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ARTICLE

Unraveling the Nexus between Sustainable Development, Bank Profitability, and Loan Loss Provisions in Vietnam: A Bayesian Vector Autoregression Perspective

Huy Nguyen Quoc , ***Hai Van Nguyen*** , ***Dinh Le Quoc*** *

Faculty of Finance and Accounting, Lac Hong University, Bien Hoa 810000, Vietnam

ABSTRACT

Financial institutions play a crucial role in financing projects and initiatives that promote sustainable development (SD). However, banks are under increasing pressure to align with the United Nations' SD goals by divesting from high CO_2-emitting industries and reallocating capital toward environmentally responsible investments. While this transition supports long-term sustainability, it can lead to short-term profitability challenges, as SD projects often involve higher risks, regulatory uncertainties, and lower immediate returns compared to traditional business activities. As a result, banks may need to adjust their loan loss provisions (LLP) to account for potential credit risks associated with these investments. This study investigates the impact of supporting SD goals on bank profitability (BP) and LLP in Vietnam from 2008 to 2019. To achieve this, we employ a Bayesian Vector Autoregression (BVAR) model, which is particularly useful in analyzing dynamic relationships, addressing heterogeneous variables, and managing small sample sizes. Our findings indicate that investing in SD projects initially reduces bank profitability due to increased costs and uncertainties, prompting banks to raise LLP. However, in the long run, such investments contribute to financial stability, enhance risk management, and strengthen the bank's overall reputation. By integrating SD principles into their investment strategies, banks can not only mitigate environmental and social risks but also create long-term value for stakeholders, reinforcing their credibility in an evolving global financial landscape.

*CORRESPONDING AUTHOR:
Dinh Le Quoc, Faculty of Finance and Accounting, Lac Hong University, Bien Hoa 810000, Vietnam; Email: dinhlq@lhu.edu.vn

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1. Introduction

This study evaluates the impact of supporting Sustainable Development (SD) goals on bank performance (BP) and loan loss provisions (LLP). Financial institutions play a critical role in providing capital for SD-related projects and activities, ensuring a balance between economic, environmental, and social factors [1]. However, in recent years, they have faced increasing pressure to comply with the United Nations' SD goals, specifically by divesting from high CO_2-emitting projects and redirecting investments towards environmentally friendly initiatives. This shift may create a trade-off between meeting SD objectives and maintaining bank profitability, as high-yield core business activities are replaced by lower-return SD projects [2]. Banks with stronger financial positions and ample liquidity are better equipped to make this transition [3, 4]. Conversely, smaller banks with limited financial resources may encounter higher credit risks when reallocating investments, as SD projects tend to be more uncertain and offer lower short-term returns. Given the vital role of banks in achieving SD goals, several studies have examined how they contribute to these objectives [2, 4–10]. However, very few studies have focused on the relationship between achieving SD goals and BP [2, 11], or banking risks [4, 11]. Notably, no current research fully explores how banks' support for implementing SD goals affects both profitability and risk, nor does it analyse the potential benefits and challenges of this process. Banks may achieve profitability while facing heightened LLP risks, or in some cases, they may balance both profitability and effective risk management, ensuring financial sustainability while fulfilling SD goals. This analysis highlights the complex relationship between SD, BP, and LLP, which can vary significantly depending on the banking system of each country.

While global governments have encouraged banks to adopt SD practices, some banking systems remain hesitant or slow in implementing these policies. Even in countries committed to SD, banks are under pressure to balance profitability with LLP obligations.

In Vietnam, on July 26, 2023, the Governor of the State Bank of Vietnam signed a decision to issue the banking sector's Action Plan to implement the National Green Growth Strategy for the period 2021–2030, as well as Vietnam's commitments made at the 26th United Nations Climate Change Conference (COP26) However, as of now, no Vietnamese bank has specifically and clearly implemented a SD strategy. Therefore, the objective of this study is to clarify the relationship between SD, BP, and LLP in Vietnam. Vietnam was chosen as the research context because the country is facing significant challenges related to the environment, climate change, and SD [8, 9]. With a population of over 100 million and a rapidly growing banking market with great potential, focusing on this relationship helps Vietnamese banks better understand the opportunities and challenges they face. This not only enables banks to seize new opportunities but also contributes to creating sustainable value for both the banks and society.

This paper contributes to the existing literature in four key areas. First, it establishes a robust theoretical foundation and provides empirical evidence on the relationship between SD, BP, and LLP. Second, based on the empirical findings, it offers valuable references for Vietnam and encourages domestic banks, as well as those in other developing nations, to take bolder steps in pursuing SD goals. Third, this research assists banks in identifying ways to optimize profitability without compromising credit risk when engaging in SD initiatives. Lastly, we offer specific policy recommendations to help policymakers and financial institutions align their strategies with SD objectives while ensuring long-term financial stability.

The remainder of this article is organized as follows. The "Literature Review" section presents an overview of prior research on the relationship between SD, BP, and LLP. Following that, the "Research Methodology" section describes the data, variables, and research rationale,

along with a summary of the descriptive statistics. The "Empirical Results" section then outlines the findings of the study. Lastly, the "Conclusions and Policy Implications" section summarizes the main insights and provides specific policy recommendations, particularly for Vietnam.

2. Literature Reviews

2.1. Related Literature

In light of the urgent threat posed by the "brown economy," SD has emerged as a critical imperative for global economies [7, 8]. Two primary theories explore the relationship between SD, BP, and LLP, offering differing perspectives. First, Ozili's [15] SD Signaling Theory suggests a positive relationship among SD, BP, and LLP. In contrast, the recently proposed Sustainable Financial Disruption Theory, introduced by Ozili [15] and further expanded by Van and Le Quoc [10], offers an alternative viewpoint on this dynamic.

According to the SD Signaling Theory, proposed by Ozili [15], banks and other financial institutions are increasingly motivated to publicly commit to SD objectives. This public commitment serves as a strategic tool for signaling positive intentions to stakeholders, thereby enhancing their institutional reputation and attracting external support. By aligning with SD goals, institutions not only appeal to environmentally conscious investors but also position themselves favorably to receive governmental incentives or backing [15]. Additionally, this alignment can enhance risk management capabilities, leading to more effective handling of LLP. Improved LLP management subsequently strengthens financial stability and reduces credit risk. As a result, a public commitment to SD goals provides dual advantages: it enhances BP while mitigating credit risk, contributing to long-term SD outcomes [11].

Ozili [2] provides evidence supporting the view that achieving SD goals positively impacts BP. This study, conducted across 28 countries, demonstrates that implementing specific SD goals leads to a significant improvement in BP in these nations. Furthermore, Kharas Prizzon and Rogerson [16] argue that allocating credit to SD purposes and engaging in SD-related lending not only yields positive social outcomes but also generates substantial profits for banks.

Jan et al. [17] conducted a panel data study over ten years (2009–2018) involving 16 Islamic banks in Malaysia and 12 Islamic banks in Indonesia. Using fixed-effects regression techniques, the study found that SD compliance practices among Islamic banks positively and significantly affect financial performance.

Yang and Liu [18] investigate the growing significance of SD goals, investment strategies, and financial knowledge in driving organizational profitability. Their research examines how SD goals, investment strategies, and financial knowledge influence the profitability of manufacturing firms in China. Additionally, the study explores the moderating role of government support in the relationship between investment plans, financial knowledge, and profitability. Their findings offer valuable insights for policymakers in developing strategies related to SD goals and investment plans to enhance organizational profitability.

Buallay et al. [19] found that Environmental, Social, and Governance (ESG) reporting improves both accounting and market-based performance of banks in developed countries following the financial crisis.

Sardianou et al. [20] emphasize the growing demand from stakeholders for sustainability information, particularly highlighting the financial sector's crucial role in driving SD, especially after the recent financial crisis. This shift has led many banks to align their sustainability disclosures with the 17 SD Goals outlined in Agenda 2030. To evaluate this alignment, the authors developed the SDG Materiality Analysis Framework, which was applied to a sample of 37 European banking institutions. Using scoring and benchmarking techniques, the framework assessed the content of sustainability reports, revealing that banks prioritize SDGs related to economic growth, decent work, fairness, and transparency in their operations.

Nigam et al. [21] underscore the importance of understanding how specific SD goals impact a bank's financial performance, particularly for advocates of sustainable banking. Their study examines the influence of key SDGs—such as poverty reduction (SDG 1), well-being (SDG 3), quality education (SDG 4), and affordable clean

energy (SDG 7)—on the profitability of Ghanaian banks, with a focus on the mediating role of inadequate finance. The results show that investing in SDGs significantly enhances commercial BP, providing policymakers with a solid foundation to convince stakeholders, including investors, consumers, and regulators, of the alignment between sustainable practices and profitability.

Bahl et al.[22] investigated how banking performance affects the achievement of specific SDGs using data from 402 employees across public, private, and foreign banks. They found a positive relationship between banking performance and the attainment of these SDGs.

Similarly, Nizam et al.[23] analyzed the impact of financial accessibility and investment in environmental finance on the financial performance of banks globally. Using cross-sectional linear regression and non-linear threshold regression methods on a sample of 713 banks from 75 countries between 2013 and 2015, the study revealed that increased financial accessibility significantly positively impacts banks' financial performance, even when controlling for bank-specific and macroeconomic variables. Notably, a 1% increase in investment in environmental sectors led to a 0.071% increase in the bank's return on equity (ROE), indicating a linear relationship between bank performance and SDG objectives.

Another perspective on the relationship between SD goals, BP, and LLP is provided by the SD Disruption Theory[10]. This theory posits that pursuing SD goals can potentially lead to a decline in BP due to the disruptions caused to traditional financial system structures. Implementing SD initiatives often requires significant investments in green projects and activities, which can strain profitability and impact LLP. Specifically, banks are required to carefully evaluate the trade-offs between the long-term benefits of SD investments and their immediate costs. When the expenses associated with green activities outweigh the anticipated returns, banks may encounter financial losses. To sustain their involvement in such projects, banks might need to increase LLP to account for the heightened risk of loan defaults associated with SD investments. While this adjustment in LLP can stabilize short-term profitability, it may also introduce long-term financial risks, particularly if green projects fail to generate expected profits. The SD Disruption Theory highlights a nuanced dynamic: while investments in SD goals might initially reduce profitability, banks can strategically manage LLP to buffer short-term impacts and promote long-term financial stability. The degree to which banks can navigate this balance, however, depends on their size and risk management capabilities. Larger banks, with more robust financial resources and diversified portfolios, are better equipped to absorb the costs of SD investments and adjust LLP accordingly. In contrast, smaller banks with limited resources may struggle to balance the demands of SD initiatives with effective financial risk management.

Ozili's[4] study supports this theory by analyzing the impact of achieving SD Goals on LLP across 28 countries from 2011 to 2019. Using Fixed Effects Regression (FEM), the study finds that bank support for SD Goals results in a significant reduction in LLP.

Similarly, Ozili[24] introduces a sustainable (or green) loan loss provisioning system that aligns loan loss provisions with SD Goals. This proposed system adjusts provisions based on the environmental benefits and costs associated with borrowers' activities. Specifically, banks would allocate additional provisions for loans to businesses that are harmful to the environment and climate, while setting aside fewer provisions for loans to eco-friendly or green businesses.

Zheng et al.[25] analyzed LLP across 22 commercial banks in Pakistan from 2010 to 2017. Their findings reveal that bank performance is crucial for maintaining profitability and solvency by moderating LLP. The study emphasizes LLP as a key indicator of risk-taking behavior and bank sustainability, providing valuable insights for future research on credit risk and managerial decision-making in the banking sector.

Meanwhile, Oanh and Dinh[8] examine the impact of expanding digital finance on SD and the associated risks affecting financial stability, finding that achieving SD significantly influences the stability of banks in Vietnam. Additionally, Dinh et al.[7] study financial stability's role in achieving SD in both developed and developing countries, demonstrating that financial stability is essential for achieving SD.

The summary table of the studies is presented in **Table A2**. It can be seen that the above studies have

the following research gaps: First, no study has clearly explained the three relationships between BP, LLP, and SD. Second, previous studies using traditional frequency methods (FEM, REM, GMM, POLS, etc.) have not approached the issue using Bayesian probabilistic methods. With the advantage of accounting for uncertainty and providing more flexible, robust results, Bayesian methods offer a deeper understanding of the relationships among variables. Third, Vietnam, as a country with a long agricultural civilization, cannot overlook credit for agriculture, forestry, and fishery issues in promoting SD. Therefore, this study further examines whether providing credit for agriculture, forestry, and fishery can promote SD and increase the profitability of banks.

2.2. Hypothesis

The relationship between SD Goals, BP, and LLP is becoming increasingly significant as the Vietnamese economy strives to achieve SD. SD Goals provide a comprehensive policy framework aimed at promoting economic growth, protecting the environment, and enhancing social quality, which directly impacts banks' strategies and operations.

In Vietnam, banks' investments in activities and projects related to SD Goals may initially reduce profitability due to higher upfront investment costs. However, in the long term, these projects could yield substantial benefits such as enhanced reputation, increased investor attraction, and SD opportunities for the banks. Therefore, it is anticipated that while implementing SD Goals might negatively affect short-term BP, the long-term effects will be positive.

Additionally, banks may use LLP as a tool to maintain profitability while investing in SD projects. LLP can help smooth out earnings by adjusting provisions to address risks arising from new or complex SD projects. In the short term, LLP might increase to reflect potential risks from these emerging projects. This approach not only helps banks sustain profitability but also balances risks and benefits, supporting the achievement of national SD Goals.

Based on these considerations, we propose the following hypothesis:

H1. *Investment in SD projects and activities helps Vietnamese banks reduce profitability while increasing LLP.*

3. Materials and Methods

3.1. Justification of Data and Variables

The study focuses on Vietnam. Data related to SD are sourced from the SDG Transformation Center (https://sdgindex.org/). Additional data for the research variables are collected from three primary sources: the Global Financial Development Index (GFDI), the World Development Indicators (WDI) from the World Bank (WB), the SDG Transformation Center, and the Food and Agriculture Organization (FAO). The symbols and measurement methods for all variables are detailed in **Table 1**. The final dataset comprises time-series data from Vietnam covering the period 2008–2019.

SD in this study is measured using 17 individual SD indicators (detailed in **Table A1**), which are aligned with the three pillars of sustainability: economic, social, and environmental, as outlined by the SD Goals. This measure, employed in previous studies by Dinh et al.[7], Oanh and Dinh[8], Kim and Quoc[9], and Van and Le Quoc[10], is considered a comprehensive index for assessing a country's level of SD. Using this measure ensures a thorough and relevant evaluation of SD issues, providing an overview of the economic, social, and environmental dimensions.

For BP, we use three indicators: return on assets (ROA), return on equity (ROE), and net interest income (NII). These indicators are commonly used in banking research as profitability measures[2]. ROA reflects a bank's overall asset management efficiency and allows for comparisons across banks of different sizes. ROE focuses on returns generated from shareholders' equity, offering insights into value creation for shareholders and evaluating internal capital utilization. NII measures the effectiveness of non-credit services, indicating the bank's flexibility and capability to offer diverse services, which is crucial as banks expand into SD areas such as green investment consulting or community financial services. The loan loss provisions (LLP) ratio is used in most studies examining the factors influencing bank loan loss provisions[24, 29].

Table 1. Variable description and source.

Symbol	Indicator	Measurement	Source
SD	Sustainable development	Integrating the three criteria of economic, environmental, and social aspects, these comprise a total of 17 criteria detailed in **Table A1**.	Sdgindex.org
ROE	Return on equity	The percentage of net income relative to shareholders' equity. It reflects the efficiency with which a bank uses its equity to generate profits. (%)	GFDI
ROA	Return on assets	The percentage of a bank's net income compared to its average total assets over the year. It indicates how effectively a bank is utilizing its assets to generate profit. (%)	GFDI
NII	Non-interest income	The percentage of a bank's total income (net interest income plus non-interest income) generated from non-interest related activities. (%)	GFDI
LLP	Bank loan loss provisions	Proportion of loan loss reserves relative to total loans (%)	GFDI
CAR	Capital adequacy ratio	The capital adequacy of deposit-taking institutions is determined by the ratio of their total regulatory capital to the risk-weighted value of their held assets (%)	GFDI
NPL	Nonperforming loans ratio	The ratio of defaulting loans (those with interest and principal payments overdue by 90 days or more) to total gross loans (the total value of the loan portfolio) (%)	GFDI
ER	Efficiency ratio	The proportion of a bank's operating expenses relative to the total of its net interest revenue and other operating income (%)	GFDI
INF	Inflation rate	Annual CPI growth rate (%)	WDI
GDP	GDP per capita growth	GDP growth per capita (%)	WDI
CA	Credit to agriculture, forestry and fishing	Credit to agriculture, forestry and fishing (Ln)	FAO

Source: Compiled by the authors.

Additionally, we control for macroeconomic factors and issues affecting BP and LLP, including Economic Growth Rate (GDP), Inflation Rate (INF), Capital Adequacy Ratio (CAR), Non-Performing Loan Ratio (NPL), and Efficiency Ratio (ER). Furthermore, recent research by Hai et al.[30] highlights a strong correlation between credit for agriculture, forestry, and fisheries (CA) and SD. As Vietnam possesses a long-standing agricultural civilization, expanding CA could potentially enhance bank profitability. Therefore, based on the findings of Hai et al.[30], we incorporate CA as a control variable in our model. Controlling for these variables ensures that external factors do not bias the analysis results, providing a more accurate understanding of the relationships between the research variables.

3.2. Research Methodology

The base model is a modified version of the model used by Ozili[2, 24]. In this model, the SD variables represent SD factors, suggesting that banks will use their decision-making authority to support SD initiatives.

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_k Y_{t-k} + \beta_x X_t + u_i + \varepsilon_t(*) \quad (1)$$

Let Y_t be a vector of endogenous variables of size 1 × 3, including SD, BP, and LLP. X_t is a vector of exogenous variables, comprising CAR, NPL, ER, INF, and GDP. k represents the optimal lag length. BP denotes BP and consists of three indicators: ROA, ROE, and NII.

In this study, we employ the BVAR methodology to examine the relationships between BP, LLP, and SD for several key reasons. First, BVAR enables the modeling of dynamic relationships among variables, allowing for an analysis of the interactions between BP, LLP, and SD over time. Additionally, the Bayesian approach enhances the accuracy of estimates by incorporating prior information, thereby reducing the risk of bias when sample sizes are small or data is noisy. This is particularly relevant for research in Vietnam covering the period from 2008 to 2019. Furthermore, BVAR is a flexible method for handling models with multiple variables and complex relationships, making it well-suited for macroeconomic and financial studies where interactions can evolve over time and be influenced by external shocks.

Bayesian VAR differs from classical VAR in that it integrates prior information with sample data (likelihood) to generate posterior distributions for the parameters. Specifically:

$$\text{Posterior} \propto \text{Prior} \times \text{Likelihood}$$

Bayesian VAR: This method incorporates prior beliefs or information (prior) about the parameters into the analysis. It then combines this prior information

with the data collected (likelihood) to estimate the posterior distributions of the parameters. This approach allows for incorporating expert knowledge and can handle smaller sample sizes more robustly.

Classical VAR: In contrast, classical VAR relies solely on sample data to estimate the parameters. It does not include prior information and provides point estimates without accounting for the uncertainty about the parameters beyond what is reflected in the sample data.

By using Bayesian VAR, researchers can refine their estimates with prior knowledge and adjust for uncertainties more effectively, particularly in cases where sample sizes are limited or data is noisy.

Research Procedures:

Stationarity Check: First, we employ the Augmented Dickey-Fuller (ADF) test to determine whether the time series data of the study variables are stationary. If the series are non-stationary, differencing is applied to achieve stationarity, ensuring that subsequent analyses are accurate and not affected by data instability.

Determining Optimal Lag Length: Correct lag length selection is crucial to prevent model bias caused by underfitting (omitting important lagged values) or overfitting (including excessive past values), thus improving the accuracy of parameter estimation and forecasting.

Stability Check: Next, we assess the stability of the Bayesian VAR (BVAR) model. Stability is essential to ensure that the model's estimates and forecasts are reliable. A stable BVAR model requires that all roots of the characteristic equation lie inside the unit circle. An unstable model could yield unreliable results, leading to distortions in analysis and forecasting. This test confirms the model's forecasting accuracy and robustness in economic analysis.

Impulse Response Functions (IRF): If the model is stable, we then perform impulse response functions (IRF) to analyze and understand the dynamic effects of shocks from one variable on the remaining variables over time.

4. Results and Discussion

4.1. Descriptive Statistical Results

Figure 1 presents the descriptive statistics of the variables. The SD index has an average value of 69.10 with a standard deviation of 2.32, indicating stability in achieving SD goals with minimal variability. ROE averages 11.59%, demonstrating a relatively strong profitability of the banks, despite a notable range from a low of 7.27% to a high of 15.75%. The ROA has a mean of 1.01%, reflecting the banks' effective use of assets to generate profits. NII averages 23.40, indicating a reliance on non-interest revenue sources. LLP averages 42.99, representing the reserve level for non-performing loans, which is a crucial factor given the volatile economic conditions in Vietnam.

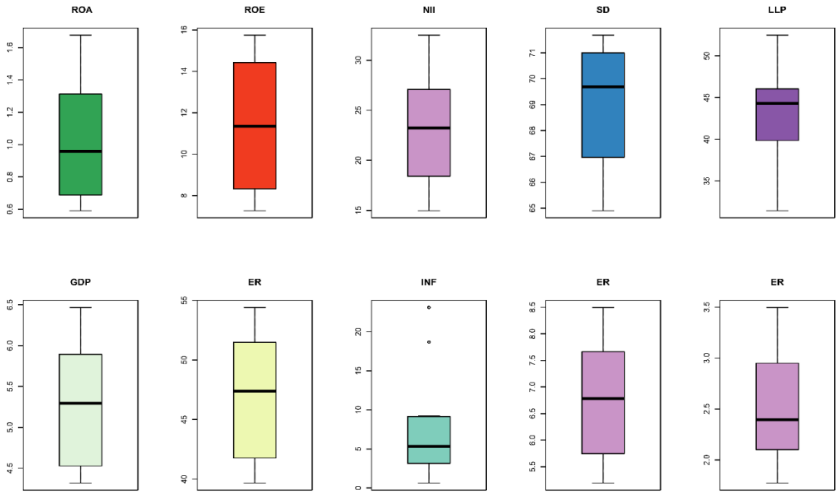

Figure 1. Descriptive statistical analysis.

Source: Calculations by the authors.

The results in **Table 2** indicate that the SD index has a notably high negative correlation with ROA, ROE, and NII with coefficients of –0.7362, –0.3074, and –0.3388, respectively. In contrast, SD shows a positive correlation with LLP, with a coefficient of 0.2925. This suggests a trade-off between SD and BP in the short term for banks in Vietnam. As banks invest more in SD objectives, associated costs increase (e.g., for green projects and environmental risk management), leading to reduced profitability and consequently lower ROA, ROE, and NII.

Table 2. Correlation results among variables.

	ROA	ROE	NII	SD	LLP	GDP	ER	INF	CAR	NPL	CA
ROA	1										
ROE	0.8519	1									
NII	0.4922	0.4871	1								
SD	–0.7362	–0.3074	–0.3338	1							
LLP	0.1079	0.379	0.6588	0.2925	1						
GDP	–0.3465	0.1089	0.0946	0.74	0.7226	1					
ER	–0.8896	–0.8491	–0.6808	0.6184	–0.3857	0.0341	1				
INF	0.5605	0.2947	0.1554	–0.8116	–0.3117	–0.4942	–0.5979	1			
CAR	0.4968	0.0746	–0.0249	–0.8342	–0.5605	–0.8596	–0.287	0.7457	1		
NPL	–0.5217	–0.6989	–0.8763	0.1184	–0.7307	–0.3484	0.7091	–0.0174	0.2878	1	
CA	–0.6205	–0.2038	–0.4754	0.9298	0.1949	0.7077	0.5800	–0.7812	–0.8162	0.1646	1

Source: Calculations by the authors.

4.2. Results of Stationarity Tests

In estimating the BVAR model, it is crucial to check the stationarity of the variables to ensure the model's accuracy and stability. The Augmented Dickey-Fuller (ADF) test is commonly employed to test for unit roots in time series data, determining whether the series is stationary.

The results of the stationarity tests are presented in **Table 3**. The variables ROA, ROE, CA, and INF are identified as stationary at level I(0), meaning they are stable over time and do not exhibit trends, thus no differencing is required. In contrast, the variables NII, SD, LLP, GDP, ER, CAR, and NPL are only stationary after first differencing, indicating that they are stationary at I(1). To ensure the validity of the BVAR model, these variables are included in the model in their first-differenced form. Using differenced variables is essential to remove non-stationarity trends, making the BVAR model more stable and reliable, and avoiding issues such as biased estimation and inaccurate results in analyzing long-term relationships between variables.

Table 3. Results of stationarity tests.

Variables	ADF Test		
	Stationarity Level	First Differencing	Stationarity Order
ROA	–2.9645**	x	I(0)
ROE	–2.857*	x	I(0)
NII	–2.443	–12.483***	I(1)
SD	–2.252	–3.955***	I(1)
LLP	–1.815	–3.389***	I(1)
GDP	–1.283	–5.143	I(1)
ER	–1.981	–3.425**	I(1)
INF	–3.265***	x	I(0)
CAR	–1.202	–3.546***	I(1)
NPL	–1.058	–2.759*	I(1)
CA	–6.553***	X	I(0)

Note: *, **, *** indicate significance at the 1%, 5%, and 10% levels. Source: Calculations by the authors. Source: Calculations by the authors.

4.3. Determining the Optimal Lag Length

The goal of this test is to select the appropriate number of lags to include in the model to avoid omitting important explanatory variables and to identify the optimal model. Determining the optimal lag length is crucial because it directly affects the accuracy and efficiency of the model's estimates.

Traditional methods, such as the Akaike Information Criterion (AIC), often tend to favor a higher number of lags, leading to unnecessarily complex models that can reduce the reliability and practicality of the analysis results [31]. In contrast, Bayesian methods for selecting the lag length involve calculating the probability of each model based on observed data through posterior probability. The Bayesian approach provides a more effective method by considering not only accuracy but also the simplicity and efficiency of the model. The results of the test, presented in **Table 4**, show that the posterior probability for a lag length of 2 is 100% across all three models. This indicates that the model with a lag length of 2 is the most probable optimal model based on the observed data. Consequently, this study opts to use a lag length of 2 as the optimal lag length for all models, ensuring that the BVAR model is constructed as effectively and accurately as possible.

Table 4. Optimal lag length selection.Bottom of Form.

Lag	Log (Marginal Likelihood)	Prior Probability	Posterior Probability
	Model 1: ROA as the Indicator of BP		
Lag 1	–199.0600	0.50000	0.0000
Lag 2	–177.8093	0.50000	1.0000
	Model 2: ROE as the Indicator of BP		
Lag 1	–224.4978	0.50000	0.0000
Lag 2	–201.0560	0.50000	1.0000
	Model 3: NII as the Indicator of BP		
Lag 1	–220.8054	0.50000	0.0000
Lag 2	–201.9583	0.50000	0.0000

Source: Calculations by the authors.

4.4. Model Stability Testing

Next, we conducted a stability test for the BVAR models to ensure the accuracy and reliability of the estimates and forecasts. **Table 5** presents the results of the stability tests for three models, where ROA represents BP in Model 1, ROE in Model 2, and NII in Model 3. The stability was assessed using the modulus of eigenvalues from the five matrices at the optimal lag length of 2.

Table 5. Model stability testing.

Eigenvalue Modulus	Mean	Std. Dev.	MCSE	Median
	Model 1: ROA as the Indicator of BP			
1	0.9643	0.0382	0.0003	0.9844
2	0.9662	0.0368	0.0002	0.9701
3	0.9128	0.0476	0.0005	0.9156
4	0.8410	0.0682	0.0007	0.8480
5	0.7313	0.1037	0.0010	0.7445
Probability of Eigenvalue within Unit Circle: 0.9960				
	Model 2: ROE as the Indicator of BP			
1	0.9615	0.0401	0.0000	0.9802
2	0.9689	0.0355	0.0001	0.9728
3	0.9084	0.0490	0.0003	0.9134
4	0.8393	0.0715	0.0007	0.8443
5	0.7254	0.1001	0.0011	0.7368
Probability of Eigenvalue within Unit Circle: 0.9972				
	Model 3: NII as the Indicator of BP			
1	0.9721	0.0358	0.0003	0.9782
2	0.9554	0.0413	0.0001	0.9603
3	0.9237	0.0466	0.0006	0.9299
4	0.8540	0.0731	0.0003	0.8633
5	0.7466	0.1300	0.0003	0.7571
Probability of Eigenvalue within Unit Circle: 0.8045				

Source: Calculations by the authors.

Unlike frequentist methods, the Bayesian approach uses the Metropolis-Hastings (MH) algorithm to estimate the regression models, with 10,000 simulations for each regression coefficient. The results are presented in terms of the mean, standard deviation, and Monte Carlo standard error (MCSE) for the regression coefficients. According to Flegal, Haran and Jones [32], a smaller MCSE is preferable, with values below 6.5% of the standard deviation being acceptable and below 5% being ideal [33, 34].

The results from **Table 5** show that the MCMC chains have converged, confirming the stability of the three models. The probability of eigenvalues being within the unit circle is 99.60% for Model 1, 99.72% for Model 2, and 80.45% for Model 3. These results affirm that the models meet the stability requirements. The next step will involve analyzing the IRF.

4.5. IRF Result

Using IRF, we can analyze how the variables within the model respond to shocks in a specific variable and trace the transmission of these shocks across the model. **Table 6** displays the IRF results for the SD variable across three different models. The findings reveal that all impulse responses are zero in the initial period, indicating that immediate shocks to SD do not have a significant impact on the other variables within the model. Starting from the second period, differences between the models emerge:

Model 1 (ROA as the Representative Variable for BP): In this model, ROA initially responds negatively in periods 2 and 3 but turns positive in periods 4 and 5. This pattern suggests that ROA experiences an immediate decline following a shock but tends to recover in the subsequent periods. Conversely, LLP shows a slight increase in period 2, followed by a decline in the following periods. This fluctuation may reflect adjustments in credit loss provisions in response to the impact of the shock on ROA.

Model 2 (ROE as the Representative Variable for BP): In this model, ROE also responds negatively in periods 2 and 3, but shifts to a positive response in periods 4 and 5. This indicates a short-term reduction in ROE after the shock, followed by a gradual recovery. LLP shows a downward trend in periods 2 and 3, continuing to decline in periods 4 and 5, with the decrease becoming more pronounced.

Model 3 (NII as the Representative Variable for BP): In this model, NII exhibits a negative response in periods 2 and 3 but shows no clear trend in the subsequent periods. This indicates a slight decrease in NII following the shock, with no significant long-term impact. Conversely, LLP reacts negatively across all periods, with a gradual decrease from periods 2 to 5. This trend suggests that increased credit losses impact provisioning levels, leading to a continuous adjustment in credit loss provisions.

These results suggest that, in the short term, banks investing in SD projects may experience a decline in NII due to the financial pressures and risks associated with green projects. To mitigate the increased credit risk from these investments, banks may need to enhance their provisioning levels. In periods 4 and 5, both NII and LLP show a positive correlation with SD, indicating that, while non-interest income has improved over the long term due to successful SD projects, LLP also increases. This indicates that although green projects can boost financial performance in the long run, they also bring about ongoing credit risks. The rise in LLP highlights the need for banks to maintain sufficient provisions to manage the potential risks from SD investments, ensuring they are safeguarded against unexpected credit losses.

Table 6. IRF results.

Period	Model 1		Model 2		Model 3	
	ROA	D.LLP	ROE	D.LLP	D.NII	D.LLP
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	−0.0229	0.0535	−0.3305	0.0096	−0.2992	0.0255
3	−0.0536	0.0046	−0.1715	0.0815	−0.0911	0.0958
4	0.0133	−0.1169	0.0310	−0.1608	0.0131	0.1659
5	0.0236	−0.1770	0.0931	−0.2404	0.0231	0.2293

Source: Calculations by the authors.

4.6. Discussion

Investments in SD projects and activities do not show immediate effects on the variables across the three models analyzed. This suggests that such investments may not have an immediate impact on BP in Vietnam in the short term.

Models 1 and 2: In periods 2 and 3, both ROA and ROE exhibit a negative correlation with SD, while LLP demonstrates a positive correlation. This indicates that when banks invest in SD-related projects, their profitability may decline in the short term, and provisions for credit losses may increase. This outcome aligns with the initial hypothesis and supports the disruption theory of SD. The higher costs associated with green projects relative to anticipated profits may expose banks to increased risk of loss. To sustain these investments, banks might need to adjust their LLP by increasing provisions for loan losses. This reflects the increased credit risk associated with SD projects in the short term. However, in the longer term, specifically in periods 4 and 5, the results improve, showing a positive correlation between SD and ROA, and a negative correlation with LLP. This suggests that as SD projects begin to generate long-term benefits, BP improves, while the need for provisioning decreases. These findings are consistent with Ozili's [2] research and support the signaling theory of SD.

Model 3: In periods 2 and 3, NII shows a negative correlation with SD, whereas LLP shows a positive correlation. This may be attributed to the high initial investment costs or adjustments in financial and operational strategies to meet SD criteria. The positive correlation between LLP and SD indicates that as banks increase their investment in SD, provisions for credit losses also rise. This could reflect either an increase in credit risk associated with new projects or a need for higher provisioning for loans and investments related to SD.

5. Further Analysis

Vietnam is an agricultural civilization with a long history of cultivation [30]. Moreover, its geographical location, bordering the South Sea, makes it prone to frequent storms and heavy rainfall. Consequently, credit provided to the agriculture, forestry, and fishery sectors tends to be highly irregular, affecting profit volatility and LLP. In this section, we further analyze the relationship between CA, BP and LLP. To achieve this, we employ the Granger causality test, which helps determine the directional relationship between these variables and provides insights into their interdependencies. This deeper examination allows us to understand how external shocks, such as extreme weather events or policy changes, influence the connection between CA, BP, and LLP over time. Such an approach not only highlights the role of sector-specific credit allocation but also emphasizes the importance of risk management strategies in ensuring financial stability in regions with high exposure to agricultural and climatic risks.

Bảng The Granger causality test results provide valuable insights into the interrelationships among ROA, ROE, NII, LLP, and CA. Initially, neither ROA nor ROE Granger-causes LLP ($p = 0.753$ and $p = 0.981$, respectively), indicating that profitability does not significantly influence loan loss provisions. However, both ROA and ROE exhibit significant causal relationships with CA ($p = 0.000$), suggesting that profitability metrics impact agricultural credit allocation. In contrast, NII does not Granger-cause LLP ($p = 0.657$) or CA ($p = 0.162$), although it has a significant causal relationship with CA ($p = 0.002$). Regarding LLP, it significantly Granger-causes both CA ($p = 0.000$) and profitability metrics such as ROA and ROE ($p = 0.000$), highlighting the effect of loan loss provisions on agricultural credit and banking profitability. Furthermore, CA Granger-causes LLP ($p = 0.000$) across all models, underscoring its critical role in influencing loan loss provisions. However, CA does not significantly Granger-cause ROA (p-values: 0.293, 0.138, and 0.595), suggesting that changes in agricultural credit do not directly influence profitability (**Table 7**).

In summary, the findings suggest that an increase in agricultural, forestry, and fishery credit (CA) significantly affects both the profitability of banks (ROA and ROE) and loan loss provisions (LLP). The analysis shows that as CA rises, it notably impacts LLP, with an indirect effect on profitability metrics. This highlights the importance of agricultural credit in shaping both the risk management strategies and financial performance of banks.

Given Vietnam's agricultural civilization, deeply rooted in rice cultivation, the role of agricultural credit becomes even more significant in supporting the sustainability of banks, particularly in sectors like agriculture, forestry, and fisheries, which are central to the country's economic structure and livelihood. This result aligns with the recent study by Hai et al.[30], which concludes that CA is an essential factor in shaping SD in Vietnam.

Table 7. Granger test results.

Hypothesis H0	Prob>Chi2	Hypothesis H0	Prob>Chi2	Hypothesis H0	Prob>Chi2
ROA has no effect on LLP	0.753	ROE has no effect on LLP	0.981	NII has no effect on LLP	0.657
ROA has no effect on CA	0.000***	ROE has no effect on CA	0.000***	NII has no effect on CA	0.162
LLP has no effect on CA	0.000***	LLP has no effect on CA	0.000***	NII has no effect on CA	0.002***
LLP has no effect on ROA	0.000***	LLP has no effect on ROE	0.000***	NII has no effect on LLP	0.135
CA has no effect on LLP	0.000***	CA has no effect on LLP	0.000***	CA has no effect on LLP	0.000***
CA has no effect on ROA	0.293	CA has no effect on ROA	0.138	CA has no effect on ROA	0.595

Note: *** indicates significance at the 1% level. Source: Calculations by the authors.

Comparing the results with previous research on the relationship between SD, LLP, and BP shows that SD projects reduce BP and increase LLP, while credit allocation for agriculture, forestry, and fishery (CA) increases bank profitability without affecting LLP. This highlights the importance of CA in promoting bank profitability. This supports the findings of Hai et al.[30] and aligns with the current situation in Vietnam, where agriculture provides a competitive advantage.

Unlike previous studies that used traditional frequency methods such as GMM, OLS, FEM, and REM, this study employs a Bayesian-based VAR method. The advantage of this approach lies in its ability to overcome the small sample size issue, which is a strict requirement in conventional VAR methods. The Bayesian method has recently been applied in fields related to finance and SD (see references[7–9, 35]), demonstrating its growing relevance and effectiveness in these areas. By integrating Bayesian techniques, this research introduces a novel approach that enhances the flexibility and robustness of the results, providing a more accurate understanding of the relationships between the variables. This method also allows for better handling of uncertainty, which further strengthens the reliability of the findings.

6. Conclusions and Policy Implications

Financial institutions are pivotal in funding SD projects, balancing economic, environmental, and social objectives. Banks are currently under considerable pressure to align with the United Nations' SD goals, which include withdrawing investments from high CO_2-emitting projects and redirecting funds toward environmentally friendly alternatives. This transition may lead to a temporary decrease in profitability, as SD projects often involve higher instability and lower returns compared to traditional core business activities. As a result, banks may need to adjust their LLP to address the credit risks associated with these SD investments. Such adjustments could reflect a strategic shift in risk management as banks navigate the challenges of aligning with sustainability goals while maintaining financial stability. This study evaluates the impact of supporting SD goals on BP and LLP in Vietnam from 2008 to 2019. We utilized the BVAR model, which is advantageous for analyzing dynamic relationships, managing heterogeneous variables, and overcoming the limitations of small sample sizes. This approach provides valuable insights into how SD goals affect financial indicators and banking risk. Our findings reveal that while investments in SD projects may lead to decreased BP and increased LLP in the short term, they offer substantial benefits in the long run. Over time, these investments not only enhance BP but also improve the institution's reputation and image within the community and the market.

Additionally, we further analyze the relationship between BP, LLP, and CA using the Granger causality test. The results reveal that CA significantly affects both BP and LLP. This demonstrates that agricultural credit not

only plays a crucial role in shaping the financial performance of banks but also influences their risk management strategies, particularly in relation to loan loss provisions.

Based on our findings, we propose several policy measures to support SD investments by banks. First, the government and regulatory agencies should introduce policies that provide incentives for banks to invest in SD projects. This could involve tax breaks, subsidies, or financial assistance to ease the immediate financial burden of shifting investments. Second, regulatory bodies should offer clear guidance and support to banks for managing LLP related to SD initiatives. This includes developing tools and processes to better assess and mitigate the credit risks of sustainable investments. Third, banks should be encouraged to publicly disclose their SD investments and their impacts on profitability and risk. The government should require regular reporting to promote transparency and facilitate knowledge sharing among banks about the successes and challenges of sustainable investments. Finally, and most importantly, we recommend that regulatory authorities implement a green loan loss provisioning system in Vietnam. This system should allocate lower provisions for loans to environmentally friendly businesses and higher provisions for loans to businesses with harmful environmental impacts, thus encouraging banks to prioritize financing green projects and reducing investments in environmentally damaging activities.

Given the significant impact of CA on both BP and LLP, it is crucial for policymakers to ensure stable and continued support for these sectors. Government policies should focus on enhancing access to credit for agriculture, forestry, and fisheries, as these sectors are essential to the national economy and the livelihood of a large portion of the population.

The limitations of this study are related to the selection of indicators representing SD goals. This research uses a single composite SD index, and the individual indices from SD1 to SD17 have not been specifically examined. Consequently, this approach may not provide a comprehensive view of how investments in specific SD projects and activities impact BP. Additionally, the current study does not capture SD goals at the global level. Therefore, future research should expand this study by investigating the effects of each individual SD goal on BP on a global scale.

Author Contributions

The research is the joint contribution of all authors, with equal participation in the study.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors do not have any competing financial, professional, or personal interests from other parties.

Appendix A

Table A1. 17 indicators for calculating the SDGI.

Sustainable Development Index (SDGI)		
Target 1	No poverty	
Target 2	No hunger	
Target 3	Good health and well-being	
Target 4	Quality education	
Target 5	Gender equality	
Target 6	Clean water and sanitation	
Target 7	Affordable and clean energy	
Target 8	Decent work and economic growth	
Target 9	Industry, innovation and infrastructure	**SDGINDEX.ORG**
Target 10	Reduced inequalities	
Target 11	Sustainable cities and communities	
Target 12	Responsible consumption and production	
Target 13	Climate action	
Target 14	Life below water	
Target 15	Life on land	
Target 16	Peace, justice and strong institutions	
Target 17	Partnerships for the goals	

Source: Compiled by authors.

Table A2. Summary of Relevant Studies.

Author (Year)	Study Period	Research Variables	Research Methodology	Findings
Ozili (2023a) [2]	Cross-country analysis across 28 countries (2011–2018)	1. Sustainable Development Goals (SDGs) (health, clean water, education, energy, climate change) 2. Bank profitability (non-interest income, return on assets, return on equity)	Fixed Effects Model	Achieving SDGs improves bank profitability
Jan et al. (2023) [17]	2009–2018	1. SD compliance practices (Sustainable development practices). 2. Financial performance of Islamic banks	Fixed Effects Model	SD compliance practices positively and significantly affect the financial performance of Islamic banks in Malaysia and Indonesia.
Yang and Liu (2023) [18]	290 legitimate surveys	1. Sustainable Development Goals (SDG) 2. Investment strategies 3. Financial knowledge 4. Government support 5. Organizational profitability	Smart-PLS	- SDGs, investment strategies, and financial knowledge significantly affect organizational profitability. - Government support moderates the relationship between investment strategies, financial knowledge, and profitability. - The study guides regulators in developing policies related to SDGs and investment strategies
Buallay et al. (2020) [19]	11 years after the 2008 financial crisis	1. Environmental, Social, and Governance (ESG) scores (Independent variable) 2. Bank performance (return on assets, return on equity, Tobin's Q) (Dependent variables) 3. Control variables (Bank- and country-specific)	Pooling regression and Instrumental Variable – Generalized Method of Moments (GMM)	- ESG improves banks' accounting and market-based performance in developed countries. - ESG weakens banks' performance in both developed and developing countries. - Similarities found in the impact of sustainability reporting on banks' performance in both developed and developing countries.

Table A2. *Cont.*

Author (Year)	Study Period	Research Variables	Research Methodology	Findings
Sardianou et al. (2021) [20]	37 European banking institutions	1. Sustainability disclosures 2. SDG Materiality (economic, social, and environmental issues) 3. 17 Sustainable Development Goals (SDGs)	Scoring – rating system	- High priority of banking sector disclosures on SDGs promoting economic growth and decent work, fairness, and transparency. - Low alignment with environmental SDGs. - Managerial implications for strategic planning and communicating sustainability disclosures.
Nigam et al. (2024) [21]	350 individuals	1. Sustainable Development Goals (SDGs) (Poverty, Well-being, Quality education, Affordable clean energy) 2. Bank profitability (Dependent variable) 3. Inadequate finance (Mediating variable)	SEM	- SDGs related to poverty, well-being, quality education, and affordable clean energy impact Ghanaian banks' profitability. - Inadequate finance mediates the relationship between SDGs and profitability. - Study highlights how sustainable practices align with profitability, useful for policymakers to persuade stakeholders.
Bahl et al. (2023) [22]	402 employees from public, private, and foreign sector banks	1. Sustainable Development 2. Financial performance	PLS-SEM	- Banking performance positively impacts the realisation of SDG1, SDG5, and SDG8.
Nizam et al. (2019) [23]	713 banks from 75 countries 2013–2015	1. Access to finance 2. Environmental financing 3. Bank financial performance (return on equity) 4. Loan growth, Management quality (bank-specific variables) 5. Macroeconomic variables	Fixed Effects Model	- Access to finance positively impacts banks' financial performance in most models.
Zheng et al. (2019) [25]	2010–2017	1. Loan loss provision (LLP) 2. Capital adequacy ratio (CAR) 3. Return on average equity (ROAE) 4. Government securities (GOV) 5. Inflation (INF) 6. Lending interest rates (LIR)	POLS, FEM, PCSE, GMM	- Return on average equity (ROAE) moderates LLP with a negative interaction, promoting profitability and solvency.
Oanh and Dinh (2024) [8]	Vietnam (2004–2022)	1. Digital financial inclusion (DFI) 2. Financial stability (FS) 3. Sustainable development	Wavelet analysis	- The influence of FS and DFI on sustainable development is observed across various quantiles and frequencies, indicating their significant role in supporting the country's transition toward sustainable development.
Dinh et al. (2024) [7]	2005–2020	1. Financial stability (FS) 2. Sustainable development 3. Fiscal and monetary policy	Bayesian regression	- High inflation and increased money supply negatively affect sustainable development in both country groups with high probabilities. - Financial stability positively impacts sustainable development when monetary policy involves foreign exchange reserves.

Source: Author's compilation.

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