






The Impact of Macroeconomic Variables on Credit Risk: Evidence Regarding Sustainable Lending in ASEAN Countries



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ABSTRACT

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This research examines the hypotheses that macroeconomic variables and environmental factors impact credit risk. This study focuses on the relationship between macroeconomics, environmental issues, and credit risk in ASEAN countries. This study applies a panel Autoregressive Distributed Lag (ARDL) model to data from the World Bank for the 2008-2019 period. The variables studied include non-performing loans (NPLs), Gross Domestic Product (GDP) growth, interest rates, inflation, and carbon emissions. The research results show that environmental factors do not affect NPLs, while macroeconomic factors do. GDP growth and inflation reduce NPLs while rising credit interest rates increase NPLs. The results imply credit risk is not considered sustainable lending. Credit risk does not consider environmental degradation as measured by increases in carbon emissions. From cross-country evidence, the effect of environmental degradation on credit quality is not found in all countries. Indeed, if environmental quality is considered, environmental degradation will be detrimental to operational and financial performance, especially for heavily polluting firms. However, poor ecological quality will harm operational and financial performance. In addition, business entities within the framework of sustainable loans have collateral consequences for business activities aimed at reducing pollution, which has implications for increasing costs. For decision-makers, both regulators and banks, in the future, banking credit distribution must seriously consider implementing sustainable lending through green credit policy schemes. Green credit schemes need to involve collaboration with banks and incorporate environmental factors into the loan portfolio. Empirically implementing green credit can improve bank financial performance and firm environmental, social, and governance (ESG) performance.

1. INTRODUCTION

Banks have a crucial role in economic development through credit creation. Credit provided by banks is a source of external financing for economic actors. Supporting the sustainability of the bank's business in providing credit is very dependent on financial performance, especially credit quality as measured by non-performing loans (NPLs). So, NPLs are one of the leading indicators in measuring a bank's economic performance. Banks that get a lot of non-performing loans from loans given to borrowers will reduce their financial performance. NPLs can be used as a measure of credit risk because of the possibility that the borrower will only be able to repay the loan once it is likely to default. Previous studies [1-3] have provided empirical evidence that increased NPLs have reduced bank profitability.

High NPLs, caused by loans on the verge of or experiencing default, can lead to a banking crisis and threaten financial stability. Furthermore, the high NPLs and NPLs that cannot be resolved can hamper economic activities [4]. Banks with serious non-performing problems can threaten the continuity

of the bank's business. Banks that mainly rely on income sourced from interest income will experience a decrease in their ability to generate interest income when their ability to provide credit decreases due to high non-performing loans.

Environmental issues concerning economic development are currently being discussed more intensely by academics and policymakers. Discussions related to environmental issues in economic development increasingly demand the critical role of approaches from various disciplines. One of the exciting issues concerning ecological problems is the issue of sustainable lending. Sustainable lending is the provision of bank loans to business entities based on decisions that consider environmental and social aspects due to the environmental and social impacts of the business activities it carries out [5]. The idea of the concept of sustainable lending is an exciting topic that is an integral part of the concept of sustainable development. Through implementing the concept of sustainable lending, the planning and implementation of credit provision programs as a source of investment financing will consider environmental, social, and governance aspects in recent developments. Governance in the lending mechanism

created by banks also supports the implementation of sustainable lending. Good governance allows banks to implement sustainable lending [6]. The credit provision based on good governance and social responsibility will support sustainable lending practices through consideration of environmental aspects. Sustainable lending through green credit can encourage sustainable development [7].

So far, studies on how economic factors impact the performance of bank business operations have dominated rather than studies relating them to environmental issues. Reflections on the influence of ecological factors on bank performance, especially related to lending activities and their risks, still need to be made available. Some of these studies [8-11] still need to be expanded to several developing countries, especially China and developed countries.

Challenges to environmental degradation have occurred since the structural transformation, rapid industrialization, and high economic growth in developing countries. One of the reasons for the decline in environmental quality is an increase in carbon emissions. The impact of increasing carbon emissions can occur in climate change.

The ASEAN region is a region that is vulnerable to climate change which can result in natural disasters that cause material and economic losses. The performance of environmental preservation in the ASEAN region is relatively behind compared to the other areas [12]. In the ASEAN region, many countries are developing countries with relatively high levels of economic growth, which affects the quality of the environment. High economic growth in the ASEAN region has caused environmental degradation [13].

It is appropriate that in the green economy concept, production activities consider aspects and impacts on the environment, including investment and financing. Reducing emissions in production activities will depend heavily on sustainable finance when access to credit is limited to invest in applying emission reduction technologies [8]. Regarding the implementation of green credit policies, Zou et al. [14] stated that green credit programs have effects on credit risk.

This research is motivated by the limited number of studies linking environmental aspects, macroeconomic factors such as GDP growth, inflation, and interest rates, and the need for implementing a green economy involved in production investment and financing activities. Therefore, NPL can be used to measure credit risk when considering environmental aspects in investment and production financing. So, NPL can also be caused by hazards that occur due to ecological damage factors, which impact the risk of non-performing loans due to reduced income of borrowers and increased production costs from companies because they have to internalize the costs of pollution incurred in production activities.

As previously stated, the research problem in this study is that with the increasing urgency of environmental issues that need to be considered in banking financing issues, studies involving ecological aspects in the context of sustainable financing are required. The implementation of sustainable financing in developing countries still needs to be improved, while the need for national investment financing is necessary to encourage economic growth. Green credit and banking have been known and implemented so far as efforts to support sustainable development as intended by the Sustainable Development Goals (SDGs). Studies related to credit risk so far, as previously stated, have focused more on macroeconomic factors and financial performance rather than environmental factors, especially in developing countries.

Cross-country studies on this issue are essential and contribute to efforts to implement sustainable financing.

The broad objective of this study is to examine the relationship between macroeconomic and environmental factors on credit risk. The specific purpose is to explore the relationship between economic growth and credit risk measured by NPLs. Second, to examine the relationship between inflation and credit risk. Third, to examine the relationship between lending rates and credit risk. Finally, to examine the relationship between carbon emissions and credit risk. The research question in this study is how GDP growth, inflation, lending interest rates, and carbon emissions affect credit risk as measured by NPLs. This research hypothesizes that GDP growth has a negative effect, while inflation, lending interest rates, and carbon emissions positively impact credit risk. ASEAN is a region where many developing countries actively expand to achieve long-run growth through increased investment. Increasing investment requires financing, one of which comes from banking. Therefore, studying ASEAN countries and examining the issue of sustainable lending across countries will provide helpful empirical and policy contributions.

This research focuses on six developing countries with relatively high economic growth and investment in the ASEAN region: Thailand, Malaysia, Singapore, Indonesia, Philippines, and Vietnam. This study applies the panel Autoregressive Distributed Lag (ARDL) model to analyze the dynamics of NPL, which involves independent macroeconomic variables, which include GDP growth, inflation and lending interest rates, and environmental variable, namely carbon emissions, with an emphasis on cross-country analysis throughout 2008-2019.

2. LITERATURE REVIEW

2.1 Macroeconomic factors and credit quality

Macroeconomic variables are most often used as the primary variable affecting bank credit quality in many studies. An increase in GDP that reflects an increase in income encourages the ability of borrowers to repay their debts. Kozarić and Dželihodžić [15] state that improving macroeconomic conditions through increasing GDP improves credit quality. The increase in GDP reflects an increase in the ability to pay debts for household and corporate borrowers to reduce NPLs. Koju et al. [16] presented their findings that the decline in GDP was the dominant factor in causing high NPLs. Likewise, Foglia [17] empirically proves that a decrease in GDP harms NPL. An increase in GDP reduces NPL; conversely, a decrease in GDP increases NPL. Also, the study by Anita et al. [18] and Ahmed et al. [19] confirmed that NPL has a negative relationship with GDP. Aggregate NPLs can be reduced by increasing economic growth.

Inflation is another major macroeconomic factor influencing credit risk as measured by NPLs. For banks, inflation is an exogenous variable that influences credit risk, but for a country's economy, inflation can be an endogenous variable that is influenced by global factors, as in the study by Arintoko et al. [20]. An increase in inflation causes increased costs for companies in running their business, reducing their ability to pay their debts. Meanwhile, for households, an increase in inflation can reduce their real income so that it can reduce their ability to pay debts. Inflation for credit users can

cause a decrease in the ability to pay debts so that NPLs increase [15]. Increased inflation will reduce income for individuals and profits for investors, both borrowers, thereby reducing their ability to repay the principal and interest on the loan [16]. Abid et al. [21] found empirical evidence that an increase in inflation has consequences for an increase in NPL and vice versa. NPLs reflecting credit quality, in a study conducted by Ghost [22], are positively affected by inflation, in which inflation increases NPLs. Kjosevski and Petkovski [23] also obtained empirical findings that inflation reduces income, reducing the ability to pay debts. For banks, the decline in the borrower's ability to pay debts impacts increasing NPLs.

Loans provided by banks contain implicit costs that offer the potential for default with increasing lending rates. Ahmed et al. [19] found evidence that interest rates increase NPLs. The increase in NPLs results from the rise in interest payments on debt, increasing the burden on borrowers and causing the risk of default. Increased lending interest rates increasingly burden borrowers in paying interest on debt, thereby increasing NPLs [24]. Other studies, including studies by Robert and Koori [25] and Messai and Jouini [26], corroborate empirical evidence that interest rates increase the NPLs of loans provided by banks.

The GDP growth, inflation, and interest rates are the primary macroeconomic factors influencing bank credit risk as measured by NPLs. Decreased credit risk is supported by an increase in GDP, a decrease in inflation and interest rates, and vice versa. The ability to repay loans by both companies and consumers is supported by increasing income, as well as inflation and loan interest rates, which are relatively low.

The negative relationship between GDP and NPL [15-19], the positive relationship between inflation and NPL [21-23], the positive relationship between interest rates and NPL [19, 24-26] are confirmed through previous research which is conducted. Several previous studies applied various approaches and models such as correlation and regression analysis [15], panel data [18, 25-26], ARDL model [17], dynamic panel, and generalized method of moments (GMM) [16, 19, 21-24], and panel vector autoregression [23] obtained the similar findings regarding the significance of macroeconomic variables on NPL according to their hypothesis. The previous literature discussion regarding the macroeconomic factors determining bank NPLs proposes the following hypotheses.

H1: GDP growth reduces NPLs, and vice versa.

H2: Inflation increases NPLs, and vice versa.

H3: Lending interest rates increase NPLs, and vice versa.

2.2 Environmental degradation and credit risk

Environmental degradation can cause residents to experience a decline in health and suffer from illness, even death, which has an impact on reducing the ability to repay debts and even failing to repay them, thus increasing non-performing loans [9]. Likewise, environmental degradation can impact worker productivity and damage machinery and equipment so that production capacity decreases, reducing profits and the ability to repay company loans. The literature links environmental degradation due to increased carbon emissions with a decrease in the financial performance of financial institutions. Environmental degradation, which causes natural disasters, impacts the ability of residents and companies to repay debts, thereby increasing bank NPLs.

Within the framework of lending sustainability, the environmental factor is the aspect that affects the credit profile. The degradation of the environment in which a business entity conducts its operations will hinder its profitability. However, poor environmental quality will harm operational and financial performance. Therefore, the credit risk used to finance its business operations has also increased. Also, within the lending sustainability framework, increased carbon emissions from production and consumption activities funded by credit result in increased costs to reduce pollution, which means reduced profits. Business entities within the sustainable lending framework have consequences for collateral regarding business activities aimed at reducing pollution, which has implications for increasing costs, for example, due to increased green tax payments. Therefore, increased carbon emissions will increase credit risk and potentially increase non-performing loans due to efforts to reduce pollution.

Research by Kumar and Firoz [27] shows that increasing company carbon emissions causes banks to face high risks. The increase in threats faced by banks has implications for improving the cost of firm debt. An increase in the price of debt can reduce the company's financial performance and, in turn, reduce the ability to repay loans, thereby increasing NPLs. The study conducted by Liu and Huang [28] obtained empirical findings that a positive shock from a business with sustainable financing harmed financial risk management by banks. The study conducted by Guan et al. [10] provides empirical evidence that the higher carbon emissions produced by an industry that uses credit financing will increase the credit risk as measured by the NPL ratio.

An increase in carbon emissions as an indication of environmental degradation can impact financial and operational performance, thereby reducing the ability to repay loans used to finance investment and working capital for business units. For workers, the decline in the quality of the living environment also impacts their productivity due to declining health, which can reduce their ability to repay loans obtained from banks. Reduced ability to repay loans by debtors will increase credit risk. The results of previous studies discussed provide empirical findings that are similar and mutually corroborate each other even with different models and country regions. Regarding the environmental aspect, the results of previous discussions in the literature, which are also crucial in determining NPLs, propose the following hypotheses.

H4: Increasing carbon emissions increases NPLs, and vice versa.

Macroeconomic factors, mainly GDP growth, inflation, and loan interest rates, cannot be separated from environmental factors in moving towards sustainable lending to support sustainable development. The business cycle and environmental sustainability form a unified environment that supports economic and business activities, supported by the rise of investment and financing sources from banks. A healthy macroeconomic and sustainable environment must support beneficial banking as a financing provider.

This study develops a model involving macroeconomic and environmental factors that impact credit risk as measured by NPL. So far, previous studies have examined banking NPLs by focusing on macroeconomic and bank-specific factors. There are still limited studies involving environmental factors and are generally limited to applying commonly used methods and models. This study contributes to an alternative model that

combines economic and environmental factors in assessing credit risk with NPL indicators for cross-country studies in developing countries with the panel ARDL model as a dynamic model. Economic growth through increasing GDP, controlled inflation and interest rates, and a low-emission environment will encourage sustainable lending with low credit risk to support sustainable development. The empirical results from this model can provide essential insights into considerations for policy-making and management of bank financial institutions in helping the implementation of sustainable lending through credit and green banking.

3. RESEARCH METHODS

3.1 Data and variables

This study constructs a model involving macroeconomic variables and variables representing environmental performance as explanatory variables. Macroeconomic variables include GDP growth, inflation, and lending rates, meanwhile, carbon emissions represent environmental degradation. Meanwhile, the dependent variable is credit risk, proxied by non-performing loans.

GDP growth, inflation, and loan interest rates were chosen as representatives of macroeconomic variables because these variables influence the ability of companies and individuals to repay loans. An increase in GDP, a decrease in inflation, and loan interest rates will increase the ability to pay loans in terms of increasing income and reducing the costs and burden of loan payments, thereby reducing NPLs. Meanwhile, carbon emissions represent environmental factors impacting company performance and productivity. A low-emission environment is an ecological indicator that supports the productivity of production factors, thereby increasing the ability to repay loans.

GDP growth is the annual percent growth. GDP calculates annual growth at constant 2015 prices and local exchange rates. Inflation is measured as the percentage change in the annual consumer price index. The lending rate is the interest rate banks charge for short-term and medium-term private sector financing, expressed in percent per annum. Meanwhile, carbon emissions are measured by CO₂ in metric tons per capita. CO₂ emissions come from both production and consumption activities.

Data are obtained from the World Bank by indicator and country. World Bank data is accessed online for selected ASEAN countries for data on NPL, GDP, inflation, interest rates, and CO₂ emissions. The data period analyzed is 2008 - 2019, the expected economic period after the global crisis and before the Covid-19 pandemic. Therefore, this period was chosen for a relatively stable data representation to support the appropriately selected model.

3.2 Unit root tests

In panel data analysis, because it contains time series elements, unit root tests are carried out in the early stages. This test is needed to identify the stationarity of the observed data in a time series. This test can determine whether the data stationarity is reached at level, I(0) or must go through the first difference, I(1). It is essential to know whether the analyzed variables tend to return to the long-run trend with the long-run relationship between the observed variables. In this study, the

number of years in the time series is greater than the number of individual countries in the panel data. It is possible to test the stationarity of the data individually and in common, as stated by Levin et al. [29]. The panel unit root test carried out in this model has greater power than standard unit root tests on time series with limited samples. The Levin, Lin & Chu test was carried out because, in panel data, this test allows, apart from time effects, individual effects, and the possibility of time trends.

3.3 Model and cointegration

The research model is designed to examine the effect of macroeconomic variables, which include GDP growth, inflation and lending rates, and carbon emissions on credit risk as measured by NPLs. The model is constructed into an Autoregressive Distributed Lag (ARDL) dynamic model. The ARDL model is applied in panel data analysis so that the analysis model is panel ARDL.

This study chose to apply the panel ARDL based on the ability of a model with a combination of time series and cross-section elements to estimate short-run and long-run dynamics compared to other models simultaneously. This model can also accommodate different integration orders related to data series, namely pure I(0) or I(1), or a mixture of I(0) and I(1) variables with the condition that no variable is I(2). Furthermore, the panel ARDL model can accommodate different lags for each variable contained in the model. Under these conditions, cointegration in ARDL is more appropriate when dealing with variables with varying orders of integration, I(0), I(1), or a mixture thereof, and when there is a single long-run relationship between variables in a relatively small sample size. Cointegration in the panel ARDL allows analysis of long-run relationships between the variables in the model. Cointegration in the model also provides for the re-parameterization of the relationship between variables into an Error Correction Model (ECM). The panel ARDL model is adopted from the model developed by Pesaran et al. [30] and Pesaran and Smith [31]. The panel ARDL(p,q) model or Pooled Mean Group (PMG) is stated in Eq. (1). Meanwhile, the ARDL model is displayed in the error correction model as in Eq. (2) to estimate short-run dynamic parameters.

$$Y_{it} = \alpha_i + \sum_{j=1}^p \beta_{ij} Y_{i,t-j} + \sum_{j=0}^q \gamma'_{ij} X_{i,t-j} + u_{it} \quad (1)$$

$$\Delta Y_{it} = \alpha_i + \theta_i (Y_{i,t-1} - \delta'_i X_{i,t-1}) + \sum_{j=1}^{p-1} \beta^*_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \gamma^{*'}_{ij} \Delta X_{i,t-j} + u_{it} \quad (2)$$

where, i and t represent country and time, respectively, Y represents non-performing loans, and X represents control variables, including GDP growth, inflation, lending rates, and carbon emissions, $X = (GGDP, IFL, LIR, LNCO2)$. The equation element $(Y_{i,t-1} - \delta'_i X_{i,t-1})$ represents Error Correction Term (ECT) with the estimated parameter of θ_i which is negative and significant. The value of ECT indicates the speed of adjustment towards equilibrium after a shock.

Panel ARDL or PMG model is appropriate for investigating heterogeneous dynamics across countries and examining long-run and short-run relationships among the variables in the model [32]. This model will also explore whether there is cointegration between variables in the model with the Kao panel cointegration test. The Kao cointegration test is suitable to be applied as one of the main tests to check the existence of

cointegration between the dependent and independent variables in cross-country panels [33].

4. RESULTS AND DISCUSSION

4.1 Results

The descriptive statistics of the variables analyzed in Table 1 show variations across countries. As the dependent variable, the NPLs with the smallest range and average have the slightest variation. Meanwhile, explanatory variables have relatively large variations. The standard deviation of inflation shows significant cross-country variations among macroeconomic variables. Lending interest rates have rather substantial variations across countries when compared to variations in GDP growth and carbon emissions in the ASEAN region.

Table 1. Common descriptive statistics

Variable	Min	Max	Mean	S.D.
NPL	0.7565	5.5988	2.3412	0.9637
GGDP	-1.5135	14.5197	4.9604	2.3260
IFL	-0.9004	23.1154	3.7092	3.8211
LIR	4.0800	16.9500	7.3556	3.3167
CO ₂	0.8256	8.7558	4.0673	2.8332

The results of the unit root tests for the data series for each variable which constitute the common unit root tests are presented in Table 2. Meanwhile, the results of the unit root tests for individual countries are presented in Table 3. The unit root test results, both common and individual, show that the data series for the model variables are all stationary at the level except for the series of carbon (CO₂) emissions, which are stationary at the first difference. So all variables are I(0) except CO₂, which is I(1). The mix of variables I(0) and I(1) allows the panel ARDL model to be applied in this study.

Table 2. Common unit root tests

Variable	Levin, Lin & Chu t
NPL	-11.2376***
ΔNPL	-5.0056***
GGDP	-11.5947***
ΔGGDP	-19.9826***
IFL	-6.7334***
ΔIFL	-10.0840***
LIR	-4.7304***
ΔLIR	-8.0667***
LNCO ₂	0.4185
ΔLNCO ₂	-8.3875***

*** p-value 0.01.

The panel cointegration test between variables in the model gives the results presented in Table 4. The test results show that through the Kao test, there is a cointegration between variables in the model. The existence of cointegration among the variables in the model is a starting point for further estimation of long-run relationships through the analysis of the panel ARDL model. Through the panel ARDL, it is also possible to estimate the short-run effect of macroeconomic variables and carbon emissions on credit risk.

Table 3. Individual unit root tests

Variable	Im, Pesaran and Shin W-stat	ADF-Fisher χ^2
NPL	-6.4250***	54.1403***
ΔNPL	-2.6517***	28.4590***
GGDP	-7.3372***	57.6069***
ΔGGDP	-14.0230***	105.119***
IFL	-4.8745***	43.1218***
ΔIFL	-8.1839***	69.7069***
LIR	-1.6199*	26.7779***
ΔLIR	-6.1838***	56.0954***
LNCO ₂	1.18394	10.9250
ΔLNCO ₂	-5.1394***	44.9722***

*** p-value 0.01, * p-value 0.1

Table 4. Kao cointegration test statistic

Statistic	Value
ADF	-3.6690***
Residual Variance	0.1517

*** p-value 0.01

The selected ARDL model in this study is ARDL(1, 1, 1, 1), based on the Akaike Information Criteria. The long-run panel ARDL model estimates provide the statistical results in Table 5. Macroeconomic variables, which include GDP growth, inflation, and lending rates, significantly affect NPLs in the long run. The estimation result rejects the null hypothesis that GGDP has no significant negative effect on NPL in the long run. The negative sign on the estimated parameter supports the hypothesis that GDP growth reduces NPLs and vice versa. It means that if GDP growth increases, NPLs will decrease, and vice versa.

Table 5. Long-run coefficients and elasticity

Variable	Coefficient	Elasticity at Means
GGDP	-0.3483**	-0.7379
IFL	-0.3222***	-0.5105
LIR	0.6765***	2.1254
LNCO ₂	0.3724	0.1797

*** p-value 0.01, ** p-value 0.05

Meanwhile, the test of the inflation variable shows that the estimation result accepts the null hypothesis that inflation has no positive effect on NPL. Empirical data generally do not support the hypothesis that increasing inflation increases NPLs and vice versa in the long run. The inflation estimated parameter, which has a negative sign, means that an increase in inflation reduces NPLs and vice versa.

Testing the influence of interest rates obtained results that rejected the null hypothesis, which stated that lending interest rates had no positive effect on NPLs. Because the test results contradict the null hypothesis and a positive sign is obtained according to theoretical expectations, the credit interest rate in this study positively affects NPL. This means that increasing lending rates increases NPLs, and vice versa. Of the three macroeconomic variables, in absolute terms, changes in lending rates have the most significant influence on changes in NPLs. The elasticity of changes in NPLs to changes in interest rates is 2.1254. The percentage increase in lending rates which increased by one percent, increased NPLs by 2.1254 percent.

Regarding environmental factors, the test of the effect of

carbon emissions accepts the null hypothesis that carbon emissions have no impact on NPL in the long run. Therefore, carbon emissions do not have a significant effect on NPLs. It means that changes in environmental quality by increasing or decreasing carbon emissions have no impact on non-performing loans. So, statistically, this study found no empirical evidence of the effect of ecological degradation, as measured by carbon emissions, on NPLs.

The estimation results of the panel ARDL model for short-run effects and error correction term (ECT) values are presented in Table 6. In the short run, only GDP growth significantly impacts NPLs. Meanwhile, inflation, lending rates, and carbon emissions do not substantially affect NPLs. In contrast to the long run, GDP growth has a positive effect on NPL in the short run. An increase in GDP growth leads to a more significant increase in NPLs.

Table 6. Short-run coefficients and ECT

Variable	Coefficient
Δ GGDP	0.0417***
Δ IFL	0.0219
Δ LIR	0.1243
Δ LNCO2	-0.2703
ECT	-0.1861***

*** p-value 0.01

Meanwhile, the ECT value of -0.1861 estimates the expected value, which is negative and greater than -1. This means there is a possibility that after there has been a shock in the explanatory variable at the previous time, the disequilibrium of NPLs will be corrected in the long run with an adjustment speed depending on the ECT value. About 18.61 percent of disequilibrium was corrected within one year.

As an individual country, the effects of macroeconomic variables and carbon emissions in the short run are presented in Table 7. There are variations in empirical findings across countries, especially the effect of macroeconomic variables on NPLs and the speed of adjustment to equilibrium. Meanwhile, the effect of carbon emissions on NPLs is not empirically proven in all countries.

Table 7. Cross-section short-run coefficients and ECT

Country	Variable				
	Δ GGDP	Δ IFL	Δ LIR	Δ LNCO2	ECT
Thailand	0.0206***	0.0303***	-0.4271***	0.7991	-0.2948***
Malaysia	0.0522***	0.0934***	0.3630***	-0.4992	-0.3028***
Singapore	-0.0091***	-0.0623***	0.2143	0.7467	-0.0559***
Indonesia	0.0591	-0.0120***	0.2884***	-1.4794	-0.0302***
Philippines	0.0806***	0.0184***	0.4223***	-0.2442	-0.0734***
Vietnam	0.0465	0.0637***	-0.1150**	-0.9449	-0.3596***

*** p-value 0.01, ** p-value 0.05

The interpretation of estimated parameters in the long run differs from that in the short run. Long-run parameters are attached to variables in levels, while short-run parameters are attached to variables in first differences.

Empirical data supports the hypothesis that GDP growth significantly reduces NPLs and vice versa, confirmed in several countries. The negative effect of GDP growth, as expected by the hypothesis, only occurs in Singapore. Meanwhile, in Thailand, Malaysia, and the Philippines, GDP growth positively affects NPLs. When the economy is

booming, the credit expansion that occurs results in an increase in NPLs. For Indonesia and Vietnam, there is no evidence of the effect of changes in GDP growth on changes in NPLs.

In the short run, empirical evidence of changes in inflation having a significant effect on changes in NPLs is found in all countries with varying effects. For individual countries, the estimated parameters for inflation give varying signs between positive and negative, which means there are positive and negative influences. In Thailand, Malaysia, the Philippines, and Vietnam, increases in inflation increase NPLs as hypothesized. Conversely, in Singapore and Indonesia, an increase in inflation lowers NPLs.

The estimation results for individual countries also provide variations in the sign of the estimated parameter between positive and negative, which means that there are variations in the influence between the positive and negative effects of lending interest rates on NPLs in each country. Lending interest rates positively affect NPLs in the short run in Malaysia, Indonesia, and the Philippines, according to the hypothesis that an increase in interest rates will burden borrowers in paying debts and interest. Meanwhile, in Thailand and Vietnam, there is a negative influence of lending rates on NPLs. Evidence of a significant effect of lending rates on NPLs has yet to be found in Singapore.

Variations in ECT values across countries indicate variations in the speed of adjustment towards equilibrium if there is an explanatory variable shock. Vietnam has an enormous ECT value, which means the speed of adjustment of NPLs toward equilibrium is the shortest. Meanwhile, the speed of adjustment toward equilibrium is the longest in Indonesia.

4.2 Discussion

In this study, GDP growth has a significant negative effect on NPL. An increase in GDP growth reduces NPL, reducing credit risk in the long run and vice versa. In the long run, this means that NPL has a negative relationship with GDP growth according to theoretical logic. According to the hypothesis, an increase in GDP growth increases the ability to pay debts for borrowers, thereby reducing non-performing loans. The results of previous studies [15-17] are confirmed by these empirical findings with a cross-country focus on ASEAN. The influence of GDP growth which reduces NPL and vice versa, from empirical evidence in individual countries in previous research results is strengthened by empirical findings from this cross-country study. In terms of the empirical conclusions, individually, in several countries, i.e., Thailand, Malaysia, and Philippines, where in the short run, GDP growth increases NPLs because the possibility of credit expansion causes an increase in NPLs. However, in the short run, the change dynamics of variables are not persistent because they tend to fluctuate.

Empirical findings show that inflation reduces NPLs in the long run and vice versa. However, these findings do not meet the expectations of the hypothesis. Similarly, in the short run, inflation reduces NPLs in Indonesia and Singapore. Conversely, inflation in Thailand, Malaysia, the Philippines, and Vietnam increases NPLs in the short run. The negative effect of inflation on NPLs in the findings of this study is in line with the results of previous studies [18, 24, 34]. The reduction in NPLs was made possible by the increased incentives for companies to operate in their business when inflation rises to a reasonable level. With an increase in

inflation, it is also possible that the borrower's balance sheet, especially business units, will be positively affected by the rise in inflation, so the ability to repay the debt will also increase. In addition, inflation can reduce the real value of repaying debts, thereby reducing non-performing loans.

The positive association between lending rates and NPLs occurs in the long run for the cross-country panel analysis, while in the short run, it does not. However, individually, empirical findings also show a positive effect of lending rates on NPLs in Malaysia, Indonesia, and the Philippines. These empirical findings corroborate the results of previous studies [19, 25, 26]. An increase in lending rates increases the burden on borrowers in repaying their debts, including interest payments.

This study did not find a significant effect of environmental degradation, as measured by increased carbon emissions, on increased credit risk as measured by NPLs. From the cross-country panel analysis, it cannot be proven that this effect is in the short or long run. Likewise, this study does not provide empirical evidence of this influence on individual countries. These results prove that the increase in carbon emissions that can drive climate change has not been positively associated with credit risk. Regardless of these conditions, bank lending still needs to implement sustainable lending, which considers environmental damage in the use of credit by borrowers. So, there is no link between environmental performance and bank loans. In assessing loan applications, financial institutions have not considered the risk of ecological damage. Because of this, collateral requirements or values do not consider the environmental performance resulting from the use of credit. Collateral requirements or collateral values may not significantly differentiate between environmentally friendly companies and those that are not, so companies are not incentivized to apply sustainable finance.

Suppose a sustainable lending or green financing scheme is implemented. In that case, the increase in carbon emissions as a reflection of a decrease in environmental performance will be internalized by the company as a borrower, which means an increase in costs which can then reduce profits and the ability to repay debts so that it can cause NPLs to increase. For banks, an increase in NPLs will reduce their ability to manage credit risk which will result in a decrease in their ability to provide credit [35]. Therefore, this condition can be an incentive for companies to invest capital for emission reductions to increase their profitability in the future. The company's efforts to protect the environment, which creates good environmental performance and low environmental risk, make it easier for companies to access credit [8]. In supporting sustainable lending, the ratio of the intensity of carbon emissions to credit used can be an indicator of green credit, encouraging the reduction of carbon emissions and credit risk [10].

5. CONCLUSIONS AND POLICY IMPLICATION

5.1 Conclusions

This research examines the influence of macroeconomic variables and environmental factors on credit risk as measured by NPL linked to sustainable lending. Increase in GDP growth is hypothesized to reduce NPLs, while inflation, loan interest rates, and carbon emissions increase NPLs. The test results show that macroeconomic factors still influence credit risk.

Meanwhile, environmental aspects do not influence credit risk in ASEAN countries. The study's results indicate no link between environmental performance and bank loans, as shown by ecological performance, which has no significant effect on credit risk.

Credit risk is still more determined by GDP growth, inflation, and lending rates. Credit risk, which is more responsive to macroeconomic factors than environmental factors, indicates that lending practices by banks still need to implement sustainable lending principles significantly. The proportion of green credit implementation still needs to be more extensive than credit in general, especially in developing countries.

In sustainable lending, however, environmental performance, for example, is measured through carbon emissions, influencing credit risk. Although the increase in carbon emissions has not yet resulted in damage to assets and factors of production and has a direct negative impact on worker productivity, the resulting environmental degradation can increase credit risk.

Efforts to reduce or prevent environmental pollution from business activities financed by credit have the consequence of increasing costs which can reduce profits so that the ability to repay loans can be reduced. However, sustainable lending applied to minimize credit risk can incentivize companies or business units to implement sustainable finance in their business operations to reduce environmental degradation.

5.2 Policy implication

Future policies related to the provision of credit should consider environmental aspects by implementing a sustainable lending scheme. In addition to considering macroeconomic factors that reflect business cycle conditions, environmental sustainability through green credit can be applied to incentivize business actors to reduce carbon emissions in their business activities. The consequences of ecological destruction, which will incur costs for recovery through internalizing costs and the imposition of green taxes, will incentivize the business sector to reduce carbon emissions to improve their business performance. Therefore, the concept of sustainable lending or green credit can be thoughtfully applied in future credit schemes for the business sector.

Especially for decision makers, both regulators and banks, in the future, providing banking credit must seriously consider implementing sustainable loans through a green credit policy scheme. Implementing bank loans with environmentally friendly credit schemes must involve collaboration with banks and incorporating environmental factors into the loan portfolio. It is essential to provide policymakers insight that the application of green credit can empirically improve bank financial performance and company environmental, social, and governance (ESG) performance. Implementation of sustainable lending or green credit in the financial services industry needs to be a severe concern for policymakers and stakeholders involving government agencies, interested ministries, and private institutions and foundations concerned with the environment.

5.3 Limitations

The ARDL model relies on the presence of cointegration to obtain long-run parameters. If there is no cointegration, then there is no meaningful long-run relationship to confirm the

theoretical relationship of the variables studied. Failure to test the existence of cointegration or long-run relationships in the panel ARDL model often results in model formulation and further analysis becoming stuck. The study has limited samples and periods, so the optimal lag selected is also defined in the panel ARDL model. This limitation affects the optimal obtaining of estimated parameter results that are valid and unbiased. Future research is expected to improve this problem with a more representative sample and extended period.

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