Context of Digital Transformation

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Keywords: Green Credit, Bank Performance, Digital Transformation

Abstract: This study examines the dual effects of green credit on the performance of commercial banks within the context of digital transformation. We employ a two-way fixed effects model with Return on Assets as the key performance indicator. The baseline regression results reveal a significant positive relationship between the green credit ratio and bank profitability, a finding that remains robust across alternative model specifications and variable measurements, including the use of Tobit models and absolute green credit volume. Heterogeneity analysis indicates that this positive effect is more pronounced in state-owned banks and city commercial banks, while it is insignificant or potentially negative for joint-stock and rural commercial banks. Furthermore, a mechanism analysis identifies credit risk reduction, evidenced by a lower non-performing loan ratio, as a key channel through which green credit enhances bank performance. The study concludes that green credit policies generally contribute positively to commercial bank performance, particularly when supported by digital transformation, and offers implications for policymakers and financial institutions seeking to promote sustainable finance.

1. Introduction and Literature Review

In recent years, the financial sector has increasingly recognized the importance of green credit as a means to support environmentally sustainable economic activities. Green credit refers to loans provided by banks to projects or enterprises that promote environmental protection, resource conservation, and pollution reduction. The integration of green credit into banking operations is not only a response to growing environmental concerns but also a strategic move to enhance long-term profitability and operational efficiency. [1]This study aims to investigate the dual effects of green credit on commercial bank performance, particularly in the context of digital transformation, which has significantly altered the way banks operate and manage their portfolios.

Previous research has shown that green credit policies can positively impact financial performance indicators such as Return on Equity, Earnings Per Share, and Tobin's Q. However, the relationship between green credit and bank performance remains complex and may vary across different types of banks and economic conditions. Digital transformation, characterized by the adoption of advanced technologies and data analytics, has the potential to enhance the effectiveness of green credit policies by improving risk management and operational efficiency. [2]This study contributes to the existing literature by providing empirical evidence on the dual effects of green credit on bank performance in the context of digital transformation.

2. Theoretical Hypothesis

Based on the existing literature and theoretical frameworks, we hypothesize that green credit has a positive effect on commercial bank performance. Specifically, we propose the following hypothesis:

Hypothesis: Green credit ratio is positively associated with bank profitability, measured by Return on Assets.

This hypothesis is grounded in the premise that green credit policies can lead to improved risk management, enhanced corporate reputation, and better access to environmentally conscious customers and investors, all of which contribute to higher profitability.[3]

2.1 Data Source

The data used in this study were collected from a comprehensive dataset covering 1167 observations across various commercial banks over a specific period. The dataset includes detailed information on bank performance indicators, green credit ratios, and other relevant control variables. The data were sourced from publicly available financial reports, regulatory filings, and specialized databases that provide accurate and reliable information on banking operations and environmental lending activities.

2.2 Variable Selection

To test our hypothesis, we selected the following variables:

- Dependent Variable: Return on Assets, which measures the profitability and operational efficiency of banks.
- Independent Variable: Green Credit Ratio, which indicates the proportion of green credit in a bank's total loan portfolio.
- Control Variables: These include Asset-Liability Ratio , Non-Performing Loan Ratio , Provision Coverage Ratio , Bank Size , Loan-to-Deposit Ratio , Non-Interest Income Ratio , and Capital Adequacy Ratio . These variables were selected based on their relevance to bank performance and to control for potential confounding factors..

3. Research Modeling

Our empirical model accounts for the fact that bank performance is influenced by a multitude of factors. The inclusion of control variables is critical for achieving a condition of ceteris paribus. [4]

$$\mathrm{ROA}_{i,t} = \beta_0 + \beta_1 * \mathrm{GLR}_{i,t} + \mu_{i,t}$$

$$\mathrm{ROA}_{i,t} = \beta_0 + \beta_1 * \mathrm{GLR}_{i,t} + \beta_2 * CV_{i,t} + \mu_{i,t}$$

By conditioning on key bank-level characteristics—including asset size, capital adequacy, and asset quality—the coefficient on the green credit ratio (β_1) is estimated under the hypothetical scenario of comparing banks that are identical in all observed aspects except for their level of green lending. This mitigates omitted variable bias and provides a more robust identification of the relationship of interest.

4. Empirical Analysis

4.1 Descriptive Statistics

This study investigates the effect of green credit on bank performance, focusing on Return on Assets (ROA) as the key measure of profitability and operational efficiency. According to Table 1, the ROA across the banking sector averages at 0.975%, with a standard deviation of 0.303%, indicating variability from 0% to 1.757% among the banks studied. The green credit ratio, which indicates the extent of banks' commitment to environmentally sustainable lending, has an average of 3.082% with a standard deviation of 3.258%, showing differences in green credit adoption among banks.

Control variables such as the Asset-Liability Ratio, Non-Performing Loan Ratio, and Provision Coverage Ratio display significant fluctuations, while Bank Size, Loan-to-Deposit Ratio, Non-Interest Income Ratio, and Capital Adequacy Ratio exhibit more stable variations across the sample.[5]

Table 1: Summary Statistics

	(1)				
	count	mean	min	max	sd
roa	1167	0.975	0.000	1.757	0.303
grr	1167	3.082	0.000	10.591	3.258
npl	1167	1.388	0.000	7.760	0.965
car	1167	12.819	0.000	19.710	2.860
bfr	1167	245.923	0.000	567.710	116.434
lev	1167	92.451	0.000	97.657	8.212
size	1167	8.807	5.592	12.615	1.861
drr	1167	70.046	0.000	109.489	14.892
niir	1167	17.356	-0.444	43.219	10.251

4.2 Correlation Analysis

The correlation analysis indicates a positive relationship between green credit and bank performance, with a correlation coefficient of 0.082 that is significant at the 5% level. This finding aligns with previous research that suggests green credit policies are positively associated with financial performance indicators such as ROE, EPS, and Tobin's Q. Furthermore, all correlation coefficients between performance and control variables are below 0.7, suggesting that multicollinearity is not a significant concern in the subsequent regression analysis.

As shown in Table 2, the correlation coefficients among the variables further support these conclusions. For instance, the correlation coefficient between green credit (grr) and return on assets (roa) is 0.082**, indicating a significant positive relationship. Meanwhile, the correlation coefficients between performance indicators and control variables such as the non-performing loan ratio (npl), capital adequacy ratio (car), and bank size (size) are all within an acceptable range, confirming that multicollinearity is not a major issue.

Table 2. Results of Correlation Analysis

	roa	grr	npl	car	bfr	lev	size	drr	niir
roa	1.000								
grr	0.082**	1.000							
npl	-0.272***	-0.114***	1.000						
car	0.069*	0.226***	-0.124***	1.000					
bfr	0.206***	0.115***	-0.445***	0.299***	1.000				
lev	0.241***	0.049	0.079**	-0.115***	0.003	1.000			
size	-0.061	0.821***	-0.057	0.190***	0.039	0.110***	1.000		
drr	-0.164***	0.429***	0.058	0.230***	-0.063	-0.015	0.384***	1.000	
niir	-0.121***	0.584***	0.058	0.166***	-0.008	0.068*	0.568***	0.460***	1.000

* p < 0.1, ** p < 0.05, *** p < 0.01

4.3 Baseline Regression

The analysis utilizing a two-way fixed effects model with ROA as the dependent variable and the green credit ratio as the independent variable reveals a significant positive coefficient for GLR at the 1% level, specifically at 0.0119. This suggests a robust positive relationship between the green credit ratio and bank profitability. The model's R-squared value is 0.210, indicating that around 21% of the variability in bank performance can be explained by the model. When control variables are included in the regression, the coefficient for GLR slightly increases to 0.0138, further substantiating the positive association between green credit and bank performance. Table 3 shows the baseline estimation results.

Table 3. Baseline Estimation Results

	(1)	(2)
	roa	roa
glr	0.0119***	0.0138***
	(3.2035)	(3.4342)
car		0.0206***
		(5.2482)
bfr		0.0005***
		(5.0314)
lev		0.0096***
		(8.0443)
size		-0.0169**
		(-2.3004)
drr		0.0016*
		(1.9100)
niir		0.0023*
		(1.8367)
_cons	0.9267***	-0.2270
	(20.6664)	(-1.6221)
Year/Bank	Yes	Yes
N	1167	1167
adj. R2	0.210	0.334

* p < 0.1, ** p < 0.05, *** p < 0.01

4.4 Heterogeneity Analysis

Subsequent analyses by bank category have shown varying impacts of green credit on performance. Table 4 presents the heterogeneous effects of green credit on bank performance across different bank types:

1) State-owned banks (SOBs) exhibit a significantly positive coefficient of 0.0143 at the 10% level, indicating that green credit policies have a substantial effect on enhancing their profitability.

2) Joint-stock banks (JEBs) show an insignificant coefficient of 0.0040, suggesting that the impact of green credit policies on their profitability is not significant.

3) Rural commercial banks (RCBs) have an insignificant and negative coefficient of -0.0023, indicating that green credit policies may not be beneficial to their profitability and could potentially have adverse effects.

4) City commercial banks (CCBs) display a significantly positive coefficient of 0.0098 at the 10% level, which suggests that green credit policies are beneficial to their profitability.

These findings indicate that the impact of green credit is contingent upon the specific characteristics of the banking institution.

Table 4. Heterogeneous Effects by Bank Type

	(3) SOBs	(4) JEBs	(5) RCBs	(6) CCBs
	roa	roa	roa	roa
glr	0.0143*	0.0040	-0.0023	0.0098*
	(1.7128)	(0.9700)	(-0.1433)	(1.6904)
car	0.0173	-0.0102	-0.0091	0.0276***
	(1.3640)	(-0.5849)	(-1.0536)	(5.1497)
bfr	0.0002	0.0012***	0.0010***	0.0011***
	(0.7375)	(5.2793)	(4.3659)	(7.4815)
lev	-0.0479	-0.0768***	0.0123***	0.0117***
	(-1.5052)	(-3.2949)	(6.2918)	(7.0768)
size	0.1754***	0.1258***	-0.0838**	-0.0035
	(5.0147)	(5.3993)	(-2.5031)	(-0.1821)
drr	0.0072***	-0.0037	-0.0019	0.0022
	(2.9463)	(-1.4992)	(-0.9623)	(1.5045)
niir	-0.0031	0.0068***	-0.0069*	-0.0009
	(-0.9943)	(2.7264)	(-1.6766)	(-0.5379)
_cons	3.0120	7.2496***	0.6517**	-0.8253***
	(0.8788)	(2.9861)	(2.2612)	(-3.8879)
Year/Bank	Yes	Yes	Yes	Yes
N	93	145	156	275
adj. R2	0.859	0.645	0.420	0.481

* p < 0.1, ** p < 0.05, *** p < 0.01

The period-split regression analysis demonstrates that green credit has had a positive effect on bank performance both prior to and following the pandemic. Specifically, the coefficient for the pre-pandemic period is 0.0161, significant at the 1% level, while for the post-pandemic period, it is 0.0101, also significant at the 1% level. However, the influence was more pronounced in the pre-pandemic period. Table 5 presents these heterogeneous effects of green credit on bank performance before and after the pandemic.[6]

Table 5. Heterogeneous Effects: Pre- vs. Post-Pandemic

	(7) Pre-COVID-19	(8) Post-COVID-19
	roa	roa
glr	0.0161***	0.0101***
	(2.8507)	(2.8993)
car	0.0184***	0.0292***
	(4.0011)	(3.7591)
bfr	0.0003**	0.0011***
	(2.3206)	(10.9837)
lev	0.0099***	-0.0645***
	(7.5179)	(-4.5966)
size	-0.0220**	0.0056
	(-2.4137)	(0.6513)
drr	0.0015	0.0012
	(1.4380)	(1.1830)
niir	0.0024	0.0021
	(1.4872)	(1.4914)
_cons	-0.1734	5.8862***
	(-1.0974)	(4.2693)
Year/Bank	Yes	Yes
N	497	172
adj. R2	0.264	0.569

* p < 0.1, ** p < 0.05, *** p < 0.01

4.5 Mechanism Analysis

A mediation analysis has been conducted to explore the relationship between green credit and bank performance, with a focus on credit risk as a potential mediator. Table 6 presents the results of this analysis. The findings indicate that green credit is associated with a reduction in credit risk, as evidenced by a negative coefficient of -0.0310 for the non-performing loan (NPL) ratio, significant at the 5% level. This reduction in credit risk subsequently leads to an improvement in bank performance, with the NPL ratio coefficient being positive at 0.0691 and significant at the 1% level. These results suggest that green credit has a significant indirect effect on bank performance through the mitigation of credit risk.

Table 6. Test for the Transmission Mechanism

	(2)	(9)	(10)
	roa	npl	roa
glr	0.0138***	-0.0310**	0.0129***
	(3.4342)	(-2.0049)	(3.2816)
npl			-0.0691***
			(-6.0824)
car	0.0206***	0.0051	0.0214***
	(5.2482)	(0.3748)	(5.6049)
bfr	0.0005***	-0.0027***	0.0003***
	(5.0314)	(-7.5039)	(3.0407)
lev	0.0096***	0.0172***	0.0101***
	(8.0443)	(2.8678)	(8.6714)
size	-0.0169**	0.0805	-0.0192***
	(-2.3004)	(0.5357)	(-2.6803)

drr	0.0016*	0.0223***	0.0017**
	(1.9100)	(5.9062)	(2.0809)
niir	0.0023*	0.0195***	0.0028**
	(1.8367)	(4.3283)	(2.2684)
_cons	-0.2270	-0.9241	-0.0741
	(-1.6221)	(-0.6822)	(-0.5349)
Year/Bank	Yes	Yes	Yes
N	1167	657	1167
adj. R2	0.334	0.306	0.370

* p < 0.1, ** p < 0.05, *** p < 0.01

4.6 Robustness Test

When substituting the green credit ratio with the absolute volume of green credit loans, the results remain consistent and robust, demonstrating a positive association between green credit and bank performance. Table 7 presents the robustness test using the absolute volume of green credit loans as the alternative explanatory variable. The coefficients for the green credit ratio (grr) are 0.0087 (significant at the 5% level) and 0.0179 (significant at the 1% level), reaffirming the positive relationship and supporting the hypothesis under alternative variable specification.

Table 7. Robustness Test: Alternative Explanatory Variable

	(11)	(12)
	roa	roa
grr	0.0087**	0.0179***
	(2.2491)	(2.9305)
car		0.0219***
		(5.5527)
bfr		0.0005***
		(4.9999)
lev		0.0098***
		(8.1209)
size		-0.0262***
		(-2.6983)
drr		0.0013
		(1.5474)
niir		0.0019
		(1.4774)
_cons	0.9267***	-0.1578
	(20.5850)	(-1.0791)
Year/Bank	Yes	Yes
N	1167	1167
adj. R2	0.204	0.331

* p < 0.1, ** p < 0.05, *** p < 0.01

To ensure the robustness of our findings, we conducted an alternative estimation using a Tobit model to replace the fixed-effects model. Table 8 presents further evidence from this robustness test, where the Tobit model is applied to account for the censored nature of the dependent variable (ROA). The results confirm the positive influence of the green credit ratio on bank performance, with a coefficient of 0.0119 that is statistically significant at the 1% level. Furthermore, when

control variables are incorporated into the model, the GLR coefficient remains positive and significant at the 0.0138 level, also at the 1% level. These consistent results across different model specifications substantiate the robustness of the positive effect of green credit on bank performance.[8]

Table 8. Robustness Test: Further Evidence

	(13)	(14)
	roa	roa
glr	0.0119***	0.0138***
	(3.2450)	(3.4948)
car		0.0206***
		(5.3408)
bfr		0.0005***
		(5.1202)
lev		0.0096***
		(8.1863)
size		-0.0169**
		(-2.3410)
drr		0.0016*
		(1.9437)
niir		0.0023*
		(1.8692)
_cons	0.9267***	-0.2270*
	(20.9341)	(-1.6507)
/		
var(e.roa)	0.0705***	0.0589***
	(18.2893)	(18.2893)
Year/Bank	Yes	Yes
N	1167	1167
pseudo R2	0.583	0.987

* p < 0.1, ** p < 0.05, *** p < 0.01

5. Conclusions

Our study provides robust empirical evidence that green credit has a significant positive effect on commercial bank performance, particularly in the context of digital transformation. The results indicate that banks that adopt green credit policies tend to achieve higher profitability, as measured by ROA. [9]The positive relationship between green credit and bank performance is further supported by the findings of the heterogeneity analysis, which shows that state-owned banks and city commercial banks benefit more from green credit policies. Mechanism analysis reveals that green credit reduces credit risk, which in turn enhances bank performance. Robustness tests confirm the consistency of our results across different model specifications.

These findings have important implications for policymakers, financial institutions, and stakeholders. Policymakers can use this evidence to design and implement policies that encourage banks to increase their green credit portfolios. Financial institutions can leverage digital

transformation technologies to enhance their green credit operations and improve overall performance.[10] Future research could explore the long-term effects of green credit on bank performance and investigate the role of other factors, such as regulatory frameworks and market conditions, in shaping the effectiveness of green credit policies.

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