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The relationship between macroeconomic factors and non-performing loans (NPLs) in Lao PDR: An application of the Vector Error Correction Model

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The role of the banking sector in driving economic development cannot be understated. Its stability is a critical factor that sets the pace for economic progress. Among the various indicators of financial stability, non-performing loans (NPLs) held by banks hold particular significance as they reflect asset quality, credit risk, and the efficient allocation of resources to productive sectors. NPLs have indeed been a subject of concern for the banking sector, with their prominence intensifying, especially after the 2008 financial crisis. This study investigates the relationship between Macroeconomic factors and non-performing loans in Lao PDR. The secondary data of four variables, namely, Interest Lending rate, CPI-Inflation, Nominal exchange rate, and Money supply from the first quarter of 2012 to the last quarter of 2021 have been collected in order to analyze the long-term relationship among economic factors and estimate the short-term adjustment toward the long-term equilibrium level. The Vector Error Correction Model (VECM) is applied to measure short-term adjustment toward the long-term equilibrium level. Based on the estimation results of the Vector Error Correction Model, two variables have a positive and significant effect on long-term non-performing loans, namely, lending interest rate, and money supply, and a significant inverse relationship with inflation, and exchange rate. Meanwhile, in the short term, only lending interest rates have a significant effect on non-performing loans.

Keywords: Non-performing loans, macroeconomic, Johansen Cointegration, Vector Error Correction Model

1. Introduction

The pivotal role played by the banking sector in driving economic growth and development is paramount. Banks act as intermediaries, bridging the gap between those with surplus funds and those seeking capital for various economic activities. A high-performing banking sector is a catalyst for economic expansion, while a dysfunctional one can impede progress. Consequently, the stability and effectiveness of the banking sector assume critical importance, essentially setting the trajectory for a nation's economic development.

A well-developed financial sector encompasses efficient banks and robust stock markets, which collectively contribute to fostering economic growth. This is achieved by directing savings towards productive investments, mitigating information disparities, and stimulating innovation (Levine, 1997). The significance of financial institutions, legal frameworks, and governmental policies in nurturing financial development cannot be overstated. Among various indicators of financial stability, non-performing loans (NPLs) are catastrophic for banks and can disrupt the entire financial system of an economy, and can even signal the onset of a banking crisis (Louzis et al., 2012). A rise in NPLs indicates an unhealthy economic condition and

poses significant risks to liquidity and profitability for banks, corporations, and individuals. The deterioration of banks' asset quality is not only financially destabilizing for the banking system, but it may also lead to economic inefficiency, impair social welfare, and contribute to declining economic activity (Ghosh, 2015).

In the financial sector of Lao People's Democratic Republic) PDR, banks have long played a central role, with State-owned commercial banks taking the lead. However, things started to change in the mid-2000s when the sector began to open up gradually. This shift gathered pace with the introduction of the new Law on Commercial Banks in 2007, which attracted a significant number of private and foreign banks into the country. This transformation has led to notable progress in the financial sector, including increased access to financial services and improved distribution of resources. The banking sector, in particular, has become a crucial part of Lao PDR's financial system, greatly influencing the country's economic stability.

Despite these positive developments, the banking sector in Lao PDR faces a significant challenge in the form of non-performing loans (NPLs). NPLs are loans that borrowers have difficulty repaying, and they can weaken a bank's financial health, which, in turn, affects the broader economy. Unfortunately, Lao PDR has been dealing with a persistent issue of rising NPLs, deviating from the international standard where an NPLs rate of 2 percent or below is considered ideal. In recent years, the NPLs rate in Lao PDR has surpassed 3 percent, highlighting the need for effective strategies to address this challenge and protect the country's financial stability (BoL, 2022).

Numerous studies have been conducted to determine the factors that contribute to non-performing loans. However, it is challenging to identify a single relationship between them, as different studies have identified varying determinants of NPLs, and these variables have exhibited different relationships with NPLs. The literature suggests two sets of factors that explain the evolution of NPLs over time. The first focuses on external events, such as overall macroeconomic conditions, which are likely to impact borrowers' ability to repay their loans. The second, which examines the variability of NPLs across banks, attributes the level of non-performing loans to bank-level factors. Empirical evidence supports both sets of factors. However, in Lao PDR, there is a lack of studies focusing on the factors that affect NPLs across the entire banking sector, with most studies focusing on specific banks. Therefore, the purpose of this study is to investigate the influence of macroeconomic factors, namely, the consumer price index (CPI), exchange rate, interest rate, and money supply on non-performing loans (NPLs) in the Lao PDR banking system over the period 2012Q1–2021Q4. The results of this study can be expected to contribute to literature relating NPLs in the country, as well as benefit policymakers. For the latter, understanding macroeconomics behavior can contribute to a better policy formulation.

The choice to explore this topic is driven by the critical role of non-performing loans (NPLs) in the world of finance. NPLs have emerged as a significant global threat to financial systems. In numerous financial stability reports published by central banks, the alarming rise in NPLs consistently stands out as one of the most pressing dangers to the stability of the banking sector. This matters because NPLs often require banks to set aside substantial amounts of capital as a safety net to cover potential losses resulting from these troubled loans. As NPLs increase in number and scale,

banks find themselves compelled to allocate more and more capital to cushion against potential losses. This continuous capital allocation can gradually erode the financial foundations of banks, potentially limiting their ability to provide new loans and support economic growth.

In the most severe scenario, a widespread surge in NPLs spanning multiple banks can trigger systemic risks that threaten the entire financial system. If not managed effectively, this situation has the potential to spark a financial crisis, lead to the failure of banks, and cast economies into broader turmoil. It is worth noting that the role of macroeconomic conditions becomes even more significant in this context. Their effects become increasingly pronounced as NPLs mount. As such, this research is driven by the need to gain a comprehensive understanding of whether and how these macroeconomic factors influence NPLs and, if they do, the specific nature of this influence.

The remainder of the study is organized as follows. Section 2 reviews the theoretical and empirical literature related to the macroeconomic factors which are expected to affect the ratio of NPLs. Section 3 discusses the methodology applied in this study. The empirical results are presented in section 4, and the last section is the conclusion of the study.

2. Literature review

2.1. Theoretical background

One definition states that a non-performing loan (NPL) refers to a financial asset that banks have not received interest or installment payments from, as per the agreed-upon schedule. Put simply, when a loan stop generating income for the bank and fails to perform according to the terms of the loan agreement with the borrower, it is classified as an NPL. The European Central Bank (ECB) has defined NPLs as loans that are either more than 90 days past-due and considered material, or loans where the debtor is unlikely to fulfill credit obligations in full without collateral, irrespective of past-due amounts or days overdue (European Central Bank 2017:49). The financial system of a country, including that of Lao PDR, relies on the level of NPLs as a percentage of total loans as an important indicator. This percentage is obtained by dividing the value of non-performing loans by the total value of the loan portfolio. The gross loan value recorded on the balance sheet, rather than only the overdue amount, should be considered as the nonperforming loan amount.

Numerous researchers have conducted studies to examine the connection between macroeconomic factors and loan quality, and have sought to link the financial condition with the stability of banks. They found that interest rates are among the most important economic factors since they have a direct influence on economic conditions, e.g. decisions relating to consumption, saving, and investment. Interest is the cost of borrowing money, usually expressed as a percentage of the amount borrowed. The interest rate is the percentage rate of interest for a specified period (monthly or annually). An increase in interest rates can have a negative effect on loan quality, as higher debt costs make it more difficult for the borrower to repay the loan. Furthermore, high interest rates are a potentially harmful option for borrowers

(Bofondi–Ropele, 2011). The impact of heightened debt costs, which can make it more challenging for borrowers to meet their repayment obligations, should be assessed with careful consideration of the initial interest rate fixation period. In cases where a loan maintains a fixed interest rate throughout its entire maturity, the debt service remains constant over the loan's term. Consequently, fluctuations in prevailing interest rates do not affect the borrower's repayment burden during this period.

However, the situation is different when a loan necessitates refinancing upon maturity. In such instances, borrowers could potentially encounter an interest rate shock, as the terms for the new loan may be substantially influenced by the prevailing interest rate environment. Therefore, the susceptibility of borrowers to changes in the interest rate landscape hinges on various factors, including the structure of the interest rate, the maturity of the loan, and the necessity for refinancing. It is imperative to appreciate these loan-specific characteristics, as they can significantly impact borrowers, particularly in a context like Lao PDR. In the case of Lao PDR, short-term loans with maturities of one to three years are prevalent, particularly for meeting working capital requirements, facilitating trade finance, and providing smaller-scale business loans. Long-term loans, on the other hand, are less common. Consequently, borrowers in Lao PDR may indeed experience the effects of interest rate fluctuations, given the prevalence of short-term loan structures.

The lending interest rate is assigned significant importance in the literature pertaining to non-performing loans (NPLs) as it influences bank deposits and loans, making it a crucial variable in the examination of loan performance within the banking system (Castro, 2013). When the lending rate is higher, this leads to increased costs on loans and advances, thereby potentially reducing borrowers' repayment capacity and increasing the default rate. Empirical evidence from studies such as Nkusu (2011), Adebola et al. (2011), and Berge and Boye (2007) has consistently demonstrated a positive correlation between the lending rate and NPLs. An escalation in interest rates diminishes the payment capacity of borrowers, thereby establishing a positive relationship between non-performing loans and interest rates (Nkusu, 2011). Cucinelli (2015) further contends that banks adopting aggressive lending policies and charging high interest rates from borrowers tend to experience higher levels of non-performing loans.

Furthermore, the literature suggests that NPLs are influenced by the nominal exchange rate. A depreciation in the exchange rate can lead to a decline in the quality of bank assets, resulting in higher levels of non-performing loans (NPLs). This situation arises when the nominal exchange rate increases, signifying a weakening of the domestic currency. As a result, borrowers who have taken out loans denominated in a foreign currency are faced with higher repayment obligations. This is a significant concern for them because they must still settle the loan in the same foreign currency. However, due to the depreciation of their domestic currency, they now require a larger amount of their own currency to obtain the foreign currency needed for repayment.

As a result, the rise in the nominal exchange rate diminishes borrowers' ability to fulfill their obligations, thereby contributing to an increase in NPLs (Nkusu, 2011). In the context of Lao PDR, where the economy experiences a degree of dollarization, commercial banks generally provide loans in the local currency. However, it is worth noting that the use of the US dollar as a lending currency is prevalent and shared

significantly a mount in the Loan portfolio (IMF, 2019). This means that borrowers in the country may opt for loans denominated in US dollars, which exposes them to exchange rate risks when the domestic currency weakens, potentially contributing to higher NPLs. In studying the determinants of asset quality in banks, Alhassan et al. (2014) employed the real exchange rate as a measurement. However, Otani et al. (2009) utilized the nominal effective exchange rate in their work, and Beck et al. (2015) also adopted nominal effective exchange rates in their study on the determinants of NPLs. Consequently, this study follows the approach of employing the nominal effective exchange rate as a measure of the foreign exchange rate, aligning with the perspectives of Otani et al. (2009) and Beck et al. (2015).

Inflation is considered another factor that potentially contributes to non-performing loans (NPLs), although its impact is ambiguous. Inflation occurs when prices of goods and services increase over time (Abel, 2005). Recent research by the International Monetary Fund (IMF, 2016) suggests that the relationship between high inflation and NPLs can have either positive or negative implications. Generally, inflation is believed to be positively associated with non-performing loans. As inflation rises, the cost of conducting business increases, leading to reduced profitability and a diminished capacity to repay debt. In a study of US commercial banks Ghosh et al. (2013) found that inflation has a positive effect on NPLs while negatively affecting borrowers' real income and impairing their ability to meet their debt obligations.

However, a study by Klein (2013) states that inflation may enhance debt servicing capacity by diminishing the value of the debt or outstanding principal sum, affecting non-performing loans. Real debt services decline with higher inflation, driving down non-performing loans. Hence, inflation may potentially diminish the debt principal amount, assisting with the decrease of property NPLs through higher repayments. Nkusu (2011) has examined the NPLs determinants of 26 advanced countries and has concluded a negative impact of inflation on NPLs. In the present study inflation will be represented by the consumer price index. The index includes all goods and services in the economic region, if they are part of the consumer spending of private households.

Money supply influences banks' financial statements through lending, investment, and profitability. An increase in broad money raises bank deposits, so a bank’s lending and investment resources grow proportionally as well. The money supply refers to the overall amount of money circulating within an economy during a specific period. It can be calculated in various forms, typically classified into three categories: Reserve Money (Mo), Narrow Money (M1), and Broad Money (M2). For our study, we selected M2 as the representative measure of money supply due to its comprehensive nature, encompassing both Reserve Money and Narrow Money.

An increase in M2 can have several consequences, some of which are less favorable. First, it can contribute to inflation, diminishing the real value of borrowers' incomes and making it more challenging for them to meet their debt obligations. Additionally, an excess of liquidity within the financial system can lead to riskier lending practices, as banks may extend loans to borrowers with less robust credit histories. This relaxation of credit standards can lead to a higher incidence of loan defaults, ultimately resulting in a rise in NPLs. A growing money supply may also

signify an increase in credit availability throughout the economy. This could prompt both individuals and businesses to seek loans, potentially leading to higher debt levels. However, the impact on NPLs hinges on the quality of credit risk assessment conducted by banks and the ability of borrowers to meet their repayment obligations. If lending standards are not upheld, it can result in a surge in NPLs. Studies by Badar et al. (2013), Akinlo and Emmanuel (2014), and Leka et al. (2019) have found a positive correlation between an increase in money supply and a rise in non-performing loans. These findings suggest that the expansion of the overall money stock may have contributed to the deterioration of banks' portfolios in the country, primarily due to inaccurate credit analysis.

2.2. Empirical review

Numerous empirical studies have explored the relationship between macroeconomic factors and nonperforming loans, revealing consistent findings. The majority of these studies indicate a positive correlation between NPLs and various factors such as interest rate, lending rate, unemployment, inflation, public debt, and exchange rate.

One notable study conducted by Badar et al. (2013) focused on the impact of macroeconomic forces on nonperforming loans in 36 commercial banks in Pakistan during the period of 2002 to 2011. The researchers examined both the long-term and short-term dynamics between NPLs and macroeconomic variables. Their analysis incorporated inflation, exchange rate, interest rate, gross domestic product (GDP), and money supply as key macroeconomic indicators. The results of their study revealed strong negative long-term associations between NPLs and inflation, exchange rates, interest rates, GDP, and money supply. These findings underscore the significance of these macroeconomic factors in influencing the occurrence and magnitude of nonperforming loans.

The study by Hoggarth et al. (2005) for United Kingdom over the period 1988–2004 found inflation and interest rates to be the main determinants of non-performing loans in the UK. Vogiazes and Nikolaidu (2011) looked at the factors that contributed to non-performing loans in the Romanian banking industry between 2001 and 2010. The findings demonstrated that Romania's NPLs were primarily determined by spending on construction and investment, unemployment, inflation, the ratio of external debt to GDP, and money supply generally construed. Accordingly, in another survey, in a comprehensive study by the ECB in 2011 over 80 economies, the asset quality of the banks is significantly influenced by the output growth, nominal exchange rate fluctuations as well as interest rate in case the assets markets have been developed too. In the study of Louzis et al. (2012), a dynamic panel data approach and variables from the macroeconomic and banking sectors to identify the causes of non-performing loans in the Greek banking sector. The empirical research demonstrated that macroeconomic factors, such as GDP, interest rate, public debt, and unemployment, as well as the bank-specific variable of management quality can be a cause of NPLs in the Geek banking sector.

Furthermore, the study by Nkusu (2011) for 26 advanced economies over the period 1998–2009 investigated the determinants of NPL ratio and of the first difference of the NPL ratio. The results showed that adverse macroeconomic

development, in particular, a contraction of real GDP, a high unemployment rate, high interest rates, a fall in house prices and a fall in equity prices negatively affected NPLs. In the same way, study by De Bock and Demyanets (2012) for 25 developing economies over the period 1996–2010 revealed that real GDP contraction, currency depreciation against the US dollar, weaker terms of trade and outflows of debt – creating capital precipitated higher aggregate NPL ratio of the banking sector. Siddiqui et al. (2012) carried out a study on the impact of interest rate volatility on non-performing loans in Pakistan in the periods between 1996 and 2012, the study concluded that interest rate is the cause of rising NPLs in Pakistan significantly. Bogdan (2017) found that the determinants of bad loans in the banks from Central and Eastern Europe are Real GDP growth rate and inflation rate CPI with a negative effect, Unemployment rate with a positive effect.

Using panel data, Beck et al. (2013) looked at the macroeconomic factors that influence non-performing loans across 75 countries. According to the study's findings, real GDP growth, share prices, currency rates, and lending interest rates were the factors that had the most significant impacts on non-performing loans between 2007 and 2012, the study identified that the interest rate has significantly negatively driven NPLs, and the banks' NPLs are generally exacerbated by the impact of the higher real money supply in the long run. Donath et al. (2014) in a study for Romania and for Baltic countries found that for the latter, lending interest was significant with a positive impact for Estonia and Lithuania, and with a negative impact for Romania. The lending interest has a positive relationship for Latvia, but not as significant as with the others. A study by Beck et al. (2013) revealed that NPLs were affected significantly by the GDP growth, stock prices, the exchange rate, and the loan interest rate.

Adebola et al. (2011) conducted a study to assess the determinants of non-performing loans (NPLs) in Islamic banking in Malaysia during the period from January 2007 to December 2009. They utilized the autoregressive distributed lag (ARDL) technique and found evidence of cointegration among the variables. The results indicated that the interest rate had a positive and significant impact on NPLs. In a similar study by Viphindrartin et al. (2020), which focused on the Non-Performing Loans of Rural Banks in Indonesia for the period from January 2015 to December 2018, the researchers employed a Vector Error Correction Model (VECM). Their findings revealed that inflation and interest rate exerted a positive and significant influence on non-performing loans in the long term. Furthermore, in the short term, credit and interest rates were the only variables that had a positive and significant effect on non-performing loans. Inflation and exchange rate variables, on the other hand, demonstrated a negative and insignificant impact on bad credit in the short term.

Okyere and Mensah (2022) analyzed the determinants of NPLs in Ghana's banking industry using monthly data from January 2007 to December 2019. They considered bank-specific and macroeconomic variables and employed the ARDL bounds test of co-integration to examine short-term and long-term relationships. The study found that bank-specific factors such as lending rate, profitability, Cost to Income Ratio, Capital Adequacy Ratio, and Net Interest Margin influenced NPLs. At the macroeconomic level, inflation and economic growth were found to reduce NPLs. Additionally, the previous year's NPLs and net interest margin decreased current NPLs, while the credit adequacy ratio promoted current NPLs in the short run.

Several empirical studies have delved into the intricate relationship between Non-Performing Loans (NPLs) and macroeconomic variables, offering valuable insights into the dynamics of these interconnections. Adebola et al. (2011) investigated this nexus in the context of Malaysia's banking sector and found that NPLs have a significant positive impact on interest rates, underlining the potential feedback effects of NPLs on the broader economy.

3. Data and Methodology

3.1. Data

The objective of this study is to investigate the impact of macroeconomic factors on nonperforming loans in Lao PDR. The data used in this study are obtained from the quarterly reports of the Central Bank of Lao PDR (Bank of Lao PDR: BoL). The study adopts the widely accepted definition of nonperforming loans, which considers loans and other assets as nonperforming when the principal and interest payments are overdue by 90 days or more. In this study, the dependent variable is defined as the ratio of nonperforming loans to total bank loans. As for the independent variables, the study examines the statistical significance of the consumer price index, Money Supply Aggregate M2, nominal exchange rate, and lending interest rates for loans. These variables are commonly studied and expected to have an impact on nonperforming loans.

In the context of analyzing the variables that influence Non-Performing Loans (NPLs), the inclusion of Gross Domestic Product (GDP) growth rate as an independent variable represents a critical aspect of macroeconomic analysis. It is well-recognized that GDP growth rate can exert a substantial influence on credit risk and the performance of loan portfolios. However, it is with regret that this study must acknowledge the omission of GDP growth rate from the analysis, owing to the unavailability of quarterly data required for its inclusion. The omission of GDP growth rate due to quarterly GDP data is not consistently reported in many datasets, rendering it challenging to procure the requisite information for this study period.

This limitation may render this analysis less comprehensive, potentially overlooking the nuanced dynamics between economic expansion or contraction and NPL dynamics during the specified timeframe. Nevertheless, the insights derived from this analysis, grounded in the data available to this study, remain pertinent in advancing our understanding of NPL determinants within the limitations of the present research context.

3.1.1. Econometric model

The model which is statistically examined to describe the relationship between NPLs and explanatory variables is constructed as follows:

$$NPLs = \beta_0 + \beta_1 LnCPI_t + \beta_2 LnMLR_t + \beta_3 LnEXR_t + \beta_4 LnM2_t + \varepsilon \qquad (1)$$

According to the model, the NPLs outline non-performing loans ratio. The data on NPLs ratio rates are reported as the average of the whole banking industry rather than as the rates of individual banks. M2 real money supply is aggregate term,

MLR is lending interest rate, and the ratio, CPI as consumer price index and EXR is nominal exchange rate. The designation "ln" is used to denote the logarithmic form of the variables under investigation, $\beta 0$ is the coefficient of the constant term, while β_1, β_2, β_3 and β_4, represent the partial coefficients of the independent variables for each specified model. All the variables in the function are predicted to have long-term relationships.

Table 1. Report of the source and expected sign of the coefficient

Variable	measurement	expected effect (coefficient)	Source
Non-performing loan ratio (NPLs)	percentage		Bank of Lao PDR, quarterly report
Money supply-M2	index	+	Bank of Lao PDR, quarterly report
Minimum loan rate (MLR)	percentage	+	Bank of Lao PDR, quarterly report
CPI- Inflation (CPI)	percentage	+/-	Bank of Lao PDR, quarterly report
Nominal exchange rate (EXR)	USD/Kip	+	Bank of Lao PDR, quarterly report

Source: own construction

An increase in the lending rate has been found to diminish the borrower's capacity to repay loans, leading to an increase in nonperforming loans (NPLs). The impact of Consumer Price Index (CPI) inflation on loan repayment capacity can vary, resulting in either positive or negative effects. Higher inflation can improve borrowers' ability to repay loans by reducing the real value of outstanding debts, thereby reducing NPLs. Conversely, inflation can weaken borrowers' repayment capacity by reducing their real income, resulting in an increase in NPLs. In the context of exchange rates, the depreciation of a country's currency can have significant implications for borrowers, especially those who have taken loans denominated in foreign currencies. When the local currency depreciates, it essentially means that it loses value relative to the foreign currency in which the loan is denominated. This can lead to an increase in the debt burden for borrowers. Therefore, an increase in the nominal exchange rate is associated with higher NPLs. Regarding Money Supply Aggregate M2, this study assumes a positive relationship with NPLs. An increase in liquidity prompts banks to extend more credit, which in turn increases NPLs within the banking sector.

The investigation is based on the following hypotheses:

H1: The inflation rate has a positive and inverse relationship with the level of Non-Performing Loan.
H2: The exchange rate has a positive relationship with the level of Non-Performing Loan.
H3: The interest rate has a positive relationship with the level of Non-Performing Loan.

H4: Money supply has a positive relationship with the level of Non-Performing Loan.

3.2. Method

The analysis is carried out in the following order. The first step is to test for the presence of unit root. This is due to the fact that most time series in economics show a trend over time and are typically not stationary (containing unit root). It follows that if series is non-stationary, the mean, variance, and covariance are not constant over time. When data contains unit root, it means any result accrued to such data will be spurious or nonsensical. Spurious regression implies that the relationship between variables may appear statistically significant, though there is no meaningful relationship among the variables.

This paper employs PP (Philip and Perron 1988) unit root tests to verify the level of integration of the variables. The null hypothesis PP test states that the series have unit root, while the alternative hypothesis rejects this claim by suggesting stationarity.

$$\Delta Y_t = \beta_0 + \gamma Y_{t-1} + \beta_1 (t - \frac{T}{2}) + u_t \quad (2)$$

$H_0: \gamma = 0$, Series has a unit root (non-stationary).
$H_1: \gamma < 0$, Series has no unit root (stationary).

Once the orders of integration of the variables are determined via unit root tests and we ensure that all the variables are integrated of order one, i.e. I (1), then the Johansen (1991) technique is employed to test for cointegration among variables within a model. The optimal lag length selections in the VAR must be satisfied to apply Johansen's approach, which is relatively sensitive to lag lengths. In this study, the optimal lag selections are based on AIC and Final Prediction Error (FPE). Once the cointegration is confirmed to exist between variables, then the third step entails the construction of error correction mechanism to model dynamic relationship. The purpose of the error correction model is to indicate the speed of adjustment from the short-term equilibrium to the long-term equilibrium state. Since the variables are supposed to be cointegrated, then in the short run, deviations from this long-term equilibrium will provide feedback on the changes in the dependent variables in order to force their movements towards the long-term equilibrium state. Hence, the cointegrated vectors from which the error correction terms are derived are each indicating an independent direction where a stable meaningful long-term equilibrium state exists.

Also, the causality relationship should be examined with the Vector Error Correction Model (VECM) method. Because if there is a cointegration relationship, there must be at least one directional causality relationship between the variables (Granger, 1988). Equation of this method is as follows:

$$\Delta Y_t = \alpha_1 + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \varphi_1 ECT_{t-1} + u_t \quad (3)$$

In Equation (1), γ_i coefficients test short-term causality and φ_1 coefficient tests long-term causality. If $\gamma_i \neq 0$ (significant), it shows short-term causality, and if $\varphi_1 \neq 0$ (significant), it shows long-term causality relationship X to Y. Δ shows the change in the independent variables and ECT_{t-1} is the lagged error correction term. Where β_i shows the speed by which the disequilibrium in short- and long-term values is adjusted by a contribution of the independent variables.

4. Empirical Result

4.1. Unit root test

Many studies point out that using non-stationary macroeconomic variables in time series analysis causes superiority problems in regression. Thus, a unit root test should precede any empirical study employing such variables. All the variables under study must be stationary, otherwise spurious regression may be found. Henceforth, the Phillip Perron (PP) Unit Root Test has been implemented to ensure that all the variables in the regression equation are stationary. The result is shown below:

Table 2. PP unit root test results

Variable	Level	t-statistics	P-Value	Result	Level	t-statistics	P-Value	Result
LnBPLs	Level	-1.4213	0.5617	Accept Null	1st difference	-4.3296	0.0015*	Reject Null
LnMLR	Level	-1.6327	0.4565	Accept Null	1st difference	-2.9435	0.0497**	Reject Null
LnCPI	Level	-1.5142	0.516	Accept Null	1st difference	-5.9463	0.0000*	Reject Null
LnEXR	Level	3.0468	1.0000	Accept Null	1st difference	-5.0218	0.0002*	Reject Null
LnM2	Level	-0.4967	0.8811	Accept Null	1st difference	-5.1610	0.0001*	Reject Null

Source: own computation
Note: the * indicate significant at 1%, and ** at 5%

The interpretation is that in level data, the p-values are higher than specified significance levels 0.05 (5%) and 0.01 (1%). So, we failed to reject the null hypothesis in both cases, at a 5% level critical value and at a 1% level critical value. Even at a 10% (0.1) level critical value, the study failed to reject the null hypothesis. Therefore, all the series are not stationary at level, the first differences of the non-stationary variables are taken. In Table 2, all the variables, in PP unit root test become stationary when their first differences are taken I (1).

Table 3. Optimal lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	220.1303	NA	4.44E-12	-11.95168	-11.73175	-11.87492
1	436.3274	360.3284	1.10E-16	-22.57374	-21.25414*	-22.11317
2	468.5526	44.75724*	8.01E-17*	-22.97514	-20.55588	-22.13076*
3	497.8376	32.53891	7.96e-17	-23.2132	-19.69427	-21.985
4	526.442	23.83697	1.08E-16	-23.41344*	-18.79485	-21.80143

Source: own computation

In order to determine optimal lag length of residuals, usual criteria were used. These are the following: Schwarz's Bayesian Criterion, Akaike's Information

Criterion, Hannan-Quinn Information Criterion, likelihood ratio, and Final Prediction Error. The criteria state that two is the optimal lag length (Table 3.)

4.2. Cointegration test

To analyze the Cointegrating relationships between the variables, the Johansen co-integration test is applied. Cointegration relationships indicate whether the variables are connected in the long term and consequently they converge to a common long-term equilibrium. The results for the Johansen cointegration test based on trace and maximum-eigen statistic are presented in Tables 4 and 5.

Table 4. Cointegration Analysis Trace statistic

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.740927	103.8490	79.34145	0.0002
At most 1	0.477534	55.22575	55.24578	0.0502
At most 2	0.381082	31.85473	35.01090	0.1048
At most 3	0.262691	14.58255	18.39771	0.1577
At most 4	0.095455	3.611618	3.841465	0.0574
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				

Source: own computation

Table 5. Cointegration Analysis Maximum Eigenvalue statistic

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.740927	48.62323	37.16359	0.0016
At most 1	0.477534	23.37103	30.81507	0.3068
At most 2	0.381082	17.27218	24.25202	0.3177
At most 3	0.262691	10.97093	17.14769	0.3140
At most 4	0.095455	3.611618	3.841465	0.0574
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				

Source: own computation

The study's outcomes demonstrate the rejection of the null hypothesis of no cointegration for both trace and maximum eigenvalues in Tables 4 and 5. Furthermore, it indicates the presence of a single cointegration vector, exceeding the critical value at a 5% level of significance. This confirmation of cointegration between Non-Performing Loans (NPLs) and the selected macroeconomic variables, as indicated by the null hypothesis rejection in both trace and maximum eigenvalue examinations, validates the utilization of VECM (Vector Error Correction Model).

These findings underscore the existence of a stable long-term equilibrium relationship, signifying shared information among these variables over time. Consequently, the application of VECM is justified, given its appropriateness for systems characterized by cointegration, facilitating the exploration of both short-

term dynamics and long-term associations. Moreover, the identification of a single cointegration vector surpassing critical values at the 5% significance level reaffirms the aptness of VECM in capturing the essential interactions between NPLs and macroeconomic variables. Therefore, the results not only substantiate the necessity of error correction modeling but also emphasize the robustness and dependability of VECM in elucidating the intricate interplay between NPLs and the broader economic context.

4.3. Vector error correction model

Since the Johansen cointegration test has shown existence of one cointegration vector, the Vector Error Correction Model was applied in order to adequately measure and model dynamics of changes and causality between variables. The long run relationship among variable is as follow:

$$ETC_{t-1} = y_{t-1} - \beta_0 - \beta_1 X_{t-1}$$

$$ETC_{t-1} = 1.000lnnpl_{t-1} - 47.567 - 9.227lnmlr_{t-1} - 4.545lnm2_{t-1} + 7.478lnexc_{t-1} + 10.828lncpi_{t-1} \quad (4)$$

Table 6 presents the results of the long-term relationship among the variables. It reveals that there is a positive relationship between lending interest rate and money supply with non-performing loans (NPLs), while the nominal exchange rate and CPI inflation exhibit a negative relationship with NPLs in the long term. All the coefficients are statistically significant at the 1% level, as indicated by their t-statistic values.

Table 6. Estimates of Vector Error Correction Estimation

Variable	Coefficient	T-statistic
Long run		
LNNPL(-1)	1.000000	
LNMLR(-1)	-9.227786	-13.4967
LNM2(-1)	-4.545655	-14.9972
LNEXC(-1)	7.477814	14.3106
LNCPI(-1)	10.82847	13.3588
C	-47.5673	

Source: own computation
Note: significant a own computation t 1% level

Specifically, the lending interest rate has a significant positive impact on NPLs, implying that an increase in the lending interest rate is associated with a rise in NPLs. This finding can be explained by the fact that higher interest rates reduce the capacity of borrowers to meet their loan obligations. This result is consistent with previous studies conducted by Nkusu (2011), Adebola et al. (2011), and Berge–Boye (2007).

In the case of money supply, this result may be explained by the fact that the expanded money supply has the capacity to extend credit more readily. This boost in

lending activity can stimulate various economic sectors, leading to increased investment, consumption, and overall economic activity. While an increase in lending activity can contribute to economic growth, it also carries certain risks. One potential risk is that banks, in their eagerness to lend, may become less stringent in their evaluation of borrowers' creditworthiness. In other words, they may relax their credit standards or criteria for granting loans. This relaxation can be driven by the desire to capture a larger share of the lending market and to meet the increased demand for credit. However, when credit standards are lowered, there is a greater likelihood of loans being extended to borrowers who may not have been considered creditworthy under stricter lending criteria. These borrowers might have a higher risk of defaulting on their loans due to their financial circumstances or inability to meet their repayment obligations. Over time, as loans are extended to riskier borrowers and economic conditions fluctuate, some of these borrowers may struggle to repay their debts. This situation can result in a higher incidence of non-performing loans within banks' portfolios. The result of the study in line with the study by Badar et al. (2013), Akinlo–Emmanuel (2014).

In case of exchange rates, the results are contrary to the initial hypothesis, which indicate that the exchange rate has a positive relationship with NPLs. However, the empirical findings from Roy (2014) on the impact of macroeconomic factors on non-performing loans in the Indian banking industry reveal an unexpected result: an increase in exchange rates, or a depreciation of currency rates, leads to a reduction in NPLs. This finding challenges the anticipated relationship between NPLs and the exchange rate, suggesting the possibility of an inverted linkage, which merits further exploration.

Regarding inflation, the study has revealed a negative association between inflation and NPLs. This finding suggests that inflation may have a beneficial effect on debt servicing capacity by reducing the value of outstanding debt or the principal sum, thereby influencing NPLs. This aligns with the findings of a study conducted by Klein (2013), which highlighted that higher inflation leads to a decline in real debt services and consequently contributes to a decrease in non-performing loans.

4.4. Short run dynamic

In the context of short-term dynamics, the Error Correlation Coefficient plays a pivotal role in quantifying the speed at which a statistical model responds to and corrects deviations or disruptions from the equilibrium. This coefficient reflects the level of correlation among errors or discrepancies observed within a short time frame, providing insights into how rapidly a model adjusts to restore equilibrium conditions following perturbations. In essence, it quantifies the model's agility in adapting to short-term variations and its ability to minimize the persistence of discrepancies during these transient periods.

Table 7. Error Correction coefficient

	D(LNNPL)	D(LNMLR)	D(LNM2)	D(LNEXC)
ECT	-0.14429	0.013394	0.034776	-0.00349
T-statistic	[-3.11511]	[0.60139]	[1.46239]	[-0.23127]

Source: own computation

The coefficient of the error-correction term estimated in the NPLs equation (as presented in Table 7) exhibits statistical significance and a negative value. This finding provides empirical evidence of a convergent process from short-term dynamics towards a long-term equilibrium among the independent and dependent variables, significant at the 5% level of significance. The magnitude of this coefficient, quantified at -0.144, signifies the rate at which adjustments occur when the system experiences disequilibrium.

To elucidate, the speed of correction when transitioning from a state of disequilibrium to long-term equilibrium amounts to approximately 14.4% of the initial disequilibrium observed within NPLs. Specifically, this implies that, in practice, 14.4% of the initial deviation from equilibrium in NPLs is rectified over each adjustment period.

For the exchange rate variable, the adjustment coefficient also carries a negative sign, although it lacks statistical significance. In contrast, for the interest rate and money supply variables, the adjustment coefficients exhibit positive values. This positive sign indicates a relative absence of significant adjustments toward long-term equilibrium in situations characterized by disequilibrium, suggesting a less pronounced correction process for these variables.

Table 8. Vector error correction model: short run dynamic

Variable	Coefficient	t-Statistic	Prob.
ECT	-0.144289	-3.115107	0.0039
LNNPL(-1)	0.121906	0.653181	0.5185
LNMLR(-1)	-1.941435	-3.159486	0.0035
LNM2(-1)	-0.419074	-1.200234	0.2391
LNEXC(-1)	0.36963	0.637907	0.5282
LNCPI(-1)	0.409303	1.515903	0.1397
C	-0.005492	-0.326463	0.7463

Source: own computation

Table 8 indicates that among the independent variables this is only lending interest rate that is statistically significant at the 5% level. Specifically, the most influential determinant of the NPLs' short term dynamics is the change of lending interest rate which indicates that lending interest rate has a causal relationship with NPLs in the short run. An increase of interest rates leads to higher debt service costs and due to the higher debt burden of economic agents the amount of non-performing loans increase and cause a rise in NPLs. The analyses also suggest that in the short

term exchange rate is associated with an increase in NPLs but not significantly. This indeed suggests that an appreciation of the exchange rate may weaken the performance of the export-oriented sectors, thereby exacerbating a banking crisis.

4.5. Causality test

In order to determine the causal relationship between the variables, Granger causality tests were applied using the same lag length as in the VECM. The null hypothesis of this test indicates non-causality and the alternative hypothesis in the case of a rejection indicating causality between the dependent and independent variables.

Table 9. Pairwise Granger causality test

Null Hypothesis:	**Observations**	**F-Statistic**	**Probability**	**Result**
LNMLR does not Granger Cause LNNPL		0.18521	0.6695	Accepted null
LNNPL does not Granger Cause LNMLR	39	7.14488	0.0112	Rejected null
LNM2 does not Granger Cause LNNPL	39	6.10646	0.0183	Rejected null
LNNPL does not Granger Cause LNM2		3.97801	0.0537	Accepted null
LNEXC does not Granger Cause LNNPL	39	11.1231	0.002	Rejected null
LNNPL does not Granger Cause LNEXC		0.78488	0.3815	Accepted null
LNCPI does not Granger Cause LNNPL	39	0.5587	0.4596	Accepted null
LNNPL does not Granger Cause LNCPI		3.45174	0.0714	Accepted null

Source: own computation

Table 9 presents the results of Granger causality tests examining the causal relationships between Non-Performing Loans and independent variables. The outcomes of these tests indicate that the null hypothesis of no causality from NPLs to the Lending Interest Rate (MLR) has been rejected, suggesting a causal relationship from NPLs to MLR. However, the hypothesis that MLR causes NPLs was accepted, implying no causal link from MLR to NPLs. This indicates a unidirectional causality running from NPLs to MLR, where changes in NPLs affect MLR, but the reverse is not supported.

Regarding the relationship between M2 (Money Supply) and NPLs, the study found evidence of causality running from M2 to NPLs, indicating that changes in money supply affect NPLs. However, there was no significant evidence of causality from NPLs to M2, suggesting that NPLs do not significantly impact money supply changes. Additionally, the analysis revealed that the Exchange Rate (EXC) Granger causes NPLs, implying that changes in exchange rates influence NPLs. Conversely, there was no evidence of causality from NPLs to EXC, indicating that NPLs do not significantly affect exchange rate fluctuations.

The apparent contradiction arises because the initial interpretation suggested that higher MLR leads to higher NPLs, while the causality results imply that changes in NPLs affect MLR but not the other way around. It is important to clarify that the Granger causality tests examine temporal relationships and directional causality. The positive impact of lending interest rates on NPLs, as discussed previously, pertains to the contemporaneous relationship between these variables and may reflect their long-term equilibrium dynamics. The Granger causality tests, on the other hand, focus on whether changes in one variable can predict changes in another variable over time. In this context, they reveal that NPLs can predict changes in lending interest rates

(MLR), suggesting that NPLs influence MLR in the short term. However, they do not necessarily contradict the long-term relationship between lending interest rates and NPLs, which may still hold but is not captured by the Granger causality tests.

4.6. Diagnostic test

VECM model is applied to investigate the existence of long-term and short-term effects among the variables. Diagnostic tests were also carried out to check whether the study results are reliable and valid. Heteroskedasticity has been conducted to examine the model's quality of this study since heteroskedasticity is considered a major problem in any regression model. For autocorrelation, the Breusch–Godfrey LM test is applied due to the method examining a higher order of correction.

Table 10. Diagnostic test

Test	**Null Hypothesis**	**p-value**	**result**
Heteroskedasticity	No Heteroscedasticity	0.1198	Accept null hypothesis
Breusch–Godfrey	No serial correlation	0.2093	Accept null hypothesis

Source: own computation

Table 10 reports the results of diagnostic tests, Breusch–Godfrey serial correlation LM tests show that no serial correlation problem exists with the model. Breusch Pagan Godfrey test for checking Heteroskedasticity shows that P value is higher than 0.05, which means that Heteroskedasticity has been removed. Therefore, the diagnostic tests that were carried out suggest that all results are reliable and valid.

5. Conclusion

The banking industry plays a pivotal role in a country's economy and is considered the cornerstone of its financial transactions. This study has aimed to contribute to the existing literature on non-performing loans by empirically investigating the factors that account for changes in NPLs within the banking sector of Lao PDR. Given that Lao PDR is a developing country, the activities of the banking sector assume a crucial role in the overall health of the economy, as commercial banks dominate the financial intermediation market in such countries.

This study covers the period from 2012 to 2021 and utilizes quarterly data to analyze the effects of macroeconomic variables, namely, lending interest rate, money supply, exchange rate, and consumer price index, on NPLs. The results of the study reveal a long-term relationship between NPLs and these macroeconomic variables, specifically taht an increase in lending interest rate and money supply tend to raise NPLs in the long run, while only the lending rate has a short-term impact on NPLs.

These findings suggest that controlling lending rates within the banking sector can prove advantageous in the management of NPLs over time. Consequently, policymakers should exercise vigilance when implementing policies that lead to substantial increases in lending interest rates and money supply. Such policies may

contribute to a prolonged escalation in NPLs. Policymakers must strike a delicate balance between stimulating economic growth through monetary measures and managing the associated financial stability risks. A comprehensive assessment of monetary policies, including interest rate controls, is imperative. While the study underscores the potential long-term impact of increasing lending interest rates on NPLs, policymakers should also consider broader ramifications on the banking sector and the overall economy, including negative effects via other channels.

Financial institutions should continuously refine their risk assessment models to incorporate the effects of money supply fluctuations on their portfolios. This involves evaluating how changes in the money supply may influence borrower behavior, credit risk, and liquidity risk. Regulatory authorities can play a pivotal role in encouraging banks to adopt more advanced risk modeling techniques. Additionally, banks should maintain stringent credit underwriting standards, refraining from extending loans to less creditworthy borrowers, especially during periods characterized by significant M2 growth.

The present study has certain limitations. It focuses solely on the influence of macroeconomic factors on the NPL rate, omitting the consideration of bank-specific factors that could potentially have a significant impact on the increasing NPLs within the banking sector of Lao PDR. To address these limitations, future research should explore additional avenues. One potential direction is to conduct studies at a disaggregated level by analyzing loans based on specific purposes, such as commercial, residential, and real estate mortgages. Another avenue is to examine the interactions and relationships between non-performing loans and different types of borrowers, including individuals/households, small and medium-sized enterprises, and corporate borrowers. This analysis would help identify the sectors that contribute the most to NPLs within the economy, potentially leading to financial sector instability.

Furthermore, a notable limitation that could potentially impact the outcomes of this study is the unavailability of data on certain critical factors. This data gap can hinder the depth and accuracy of this analysis, as it restricts this study's ability to comprehensively assess the intricate relationships between various variables. In particular, the absence of data related to key influencing factors might result in an incomplete understanding of the dynamics at play. This limitation underscores the importance of considering the available data's scope and reliability when drawing conclusions from the study's findings. Future research should prioritize efforts to obtain more comprehensive datasets to enhance the robustness of analyses in this domain.

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