Determinants of Credit Risk under Basel II Accord: Case of Vietnam Banking Sector

International Conference on Emerging Challenges:

Smart Business and Digital Economy

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Abstract

Research purpose:
In this research study, the credit risk of the Vietnamese commercial banking system is assessed by investigating its underlying determinants. From there, propose solutions to support risk management in Vietnam banking sector.

Research motivation:

The research propose the new measurement towards credit risk of Vietnam Banking sector, which include not only Expected Loss but also Unexpected Loss factors based on the Basel II Accord. This new measurement method is different from previous research such as using non-performing loans by Chaibi and Ftiti (2015). Based on the methodology and results obtained, this study has been compared with state-of-the-art research relating to the factors which have impacts on the credit risk of Banking sector, specifically in Vietnam proportion updated by time.

Research design, approach, and method:
Applying a quantitative research method using regression models, this study integrates the Basel II Accord to identify factors impacting the expected loss and unexpected loss values. The data used in the study comes from both primary and secondary sources, which spanned from 2010 to 2021.

Main findings:
Using measurements of the "Expected Loss" and "Unexpected Loss" metrics aligned with the Basel II Accord, the findings reveal that these two indicators can be mainly explained by 3 bank performance factors, including "Asset Composition", "Structure Owner", "Bank Size", and a macroeconomic factor, "Exchange Rate".

Practical/managerial implications:
Large banks sustain viability through sufficient capital reserves, risk management, and international peer tracking. Stress testing across exchange rate scenarios and diverse loan portfolio currency types mitigate exchange rate risk. Prudent loan-to-assets ratio, diversified loans, and vigilant credit assessment alleviate concentration risk. Active monitoring of macroeconomics, internal changes, and quantified impact safeguards against expected and unexpected losses, fostering an adaptable risk management framework.

Keywords: *Credit risk, Commercial bank, Basel II Accord, Expected Loss, Unexpected Loss.*

1. INTRODUCTION

Banks constitute the cyclic capital system of each nation's economy. Within the banking sector, capital supply and credit provision activities hold significant importance, facilitating the circulation of money from idle resources to the right places requiring capital for business operations. Adequate capital and credit provisioning can lead to financial prosperity. However, their associated risks, when materialized, can trigger economic downturns at the national level and potentially cascade into global economic collapse. Recognizing the importance of this issue, many research articles on factors

N. D. Nguyen and P. T. T. Hong (eds.), *Proceedings of the 11th International Conference on Emerging Challenges: Smart Business and Digital Economy 2023 (ICECH 2023)*, Advances in Economics, Business and Management Research 274,
https://doi.org/10.2991/978-94-6463-348-1_17

affecting credit risk in the world have been conducted. In Vietnam, where the financial system is dominated by banking sector, credit risk is given special attention by the state bank through a plan to implement the Basel II standards for the entire banking system starting from March 17, 2014.

Determinants of credit risk are also found through measuring their impact on bad debt loan ratio, which is conducted by authors Le Thanh Tam (2021), Le Duy Khanh (2021). Although this measurement method is simple and easy to apply, it contains some limitations in the ability to predict the level of credit risk of a bank in the future, which creates space for this paper to be conducted. To gain a more comprehensive view of credit risk, Monika Papouskova and Petr Hajek (2019) stated that they constructed a credit risk assessment model using the Expected Loss and their results demonstrate superior outcomes compared to conventional methods. Martin Krebs (2021) demonstrates that economic capital (determined by Unexpected Loss) is a crucial measure for the amount of capital needed to cover credit losses at any level of confidence.

Therefore, measuring credit risk using both Expected Loss and Unexpected Loss indices provides a solid foundation for an optimal model that meets the requirements of the Basel II Accord. With the comprehensive identification and study of determinants affecting them, spanning macro-economics, industry and bank performance factors, the research topic on "Determinants of credit risk under Basel II Accord: case of Vietnam banking sector" assumes essential significance in both practical and theoretical contexts. In this research, factors which have impacts on the credit risk of Vienam commercial bank have been studied with two main characteristics namely Expected Loss (EL) and Unexpected Loss (UEL).

2. LITERATURE REVIEW

2.1. The Basel II Accord and the Credit Risk Assessment Framework in the Banking System

2.1.1 The Credit Risk and the Emergence of the Basel II Accord

There are various definitions of credit risk, but the most common understanding is that credit risk is the risk that arises when a party with an obligation to pay in a credit relationship is unwilling or unable to meet their payment obligations to the counterparty as agreed. According to Le and Cu (2021), credit risk management can be defined as the process of identifying and analyzing risk factors, measuring the level of risk, based on that, selecting and implementing management credit activities in order to limit and mitigate risks during the credit granting process.

Credit risk management in banks is typically carried out through a rigorous process, from risk detection, measurement, and control to risk mitigation. To ensure efficiency and consistency, establishing a governance model according to international standards on credit risk management to achieve high efficiency. Therefore, the Basel Committee on Banking Supervision (BCBS), a banking supervisory committee, was established to narrow the gap in international observation scope and provide comprehensive and consistent supervision of the banking systems in member regions. After its establishment, the BCBS has issued a series of international banking regulations standards, the most notable being the Basel standards that govern capital adequacy agreements.

In 1988, the BCBS introduced the capital measurement system - the Basel Capital Accord, also known as Basel I - to establish capital standards to limit the business risks of banks and strengthen the financial system. However, financial crises and associated risk crises in banks have shown that the standards for assessing bank's capital adequacy are no longer accurate. Therefore, in 2004, policymakers began researching an improved version of Basel I. In January 2007, Basel II came into effect and was fully implemented starting from 2010.

2.1.2 Measurement and Evaluation of Credit Risk in Banks according to Basel II.

The Basel II Accord (2004) stipulates that banks can choose one of two approaches to measure and evaluate credit risk: the Standard Approach (SA) or the Internal Rating Basel (IRB) approach. Under the SA, banks are required to classify risks into supervisory categories based on observable characteristics and then assign fixed risk weights to each supervisory category.

With the IRB approach, commercial banks assess the components and levels of risk in their asset portfolios. Basel II provides two methods: the Foundation IRB (F-IRB) and the Advanced IRB (A-IRB), allowing banks to choose the one that suits their scale, characteristics, and resources. The main difference between the two lies in the use of internal estimates to measure risk. However, both methods utilize fundamental bank risk parameters, including the probability of default (PD) and the loss given default (LGD). The LGD is determined by the formula:

$$\text{LGD} = \frac{EAD - the\ recoverable\ amount}{EAD} \quad (1),$$

where the recoverable amount is estimated based on collateral assets, customer asset structures, and macroeconomic factors, the Exposure at Default (EAD) represents the outstanding balance at the time of default, and the Effective Maturity (M) is also considered.

To address this issue, Yanenkova, I et al. (2021) proposed the inclusion of Unexpected Loss (UEL) alongside Expected Loss (EL) to evaluate credit risk in banks. The UEL value is determined by the standard deviation of EL and represents potential losses that may occur but has not been anticipated by the bank. In their research titled "Unexpected Loss, Expected Loss & Economic Capital," the authors demonstrated that:

$$UEL = EAD * \sqrt{[PD^2 * \sigma_{LGD}^2 + (LGD^2 * \sigma_{PD}^2)]} \quad (2),$$

According to the Basel II Accord, EL is accounted for as a cost to the bank (offset by risk provisions), while UEL is offset by economic capital. Therefore, the ultimate purpose of determining EL and UEL is to determine economic capital and credit risk provisions in commercial banks, providing a comprehensive view of credit risk. Monika Papouskova and Petr Hajek (2019) constructed a credit risk assessment model using Expected Loss (EL) and reported superior results compared to conventional methods. Krebs, M et al. (2021) demonstrated that economic capital (determined by UEL) is an essential measure of the capital required to cover credit losses at any confidence level.

2.2 Factors affecting credit risk

Gross Domestic Product: is the market value of all final goods and services produced within a specific territory during a certain period. The Chinese commercial banking system suggests that GDP has a positive impact on credit risk in a positive manner (Twum et al., 2021). However, the negative impact of credit risk from GDP was demonstrated by studies conducted in Central and Eastern European countries, namely Italy, Greece, and Spain (Škarica, 2014; Messai & Jouini, 2013).

Inflation Rate: is the overall rate at which the prices in the economy are increasing. The inflation rate helps provide a measure of the decrease in the purchasing power of money, which is used to calculate real interest rates and adjust wage levels. In the short term, the inflation rate has a relatively strong impact on credit risk in the form of non-performing loan ratios. However, in the long run, the inflation rate does not have significant implications for credit risk assessment (Kepli, 2021). When analyzing credit risk in the banking sector in Nepal, the inflation rate adversely affects the non-performing loan ratio (Poudel et al., 2013).

Exchange Rate: is the price of one currency expressed in terms of another currency. In a study on key determinants influencing non-performing loan ratios with data collected from 75 countries worldwide, Beck et al. (2015) found that when the exchange rate decreases, the non-performing loan ratio tends to increase. Merz, (2017) discovered that fluctuations in exchange rates significantly impact the value of the non-performing loan ratio. There are slight variations in the influence between countries with high and low demand for international money supply.

Interest Rate: is defined as the cost of credit for a specific loan. When analyzing factors influencing the value of non-performing loans in commercial banks in Spain, two authors found that along with the increase in GDP and the decrease in the interest rate, the value of problematic loans, which is the foundation of non-performing loans, decreases (Jimenez & Saurina, 2006). Similar findings were observed by Quagliariello (2003) in Italy, Peng (2003) in Hong Kong, and Arpa et al. (2001) in Austria.

Market Share: can be understood as the portion of the market for a particular product that a business occupies, which is considered a key factor influencing a bank's profitability. When analyzing the relationship between profitability and market share, Etale (2016) found a positive relationship, indicating that the larger the market share, the higher the profitability. However, in order to increase market share, banks may have to employ risky financial policies, which can reduce the safety and sustainability of the bank. Therefore, the relationship between credit risk and market share is a negative correlation (Mishi et al., 2016).

Profitability: is an essential measure of financial efficiency for any bank. Analyzing a bank's profitability provides insights into the effective utilization of assets. There are several methods to measure a bank's profitability, but the best widely used indicator is the Return on Assets (Adem, 2022; Jahan, 2018). When conducting research and establishing an inverse relationship between profitability and the ratio of non-performing loans in banks, Louzis et al. (2012) attributed the main reason to the hypothesis of "poor management." Similar findings were also identified by (Le et al., 2021) in their study.

Bank Size: is measured by the natural logarithm of total assets. This measure is widely used in many empirical studies (Moussa, 2019; Adem, 2022). Bank size can have both positive and negative impacts on credit risk. According to the "Too Big to Fail" theory, larger banks tend to have less risk of default. Large banks can benefit from certain advantages, particularly economic advantages, due to their size (Hu et al., 2004; Nguyen & Tran, 2017).

Asset Composition: refers to the ratio of loans to total assets. This ratio reflects the credit growth rate and the risk appetite of the bank. Previous studies have shown that a higher loan-to-asset ratio leads to higher credit risk due to information asymmetry issues. Nikolaidou and Vogiazas (2017) demonstrated a positive relationship between asset structure and credit defaults in a study on banking activities near the Sahara. Additionally, Khemraj and Pasha (2009) argued that rapid credit growth is often accompanied by poor lending decisions.

Delta Share Price: reflects the changes in the value of stocks if the bank is a publicly traded bank listed on the stock exchange. Beck et al. (2013) investigated the impact of stock price volatility on credit risk. According to the authors, in large countries, stock prices have a significant impact on the increase in non-performing loans. However, in countries with small market capitalization, these effects are not statistically significant.

Structure Owner: can be measured by the concentration of ownership rights. Siddika and Haro (2019) examined the impact of ownership concentration on bank risk and found that a high concentration of ownership has a negative impact on bank risk. However, when analyzing the impact of structure owner on credit risk in Chinese commercial banks, Liu et al. (2019) discovered that a higher level of government ownership increases credit risk, indicating a negative relationship. This finding is also consistent with the research by Shleifer and Vishny (1986), and Shehzad et al. (2010).

Income Diversification: refers to the proportion of non-interest income to the total income of the bank. According to proponents of the "portfolio theory", banks minimize organizational risk by diversifying their income sources, reducing uncertainty in lending, creating additional reserves, and increasing lending profitability. Based on this, several studies have confirmed an inverse relationship between credit risk and income diversification (Ghosh, 2017; Adem, 2022).

Operational Efficiency: is the ratio of service expenses to service income of the bank. According to the "bad management theory," a positive relationship exists between low-cost operational efficiency and credit risk due to inadequate collateral evaluation, poor credit scoring, and low borrower monitoring. Bank owners generate more revenue and can successfully manage underlying economic instability and avoid collapse during economic crises (Berger & DeYoung, 1997).

Loans Deposit Ratio: is the ratio of the total amount of loans (credit) a bank has provided to the total amount of customer deposits within a specific time period. CDR is a tool to assess the liquidity of a bank and measure the capital ratio that the bank has used to grant credit against total deposits received. Le, Doan and Bui, (2021) argue that when lending exceeds bank deposits, banks have an incentive to reduce their risk provisioning ratio to avoid signaling their need to attract external capital, thereby increasing credit risk.

After reviewing the last papers, the above factors are considered in the study's model with the new context of Vietnam's banking sector.

3. RESEARCH METHODOLOGY

3.1 Data

The dataset was collected from 35 banks in the Vietnamese banking system in the period from 2010 to 2021. Data sources are primary and secondary. Secondary data is collected from previous studies and compiled by Le, T. D. et al. (2022) in addition to many different sources, including macroeconomic indicators and banking factors industry trade based on published documents of commercial banks. Primary data on EL and UEL indexes are calculated through the above secondary data; Then, the data is used to study factors affecting credit risk in the commercial banking system.

3.2 Research Variables

The summary of variables in the model and measurement, respectively are presented in **Table 1** as follows:

Table 1. Summary of variables in the model

a) Dependent variables

Name of variables	Code	Measurement	Source
Unexpected Loss	UEL	The standard deviation of loss $UEL = EAD\sqrt{[PD^2 * \sigma_{LGD}^2 + LGD^2 * \sigma_{PD}^2]}$ PD is the probability that a customer will default on their debt. EAD is the total outstanding debt of a customer at the time they default. LGD is the estimated loss ratio.	Basel II (2004)
Expected Loss	EL	$EL = PD \times EAD \times LGD$ PD is the probability that a customer will default on their debt. EAD is the total outstanding debt of a customer at the time they default. LGD is the estimated loss ratio.	Basel II (2004)

b) Independent variables

Name of variables	Code	Measurement	Source

Gross Domestic Product	GDP	$GDP = C + I + G + NX;$ C is consumer spending, I is business investment, G is government spending, NX are net exports.	Twum et al. (2021); Škarica (2014); Messai and Jouini (2013).
Exchange Rate	EXCHANGE	The value of VND compared to the value of the US dollar.	Beck, R. et al. (2015); Merz (2017).
Inflation Rate	INFLATION	The value of the end-of-year CPI index is divided by the value of the beginning-of-year CPI index.	Kepli (2021); Poudel et al. (2013); Aver (2008).
Interest Rate	INTEREST	The average interest rate of the banking system with a 1-year term.	Fuentes and Maquieira (2003); Peng et al. (2003).
Market Share	MARKETSHARE	The amount on deposit at a particular bank is divided by the total amount on deposit at all banks.	Etale (2016); Mishi et al. (2016).
Bank Size	SIZE	The natural logarithm of the total assets of the bank.	Moussa (2019); Adem (2022).
Income Diversification	INCOMEDIVER	The ratio of non-interest income to the total income of the bank.	Ghosh (2017); Adem (2022); Zhou (2014).
Asset Composition	ASSETCOMPOS	The loan-to-asset ratio.	Khemraj and Pasha (2009); Nikolaidou and Vogiazas (2017).
Loans Deposit Ratio	LOANSDEPOSIT	The ratio of the total loans and total deposits.	Chhetri (2021); Le, Doan and Bui (2021); Jha and Hui (2012).
Structure Owner	OWNER	The percentage of the bank owned by the state.	Siddika and Haro (2019); Liu et al. (2019); Shleifer (1986).
Operational Efficiency	OPERATIONAL	The ratio of operating expenses to income from service activities.	Berger and DeYoung (1997).
Delta Share Price	DSP	The ratio of the average stock price on the first day of the year to that at the end of the year.	Beck et al. (2013); Škarica (2014).
Return on Assets	ROA	The ratio of Net Income and Average Total Assets.	Jahan (2018); Adem (2022); Le, Doan and Bui (2021).

Source: authors, 2023

3.3. Research model

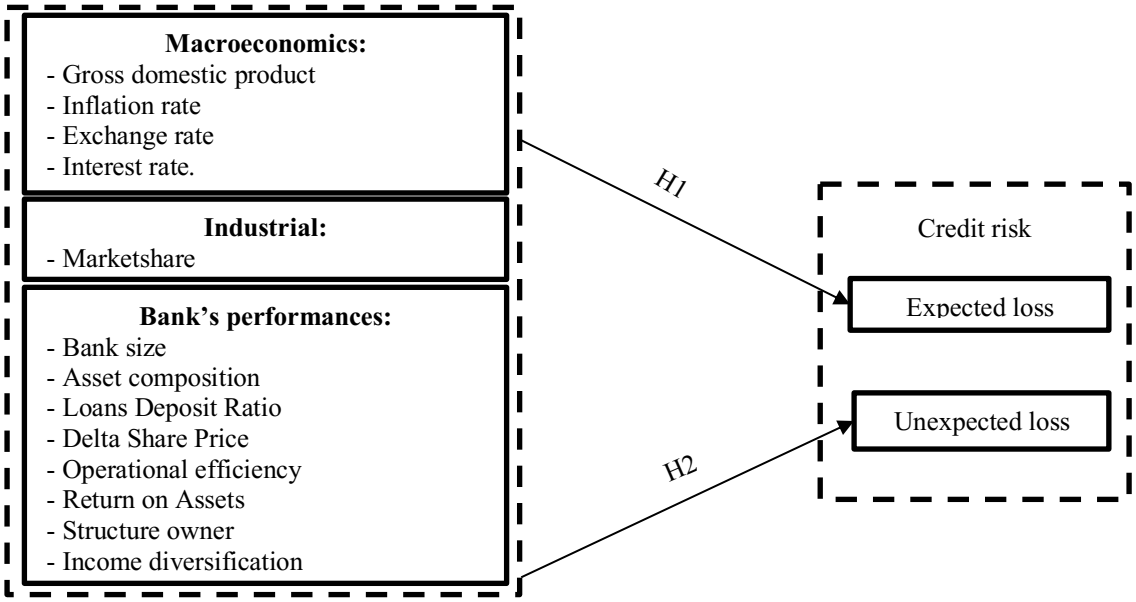
Based on a literature review on groups of factors affecting credit risk, the authors propose a research model, as shown in **Figure 1**. The model was conducted to test the following research hypotheses:

H1: Macroeconomic factors, industry, and commercial bank's performance factors have an impact on the expected loss of credit risk at the bank.

H2: Macroeconomic factors, industry, and commercial bank's performance factors have an impact on the unexpected loss of credit risk at the bank.

This proposed model will be applied to test the definition and discuss the model results in the next section.

Figure 1. Proposed research model



Source: authors, 2023

4. RESEARCH RESULTS AND DISCUSSION

4.1 Descriptive statistics

The independent variables are considered to use in the model with sample size of 251 are summarized through the results of descriptive statistics in **Table 2**. Based on the above descriptive statistics, in this observation period, the macroeconomic factors changed stably. Some commercial bank performance factors such as ROA, LOANSDEPOSIT, OWNER, and MARKETSHARE had strong fluctuations.

Table 2. Descriptive statistics for variables included in the model

Variable	Minimum	Maximum	Mean	Std. Dev.
GDP	147.20	366.14	255.18	68.21
INFLATION	0.01	0.19	0.06	0.05
EXCHANGE	18612.00	23208.00	21609.78	1336.97
INTEREST	0.03	0.14	0.07	0.03
ROA	-5.51	8.10	0.89	0.94
SIZE	15.68	21.29	18.75	1.20
LOANSDEPOSIT	0.28	45.30	1.52	4.06
ASSETCOMPOS	0.15	1.00	0.59	0.15
INCOMEDIVER	-0.04	0.52	0.13	0.09
OPERATIONAL	0.07	0.50	0.22	0.07
DSP	0.25	2.57	1.03	0.25
OWNER	0.00	1.00	0.19	0.34
MARKETSHARE	0.00	0.19	0.04	0.05

Source: authors, 2023

4.2 Correlation matrix

To preliminarily investigate the parameters of the dataset, consider the correlation coefficient matrix and use the Pearson test to test the significance of this correlation coefficient. The results are shown in **Table 3** as follows.

Table 3. Matrix of correlation coefficients between variables

	GDP	INFLATON	EXCHANGE	INTEREST	ROA	SIZE	LOANSDEPOSIT
GDP	1						
INFLATION	-0.68**	1					
EXCHANGE	**0.95****	-0.62**	1				
INTEREST	**-0.84****	**0.95****	**-0.8****	1			
ROA	0.16*	0.016	0.13*	-0.031	1		
SIZE	0.39**	-0.27**	0.36**	-0.33**	0.15*	1	
LOANSDEPOSIT	-0.14*	0.061	-0.16**	0.11	0.096	-0.031	1
ASSETCOMPOS	0.31**	-0.26**	0.31**	-0.29**	0.28**	0.4**	0.32**
INCOMEDIVER	0.37**	-0.24**	0.3**	-0.29**	0.23**	0.44**	0.33**
OPERATIONAL	0.22**	-0.41**	0.24**	-0.4**	-0.08	-0.04	0.08
DSP	0.3**	-0.19**	0.28**	-0.24**	0.02	0.16*	-0.02
OWNER	-0.07	0.01	-0.01	0.08	-0.08	0.53**	0.00
MARKETSHARE	0.05	-0.04	0.04	-0.05	-0.02	0.81**	-0.11

	ASSETCOMPOS	INCOMEDIVER	OPERATIONAL	DSP	OWNER	MARKETSHARE
ASSETCOMPOS	1					
INCOMEDIVER	0.31**	1				
OPERATIONAL	0.18**	0.25**	1			
DSP	0.1	0.15*	0.07	1		
OWNER	0.32**	0.09	-0.05	0.01	1	
MARKETSHARE	0.34**	0.17**	-0.03	0.05	**0.83****	1

Where (*), (**) correspond to the significance level of 0.05 and 0.01, respectively.

Source: authors, 2023

Correlation analysis shows that pairs of variables such as MARKETSHARE and SIZE, MARKETSHARE and OWNER, EXCHANGE and GDP, INTEREST and EXCHANGE, INTEREST and INFLATION, INTEREST and GDP are pairs of variables with relatively large sample correlation coefficients (larger than 0.7), which may result in multicollinearity. Using the variance inflation factor (VIF) to assess whether the sample has multicollinearity or not, obtained **Table 4** as follows. By sequentially removing INTEREST and GDP, the VIF factors are small enough and there is no multicollinearity in the sample, leading to the results of testing the hypotheses in section 4.3. The variables which are removed to minimize multicollinearity are GDP, INTEREST, MARKETSHARE. In summary, the 10 remaining variables are considered in the model.

Before using linear regression to validate the hypotheses, data were standardized to a mean value equal to 0 and a standard deviation equal to 1.

Table 4. Variance inflation factor of the independent variables

Variable code	VIF	Variable code	VIF
GDP	16.1221	ROA	1.2617
EXCHANGE	14.7993	INCOMEDIVER	2.0899
INTEREST	35.2555	LOANSDEPOSIT	1.6656
INFLATION	19.3718	ASSETCOMPOS	1.7963
MARKETSHARE	12.6332	OPERATIONAL	1.6728
SIZE	8.2420	DSP	1.1026
OWNER	4.3645		

Source: authors, 2023

4.3 Regression results

The study has evaluated by constructing two models with dependent variables EL and UEL corresponding to two equations for hypotheses **H1** and **H2**.

With hypothesis **H1,** consider the following model.

$$EL = \beta_1 + \beta_2 * INFLATION + \beta_3 * EXCHANGE + \beta_4 * ROA + \beta_5 * LOANSDEPOSIT + \beta_6 * ASSETCOMPOS + \beta_7 * INCOMEDIVER + \beta_8 * OPERATIONAL + \beta_9 * DSP + \beta_{10} * OWNER + \beta_{11} * SIZE + \varepsilon. \quad (3)$$

Regarding hypothesis **H2,** the following model has been proposed.

$$UEL = \beta_1 + \beta_2 * INFLATION + \beta_3 * EXCHANGE + \beta_4 * ROA + \beta_5 * LOANSDEPOSIT + \beta_6 * ASSETCOMPOS + \beta_7 * INCOMEDIVER + \beta_8 * OPERATIONAL + \beta_9 * DSP + \beta_{10} * OWNER + \beta_{11} * SIZE + \varepsilon. \quad (4)$$

Table 5. Regression result with the dependent variable is EL

Variable	Coefficient	Std. Error	p-value	VIF	Conclusion
(const)	0.000	0.039	1.000		
INFLATION	-0.028	0.054	0.605	1.950	No statistical significance
EXCHANGE	0.116*	0.057	0.042	2.151	Have a positive impact
ROA	-0.031	0.043	0.468	1.228	No statistical significance
LOANSDEPOSIT	-0.022	0.048	0.639	1.505	No statistical significance
ASSETCOMPOS	0.058	0.051	0.265	1.758	No statistical significance
INCOMEDIVER	0.049	0.052	0.345	1.765	No statistical significance
OPERATIONAL	0.009	0.046	0.838	1.397	No statistical significance
DSP	-0.031	0.041	0.451	1.094	No statistical significance

OWNER	0.422**	0.052	0.000	1.827	Have a positive impact
SIZE	0.407**	0.060	0.000	2.430	Have a positive impact
R^2 = 0.639			$R^2_{adjusted}$= 0.624		
F-statistic = 42.47			p-value = $1.3 * 10^{-47}$		

Where (*), (**) correspond to the significance level of 0.05 and 0.01, respectively.

Source: authors, 2023

Based on the results obtained from the linear regression model with the dependent variable being expected loss (EL) at a significance level of 0.05, from a statistical perspective, it can be asserted that three variables in the study have an impact on EL, including the variables EXCHANGE, OWNER, and SIZE. And all have a positive impact. With the F-test result for the EL response variable to test whether the model depends on independent variables or not, the p-value of this test is $1.30 * 10^{-47}$. The coefficient of determination of this model is $R^2_{adjusted} = 0.624$. The variance inflation factors (VIF) are not too large (not exceeding 3). Hence, the model's variables are considered not multicollinearity, and the model is appropriate.

The linear regression model returns the largest regression coefficient for the OWNER variable. It reflects an inference that the OWNER variable has the most substantial impact on credit risk value. This result is consistent with the research findings of Liu et al. (2019) when analyzing the relationship between state ownership ratio and credit risk issues at Chinese commercial banks. It is a positive relationship.

In addition, the SIZE variable reflecting the scale of the bank is also a variable that has a significant impact on the EL response variable with a regression coefficient of 0.407 at a significance level of 0.01. The view of "Too big to fail" can be seen when it comes to commercial banks in Vietnam is not appropriate. The returned result is similar to the results of Fu, Lin and Molyneux (2014) when analyzing Asian banks, where the above group of authors concluded that large banks face more risks than small banks. All three variables above belong to the group of scale indicators in combination with the bank performance variables. As a consequence, the bank size variable has a positive impact on credit risk.

Finally, the EXCHANGE variable at a significant level of 0.05 also positively impacts on the bank's credit risk. The results obtained from this model are similar to those obtained from the study by Merz (2017). The result that reaffirms the view that countries that require a relatively low international money supply like Vietnam will have a rather strong reaction between credit risk and exchange rate. As a result, hypothesis **H1** is confirmed. The bank's performance has significant impacts on credit risk.

For the second model - the model using UEL as the dependent variable, the results are displayed in **Table 6**. The F-test of the dependence of the variables is also consistent with the p-value of $4{,}19.10^{-56}$. The coefficient of determination $R^2_{adjusted}$ in this model is 0.681. Three significant variables at 0.01 significance level are ASSETCOMPOS, OWNER, SIZE and all three variables have a positive impact on UEL. In summary, hypothesis **H2** is confirmed from the results of the above regression model.

Table 6. Regression result with the dependent variable is UEL

Variable	Coeffcient	Std. Error	p-value	VIF	Conclusion
(const)	0.000	0.036	1.000		
INFLATION	-0.022	0.050	0.658	1.950	No statistical significance
EXCHANGE	0.069	0.052	0.189	2.151	No statistical significance
ROA	0.055	0.040	0.116	1.228	No statistical significance
LOANSDEPOSIT	-0.065	0.044	0.141	1.505	No statistical significance
ASSETCOMPOS	0.137**	0.047	0.004	1.758	Have a positive impact
INCOMEDIVER	-0.006	0.047	0.907	1.765	No statistical significance
OPERATIONAL	0.039	0.042	0.359	1.397	No statistical significance
DSP	-0.001	0.037	0.986	1.094	No statistical significance
OWNER	0.409**	0.048	0.000	1.827	Have a positive impact
SIZE	0.446**	0.056	0.000	2.430	Have a positive impact

$R^2 = 0.694$	$R^2_{adjusted} = 0.681$
F-statistic = 54.44	p-value = $4.2 * 10^{-56}$

Where (*), (**) correspond to the significance level of 0.05 and 0.01, respectively.

Source: authors, 2023

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Linear regression models were used to examine the impact of factors from the macroeconomic environment, industry environment, and bank performance factors on credit risk within banks, measured by Expected Loss (EL) and Unexpected Loss (UEL) according to the Basel II Accord. With a total sample size of 35 Vietnamese commercial banks spanning from 2010 to 2021, the study yielded practical significance. Credit risk measured under the Basel II standard was authenticated and represented by EL and UEL ratios, showing an increasing trend over the years. To explain this heightened credit risk issue, along with the findings from Section **4**, the study indicated that within the linear regression model with EL as the dependent variable, there was a statistically significant impact of one macroeconomic factor as exchange rate (EXCHANGE), and three bank performance factors namely structure owner (OWNER), bank size (SIZE), and return on assets (ROA). Furthermore, using the linear regression model, the study demonstrated a statistically significant impact of 3 bank performance factors, asset composition (ASSETCOMPOS), structure owner (OWNER), and bank size (SIZE), on dependent variable UEL, with a confidence level of 69%.

Therefore, the study not only obtains practical significance, but the study also achieves theoretical outcomes. Applying the Basel II standard in measuring credit risk is necessary and aligns with the risk management requirements of Vietnam's commercial banking system. The research provides meaningful and specific information about the comprehensive impact of both macro-environmental factors and bank performance factors on credit risk, contributing to Vietnamese bank managers with a foundational basis to enhance risk management practices.

5.2. Recommendation

Firstly, commercial banks should adopt specific risk management strategies that closely align with practical scenarios. To effectively execute this, the Vietnamese commercial banking system needs to examine the factors influencing credit risk and implement appropriate measures to mitigate it. Based on the findings discussed above, this research proposes that commercial banks should pay particular attention to bank size, followed by exchange rates, asset structure, shareholder composition, and the bank's profit-generating capability.

From there, the study suggests several strategies for banks:

1. For large and state-owned banks, managing risk appetite becomes crucial in ensuring the sustainability and stability of the financial system. Maintaining adequate capital levels and building sufficiently large reserves to handle adverse situations helps ensure that banks can confidently address risks without relying on government support.
2. Banks need to monitor the financial status of their international counterparts, especially in countries with volatile exchange rates. Conducting stress tests under varying exchange rate conditions enables the assessment of unexpected impacts on loan portfolios and the bank's financial standing. Additionally, diversifying currency types within the loan portfolio contributes to minimizing the adverse effects of exchange rate fluctuations on credit risk.
3. Banks should establish a reasonable loan-to-assets ratio based on financial standards and the repayment capacity of clients. Strengthening the credit risk assessment process for large and complex loans while diversifying the loan portfolio and investment types helps mitigate the negative impact of concentration risk.

Secondly, banks must meticulously monitor and control changes in both the macroeconomic environment and internal bank dynamics as they emerge. This proactive approach aids in early detection of latent signs of impending shifts and enables timely adaptation. To achieve this, quantifying the impact of variables at different stages, leading to expected loss (EL) and unexpected loss (UEL), is essential. The risk management framework requires the capacity for flexible adjustments to cope with the ever-evolving business environment. Such flexibility optimizes risk management and minimizes the effects of fluctuations.

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