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## RESEARCH

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# Macro Determinants on Non-performing Loans and Stress Testing of Vietnamese Commercial Banks' Credit Risk

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**Abstract:** This study investigates the relationship between several macroeconomic factors and the nonperforming loan ratio in the Vietnamese banking system by using panel regression models. The study employs a sample of eight listed banks representing approximately 50% of the market share of the banking system operating from the fourth quarter of 2008 to the second quarter of 2013. Consistent with international and domestic evidence, we have found that the GDP growth rate is negatively related to nonperforming loans (NPL) while the lending rate is positively related to NPL. Contrary to other studies, the inflation and exchange rates have not been found statistically significant with nonperforming loans for the Vietnamese commercial banks. The study also employs both a conventional approach and a value-at-risk (VaR) approach to conduct macro stress testing in order to predict the levels of the nonperforming loans and the expected losses that banks could suffer. The forecast result shows that under adverse and stressed scenarios the minimum capital requirement for banks to survive is about 6% at the end of 2014. Implications will then be provided for bankers and policy makers accordingly.

*Keywords:* Nonperforming loans, capital adequacy, stress testing, vector autoregressive model.

## 1. Introduction

A sound financial system is crucial for every economy since financial institutions, especially commercial banks, not only facilitate the credit flow in the economy but also promote the productivity of business units via funding investment. During past decades, studies have shown that most banking failures or crises are

caused by nonperforming loans (NPL) (Brownbridge, 1998) [1], e.g. the 1997 Asian financial crisis (Yang, 2003) [2] and the recent 2008 global financial crisis (Diwa, 2010) [3]. As the main operations of commercial banks are to accept deposits and provide loans, they are exposed to the credit risk of having bad loans, which are known as NPL. NPL have increasingly gained international attention over the last several decades. As the increase in NPL has been found to be associated with bank

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failures and financial crises in both developing and developed countries, emphasis is placed on NPL when financial vulnerabilities are examined (Khemraj and Pasha, 2009) [4].

NPL are claimed as one of the main reasons causing a significant decrease in the Vietnamese banks' profitability during Vietnam's economic slowdown in 2012. Many banks used a huge amount of provisions to deal with bad debts, capital that could have been deployed elsewhere, and this resulted in a reduction of banking system's aggregate profitability to only 28,600 billion VND in 2012, a decrease of about 50% when compared to 2011 (SBV). That situation prompted the need to control the rising NPL for the economic growth of the country. Therefore, this study is conducted to explore the reasons behind these NPL.

Since the 1990s, in response to the increased financial instability in many countries, a number of policy makers and researchers have become interested in studying vulnerability in financial systems. Therefore, stress testing credit risk and other types of risk with various techniques have been increasingly used to assess the resilience of individual banks as well as financial systems in extreme scenarios (Christian, Claus, and Maher, 2011) [5]. Moreover, stress testing is also required as part of banks' internal analysis under Basel II and III requirements.

The SBV's Circular 13/2010/TT-NHNN issued in 2010 is considered as one of the first legal documents requiring stress-testing for liquidity risk, but it does not detail the implementation. For example, the circular states that the credit institutions should stress test that it would remain solvent under stress circumstances of cash flow from operating activities. In fact, while there is growing concern about stress testing in Vietnam, there are still limitations on knowledge and application of this issue at management levels in commercial banks, especially domestic ones

(Vinh, 2012) [6]. Importantly, the shortage of instructions on stress testing techniques and their application prevents consistent implementation. Therefore, the objective of this paper is twofold: firstly, we attempt to analyze the sensitivity of NPL to the macroeconomic factors; then, we expand the results to develop a macro stress testing framework for the credit risk of commercial banks in Vietnam.

A comprehensive review of materials relating to NPL and the banking stress testing technique will be briefly presented in the next section. Then, the paper describes the Vietnam banking sector in the current situation with regards to the determinants of NPL. In Part four we introduce the research methodology. Part five presents the empirical analysis and findings. Finally, in Part six we conclude the research.

## 2. Materials

### 2.1. Determinants of NPL

Sinkey and Greenwalt (1991) [7] focused on large commercial banks during the period 1984-1987. Their model presented the significant negative relationship between loss rates and the average ratio of capital to assets. Their model suggested that the stronger a capital position a bank maintained, the lower its loss rate would be.

Berger and DeYoung (1997) [8] investigated problem loans and cost efficiency in commercial banks using Granger-causality techniques to test hypotheses on the relationship of loan quality, cost efficiency and bank capital. They indicated that banks with low capital would have incentives to add more risky loans to their portfolios, hence, increasing the number of NPL.

Recently, Saba et al. (2012) [9] studied determinants of NPL in the US banking sector employing correlation and regression tests

during the years from 1985 to 2010. The tests indicated that Real GDP per Capita, Inflation and Total loans had significant impacts on the nonperforming loan ratio.

Louzis et al. (2012) [10], Salas and Saurina (2002) used dynamic panel data methods to investigate the determinants of NPL in the banking sector and found that NPL were caused primarily by macro-fundamentals like GDP, unemployment, interest rates and by management quality. More recently, Klein (2013) [11] studied NPL in Central, Eastern and South-Eastern Europe (CESSE) in the period 1998-2011 and found that NPL strongly responded to macroeconomic factors such as GDP growth, unemployment rate, and inflation. In addition, bank specific factors were also found to be correlated with the nonperforming loan ratio.

Rajan and Dhal (2003) [12] investigated the response of NPL to terms of credit, bank size and macroeconomic conditions in India. The empirical analysis suggested that terms of credit variables had a significant effect on the banks' non-performing loans in the presence of bank size and macroeconomic shocks. Moreover, alternative measures of bank size could give rise to differential impacts on bank's non-performing loans.

Yang (2003) [2] investigated the relationship of the 1997 Asian financial crisis to the non-performing loans of commercial banks in Taiwan. Diwa (2010) [3] investigated the impact of the 2008 global financial crisis on the Philippine's financial system.

Along with the development of financial institutions, the problem of nonperforming loans also emerges as a controversial issue in Vietnam's banking system. Q. Anh and N. D. Hung (2013) [13] investigated the factors leading to bad loans of commercial banks in Vietnam by employing a panel data set with 10 large Vietnamese commercial banks operating in the period from 2005-2006 and 2010-2011. Their findings supported most studies on the

impacts of GDP growth rate, inflation, former NPLs, cost inefficiency, bank size, and fast credit growth on nonperforming loans.

## 2.2. Banking stress testing

Wong et al. (2006) [14] developed a framework for stress testing of the credit risk of banks in Hong Kong. They showed a significant relationship between the default rate of bank loans and key macroeconomic factors, including Hong Kong's GDP, interest rates and property prices and the Mainland's GDP. They also performed macro stress testing to assess the vulnerability and risk exposures of banks' overall loan portfolios and mortgage exposures to a variety of shocks, similar to those that had occurred during the Asian financial crisis. The results indicated that even with VaR at a confidence level of 90%, banks would continue to make a profit in most stress scenarios. However, in extreme cases of the VaR at a confidence level of 99%, some banks could incur material losses, but the probability of such events was extremely low.

In Vietnam, one of a few studies on stress testing is P. D. Quyen (2012) [15] which employed a Vector autoregressive model and historical data to construct macro scenarios with GDP growth rate, inflation, lending rate and exchange rate. In the research, the author used a panel data of 54 developing economies during 2000-2011 to estimate the impact of some macro elements on NPL, and finally constructed scenarios to gauge the change in the NPL of Vietnamese commercial banks.

## 3. Overview of the nonperforming loan situation in Vietnam

### 3.1. NPL in relation with macroeconomic indicators

In the following section, five macroeconomic indicators, including GDP growth, inflation,

unemployment, lending rates as well as the exchange rate in Vietnam over the period from 2002 to 2012, are observed in their relationship with nonperforming loan ratios.

### 3.2. Real GDP growth rate

On average, the annual growth rate of Vietnam was about 7% a year between 2003 and 2012. In this period the average growth was 8.1% in 2003-2007, and 5.9% in 2008-2012. The GDP growth of Vietnam was as high as 8.5% until 2007; however, due to the global financial crisis and economic downturn, the growth rate came down to 6.31% in 2008, 5.32% in 2009, and more recently, only 5.03% in 2012, the lowest level since 1999 (GSO).

As shown in Figure 1, in general, like other economies, there is a negative relationship between GDP and NPL. The explanation provided by the literature for this relationship is that strong positive growth in real GDP usually translates into more income, which improves the debt servicing capacity of borrower, which in turn contributes to lower non-performing loans.

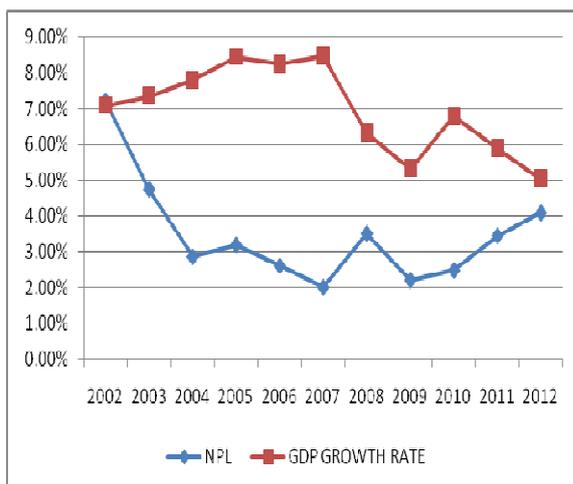


Figure 1: NPL and GDP growth rate  
Source: SBV, GSO.

### 3.3. Consumer price index

Figure 2 shows that NPL were positively related to inflation from 2008 to 2011. Meanwhile, Figure 2 also displays an inverse relationship between these two variables from 2002 to 2007. Typically, the inflation increased significantly from approximately 5% in 2002 to nearly 10% in 2004 while the NPL ratio decreased from more than 7% to about 3% during the same period. The rise of inflation in 2004 may be explained by the governmental promotion of economic growth and domestic demand. In the meantime, as the total outstanding loans of the whole system increased, the decline in the nonperforming loan ratio was recognized. In 2008, due to the lagged effects of the global crisis as well as the soar in inflation and other adverse events, those factors have simultaneously caused Vietnam's NPL to increase. As shown, NPL changed along with the movement of inflation from 2008 till 2011.

### 3.4. Unemployment rate

As presented, most previous studies found a positive relationship between unemployment and nonperforming loan ratios (Ahlem and Fathi, 2013) [16]. Figure 3 illustrates the relationship between NPL and the unemployment ratio in Vietnam context and, in general, there is a positive relationship between the unemployment rate and the NPL.

### 3.5. Lending rate

In recent years, the lending rates in Vietnam are considered to have been driven by the market even though deposit rates are still capped by the SBV. Nevertheless, according to the Civil Law, the bank lending rate is capped at 1.5 times the prime rate given by the SBV, which has been maintained at 9% since 2010 - in Vietnam the SBV apply both direct and indirect measures to control interest rates.

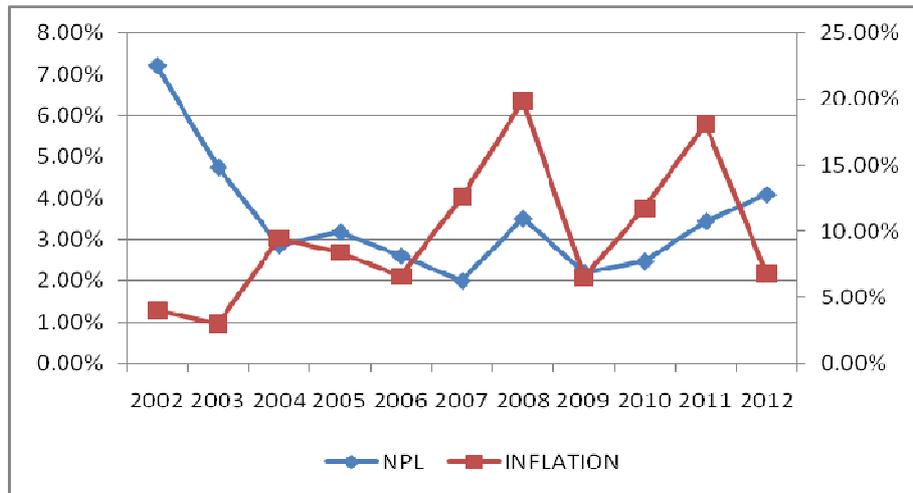


Figure 2: The relationship between NPL and inflation  
Source: SBV, GSO.

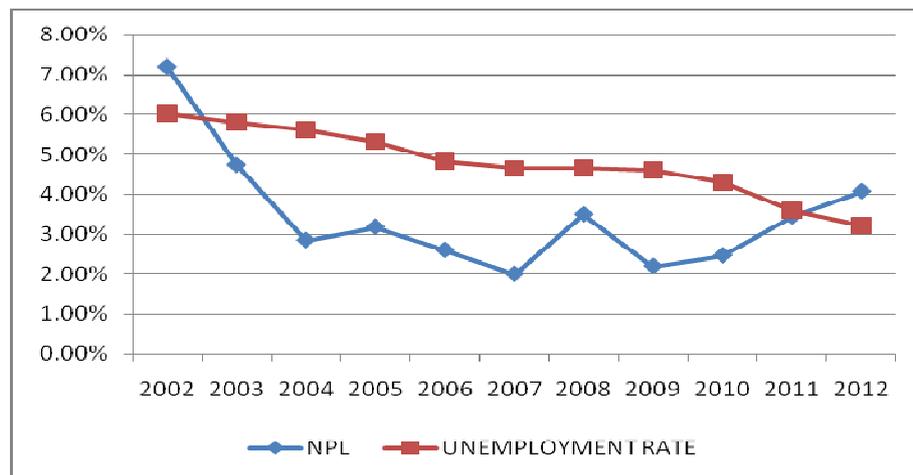


Figure 3: The relationship between NPL and unemployment rate  
Source: SBV, GSO.

From Figure 4, NPL are assumed to be negatively associated with the lending rate for some periods before 2006; however, they have moved together since 2007. In 2008, due to a surge in the inflation rate, banks' lending rates had fluctuated abnormally. In the third quarter of 2008, the deposit rates experienced 19-20% per year and the lending rate climbed to 21% accordingly (SBV). This might have a negative impact on the economy such as a decline in business production, as well as borrowers' capability to service debts.

### 3.6. Exchange rate

The foreign exchange rates such as the EUR/USD, the USD/JPY or the USD/VND are critical because of their impacts on import and export activities, trade balances, national debt, and direct and indirect foreign investments. Figure 5 depicts the change of the USD/VND exchange rate in terms of the fluctuation of the NPL ratio in Vietnam from 2002 to 2012.

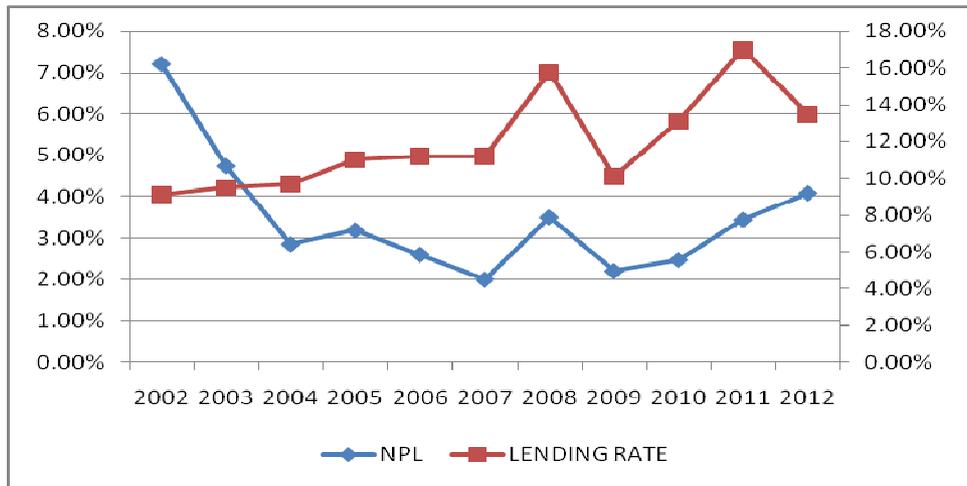


Figure 4: NPL and lending rate  
Source: WB, SBV.

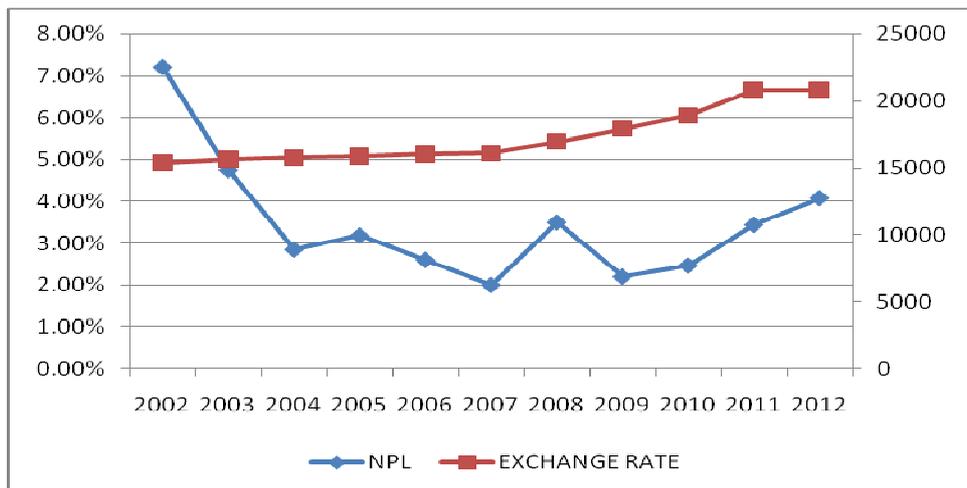


Figure 5: NPL and VND/USD exchange rate  
Source: ADB, SBV.

Figure 5 shows that the USD/VND exchange rate did not vary much from 2002 to 2007; however, since 2008, this rate accelerated dramatically due to the impact of high inflation in the first half of 2008 and the effect of the global crisis on the Vietnamese economy in the second half of the same year. In 2009 and 2010, the exchange rate continued to increase and hence the VND depreciated. Specifically, within five years, the Vietnam Dong has been devaluated nearly 30%, from

around 16,000 VND/USD in 2007 to nearly 21,000 VND/USD in 2011 (SBV). In general, NPL and the VND/USD display a slight positive relationship.

In summary, several relationships between the NPL ratio and some key macroeconomic variables have been observed. Typically, the negative relationship between NPL and GDP growth rates is consistent with the literature. The lending and inflation rates are likely to

correlate positively with NPL in recent years. The exchange rate and unemployment seems to show a slight positive relationship with NPL during the period 2002-2012.

## 4. Methodology

### 4.1. The data employed

The data relating to NPL are obtained and calculated from banks' financial statements. As the data for all Vietnamese banks are not widely available, we take a sample of 8 commercial banks currently listed in the stock exchanges. Two reasons for choosing these banks are that they contain approximate 50% of the assets of the Vietnam banking system and they provide more sufficient data compared to others. The data was obtained quarterly from Q4 in 2008 to Q2 in 2013 from the banks and hence includes 152 observations of NPL. We have chosen this particular range since there is inadequate quality data before 2008.

The data relating to macroeconomic factors are taken from the websites of the General Statistics Offices, the State Bank of Vietnam and the World Bank, and also from Vietnam Economic Times and Vietnam Banking news, etc. The macroeconomic data was taken over a longer period from Q1 in 2005 to Q2 in 2013, and we

used the extra data to improve our macro-economic forecasting part of the analysis.

The statistical description presents the characteristics of the data of each variable used in the study. Notably, the average NPL ratio of examined banks is 2.12% and the standard deviation is 0.014759. The disparity between the nonperforming loan ratios among banks and among examined periods is relative high, ranging from 0.34% to 9.04%.

Concerning macroeconomic variables, the GDP growth rate's average is 6.31% and its standard deviation is 0.014954. The range of GDP is from 3.1% to 8.5%, relatively narrow compared to other macroeconomics indicators like inflation, with the range from 2.4% to 20.1% and LEN from 9.54% to 20.1%. It should be noted that each macro variable consists of 34 observations, since we obtained data in 34 time periods from Q1 in 2005 to Q2 in 2013.

As the objectives of this study are to define the macroeconomic determinants of NPL and to apply macro stress testing to the Vietnam banking system, the analysis will include two primary stages: Firstly, we define the determinants of NPL using a panel regression model. Secondly, we conduct macro stress testing using the VaR approach.

Table 1: Summary statistics

	<b>NPL</b>	<b>GDP</b>	<b>CPI</b>	<b>LEN</b>	<b>EXR</b>
Mean	0.021238	0.06305	0.110773	0.126347	0.008384
Median	0.01851	0.0635	0.085974	0.1185	0.001191
Maximum	0.09044	0.085	0.279041	0.201	0.093545
Minimum	0.003358	0.031	0.024019	0.0954	-0.00974
Std. Dev.	0.014759	0.014954	0.064316	0.023594	0.020185
Observations	152	34	34	34	34

#### 4.2. Defining the determinants of NPL - Panel regression model

The panel regression model used is as follow:

$$NPL_{i,t} = \beta_0 + \beta_1 NPL_{i,t-1} + \beta_2 GDP_t + \beta_3 LEN_t + \beta_4 INF_t + \beta_5 EXR_t + \varepsilon \text{ (Equation 1)}$$

Where

- $NPL_{i,t}$ : The nonperforming loan ratio of bank  $i$  at time  $t$ . This is measured by the sum of sub-standard (group 3), doubtful (group 4), and potentially irrecoverable loans (group 5) to total loans lent to customers.

- $NPL_{i,t-1}$ : The nonperforming loan ratio of the previous quarter. According to Salas and Saurina (2002), the nonperforming loan ratio is closely related to that of the previous period since it is not immediately written down from a bank's balance sheet. The nonperforming loan ratio is assumed to be autoregressive, hence the coefficient of this variable ( $NPL_{i,t-1}$ ) should be positive.

- $GDP_t$ : Year-on-year GDP growth rate at quarter  $t$ . A growing economy is likely to be associated with rising incomes and less financial distress. GDP growth is therefore expected to be negatively related with NPL.

- $LEN_t$ : Interest rate of the economy at time  $t$ . It is understood that a hike in interest rate weakens borrowers' ability to service debts. So, NPL may be positively related with lending rate.

- $INF_t$ : Year-on-year change in CPI representing the inflation at quarter  $t$ . According to Nkusu (2011) [17], inflation affects borrowers' debt servicing capacity through different channels. On the one hand, higher inflation can make debt servicing easier, either by reducing the real value of outstanding loans or being associated with low unemployment, as the Phillips' curve suggests. On the other hand, inflation can also weaken some borrowers' ability to service debt by reducing real income when wages are sticky.

Therefore, the coefficient of this variable can be positive or negative.

- $EXR_t$ : The quarterly change in the VND/USD exchange rate at time  $t$ . An appreciation of exchange rate can have mixed effects. It may weaken the competitiveness of export-oriented firms and adversely affect their ability to pay their debts (Fofack, 2005) [18]. However, it may improve the debt servicing capacity of borrowers whose loans are in foreign currencies. So, the relationship between EXR and NPL may be mixed.

#### 4.3. Conduct macro stress testing using - VaR approach

VaR is one of the most important and widely used statistics that measures the potential of economic losses. VaR measures the worst case loss over a specified time period. Similar to the previous approach, the VaR approach also includes three steps as follows:

##### *Step 1: Construct the macroeconomic scenarios*

Sensitivity analysis is applied to conduct stress testing in the VaR approach. In particular, one macro variable is shocked artificially while the other variables are obtained stochastically in each stress scenario.

##### *Step 2: Predict bank's NPL ratio with constructed scenarios*

Using the panel regression results, the forecast values of macroeconomic variables are substituted to obtain the levels of NPL. Since both the baseline and stress scenarios contain stochastic macroeconomic indicators, the forecast NPL in this approach should be stochastic instead of deterministic as in the conventional approach. In general, we

calculate the forecast values of NPL by the following equation:

$$NPL_t = \beta_0 + \beta_1 NPL_{t-1} + \beta_2 [Z_t] \text{ (Equation 2)}$$

$$Z \sim N(\mu_z, \sigma_z)$$

Where  $Z_t$  is a vector of economic variable, normally distributed at time  $t$ .

*Step 3: Measure banks' capital adequacy under the predicted NPL in Equation 3*

$$CAR_t = CLP_t = NPL_t \times [LGD_t] \text{ (Equation 3)}$$

$$LGD \sim \text{Beta}(\mu_{LGD}, \sigma_{LGD})$$

In VaR approach, stochastic Loss Given Default (LGD) is used to measure the VaR for bank's expected losses or capital adequacy ratio. Following Greg and Rogers (2002) [19], we assume LGD follows a beta distribution that is bound between 0 and 1.

## 5. Results

### 5.1. Descriptive findings

*Stage 1 - Define the determinants of NPL using a Panel regression model*

This section examines the relationship between the macroeconomic variables and NPL ratios. Firstly, we calculate the pearson's correlation coefficient to test how well the

variables are related. Secondly, we run regression Equation 1 with three alternative regression methods of Panel data including the Pooled OLS, the Fixed effect model (FEM), and the Random effect model (REM). Then, we conduct the F-test, LM test, Hausman test and other tests to choose the most suitable model for the second stage.

### 5.2. Correlation coefficient and multi-collinearity

Table 2 presents a pearson's correlation analysis for a pair of variables. The test shows that all of the independent variables are significantly related to NPL at a critical value of at least 10%. The auto regression parameter, NPL at one period lag, is found to have a strong and positive linear relationship with NPL, while other variables have negative but weak associations with NPL. Initially, LEN has a negative coefficient as expected.

Also shown in Table 2, the absolute values of correlation coefficients between independent variables vary from -0.22 to 0.81. There is a correlation coefficient of 0.81 of CPI and LEN indicating an issue of multi-collinearity among these variables.

Table 2: Pearson correlation

Correlation						
Probability	NPL	NPL_L1	GDP	LEN	CPI	EXR
NPL	1.000000					
NPL_L1	0.908753	1.000000				
GDP	-0.202574	-0.176047	1.000000			
LEN	-0.144476	-0.206793	0.514724	1.000000		
CPI	-0.187280	-0.221201	0.288876	0.810514	1.000000	
EXR	-0.202181	-0.160389	0.220900	0.094999	0.017258	1.000000

Based on the result of initial regression we find that LEN has a consistently better significant p-value than CPI, therefore we choose LEN instead of CPI to remain in the model.

### 5.3. Pooled OLS, fixed effects and random effects models

Three main regression methods were used consisting of: (i) the Pooled OLS, (ii) the Fixed Effects Model (FEM), and (iii) the Random Effects Model (REM). In order to decide which model is suitable for our study, a fixed effect is tested by the F-test, while a random effect is examined by Breusch and Pagan's (1980) Lagrange multiplier (LM) test. The former compares the FEM and Pooled OLS to see how much the fixed effect model can improve the

goodness-of-fit, whereas the latter contrasts a random effect model with OLS. When both fixed effects and random effects are statistically significant, we will conduct a Hausman test to choose the better.

Using E-views to conduct the F-test, the p-value of 0.0982 obtained is more than 0.05, hence we cannot reject  $H_0$  at significant level  $\alpha = 0.05$  and therefore the Pooled OLS model is chosen.

Further conducting the LM test, as presented in Table 3, we cannot reject  $H_0$  because the p-values of the three estimations are all higher than the critical level  $\alpha = 0.05$ . Therefore, the Pooled OLS is preferred to the REM.

Table 3: Lagrange multiplier (LM) test for panel data

Probability in ()			
Null (no rand. effect) Alternative	Cross-section One-sided	Period One-sided	Both
Breusch-Pagan	0.932880 (0.3341)	0.127890 (0.7206)	1.060770 (0.3030)

Based on the results of the F-test and the LM test, the Pooled OLS is the best choice. We continued examining the Hausman test which compares the FEM with the REM to verify our choice. The p-value of 0.9584 was obtained - much higher than 0.05. So the REM is more favored than the FEM.

To sum up, when combining the results of the three tests altogether, the Pooled OLS is considered as the most appropriate model.

### 5.4. Redundant variables test

The Pooled OLS model presents four independent variables having statistically significant coefficients with NPL, including

lagged NPL, GDP, LEN and CPI. Only EXR has no significant relationship with NPL. In addition, we are interested in finding the most appropriate model for the purpose of forecasting for our next stage.

As mentioned, CPI should be removed from the regression model. In addition, since the EXR has no significant coefficient with NPL, this raises a concern if the regression model has a redundant variable. Hence, a redundancy test (Wald test) is used to examine the suspected variable EXR. EXR is removed from the regression after the test. Consequently, GDP, LEN and the lagged NPL are left in the model where the F-statistic increases to 233.56 from 144.27 in the former model.

Table 4: Pooled OLS after removing CPI and EXR

Variable	Coefficient	Std. Error	t-statistic	Prob.
Dependent variable: NPL				
Sample (adjusted): 2009Q1 2013Q2				
Total panel (balanced) observations: 144				
C	8.05E-05	0.003779	0.021303	0.9830
NPL(-1)	0.992068	0.038490	25.77459	0.0000
GDP	-0.139309	0.063842	-2.182073	0.0308
LEN	0.062007	0.028169	2.201262	0.0294
R-squared	0.833467	Mean dependent var		0.021124
Adjusted R-squared	0.829899	S.D. dependent var		0.014733
S.E. of regression	0.006077	Akaike info criterion		-7.341386
Sum squared resid	0.005169	Schwarz criterion		-7.258891
Log likelihood	532.5798	Hannan-Quinn criter.		-7.307865
F-statistic	233.5589	Durbin-Watson stat		1.873308
Prob (F-statistic)	0.000000			

## Stage 2 - Macro stress testing for credit risk - VaR approach

The VaR method is very popular in risk management, especially in developed countries; yet the VaR is rarely applied in Vietnam due to the immaturity of risk management in the country. Therefore, this section aims at introducing the more sophisticated Monte-Carlo method of VaR approach to conduct stress testing for credit risk in Vietnam's banking system. The framework for the VaR approach is based on Wong et al (2006) [14].

*Step 1: Construct the macroeconomic scenarios*

As mentioned earlier, GDP and LEN variables are obtained to establish the macro scenarios.

**For the baseline scenario**, the values of GDP and LEN in the forecast periods have been obtained stochastically, based on the means and standard deviations from the historical data (see Table 1, above).

**For stress scenarios**, the effect of artificial shocks are introduced, including GDP shock and LEN shock, to test a bank's resilience in adverse circumstances. Because data has been obtained since 2005, the baseline scenario

already captures the adverse situation of the global financial crisis that occurred in 2007-2008. In each stress scenario, one out of two variables- GDP or LEN - will be shocked, and the other will be obtained randomly as those in the baseline. The two stress scenarios are defined as follows:

- **Stress scenario with decreasing GDP shocks:** Vietnam's real y-o-y GDP growth rate reduce to 4.90%, 4.95%, 2.5%, 3.3%, 3.6% and 4% respectively in each of the six consecutive quarters starting from 2013: Q3.

- **Stress scenario with increasing LEN shocks:** The Bank lending rate is 14.5% in the first quarter, then increases to 16.6% in the second, followed by no change in the third quarter, then accelerates to 20.1% in the fourth and fifth quarters, and finally goes to a peak of 22% in the sixth quarter.

*Step 2: Prediction of the bank's NPL ratio with constructed scenarios*

This section applies Monte-Carlo simulation to conduct stress-testing in the VaR

approach. The forecast NPL in the baseline and stress scenarios will be measured by the following equations:

a) Baseline scenario

$$NPL_t = 8.05^{-5} + 0.992068 NPL_{t-1} - 0.139309 [GDP_t] + 0.062007 [LEN_t] \quad (\text{Equation 4})$$

$$GDP \sim N(0.06305, 0.014954)$$

$$LEN \sim N(0.126347, 0.023594)$$

The constant and correlation parameters' values are employed from the Pooled OLS's results in Table 4. GDP and LEN are normally distributed in this scenario. For simplicity, we assume GDP and LEN are normal distribution,

b) Stress scenario with *decreasing* GDP shock

$$c) NPL_t = 8.05^{-5} + 0.992068 NPL_{t-1} - 0.139309 GDP_t + 0.062007 [LEN_t] \quad (\text{Equation 5})$$

$$LEN \sim N(0.126347, 0.023594)$$

In this scenario, the LEN variable is stochastic while the GDP variable is shocked with the artificial values mentioned in the first step of this approach. The reverse method will be applied for the second stress scenario.

d) Stress scenario with *increasing* LEN shock

$$e) NPL_t = 8.05^{-5} + 0.992068 NPL_{t-1} - 0.139309 [GDP_t] + 0.062007 [LEN_t]$$

$$GDP \sim N(0.06305, 0.014954)$$

Applying Monte-Carlo simulation, thousands or even millions of results for NPL will be obtained; yet, as the number of runs is increased, the mean and standard deviation of NPL fluctuate closely to a specific value. Table 13 presents as to result of each the baseline, stress scenarios and the corresponding NPL of a hypothetical bank (assuming the bank's NPL equal 3% as end of Jun 2013).

After running a number of simulations, the mean levels of forecast NPL are obtained as they are for the end of 2014 which are approximately 3% in the baseline scenarios, and around 5.5% in the stress scenarios. The expected level of NPL under the stress scenarios in the VaR approach is much lower than that in the conventional approach. This is because either the macro variable GDP or LEN (sensitivity analysis) is shocked in the former approach, instead of both variables GDP and LEN (scenario analysis) in the latter one.

Table 5: Predicted NPL from 2013: Q3 to 2014: Q4 under baseline and stress scenarios using Monte Carlo simulation  
(Unit: %)

Period	Baseline			Stress scenario			Stress scenario		
	GDP	LEN	NPL	GDP shock	LEN	NPL	GDP	LEN shock	NPL
2013:Q3f	8.37	14.43	2.71	4.90	13.95	3.17	4.85	14.50	3.21
2013:Q4f	4.80	14.25	2.91	4.95	10.70	3.12	4.30	16.60	3.62
2014:Q1f	7.08	10.46	2.56	2.50	15.04	3.69	5.09	16.60	3.92
2014:Q2f	4.43	13.46	2.77	3.30	10.30	3.85	5.82	20.10	4.33
2014:Q3f	8.22	15.31	2.56	3.60	14.28	4.21	5.35	20.10	4.81
2014:Q4f	7.31	13.57	2.37	4.00	14.90	4.55	5.51	22.00	5.37

*Step 3: Measure of banks' capital adequacy under the predicted NPL*

Wong et al. (2006) [14] used 10,000 Monte-Carlo simulation runs to simulate future paths to conduct credit losses distribution for each baseline and stress scenario. However, a range of 1,000; 2,000; 5,000 and 10,000 simulations can be used for market risk; but a minimum number of 50,000 simulations is recommended for credit risk (financial-risk-manager.com).

In order to conduct a Monte Carlo simulation, lots of professional simulation software can be applied, such as multi-GPU systems or Frontline Systems' Risk Solver, etc. Of the available software, Microsoft Excel is one of the common tools used to perform Monte Carlo simulations; for 50,000 simulation paths, Excel 2007 is adequate for our calculation purposes for both baseline and stress scenarios. The simulated 50,000 NPL in 2014: Q4 is then used to construct the frequency distributions of Credit Loss Percentages (CLP). For a given bank, the percentage of credit loss is simply the product of the default rate and Loss Given Default (LGD) (Greg and Rogers, 2002) [19]. The LGD is the loss amount when a borrower defaults on a loan (investopedia.com).

In this section, the default rate can be obtained by the forecast NPL in the second step of this approach. However, to calculate bank CLP also depends on the appropriate LGD measured by the recovery rate (RR).

Based on the results of S&P's recent study on the US recovery rate from 1987-2012: Q1 (see Table 6) the US senior secured bonds' recovery rate of 62.7% and standard deviation of 32.7% are used as proxies for the recovery rate of the Vietnam banking system. However, instead of using the mean of 62.7% as a deterministic value for the recovery rate, the authors conduct a beta distribution to model the stochastic recovery value.

Our calculation processes in this section can be described as follows:

$$CAR_t = CLP_t = NPL_t \times LGD_t \text{ (Equation 6)}$$

$$LGD_t = 1 - [RR_t]$$

$$RR \sim \text{Beta}(62.7\%, 32.7\%)$$

Noticeably, the beta distribution of the bank's recovery rate is bound between 0 and 1.

Figure 6(a) and 6(b) illustrate the simulated frequency distributions of CLP under the baseline and stress scenarios. As shown in the figures, the stress scenarios with GDP and LEN shocks will shift the CLP distribution to the right, suggesting that the shocks have resulted in increases in the expected percentage of credit losses.

Table 7 summarizes the distributions of credit loss for a typical Vietnamese commercial bank under the baseline and the two stress scenarios. For the baseline scenario in 2014: Q4, the expected CLP is 0.84% whereas for the stress scenarios, the expected CLP is higher, 1.59% and 1.61% respectively. The maximum CLP is more interesting; this equals the adequate amount of capital that bank should reserve to absorb for the credit losses.

Table 6: S&P's recovery ratings: Historical ultimate recovery rates  
Recovery as % or par at emergence: 1987 - 1Q2012

	Recovery	Standard deviation	Observations
Bank debt	78.0%	30.3%	1,670
Senior secured bonds	62.7%	32.7%	375
Senior unsecured bonds	46.9%	33.7%	1,223
Senior subordinated bonds	32.9%	35.2%	561
Subordinated bonds	28.5%	34.2%	432
Junior subordinated bonds	18.7%	29.6%	54

Source: Standard & Poor's.

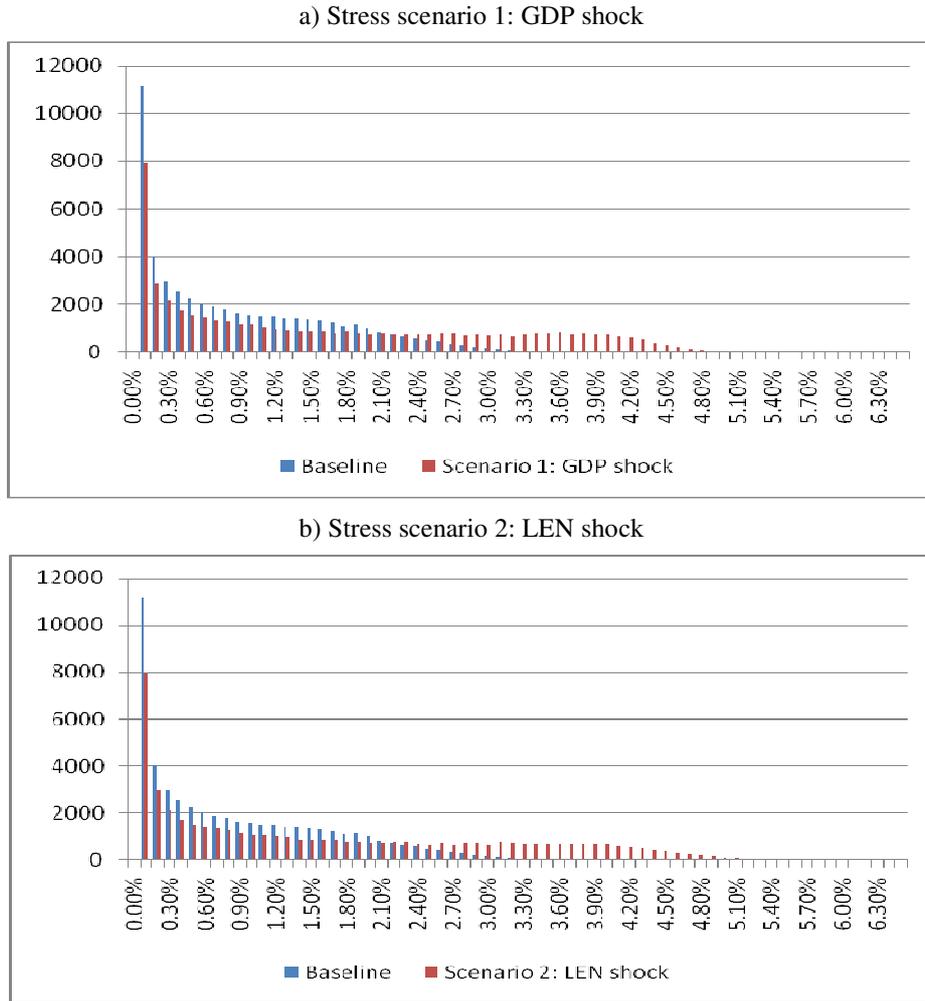


Figure 6: Simulated frequency distributions of credit loss under baseline scenario and stress scenarios  
 Note: Each distribution is constructed with 50,000 simulated future paths of default rates.

Table 7: The mean and VaR statistics of simulated credit loss distributions  
 (Unit: %)

Credit losses	Baseline scenario	Stress scenario	
		GDP shock	LEN shock
Mean	0.84	1.59	1.61
VaR at 90% CL	2.04	3.75	3.81
VaR at 95% CL	2.39	4.08	4.21
VaR at 99% CL	2.96	4.51	4.78
VaR at 99.9% CL	3.55	4.92	5.34
VaR at 99.99% CL	4.12	5.27	5.70

Table 7 presents the VaR at confidence levels of 90%, 95%, 99%, 99.9% and 99.99% to examine the change of CLP under each scenario. For instance, under the extreme case for the VaR at a 95% confidence level, the maximum of CLP is 4.21% under all scenarios, i.e. if the bank had a reserve of 4.21% in capital this would be adequate capital to absorb losses without the bank becoming insolvent for all three scenarios-baseline, GDP shock and LEN shock. If we require a 99.99% confidence level, then banks would need to reserve at least 5.70% in capital. Typically, a bank would add an additional buffer to the 5.70% number to give themselves additional cushion. Hence, the results of CLP in this table also suggest that banks should reserve a minimum capital level of 6% of total loans in order to promote stability and efficiency in the adverse scenarios.

## 6. Conclusions

*Firstly*, in line with previous research, our empirical results confirm that macro factors, such as the GDP growth rate (GDP) and the lending rate (LEN), have significant impacts on the level of NPL. In particular, GDP is found to have a strong negative association with NPL reported by Vietnamese commercial banks, suggesting an improvement in economic growth is an outcome of lower NPL. We have also confirmed a significant positive relationship between LEN and NPL. Hence a higher lending rate may cause an increase in the level of NPL. However, unlike other researchers our results reveal that, in the Vietnamese commercial banks, inflation and the exchange rate are significant determinants of NPL. It is therefore suggested that the banks should focus their attention particularly on the growth rate of the economy as well as the lending rate to borrowers, when providing loans in order to restrain the level of defaulted loans.

*Secondly*, the study provides a framework of macro stress testing using the credit risk model to calculate the VaR and to forecast the value of NPL and banks' performance at a point in future time or specifically the fourth quarter of 2014. The forecast results indicate that the minimum capital requirement for banks to survive the shocks is about 6%. This figure is lower than the typical Basel I 8% figure. We believe the difference may be due to: (i) Vietnamese banks incorrectly reporting their NPLs, with a figure lower than those reported by the SBV in 2014 (3.79%), and rating agencies such as Moody's in 2014 (15%); and (ii) Basel are designed for all regions and all kinds of banks hence their number has to be more conservative. Therefore, banks need to manage their capital above this level and regulators may need to consider this level of capital as the benchmark for banks to follow.

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