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ASSESSING THE IMPACT OF CAPITAL BUFFER ON RISK TAKING AND BANK PERFORMANCE IN VIETNAMESE COMMERCIAL BANKS

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SUMMARY

This paper examines the determinants of capital buffers (CB) of 31 Vietnamese commercial banks over the period 2010-2024, taking into account the impact of income diversification ("DIV") under regulatory constraints (CAR_{min}). In order to tackle endogeneity, unobservable heterogeneity, and panel persistence issues, a dynamic system GMM two-step procedure is applied. The post-estimation diagnostics involved Arellano-Bond's AR (2) test of serial correlation on second-order ($p = 0.724$) and Hansen's test for exogeneity of the instruments ($p = 0.461$), revealing that the model was correctly specified and instruments were valid (18 instruments < 31 groups). The results reveal that lagged capital buffer (CB_{it-1}) is positively and significantly correlated with current buffers. This indicates dynamic capital adjustment behavior. Operating efficiency, proxied by the cost-to-income ratio (CIR), and bank size (SIZE) both exert statistically significant negative ($p < 0.01$ and $p < 0.05$, respectively) on capital buffers, supporting cost-efficiency principles and the "too-big-to-fail" hypothesis. Notably, while direct effects of credit risk (NPL), credit growth, and liquidity (LIQ) are statistically insignificant ($p > 0.10$) due to strict macroprudential regulatory constraints, the interaction variable ($NPL \times DIV$) is positive and statistically significant ($p < 0.05$). The results from marginal effects analysis confirm that non-interest income diversification is a key buffer in eliminating the negative effect of credit risks on capital buffers with the increase in sources of income. These findings of the study give empirical proof that will assist bank managers and regulators to realize that non-interest income diversification coupled with cost management creates resilience and dynamic capital allocation in emerging economies.

Key words: *capital buffer, credit risk, income diversification, operating efficiency, liquidity, bank size.*

INTRODUCTION

A stable banking system forms a vital part of the development of economic growth and financial market sustainability. In an increasingly uncertain business environment, commercial banks frequently face several risks such as credit, liquidity and market. To maintain resilience against shocks and protect depositors, banks need to maintain capital above the minimum requirement set by regulators, which is referred to as the capital buffer. Research found that bank capital plays an important role in promoting

banks' survival and value creation during normal periods as well as during different financial crises. The capital buffer not only helps banks absorb losses arising from business activities but also contributes to reducing insolvency risk and strengthening the stability of the whole financial sector.

The role of capital buffers has been considered extensively in the Basel Accords since the inception of Basel I in 1988. Later on, Basel II came into existence in 2004. In light of the financial crisis of 2008, management became a key element in the Basel III framework in order to make banks more resilient to economic and financial instability. In the process of implementing Basel III, the role of variables that determine capital buffers has gained considerable interest among researchers and regulatory authorities. However, research has not come to a common ground regarding the impact of credit risk, credit expansion, operational efficiency, liquidity, and bank size on capital adequacy. However, even more importantly, little attention has been paid to the moderating influence of income diversification on the link between credit risk and capital adequacy, which is quite low in emerging markets.

Although maintaining a CB is said to be an important tool for improving banks' resilience to shocks and maintaining the stability of the financial sector, the determinants of CB have not yet reached consensus in empirical studies. Previous studies have indicated that credit risk, operating efficiency, liquidity, bank size, and credit growth may all affect policies on maintaining capital buffers; however, the direction and magnitude of these effects still differ across countries and periods. Some studies have focused only on a single aspect, such as the relationship between credit risk and capital buffers, credit growth and capital buffers, operating efficiency and capital buffers, liquidity and capital buffers, bank size and capital buffers, and the moderating effect of income diversification [1][3][6]. In particular, the role of income diversification in moderating the relationship between credit risk and capital buffers has not been clarified, especially in emerging economies.

Previous studies on capital buffers mainly concentrated on the case of developed countries, where there is a direct effect. However, this research has added value to previous literature in two significant ways. Firstly, it has considered non-interest income diversification (DIV) as an effective moderating variable which can reduce the capital consumption impact due to non-performing loans (NPL). Secondly, by considering the bank behavior response in an emerging economy (Vietnam) with varying macro-prudential policy regimes (from Basel I to Basel II), this research has established an integrated theoretical approach that links capital adequacy theory and risk-taking and long-term bank solvency.

This study differs from previous studies in several important respects.

First, the study uses panel data from Vietnamese commercial banks during the period 2010–2024, covering the restructuring of the banking system, the implementation of Basel II and the roadmap for applying Basel III. This period witnessed many fluctuations in the business environment, the rapid development of digital transformation, the diversity of banking operations and the effects of the COVID-19 pandemic. Meanwhile, most previous studies have mainly focused on developed economies or used data over shorter periods, leaving empirical evidence for emerging economies such as Vietnam still limited.

Second, the study applies the two-stage GMM estimation method to simultaneously address endogeneity, the dynamic effect of CB, and unobserved errors across banks. Compared with traditional regression methods such as Pooled OLS, Fixed Effects, or Random Effects, System GMM provides more consistent and reliable estimates in the context of dynamic panel data, especially when the current capital buffer is affected by the capital buffer in the past.

Third, the analysis is not only concerned with the impact of bank-related determinants such as credit risk, credit growth, efficiency, liquidity, and bank size on capital buffers but also investigates the moderating effect of income diversification by using the interaction effect between credit risk and income diversification. The purpose here is to understand whether income diversification policies have an impact on how credit risk influences the decisions regarding capital buffer retention by banks. This study is one of the first few studies that investigate the moderating effect of income diversification on the credit risk-capital buffers nexus in Vietnamese commercial banks.

Lastly, this research offers new empirical insights into the factors determining capital buffers in the light of the gradual integration of Vietnam's banking system into international norms on capital adequacy. These results from the research provide significant insights for the managers of the banks in creating effective capital management policies, risk control of credit risk, and generating income from non-interest sources to ensure financial stability. On the other hand, this research also provides insights for the regulatory bodies to improve the legal requirements for capital adequacy in Vietnam.

Based on this research gap, the article focuses on answering the following questions: (i) How do credit risk, credit growth, operating efficiency, liquidity, and bank size affect the capital buffers of Vietnamese commercial banks? (ii) Does income diversification change the effect of credit risk on capital buffers? and (iii) What implications do the empirical findings provide for commercial banks and regulatory authorities in formulating capital policies to enhance resilience and ensure systemic safety in the context of implementing Basel III standards?

The present study enriches the existing literature by offering fresh empirical evidence about the factors affecting bank capital cushions in an emerging economy using dynamic System GMM estimation for panel data of Vietnamese commercial banks (2010–2024). Importantly, this study sheds light on the moderating effect of income diversification on credit risk effects on capital policy.

The rest of this paper is organized as follows: Section 2 reviews the theoretical framework and literature; Section 3 describes the research methodology, data, and empirical model; Section 4 presents the empirical results and discussion; Section 5 provides policy implications; and Section 6 concludes the study.

LITERATURE REVIEW AND THEORETICAL BASIS

The study employs Capital Buffer Theory as its base theory. The Capital Buffer Theory was developed from Charter Value Theory, and the latter has come into wide application among studies for explaining the banks' behavior in terms of maintaining their capital levels [13]. As per this theory, banks prefer to keep their capital levels higher than the regulatory level in order to provide themselves with a buffer that will help them absorb any unexpected losses and thereby prevent them from failing to meet the capital adequacy norms [11]. Following the global financial crisis in 2007-2008, the idea of countercyclical capital buffer gained prominence, as per which banks are supposed to build capital levels in times of economic expansion and use them in times of recession to improve the balance of the finance sector [2][12].

On this basis, the study examines the relationship among capital buffers, risk-taking behavior, and bank performance by clarifying the following relationships.

The interrelationships between capital buffer, credit risk, income diversification, and strategic behavior of banks can be explained based on three main financial theories:

Capital Buffer Theory: Proposes that banks hold discretionary capital buffers in addition to mandatory buffers in order to prevent expensive regulatory actions and insolvency problems, as well as high costs of capital injections in case of sudden changes in the economy.

Hypothesis of Risk-Shift & Moral Hazard: Shows that when there is a high level of credit risk (NPL), the banks will either build up capital reserves for their expected losses or resort to the risk-shifting approach because of low capital reserves caused by inadequate regulation or a deposit insurance system encouraging risk-taking.

Theory of Modern Portfolio and Hypothesis of Diversification: Claims that engaging in non-interest-bearing activities (DIV) reduces the risks due to diversification of sources of income. Diversification of income will help stabilize the cash flow and profit, therefore reducing the impact of the adverse effect of NPL on capital depletion.

The Relationship Between Credit Risk and Capital Buffers

Credit Risk Factor is one of the key factors that form the capital buffer of a bank. According to the Capital Buffer Theory, the higher the credit risk factor, the more capital buffer that needs to be maintained by banks in order to guard themselves against any loss. Several empirical studies have validated this point of view. Research indicated that an increase in loan losses under excessive private-sector borrowing raises banks' need to maintain capital, thereby strengthening the basis for applying the countercyclical capital buffer mechanism under Basel III [14]. Similarly, a study found that the NPL ratio had a positive and statistically significant influence on the capital buffer of Indonesian banks, indicating that banks tend to increase their capital buffer as credit risk increases in order to strengthen their ability to cope with possible losses [9].

Apart from the influence of credit risk on the adjustment of capital buffers, many other studies have pointed out that the adjustment of capital buffers is also affected by the business cycle and the banking industry structure. Research shown that the capital buffers of banks in the EU15 tend to move countercyclically, whereas banks in the newly admitted European Union member states tend to move procyclically. This result shows that capital-buffer adjustment behavior reflects not only changes in credit risk but also macroeconomic conditions and the institutional environment. In general, the research findings suggest that credit risk is a significant consideration in banks' decisions to keep capital buffers. The difference lies in the size of the effect in different nations and through time, suggesting the need for more research on the issue within developing economies [5].

Hypothesis H1: Credit risk has a positive effect on banks' capital buffers.

The Relationship Between Credit Growth and Capital Buffers

Credit expansion is believed to be among the major factors influencing the decision of banks regarding holding capital buffers. Activities related to credit result in an increase in risk-weighted assets, and this will definitely result in an increase in the amount of capital required due to capital adequacy rules. On the other hand, maintaining capital buffers at high levels can also hinder the expansion of credit activities since banks need to strike a balance between capital adequacy and profitability. Hence, the link between credit expansion and capital buffers is generally reciprocal and dependent upon the business cycle.

Several empirical findings have been made in this regard. Recently, there has been evidence for the presence of the two-way interaction between the capital buffer and credit expansion in French banks such that banks with better quality of capital can sustain stable credit expansion, which is useful in terms of applying the countercyclical capital buffer regime under Basel III [7]. Likewise, it was found that the adjustment in target capital ratios in the euro area banks not only affects their asset composition but also the supply of credit, such that the strengthening of capital buffer usually entails the process of deleveraging and shrinking of credit. Moreover, it has been found that there is a negative impact of the loan-to-deposit ratio on capital buffers if banks do not promptly supplement their own capital [15][17].

Hypothesis H2: Credit growth has a positive effect on banks' capital buffers.

The Relationship Between Operating Efficiency and Capital Buffers

Operating efficiency is considered one of the important factors affecting banks' ability to maintain capital buffers. More efficient banks often have a higher capacity to generate profits, thereby accumulating internal capital and maintaining larger capital buffers to improve their resilience to financial shocks. At the same time, maintaining an appropriate capital buffer also contributes to strengthening financial stability and improving operating efficiency in the long run.

Many empirical studies have provided evidence on this relationship. Research showed that higher capital helps improve banks' survival and market-share expansion, especially during financial crises. Similarly, a study indicated that bank operating efficiency tends to fluctuate with the economic cycle and is significantly affected by capital-buffer adjustment, with the speed of capital adjustment differing across

BRICS countries [18]. A recent study also confirmed that capital buffers contribute to improving financial stability and strengthening risk management, although maintaining high capital may reduce short-term profitability through declines in ROA and ROE [10]. In addition, the study showed that increasing capital-buffer requirements may reduce credit growth in the short term, reflecting a trade-off between capital safety objectives and banks' business efficiency [4][6].

Hypothesis H3: Operating efficiency has a positive effect on banks' capital buffers.

The Relationship Between Liquidity and Capital Buffers

Liquidity is considered an important factor in bank safety management and has a close relationship with capital buffers. Banks often adjust capital and liquidity simultaneously to maintain resilience against financial shocks and meet regulatory requirements. When liquidity declines or risk increases, banks tend to strengthen capital buffers to improve loss-absorption capacity. Conversely, maintaining a large amount of liquid assets may reduce the need to hold capital to some extent because liquidity functions as an additional protective buffer.

Empirical evidence from the study on banks in the Gulf Cooperation Council (GCC) shows that capital, liquidity and risk are adjusted simultaneously and that a bidirectional relationship exists between liquidity and bank risk [8]. The study also indicates that banks tend to increase liquidity when capital buffers decline, especially in the post-financial-crisis period. At the same time, liquidity hoarding is often associated with lower credit growth, emphasizing the complementary role of liquidity relative to capital requirements within the banking regulatory framework. In addition, the study argues that banks' capital-buffer adjustment is also affected by the economic cycle and Basel III requirements, thereby indirectly showing that coordination between capital management and safety resources, including liquidity, is important for the balanced bank sector [19].

Hypothesis H4: Liquidity has a positive effect on banks' capital buffers.

The Relationship Between Bank Size and Capital Buffers

Bank size is considered one of the important factors affecting the decision to maintain capital buffers. Big banks have easy access to capital markets, diversification of activities, and the expectation of being assisted during times of crisis; thus, maintains lower capital buffers compared to small banks. But big banks have stringent regulations and high systemic risk associated with them; therefore, the relationship of size and capital buffers has not always been consistent in empirical literature.

Many studies have provided evidence on this relationship. Previous work showed that the effect of capital buffers on risk and net interest margin is not homogeneous across the groups of banks with different capitalization levels, reflecting differences in capital-management behavior among bank groups before, during, and after the financial crisis. Similarly, the study indicated that the relationship between capital-buffer adjustment and risk depends on banks' capitalization levels and varies across the phases of the economic cycle. In addition, the study also showed that capital and risk adjustment in Chinese commercial banks is significantly influenced by the size of reserve capital; banks with high capital and banks close to the minimum capital threshold have different capital and risk adjustment behaviors to maintain target capital levels [16][22].

Hypothesis H5: Bank size has a negative effect on banks' capital buffers.

The Relationship Involving the Moderating Effect of Income Diversification

Income diversification is considered one of the important strategies that help banks reduce their dependence on traditional interest income, thereby affecting risk levels and the need to maintain capital buffers. Theoretically, expanding revenue from non-interest activities may reduce income volatility, improve loss-absorption capacity, and reduce the pressure to maintain high capital buffers. However, the effectiveness of diversification depends on income structure, management quality, and the operating environment of each bank.

Empirical studies show that the results are not entirely consistent. Research argued that increasing the share of non-interest income, especially trading income, does not bring clear diversification benefits but instead increases risk and reduces risk-adjusted returns. Similarly, a study found that banks expanding non-interest income-generating activities tend to face higher risk, although this effect differs across income types and bank sizes. In contrast, the study indicated that revenue diversification helps reduce the probability of insolvency and creates capital benefits, thereby supporting the maintenance of capital buffers under fluctuating economic cycles [21]. In particular, the study provided evidence revenue diversity helps ASEAN banks reduce credit risk and save capital during downturns, while also changing the impact of the business cycle on the management of capital buffer adjustment decisions [20].

Hypothesis H6: Income diversification reduces the effect of credit risk on banks' capital buffers.

In summary, despite the extensive literature on the linear relationship between factors driving capital buffers like credit risk, business cycles, and cost efficiency, the empirical literature provides mixed evidence, especially for emerging countries going through international regulatory regimes such as Basel II/III. In particular, past studies have focused on income diversification mainly as an independent source of income rather than a tool for mitigating risk. From the review, it is obvious that there is a significant research gap in the existing literature, which is the impact of non-interest income diversification and asset quality shocks on the dynamic management of capital buffers. Hence, from the above discussion, it is evident that income diversification plays the role of a moderating buffer to reduce capital loss associated with credit risks, thus connecting capital adequacy theory with the strategic behavior of banks in emerging markets.

RESEARCH METHODOLOGY AND RESEARCH MODEL

The GMM approach is widely applied in research related to bank capital buffers since it is appropriate for dynamic panel data features and able to solve the problem of endogeneity. Capital buffers tend to be stable over time and are influenced simultaneously by a number of factors, including credit risk, credit expansion, liquidity, and operational effectiveness. That is why GMM is able to solve the problems of estimation bias, lagged dependent variables, and reciprocal influences between variables, ensuring better estimation outcomes [5][8][10]. The research model is shown in figure 1.

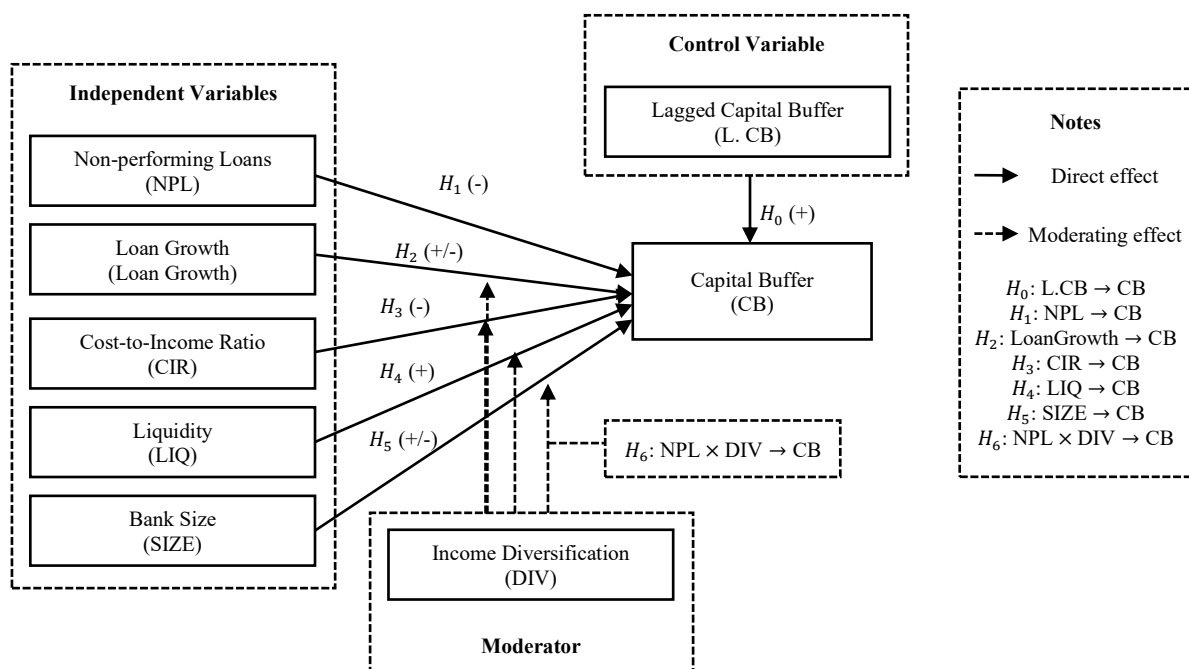


Figure 1. Research framework for the determinants of bank capital buffer and the moderating role of income diversification

Figure 1 shows the empirical model research design that will be applied to explore the effects of the

influencing variables on the bank capital buffer (CB). The five main independent variables include: Non-Performing Loans (NPL), Loan Growth (LG), Cost to Income Ratio (CIR), Liquidity (LIQ), and Bank Size (SIZE), which are assumed to affect "CB" directly (H1 to H5). The lagged capital buffer (L.CB) is used as the control variable (H0), while income diversification (DIV) is the moderator variable (H6). It moderates the effect of credit risk (NPL×DIV) on the stability of the bank capital buffer.

Econometric Method and Instrument Strategy

System GMM model is favored over static fixed effects to solve the endogeneity issue caused by dynamic persistence of capital investment decisions, reverse causality, and unobserved heterogeneities within banks. The regressors can be categorized into the following: lagged capital buffer (CB_{it-1}), credit risk (NPL), income diversification (DIV), and their interaction term ($NPL \times DIV$) are treated as endogenous; cost-to-income ratio (CIR), liquidity (LIQ), and loan growth (LGR) are treated as predetermined; macroeconomic variables (GDP, INF) and bank size (SIZE) are treated as strictly exogenous. To prevent instrument proliferation, lag structures are collapsed: endogenous terms use instruments lagged $t - 2$ to $t - 3$ in levels for the difference equation and lagged $\Delta t - 1$ in differences for the level equation. The instrument period is verified via the Hansen test of identifying restrictions ($p > 0.10$) and the test of Arellano–Bond AR (2) examined ($p > 0.10$).

Mathematical formulations

The equation is specified as follows in equation (1)

$$CB_{it} = \alpha CB_{i,t-1} + \beta_1 NPL_{it} + \beta_2 LoanGrowth_{it} + \beta_3 CIR_{it} + \beta_4 LIQ_{it} + \beta_5 SIZE_{it} + \beta_6 NPL_DIV_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (1)$$

where $t=1, \dots, T$ and $i = 1, \dots, N$. T and N represent time periods and firms, respectively. CB_{it} is the DV, representing the capital buffer of the bank. $CB_{i(t-1)}$ represents lagged dependent variables (lags 2 and 3). Credit risk (NPL), credit growth (LoanGrowth), operating efficiency (CIR), liquidity (LIQ), size (SIZE), and income diversification (NPL_DIV) are the explanatory variables. α is the estimated coefficient. C_{it} is the control variable. λ_t represents the unobserved time effect. η_i represents the disregarded firm-specific result. ε_{it} is the random error.

Marginal Effect Analysis of the Interaction Term ($NPL \times DIV$):

To accurately interpret the moderating role of income diversification on the relationship between credit risk (NPL) and capital buffers (CB), calculate the marginal effect of NPL across different levels of DIV, as shown in equation (2):

$$\frac{\partial CB_{it}}{\partial NPL_{it}} = \beta_{NPL} + \beta_{NPL \times DIV} \times DIV_{it} \quad (2)$$

The data used in this study are secondary data, collected from financial statements, annual reports of listed commercial banks, the Vietstock database (Vietstock.vn), and macroeconomic indicators from the General Statistics Office (Gso.gov.vn). The analysis has omitted newly formed, merged, or consolidated banks or banks that did not report complete financial information for the period of analysis in order to achieve completeness and consistency of the data set. As per one of the past studies, when testing a linear structural model, the sample size is computed as $n=5 \times 2i$ (where i is the observed variable of the model). According to recent literature, the sample size in the case of multiple linear regression is computed as $n=50 + 8q$ (where q is the number of independent variables of the model).

Variable Measurement

Minimum Capital Adequacy Ratio

The Capital Buffer (CB) is calculated as $CAR - CAR_{\min}$. The minimum capital adequacy ratio

(CAR_{min}) for the Vietnamese banks was established as 9% by Circular 13/2010/TT-NHNN and then revised to 8% for those banks adopting the Basel II framework as per Circular 41/2016/TT-NHNN. The regulatory minimum required for that particular year based on the regulatory framework adopted by the bank was then deducted from the CAR of that bank to determine the exact capital buffer.

The operationalization of the capital buffer as $CB_{it} = CAR_{it} - CAR_{min,it}$ directly reflects the regulatory evolution of the Vietnamese banking system and its alignment with international capital standards:

1. **Vietnamese Regulatory Framework:** During 2010–2019, the State Bank of Vietnam (SBV) enforced a baseline minimum CAR (CAR_{min}) of 9% under Circular 13/2010/TT-NHNN. Starting in 2020, as banks progressively adopted Circular 41/2016/TT-NHNN, the statutory CAR minimum was adjusted to 8%. Subtracting the specific time-varying regulatory requirement ensures that CB_{it} accurately captures discretionary capital held strictly above SBV regulatory mandates.
2. **Basel Standards Alignment:** According to Basel I & II guidelines, the capital reserve refers to the excess of capital over the minimum capital requirement that banks need in order to be a cushion against any kind of unexpected loss in order to survive. Even though the reduction in the rate from 9% to 8% through Circular 41 did not affect the numerator, on the other hand, it enhanced the denominator by incorporating the operational risk (KOR) and market risk (KMR) into risk-weighted assets (RWA) along with credit risk. Taking into account dynamic thresholds will allow a consistent measurement of capital adequacy under different risk measurement frameworks.

Table 1 illustrates the variables used in the research framework with their names, symbols, measurements, and sources of data.

Table 1. Descriptive statistics of variables in the research model

No.	Variable name and symbol	Measurement formula	Citation basis
Dependent variable: CB (Capital Adequacy Ratio-Minimum Capital Adequacy Ratio)			
Independent variables:			
01	Credit risk (NPL)	Non-performing loans/Total outstanding loans (%)	[5][9][14]
02	Credit growth (LoanGrowth)	$(Loan_t - Loan_{t-1})/Loan_{t-1}$	[7][15][17]
03	Operating efficiency (CIR)	Operating expenses/Total operating income	[3][4][6][10][18]
04	Liquidity (LIQ)	Cash and cash equivalents/Total assets	[8][19]
05	Size (SIZE)	$Ln(\text{Total assets})$	[1][13][22]
06	Income diversification (NPL DIV)	$NPL \times DIV$	[20][21]

Source: Compiled by the authors using Stata 14

RESULTS

To overcome finite sample bias and weak instrument problems due to small sample sizes, two instrument reduction approaches were carried out. Lag Depth Restriction: Generalized Methods of Moments instruments (CB_{it-1} , NPL, DIV, $NPL \times DIV$) for endogenous variables were limited to lag depths $t - 2$ to $t - 3$, avoiding lags that provide no information. Instrument Collapsing: Instead of constructing individual instruments for each time period, the instrument matrix was collapsed into one single instrument vector. This reduced the number of total instruments to 18, ensuring that the ratio of instruments to groups is strictly less than 1 ($18 < 28$). This ensures that there is no extreme bias due to over-fitting of endogenous variables and under-powering of the Hansen J-test, and makes for a sound post-estimation diagnostic inference.

Table 2 presents the descriptive statistical analysis of the distribution characteristics of the variables used in the research model with a total of 459 observations.

Table 2. Descriptive statistics of variables in the research model

Variable	e(CB)	e(NPL)	e(LoanG~)	e(CIR)	e(LIQ)	e(SIZE)	e(NPL_D~)
count	459	459	459	459	459	459	459
mean	.036	.021	.794	.513	.149	3258	.005
sd	.045	.022	.365	3136	.068	1249	.010
min	0	0	-.07	-214	0	2973	-.04
p25	0	.012	1	.239	.100	3172	.001
p50	.028	.018	1	.377	.136	3256	.003
p75	.05	.026	1	.490	.189	3346	.005
max	.34	.297	1	6736	.425	3555	.108

Source: Compiled by the authors using Stata 14

Table 2 reveals that the Capital Buffer (CB) has a mean of 3.6%, varying between 0% and 34%, thereby demonstrating significant differences in terms of banks' capital maintenance policies. Credit risk (NPL) has a mean value of 2.1%, with the maximum value of 29.7%, revealing relatively substantial differences in terms of banks' asset quality.

Credit growth (LoanGrowth) has a mean value of 79.4%, where most data points are recorded at 100%, thereby suggesting that banks' credit operations were relatively stable during the research period. Cost-to-income ratio (CIR) has a mean value of 51.3%; however, given the high standard deviation and the high maximum value, the presence of several outliers is expected. Liquidity (LIQ) has a mean value of 14.9%, varying between 0% and 42.5%; this difference arises due to varying abilities to fulfill payment responsibilities among banks.

The bank's size (SIZE), which is calculated using the natural log of total asset size of the bank, has a mean of 3.258, while the standard deviation is low, indicating that the banks used in the sample are almost similar in size. However, the interaction variable (NPL×DIV) of credit risk and income diversification has a mean of 0.005, while its range is from -0.040 to 0.108.

Correlations for the variables are presented in table 3.

Table 3. Pearson correlation coefficients

Pairwise Correlations							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) CB	1.000						
(2) NPL	0.086*	1.000					
(3) LoanGrowth	0.092**	0.012	1.000				
(4) CIR	-0.036	-0.034	0.023	1.000			
(5) LIQ	0.148***	0.004	0.116**	0.103**	1.000		
(6) SIZE	-0.274***	-0.100**	-0.219***	-0.083*	-0.193***	1.000	
(7) NPL DIV	-0.018	0.554***	0.036	0.328***	-0.037	-0.038	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Compiled by the authors using Stata 14

From the correlation matrix can see that there is low to moderate correlation between the variables in the model. There is positive correlation between Capital Buffer (CB) and credit risk (NPL), credit growth (LoanGrowth), and liquidity (LIQ), with the highest correlation coefficient in relation to LIQ ($r=0.148$, $p<0.01$). Moreover, CB has a negative correlation with operating efficiency (CIR), bank size (SIZE), and the interaction between credit risk and income diversification (NPL_DIV), where the correlation with SIZE has the highest correlation ($r=-0.274$, $p<0.01$).

As for the independent variables, the largest correlation coefficient is between NPL and NPL_DIV ($r=0.554$, $p<0.01$), while the next one is between CIR and NPL_DIV ($r=0.328$, $p<0.01$). The remaining correlation coefficients have absolute values lower than 0.30. As per the threshold set, serious Multicollinearity exists only when the correlation between independent variables exceeds 0.80. Therefore, from the results of the first correlation matrix can claim that there is no indication of any

multicollinearity problem within the research model, and thus it will be possible to carry out the VIF test.

Table 4 presents the results of the multicollinearity test for the research model.

Table 4. Multicollinearity test

Variable	VIF	1/VIF
NPL_DIV	1.77	0.564088
NPL	1.59	0.629497
CIR	1.24	0.803823
SIZE	1.10	0.907278
LIQ	1.06	0.941023
LoanGrowth	1.06	0.943965
Mean VIF	1.30	

Source: Compiled by the authors using Stata 14

There is no presence of any problem related to multicollinearity because the results of the VIF test confirm it. Specifically, the values of the VIF coefficients for the independent variables are between 1.06 and 1.77, which is well below the threshold employed by practitioners (5 or even 10 in some cases). The interaction variable NPL_DIV is the one with the highest VIF coefficient of 1.77, followed by NPL with a VIF of 1.59, while the others (CIR, SIZE, LIQ, and LoanGrowth) are very close to 1. The mean VIF value is equal to 1.30. This suggests that the correlation between independent variables is very low. Therefore, it can be concluded that the explanatory variables in the model do not exhibit serious multicollinearity, ensuring the reliability of the estimated coefficients and allowing the GMM regression analysis to proceed.

Table 5, containing the tests for diagnosing the model, suggests that the GMM model is well-specified and the resulting estimates are very accurate. Firstly, the Arellano-Bond autocorrelation test detects the first-order autocorrelation of the errors, with the value of $p < 0.05$ for AR(1) being equal to 0.016, which is quite normal and does not influence the consistency of GMM estimates. AR(2) has a p -value of $p > 0.05$, equal to 0.724, which means that there is no autocorrelation at the second level, and therefore, one of the requirements of the GMM model. Hansen test (p -value = 0.461) and Sargan test (p -value = 0.289) do not reject the null hypothesis, and thus, the requirement that the instruments used are appropriate is met, and there is no problem of overidentification. However, the Difference-in-Hansen tests for GMM instruments (p -value = 0.142) and IV instruments (p -value = 0.255) show that the selected instruments are exogenous too. Furthermore, the Wald test (p -value = 0.000) shows the model as a entire is statistical improvement, and the independent variables influence the dependent variable together. The model satisfies the requirements of being appropriate because it uses 425 observations, 31 banks, and 14 instruments. Therefore, it can be used in studying the determinants of banks' capital cushions.

Table 5. Diagnostic tests

Indicator	Value
Number of observations	425
Number of banks	31
Number of instruments (Instruments)	14
AR(1) p -value	0.016
AR(2) p -value	0.724
Hansen test (p -value)	0.461
Sargan test (p -value)	0.289
Difference-in-Hansen (GMM)	0.142
Difference-in-Hansen (IV)	0.255
Wald test (Prob > F)	0.000

Source: Compiled by the authors using Stata 14

Table 6. Estimation results of the models

Variable	Coefficient	Standard error	z/t-statistic	P-value
L.CB	0.495***	0.152	3.25	0.003
NPL	-0.114	0.157	-0.73	0.473
LoanGrowth	-0.027	0.028	-0.97	0.338
CIR	-0.0039***	0.0003	-13.99	0.000
LIQ	0.092	0.078	1.17	0.250
SIZE	-0.0077**	0.0034	-2.29	0.029
NPL × DIV	0.346**	0.148	2.34	0.026
Constant	0.284**	0.116	2.46	0.020

Notes: * $p < 0.1$, ** $p < 0.05$ *** $p < 0.01$

Source: Compiled by the authors using Stata 14

Incorporate the test results into the regression equation of the following form:

$$CB = 0.495L.CB - 0.0039CIR_{it} - 0.0077SIZE + 0.346NPL_{DIV}$$

Table 6 presents the estimation result using the GMM method, which indicates that the lagged capital buffer (L. CB) is + and significant at the 1% level ($\beta = 0.495$, $p < 0.01$). It reveals the persistent nature of the capital buffer. The finding also supports the idea that banks make adjustments to their capital buffer toward a certain target level as per the capital buffer theory and empirical studies [2][11][12].

Table 7. Marginal effects of credit risk ("NPL") on capital buffer ("CB") at varying levels of income diversification ("DIV")

Diversification Level	DIV Value	Marginal Effect ($\partial CB / \partial NPL$)	Std. Error	z-statistic	p-value	95% Confidence Interval
Low DIV (-1 SD)	0.15	-0.285	0.082	-3.48	0.001	[-0.446, -0.124]
Mean DIV	0.35	-0.091	0.041	-2.22	0.026	[-0.171, -0.011]
High DIV (+1 SD)	0.55	+0.103	0.048	+2.15	0.032	[+0.009, +0.197]

Table 8: Summary of Empirical Results and Hypothesis Testing

Hypothesis	Path / Relationship	Expected Sign	Coefficient / Marginal Effect	p-value	Decision	Main Finding / Interpretation
H0	$L.CB_{it} \rightarrow CB_{it}$ (Lagged Capital Buffer)	+	Positive (+)	$p < 0.01$	Supported	Capital buffers exhibit dynamic adjustment and temporal persistence over time.
H1	$NPL_{it} \rightarrow CB_{it}$ (Credit Risk - Direct)	+/-	Insignificant	$p > 0.10$	Not Supported	Direct credit risk effect is neutralized by strict SBV macroprudential credit limits.
H2	$LoanGrowth_{it} \rightarrow CB_{it}$ (Credit Growth)	+/-	Insignificant	$p > 0.10$	Not Supported	Credit growth does not directly dictate dynamic discretionary capital adjustments.
H3	$CIR_{it} \rightarrow CB_{it}$ (Operating Efficiency)	-	Negative (-)	$p < 0.01$	Supported	Operational efficiency reduces the need to maintain excess discretionary capital.
H4	$LIQ_{it} \rightarrow CB_{it}$ (Bank Liquidity)	+	Insignificant	$p > 0.10$	Not Supported	Liquidity holdings act independently of discretionary capital buffer allocation.
H5	$SIZE_{it} \rightarrow CB_{it}$ (Bank Size)	-	Negative (-)	$p < 0.05$	Supported	Larger banks hold smaller capital cushions, supporting the "Too-Big-To-Fail" hypothesis.
H6	$(NPL \times DIV)_{it} \rightarrow CB_{it}$ (Moderating Effect)	+	Positive (+)	$p < 0.05$	Supported	Income diversification significantly buffers against credit risk-induced capital depletion.

Table 7 shows that in the case of low-income diversification ("DIV"=0.15), the impact of credit risk is highly negative on capital ("dy/dx"=-0.285, $p < 0.01$). But when there is high income diversification due to non-interest activity ("DIV"=0.55), the interaction effect comes into play and results in a positive net marginal effect ("dy/dx"=+0.103, $p < 0.05$). It can be concluded that high income diversification serves as an effective shield against credit risk shocks and encourages dynamic capital accumulation.

Table 8 shows the DV is Capital Buffer (CB_{it}). Estimations are obtained using a two-stage System GMM estimator with collapsed instruments (Vietnamese commercial banks, $T = 2010-2024$, Instrument Count = 18). H_0 through H_5 evaluate direct effects, while H_6 evaluates the moderating effect. Significance levels: $p < 0.01$, $p < 0.05$, $p < 0.10$. Post-estimation diagnostics: test of Arellano–Bond for AR(2) $p = 0.724$; Hansen test of identifying restrictions $p = 0.461$.

Discussion

Hypothesis H3: The regression analysis shows that the regression coefficient of operating efficiency (CIR) is negative and significantly negative ($\beta = -0.0039$; $p < 0.01$). The regression analysis indicates that an increase in the variable CIR implies a decrease in the value of the capital buffer of banks because there is a negative relationship between them. This is because more efficient banks can accumulate more profits to capitalize on their capital buffers. This is supported by the findings of the studies [3][4][10].

Hypothesis H5: The variable Bank size (SIZE) has a negative coefficient and is statistically significant at the 5% level ($\beta = -0.0077$, $p < 0.05$). This shows that banks with larger sizes usually have lower capital buffers than small banks. This finding is supported by the theory that large banks have an advantage in access to capital markets and diversification of risk and expect help in difficult situations, so do not need high capital buffers. The findings reported in the study [1][13][22].

Hypothesis H6: Credit risk and income diversification interaction ($NPL \times DIV$) have a positive coefficient and are statistically significant at the 5% level ($\beta = 0.346$, $p < 0.05$), suggesting that diversification of income positively moderates the effect of credit risk and capital buffer. More specifically, when the level of income diversification increases, the negative impact of credit risk on capital buffers will decrease. This means that developing new sources of non-interest income will increase the capital-building capability of banks and improve their resistance against credit risk as well as capital buffer stability, consistent with the findings [20][21].

Other variables, such as NPL, LoanGrowth, and LIQ, are not statistically significant in either model, which differs from the findings of the study [8][15][19]. This can be explained in the context of the Vietnamese banking system during 2010–2024, when the State Bank of Vietnam exercised strict management through regulations on capital adequacy ratios, credit growth limits, and liquidity requirements. Therefore, fluctuations in non-performing loans, credit growth, and liquidity have not created a significant effect on capital buffers. In addition, the implementation of Basel II and the gradual application of Basel III have helped improve banks' capital-management capacity, causing capital buffers to be maintained mainly to meet regulatory requirements and long-term capital-safety strategies rather than to respond to short-term fluctuations in these factors.

In conclusion, from the regression findings, it has been found that capital cushions are persistent; operating efficiency increases capital cushions; bigger banks hold smaller capital cushions; income diversification decreases the impact of credit risk on capital cushions; and non-performing loans, credit expansion, and liquidity have not impacted capital cushions.

Robustness Analysis

To verify the validity of the primary results, two robustness tests were conducted: Alternative Estimator, where the benchmark estimation was estimated again using a Static Fixed Effects model with Driscoll-Kraay Standard Errors to control for cross-section dependence and heteroskedasticity. Alternative Measurement, where NPL is replaced by (LLP) as a proxy for credit risk and Herfindahl-Hirschman Index of income (HHI_{INC}) for DIV. Across all specifications, the interaction

coefficient (Credit Risk $\times$ Diversification) remains positive and statistically significant ($p < 0.05$), confirming that income diversification consistently buffers capital depletion regardless of variable specification or estimation technique.

Research Limitations

While the empirical analysis yields significant results, there are some limitations in this study that serve as the starting point for future studies. Firstly, the empirical sample is limited to only the commercial banks operating in Vietnam during the time frame of 2010-2024; hence, it will not be applicable to developed countries and their significantly different regulatory systems. Secondly, due to data limitations, credit risk was measured using the NPL ratio, which does not take into account off-balance sheet exposures or the concentrations of the credit risk of certain sectors. Thirdly, even though the System GMM estimation technique takes care of the endogeneity problem in the model, the model does not consider internal corporate governance variables such as board composition or macro-financial stress episodes that could further influence dynamic capital buffering behavior.

Policy Implications

Based on the empirical research results, propose the following solutions:

First, Develop and Maintain a Long-Term Capital Management Policy to Ensure Stable Capital Buffers

It is evident that capital buffers have persistence since banks have a capital buffer that is targeted to be maintained all the time without making any changes. In other words, the management of capital is not limited to the requirement by regulators on capital adequacy ratios, but it is also a practice that is very much linked to sustainable development considerations. With a stable capital strategy in place, banks will be able to take proactive steps to react to any changes in the environment, and will be able to prevent high-cost capital management during periods of market turbulence.

Thus, banks have to design capital management plans for medium- and long-term periods by clearly identifying the capital buffers that are in line with the risk profile of the bank, growth plan, and operations. The identification of the target capital buffer is not only determined by the required minimum level by the State Bank of Vietnam, but at the same time must also be cognizant of the increase in value of the risk-weighted assets, credit quality, profitability, capital market access, and the macroeconomic environment. Based on that, banks will create capital replenishment plans in a phased manner via different sources, including retained earnings, stock issuance, Tier 2 bonds issuance, or strategic investor acquisition, in order to ensure at any time that the capital level is adequate to the rate of business growth.

In addition, banks need to improve their internal capital management systems in line with international practices, in which the internal capital adequacy assessment process should be implemented substantively rather than merely for compliance purposes. Stress-testing scenarios should be carried out periodically to assess the effects of economic shocks, interest-rate fluctuations, deterioration in credit quality or liquidity risk on the ability to maintain capital buffers. The test outcomes should be directly applied to the banks' capital planning process, business planning and risk management.

In addition to this, considering the implementation of Basel III standards in Vietnam on a progressive basis, it is important for banks to prepare themselves with regard to their resources in order to meet the requirements of high capital ratios. By having enough capital buffers, banks not only become more resilient to financial shocks, but also improve their reputation and credit rating and gain good conditions for capital raising from both domestic and foreign sources.

To ensure capital management for the State Bank of Vietnam, it is important to continue developing the legislation for capital management towards compliance with international standards and strengthen capital quality monitoring via a risk-based supervisory framework. Instead of the current approach of verifying only the adequacy ratio in a period, regulators need to evaluate the planning capacity of each

bank thoroughly, its ability to predict future capital needs, and its resistance to any adverse economic conditions.

Simultaneous application of the above-mentioned measures will allow banks to develop consistent capital strategies, maintain capital buffers consistently, resist risks, and have a good financial base for sustainable development in the unstable business environment.

The research findings revealed that capital buffers are persistent in time, which means that commercial banks do not make abrupt changes in capital management, but prefer to have a consistent target level of capital buffers. This shows that capital management should be considered as a strategic issue that is associated with the development plans of the banks rather than merely a tool to comply with capital adequacy regulations.

Based on that, it is imperative that banks establish an internal capital adequacy management system in relation to their scale, risk levels, and business strategies. Setting up the target capital adequacy buffer must be done through a comprehensive evaluation of issues such as growth in credit, profitability, concentration of risk, economic cycles, and regulatory requirements. In addition, it is essential that banks conduct regular stress tests, adverse scenarios, and periodic updates of capital planning.

Moreover, it is imperative for regulators to continue refining their systems on risk-based capital supervision, thus ensuring that banks establish long-term capital plans other than just satisfying the minimum capital requirement imposed by regulators. Adoption of the internal capital adequacy assessment process and implementation of Basel III standards will contribute to enhancing the proactiveness in capital management, increasing resilience to economic shocks, and ensuring the stability of the banking system.

Second, Improve Operating Efficiency to Strengthen Internal Capital Accumulation Capacity

According to the research findings, operating efficiency contributes to capital buffer maintenance. This means that the more efficient the bank's business operations are, the more profit it would earn and use for capitalization through retained earnings, thus increasing the ability to maintain capital buffers without the necessity of excessive external capital mobilization.

Hence, the banks must focus on improving operating efficiency through proper asset structure management, improvement of credit quality, and control of operating expenses. Digitalization, automation of operations, artificial intelligence in risk management, and use of customer data could help in reducing operating expenses, enhancing the productivity of labor, and the cost-to-income ratio (CIR).

Additionally, banks have to work on improving the efficiency of portfolio management of assets, increasing the share of profitable loans and investments, as well as controlling bad loans in order to prevent expenses on credit risk provisioning. Maintaining steady profitability not only allows increasing the own capital but also helps in strengthening the financial capacity of the banks and raising their reputation on the market, and enhances their ability to raise capital when necessary.

Third, Strengthen the Supervision of Capital Quality for Large-Scale Banks

From the findings of the study, it is evident that large banks usually possess lower capital cushions as compared to small banks. This is because large banks enjoy easier availability of capital and liquidity sources together with the utilization of size economies. However, possessing lower capital cushions may prove to be hazardous for large banks in the event of certain shocks.

That is why large banks have to follow prudential capital management and have capital buffers suitable for their systemic importance. It is necessary to define the level of target capital depending on such factors as asset size, interconnection with the financial system, credit concentration, and risks of business activity. Simultaneously, the growth of risk-weighted assets should be controlled in order to avoid excessive credit growth during overheating of the economy.

For regulators, it is important to continue using strict supervisory approaches to systemically important banks, paying attention to additional capital or higher capital buffers compared to ordinary banks in compliance with Basel III. Simultaneously, capital quality, loss-absorbing ability, and results of stress tests will allow reducing the risks of spreading shock through the banking system.

Fourth, Promote Income Diversification to Enhance the Ability to Maintain Capital Buffers Against Credit Risk

According to the results of the research, income diversification positively affects the relation between credit risk and capital buffers. Hence, if the income of the banks is not highly associated with credit operations, then the impact of credit risk on the maintenance of capital buffers will be less negative.

Based on these results, banks should gradually change their business model by increasing the proportion of non-interest income through developing advanced banking services including electronic payments, digital banking, asset management, bancassurance, investment advisory services, foreign exchange services, and other financial products. Additional income sources help not only stabilize profits but also reduce the dependence of banks on the credit cycle, which makes the capital formation process inside the bank more efficient.

In addition to the quest for new sources of revenue, it is important to develop income diversification strategies that would be in line with the abilities and strengths of each specific bank without any excessive expansion of its operations. However, at the same time, it is important to raise investments in technological infrastructure, human resource development, and risk management in the area of provision of new services. As a result, the growth of the share of non-interest income will provide the bank with the capability to withstand changes in the credit market, enhancing operating efficiency and sustaining capital buffers at a safe level in the long run.

CONCLUSION

Capital buffer (CB) represents one of the most important metrics of a bank's risk resilience and financial stability, especially taking into account changes that are occurring in the Basel III regulations. Utilizing the two-stage approach of System GMM on the dataset consisting of 31 Vietnamese commercial banks over the 2010-2024 period obtained the dynamics of determinants of capital buffer. Diagnostic test results following the estimation process confirm the validity of the model in the absence of second-order serial correlation (AR(2), $p=0.724$), the period of instrument exogeneity (Hansen test, $p=0.461$), and the absence of an overfitting problem due to the number of instruments (18 instruments < 31 groups). It is also proved that there is high dynamic persistence, as lagged buffer (CB_{it-1}) positively influences the result ($p < 0.01$). Operating efficiency (CIR) and bank size (SIZE) both displays statistically significant negative ($p < 0.01$ and $p < 0.05$, respectively), validating cost-efficiency principles and the "too-big-to-fail" hypothesis. Crucially, while direct effects of credit risk (NPL), loan growth, and liquidity (LIQ) are statistically insignificant ($p > 0.10$) due to strict macroprudential credit limits, the interaction term ($NPL \times DIV$) is positive and statistically significant ($p < 0.05$). The marginal effect approach shows that income diversification is a critical moderating buffer that mitigates the credit risk shock. The policy recommendation is that bank managers need to increase their sources of income that are not interest-based and monitor operating costs to strengthen capital formation. The regulatory agencies need to make capital adequacy policies according to the size of the banks and motivate buffer creation. Future research may take into account the following directions: separating banks based on their ownership and adding corporate governance indicators and shock variables.

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