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## A BAYESIAN ANALYSIS OF DETERMINANTS OF NET INTEREST MARGINS OF COMMERCIAL BANKS IN VIETNAM

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### Abstract

The current article investigates the impact of bank-specific and macroeconomic factors on the net interest margin (NIM) of commercial banks in Vietnam. In order to explore the association, we performed Bayesian linear regression on a dataset of 24 banks from 2008 to 2020. Our research result reveals that bank size (LNSIZE), profitability (ROA), operational cost to operating income ratio (BOPO), loan-to-deposit ratio (LDR), and non-performing loan ratio (NPL) of a bank positively affect the NIM of banks. On the contrary, bank liquidity (GWM) and loan market power (MPR) negatively affect the NIM of banks. Moreover, we suggest that macroeconomic factors, including GDP growth (GDP) and M2 money supply growth (M2), have a negative impact on NIM. Furthermore, the impact of the inflation rate (INFL) on NIM is relatively low. Our article highlights new information that improves the understanding of the NIM of banks in emerging economies like Vietnam.

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### Key Words

Commercial banks; net interest margin; Bayesian linear regression; Vietnam.

## INTRODUCTION

A commercial bank is a financial intermediary operating for profit. In particular, a commercial bank provides financial services to customers and collects fees and charges interest from the provided services to create profits (Asmar, 2018; Khoa et al., 2022). Moreover, a commercial bank acts as an intermediary for transferring capital from overfunded to underfunded places through deposit mobilization and lending to customers (Tarus, Chekol, & Mutwol, 2012). Commercial banks are the main pillars of maintaining a stable economic and financial system, particularly in developing countries, where bank loans are vital for development (Rudhani & Balaj, 2019; Tran, Nguyen & Duong, 2022). Therefore, the performance of banks is a key influencer of the economic and financial stability of any country. Rapid technological advancement, the introduction of new financial products, and the trend of globalization have increased the size and complexity of banking institutions (Moch, 2018). Furthermore, regulators have advocated the creation of larger and more complex institutions by encouraging other banks to acquire failed banks to limit the negative consequences during crisis (Barth & Wihlborg, 2016). Although banking institutions have become more complex, performance is still the main driver of their operations. NIM is an indicator reflecting the bank's performance, which is measured by the difference between interest income and expenses payable to bank investors. However, in order to achieve the profit target, commercial banks can increase the lending rate and reduce the deposit rate. However, this will make it difficult for individuals and enterprises that need capital to have access to unemployed capital and reduce the customer's debt repayment ability.

Additionally, in the context of complicated and prolonged pandemic development, business activities of individuals and enterprises become more difficult, resulting in a reduction in their debt repayment ability on schedule if they have to repay too much interest. Therefore, commercial banks have to reduce lending interest rates to support business activities as well as stimulate economic development. The income of the majority of banks comes from credit extension activities, specifically lending activities. A reduction in lending rates will reduce a bank's income as well as deposit interest rates in order to ensure that the bank's operation is still profitable. If the deposit interest rates are too low, it will be difficult for commercial banks to mobilize unemployed capital from the public.

**Figure 1:** NIM trend of Vietnam banks

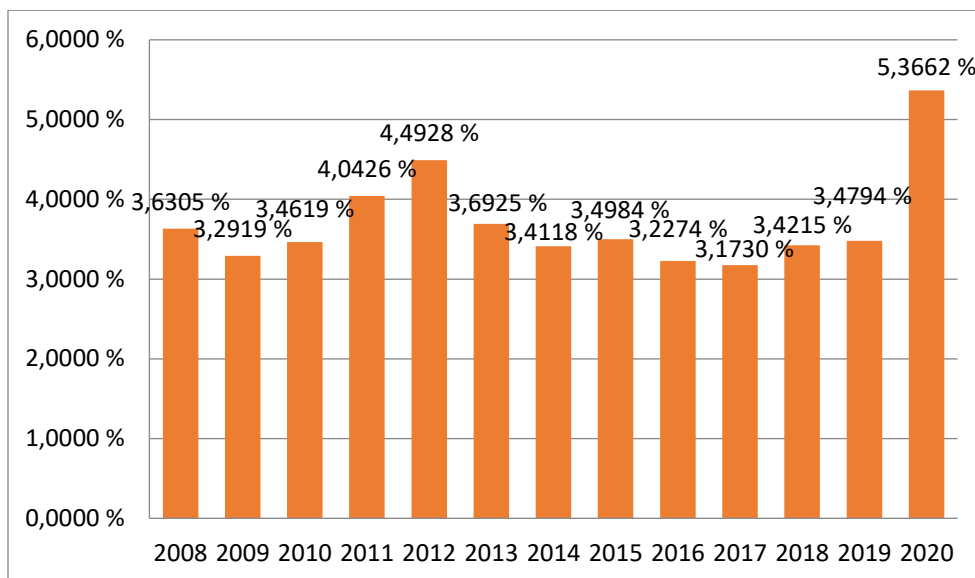


Figure 1 illustrates that the NIM decreased slightly between 2008 and 2009 and increased slightly between 2009 and 2012. Then, NIM fluctuated insignificantly in value from 3.1730% to 3.6925% between 2013 and 2019 and increased significantly in 2019–2020. In particular, in 2008–2009, the impact of the Global Financial Crisis of 2008–2009 negatively influenced Vietnam's economy. The reduction in lending interest rates to a single digit in early 2009 and interest rate support policies made credit activities of banks become tightened, resulting in a reduction of interest margin from 3.6305% in 2008 and 3.2919% in 2009. In 2010–2012, the economy gradually recovered from the crisis through monetary and fiscal policy in a strict direction to control inflation and stabilize the government's macroeconomy, and signs of further improvement were observed in the activities of the banking industry. In 2010–2011, the high inflation rate led to an increase in the lending and deposit interest rates of commercial banks, which made the NIM of banks increase significantly to 11.9075% in 2011. In 2013–2019, the State Bank of Vietnam (SBV) issued decisions to reduce lending interest rates, market interest rates, and control inflation, such as Decision No. 2646/QD-NHNN 2012, Decision 643-NHNN 2013, Decision 1424/QD-NHNN 2017, and Decision No. 1870/QD-NHNN 2019. Meanwhile, those policies affected the NIM of commercial banks, which fluctuated around 3.41% on average. 2019–2020 was the period when the whole world, in general, and Vietnam, in particular, faced a health crisis. Particularly, the outbreak and prolongation of the COVID-19 pandemic made life and economic activities become worse. People's production and business activities became difficult. SBV issued Circular No. 01/2020/TT-NHNN stipulating that credit institutions and foreign bank branches rescheduled debt repayment terms, applied exemption or reduction in interests and fees, and kept unchanged debt groups to support customers affected by the COVID-19 pandemic. Although lending interest rates were adjusted down to support customers, such

adjustment resulted in a significant reduction in deposit interest rates, only 3–5% per year on average, which created a large difference, helping the operation of commercial banks in this period gain high profits. In particular, the average NIM of commercial banks increased markedly from 3.4794% in 2019 to 5.3662% in 2020.

The present article contributes to the existing literature in numerous ways. First, unlike previous studies, we investigated the factors affecting the NIM of commercial banks through the use of the Bayesian regression method. In contrast to the frequency school regression, Bayesian regression models utilize poor distributions allowing us to incorporate external knowledge into our research model (van de Schoot et al., 2021). Second, we utilized 24 Vietnamese banks from 2008 to 2020 to study the Vietnamese banking system. Therefore, the sample of the article is small (only 312 observations). In this case, the Bayesian regression method performs better than the frequency school regression models (Bui & Thach, 2023). Third, because we consider both bank-specific factors and macro factors to analyze their effect on NIM, we have an overview of the set of factors affecting NIM and the effect of each factor on NIM. Our findings will assist bank managers in providing appropriate strategies to increase the NIM for banks in the context of Vietnam. Besides, the results of the present paper are reference material for researchers in this field.

The rest of the current article is structured as follows. Section 2 briefly presents the literature review. Section 3 describes the dataset, the experimental data, model, and method and provides some summary statistics. Section 4 presents and discusses the research results. Finally, Section 5 summarizes the main conclusions.

## LITERATURE REVIEW

NIM is a measure of the performance as well as the profitability of banks (Kumar, 2014). NIM is calculated by subtracting operating expenses from gross income (Ben Khediri & Ben-Khedhiri, 2011). From the perspective of industrial organizations, the difference between the price of bank intermediation and the cost of its output represents the bank's interest profitability covering the cost of intermediation. Bank-specific factors, information premiums for evaluating and monitoring investments, market structure, and risk management premium should all be reflected in the margin. NIM is a metric summarizing a bank's net interest rate of return on its core borrowing and lending activities (Khoa et al., 2022). NIM indicates the ability of the board of directors as well as the bank's staff to maintain the growth of revenues in comparison with the increase in costs (Sarwar, Muhammad, & Zaman, 2020). The change in NIM assists bank managers in making reasonable investment decisions by assessing the received income rate and the costs incurred. From an economic aspect, a higher NIM indicates that the banks are operating more efficiently, controlling payable costs more strictly, and managing profitable properties better. Hence, banks earned high profits, helping them to increase competitiveness in the market

as well as limit risks when the macro environment fluctuates. Additionally, from a social aspect, when the NIM is high and banks make a lot of profits, bank borrowers suffer from high interest rates, resulting in numerous difficulties in production and business activities and limiting the development of the economy.

The starting point of the factors affecting the bank's NIM may be the dealership model proposed by Ho and Saunders (1981). In the dealership model, Ho and Saunders (1981) considered banks as intermediaries between borrowers and lenders in the financial market. In order to analyze the determinants of bank profitability, the model proposed by Ho and Saunders has been extended by other researchers to consider the determinants of the bank's NIM in various countries and regions worldwide. Most studies divide the determinants of the bank's NIM into two main groups: the first is the group of bank-specific factors, and the second is macroeconomic factors.

## **Bank-Specific Factors**

### **Bank Size**

Bank size is measured in different ways, such as total assets, number of employees, number of customers, number of branches, customer deposits, and capital base. When evaluating the effect of bank size on the NIM of the bank, there are 2 groups of different views. According to resource-based theory, organizations with strategic resources have a competitive advantage over other organizations (Barney, 1991). Strategic resources are characterized by specific attributes, including essential resources that can enhance the performance of an organization and repel threats to its development, in addition to resources that the competitors cannot imitate, known as limited or irreplaceable resources. In light of this, Raharjo, Hakim, Manurung, and Maulana (2014) found a positive effect of bank size on NIM. The second group believes that the larger the size of assets, the lower the NIM because the higher the total assets, the less flexible, rigid, and bureaucratic it becomes, reducing the NIM of the bank. This research group received the support of Lestari, Chintia, and Akbar (2021), Khan and Jalil (2020), Hussain (2014), and Gul, Irshad, and Zaman (2011). They detected a negative effect of bank size on NIM. However, Pham, Tran, and Vo (2018), Megawaty and Ugut (2022), and Hanzlík and Teplý (2022) found that bank size did not affect banks' NIM.

### **Profitability**

Bank profitability is a key indicator of bank performance. It represents the return rate a bank has been able to generate from using the resources at its command to produce and provide services. Raharjo et al. (2014) observed the factors affecting the NIM of banks and detected that the profit margin was remarkably affected by the bank's profitability. Moreover, Endri and Marlina (2020) revealed that banks with high profitability have high NIM.

### **Operational Cost to Operating Income Ratio**

The operating expenses to gross income ratio capture the bank management's efficiency showing the number of expenses for every dollar of income the bank generates. In previous studies, Hanzlík and Teplý (2022), Sarwar et al. (2020), Pham et al. (2018), Khanh and Tra (2015), and Ben Khediri and Ben-Khedhiri (2011) indicated that operational cost to operating income ratio negatively affected NIM. Even so, Mustafa-Zatriqi and Ahmeti (2022), Lestari et al. (2021), Lee and Isa (2017), and Raharjo et al. (2014) found that operational cost to operating income ratio positively affected NIM. However, Islam and Nishiyama (2016), Khan and Jalil (2020), and Endri and Marlina (2020) demonstrated that the operating cost to operating income ratio had no effect on the bank's NIM.

### **Bank Liquidity**

Liquidity is a measure of the available cash and other assets of a bank to quickly pay bills and meet short-term business and financial obligations. Raharjo et al. (2014) and Hussain (2014) revealed that liquidity negatively impacted the bank's NIM. On the contrary, Islam and Nishiyama (2016) demonstrated that banks with higher liquidity had higher NIM. Meanwhile, Mustafa-Zatriqi and Ahmeti (2022) and Megawaty and Ugut (2022) concluded that liquidity had no effect on the bank's NIM.

### **Loan-to-Deposit Ratio**

The loan-to-deposit ratio (LDR) is the ratio between the bank's total loans and deposits. The ratio is generally expressed in percentage. If the ratio is less than one, this means the bank relies on its deposits to lend its customers without borrowing outside. On the contrary, if the ratio is more significant than one, this means the bank borrowed the money it lent back at a higher interest rate rather than relying entirely on its deposits. Banks may only make optimal returns if the ratio is high. Banks may need more liquidity to cover unforeseen funding requirements or economic crises if this ratio is too high. Mustafa-Zatriqi and Ahmeti (2022), Endri and Marlina (2020), Asmar (2018), and Raharjo et al. (2014) indicated that the loan-to-deposit ratio positively affected NIM. Studies by Hanzlík and Teplý (2022), Lestari et al. (2021), Islam and Nishiyama (2016), and Pham et al. (2018) demonstrated that the loan-to-deposit ratio and NIM had no relationship.

### **Non-Performing Loan**

A non-performing loan (NPL) is a loan that is not repaid because the borrower has not made scheduled payments within a certain period. While the exact elements of default can vary based on the terms of the particular loan, "nonpayment" is generally defined as nonpayment of principal or interest (Tran et al., 2022). Islam and Nishiyama (2016) illustrated that the non-performing loan ratio had no effect on the NIM. However, Mustafa-Zatriqi and Ahmeti (2022), Raharjo et al. (2014), and Tarus et al. (2012) detected a positive impact of non-performing loan ratio on NIM. On the contrary, Endri and Marlina (2020), Lestari et al. (2021), Khan and Jalil (2020), and Sarwar et al. (2020) demonstrated that the non-performing loan ratio negatively influenced NIM.

### **Market Power Ratio**

Raharjo et al. (2014) found no evidence regarding the effect of loan market power on the NIM of banks. Meanwhile, the research results of Mustafa-Zatriqi and Ahmeti (2022), Khan and Jalil (2020), Islam and Nishiyama (2016), Khanh and Tra (2015), and Tarus et al. (2012) indicated that loan market power had a negative effect on the NIM of banks. In contrast, Sarwar et al. (2020), Lee and Isa (2017), and Hussain (2014) concluded that loan market power and banks' NIM had a positive relationship.

### **Macroeconomic Factors**

#### **Inflation**

Inflation is used as a measure of macroeconomic stability, and it is computed by the annual consumer price index. Several pieces of literature have empirically examined the relationship between NIM and inflation. Some researchers demonstrated that an increase in inflation motivates bank performance and NIM. For instance, Hanzlík and Teplý (2022), Pham et al. (2018), Khanh and Tra (2015), Hussain (2014), Raharjo et al. (2014), Tarus et al. (2012), and Gul et al. (2011) found that the inflation rate positively affected the NIM. Notwithstanding, some literature reported otherwise. The negative impact of the inflation rate on NIM was noticed by Lestari et al. (2021) and Khan and Jalil (2020). This result implies that banks' performance and lending decrease when the inflation rate rises in an economy. However, the research results of Megawaty and Ugut (2022), Endri and Marlina (2020), and Islam and Nishiyama (2016) indicated that the inflation rate had no effect on NIM.

#### **GDP Growth**

The metric of gross domestic product (GDP) growth measures the economy's overall health. The results of the impact of this factor on NIM in previous studies are different. In previous studies, Hanzlík and Teplý (2022), Islam and Nishiyama (2016), Tarus et al. (2012), and Gul et al. (2011) found that economic growth had a negative effect on NIM. However, Megawaty and Ugut (2022), Khanh and Tra (2015), and Hussain (2014) found no evidence regarding the effect of GDP growth on NIM.

#### **Money Supply**

Monetary policy is the framework used by the Central Bank to perform its regulatory function to facilitate economic growth and stability (Nikhil & Deene, 2023). Monetary policy is determined by the relationship between the cost of borrowing money in an economy and the total amount of money available. Additionally, the Central Bank adjusts the interest rate and required reserve along with purchasing the country bond to control the money supply. The link between monetary policy and NIM has gained prominence recently, particularly after the 2008-2009 Global Financial Crisis. Khan and Jalil (2020) researched the role of factors and their impact on the NIM of banks in Pakistan and found that money supply growth and banks'

NIM had a positive relationship. Khan and Jalil (2020) explained that an increase in money supply resulted in more cash in the banks. Therefore, they increased lending, hence increasing their profits.

## DATA, MODELS, AND EMPIRICAL STRATEGY

### Dataset

We gathered secondary data on the variables at the bank level from audited consolidated financial statements of 24 joint-stock commercial banks from 2008 to 2020. In 2008–2020, we eliminated banks involved in mergers and acquisitions (M&A) events because the data of these banks were volatile and heterogeneous, thus distorting the estimation result. In addition, banks with incomplete data in 2008-2020 were removed from the sample. We tested outliers before estimating the model. Due to outliers, errors decreased, and the generalizability of the results was enhanced. Therefore, the final data included 312 observations of 24 joint-stock commercial banks in 13 years. Meanwhile, annual data on macroeconomic variables were obtained from the World Development Indicators of the World Bank.

### Models

In order to examine the effect of factors on the bank's NIM, we first consider the bank-specific factors affecting the bank's NIM as follows:

$$NIM = \alpha_0 + \beta_i BSF_i + \varepsilon. \quad (1)$$

Next, we add macroeconomic factors to equation (1) in order to examine the effect of these macroeconomic factors on the NIM of banks. Therefore, equation (2) has the following form:

$$NIM = \alpha_0 + \beta_i BSF_i + \gamma_j MF_j + \varepsilon. \quad (2)$$

where  $\alpha_0$ ,  $\beta_i$ , and  $\gamma_j$  are the coefficients of determinant variables;  $\varepsilon$  is the error term; NIM is the net interest margin (dependent variable); BSF is a vector of bank-specific factors; and MF is a vector of macroeconomic factors. Bank-specific factors include bank size, profitability, operational cost to operating income ratio, bank liquidity, loan-to-deposit ratio, non-performing loan ratio, and loans market power of banks. Macroeconomic factors comprise inflation rate, economic growth, and growth of money supply M2. Details of the measurement of each variable based on the definition are given in Table 1.

**Table 1:** Research variables measurements.

Variables	Symbol	Measurements
Dependent variable		



Net interest margin	<b>NIM</b>	Interest earned minus interest payments divided by total assets
<b>Independent variables</b>		
<b>Bank-specific variables</b>		
Bank size	<b>LNSIZE</b>	The logarithm of bank's total assets
Profitability	<b>ROA</b>	Total net income over total asset
Operational cost to operating income ratio	<b>BOPO</b>	The ratio of operating expenses to gross income
Bank liquidity	<b>GWM</b>	Liquid assets over total assets
Loan-to-deposit ratio	<b>LDR</b>	Total loan to total deposit ratio
Non-performing loan	<b>NPL</b>	Non-performing loan to total loan ratio
Market power ratio	<b>MPR</b>	The ratio of bank loans at time t to total loans within the banking sector
<b>Macroeconomic variables</b>		
Inflation	<b>INFL</b>	Annual rate of inflation (%)
GDP growth	<b>GDP</b>	Annual growth rate of GDP (%)
Money supply	<b>M2</b>	Annual growth rate of M2 (%)

### Empirical Strategy

Unlike previous studies using the frequency approach, we utilized the Bayesian approach, particularly Bayesian linear regression, in order to explore the factors affecting the NIM of banks in Vietnam. Bayes' theorem delineates an event's conditional probability based on data and previous information about the event or conditions associated with the event (van de Schoot et al., 2021).

Following the Bayesian view (Bayes, 1763), we built a Bayesian linear regression using a probability distribution of the following form:

$$y \sim N(\beta^T X, \sigma^2 I). \quad (3)$$

Here,  $y$  is formed from a normal distribution described by mean and variance values. The mean of Bayesian linear regression is the displacement of the prediction matrix multiplied by the weight matrix. The variance is the identity matrix multiplied by the square of the standard deviation ( $\sigma$ ).

Not only is the output ( $y$ ) formed from the probability distribution, but also the model parameters are also derived from the distribution. The posterior probability of the conditional model parameters based on the inputs and outputs has the following form:

$$P(\beta|y, X) = \frac{P(y|\beta, X)P(\beta|X)}{P(y|X)}. \quad (4)$$

Here,  $P(\beta|y, X)$  is the posterior probability distribution;  $P(y|\beta, X)$  is the likelihood of a dataset;  $P(\beta|X)$  is a prior probability distribution; and

$P(y|X)$  is a standard constant and can be eliminated. Therefore, equation (4) is often simplified as follows:

$$P(\beta|y, X) = P(y|\beta, X)(P(\beta|X)). \quad (5)$$

Bayesian regression will proceed through the following three steps when testing the hypothetical relationship between bank's NIM and explanatory variables. Firstly, we provide a prior assumption to have a normal distribution with a mean of zero for the total coefficients for the coefficients. Such a prior specification signifies that coefficients resulting from Bayesian regression are more likely to have values close to zero than non-zero values. Most importantly, we do not favor the Bayesian analysis results of research hypotheses in a negative or positive direction. Secondly, regarding the likelihood functions of the coefficients, we suppose normal distributions with the parameters obtained from equations (1) and (2). Finally, we employ Markov Chain Monte Carlo (MCMC) combined with Gibbs Sampling techniques to approach the corresponding posterior distributions of the coefficients by 12,500 withdrawal times of estimation and simulation drawn from a posterior distribution. As usual, we will have the first 2,500 withdrawal times removed. MCMC technique is frequently utilized for adjusting complex models in various fields (Gelman & Rubin, 1992; Roy, 2020).

## RESULTS AND DISCUSSION

### Some Facts

Table 2 presents descriptive statistics of all variables in the model. The main descriptive criteria comprise mean, standard deviation, and maximum and minimum value. The first is a group of bank-specific variables: banks' NIM in 2008–2020 had an average value of 3.7069%, the highest value of 49.1020%, and the lowest value of -1.2709%. The average total assets size of commercial banks is 18,3769, with the highest value of 21.1398 and the lowest of 14.6987. The average return on assets (ROA) ratio is 0.9640, with the lowest value of -5.9929 and the highest of 5.9518. The average of operational cost to operating income ratio is 0.7881, with the largest value of 86.3019 and the smallest of 0. Generally, the liquidity of commercial banks is quite stable, having an average value of 0.2099, a maximum of 1.2566, and a minimum of 0.0452. The loan-to-deposit ratio had an average value of 88.5189%, a maximum of 209.1146%, and a minimum of 23.5094%. Banks have an average non-performing loan ratio of 1,8092%, a maximum of 11,4017%, and a minimum of 0%. The loan market power of banks has an average value of 16.2057%, a maximum of 100%, and a minimum of 0.2116%. The second is a group of macroeconomic factors: Vietnam's inflation rate average is 7.222%, with the largest value of 23.115% (in 2008) and the lowest of 0.631% (in 2015). In addition, Vietnam had an average economic growth of 5.929%, a maximum growth rate of 7.076% in 2018, and a minimum growth rate of 2.906% in 2020. Finally, broad money growth had

an average annual rate of 18.5592%, a minimum rate of 11.94% in 2011, and a maximum rate of 29.71% in 2010.

**Table 2:** Descriptive statistics

Variables	Mean	Std. Dev.	Min	Max
<b>Dependent variable</b>				
NIM	3.7069	3.0509	-1.2709	49.1020
<b>Independent variables</b>				
<i>Bank-specific variables</i>				
LNSIZE	18.3769	1.2733	14.6987	21.1398
ROA	0.9640	0.8960	-5.9929	5.9518
BOPO	0.7881	4.8591	0.0000	86.3019
GWM	0.2099	0.1252	0.0452	1.2566
LDR	88.5189	21.0779	23.5094	209.1146
NPL	1.8092	1.4471	0.0000	11.4017
MPR	16.2057	22.2103	0.2116	100.0000
<i>Macroeconomic variables</i>				
INFL	7.2220	6.3870	0.6310	23.1150
GDP	5.9290	1.0570	2.9060	7.0760
M2	18.5592	5.5019	11.9425	29.7146

Table 3 presents the Pearson correlation matrix of the variables. It shows that NIM is negatively correlated with LNSIZE, BOPO, GWM, GDP, and M2, while other factors are positively correlated. Meanwhile, all absolute values of the correlation coefficients among the independent variables in Table 3 are less than 0.4, so multicollinearity does not appear in our study.

**Table 3:** Correlation matrix of the variables.

	NIM	LNSIZE	ROA	BOPO	GWM	LDR	NPL	MPR	INFL	GDP	M2
NIM	1.00										
LNSIZE	-0.02	1.00									
ROA	0.32	-0.04	1.00								
BOPO	-0.10	-0.07	0.46	1.00							
GWM	-0.11	-0.23	0.09	0.07	1.00						
LDR	0.10	-0.10	0.21	-0.09	-0.14	1.00					
NPL	0.00	-0.02	0.14	-0.04	-0.05	-0.09	1.00				
MPR	0.01	0.38	0.05	-0.04	-0.08	0.14	0.11	1.00			
INFL	0.02	-0.39	0.17	0.10	0.33	0.11	-0.07	-0.02	1.00		
GDP	-0.16	0.02	0.08	0.02	0.02	0.00	-0.04	0.00	-0.08	1.00	

M2	-0.03	-0.35	0.19	-0.07	0.16	0.00	0.06	-0.02	0.19	-0.14	1.00
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### Estimation Results

Tables 4 and 5 display the results of our Bayesian linear regression. Table 4 presents the effect of bank-specific variables, while Table 5 presents the influence of bank-specific variables and macroeconomic variables on NIM. In order to describe an impact, we indicate a 95%-credible interval for coefficients, that is, an interval containing the parameter of interest with a certain probability.

**Table 4:** Regression of bank-specific variables on the NIM

Dependent variable: NIM				
Independent variables	Posterior mean	Posterior probability	Efficiency	Rc
LNSIZE	0.0933	0.9401*	1.0000	1.0001
	[-0.0230; 0.2106]			
ROA	1.2117	1.0000*	1.0000	1.0000
	[0.7994; 1.6170]			
BOPO	0.0484	0.9003*	1.0000	1.0000
	[-0.0250; 0.1225]			
GWM	-1.1504	0.9221**	1.0000	1.0001
	[-2.6873; 0.4436]			
LDR	0.0067	0.8166*	0.9836	1.0000
	[-0.0081; 0.0217]			
NPL	0.1286	0.8712*	1.0000	1.0000
	[-0.0943; 0.3526]			
MPR	-0.0054	0.7611**	1.0000	1.0000
	[-0.0204; 0.0097]			
constant	0.2766	0.6185*	0.9637	1.0000
	[-1.5832; 2.0925]			
var	8.3817	—	0.9305	1.0001
	[8.3458; 7.1397]			

Notes: 95% credible interval in brackets. \*Probability of mean > 0. \*\*Probability of mean < 0.

Firstly, we consider the effect of bank-specific factors on a bank's NIM. Tables 4 and 5 demonstrate that a higher bank size (LNSIZE) strongly affects the bank's NIM, with a probability that the bank size variable has a positive influence of 94.01% (Table 4) or 99.50% (Table 5). The posterior mean coefficient is  $\beta = 0.0933$  or  $\beta = 0.1858$ . Our result demonstrates that the larger the bank's asset size is, the higher the NIM will be. Large banks have reputable brands and high confidence among customers and investors. They may invest in more contemporary technologies and have a competitive

advantage owing to scale, favoring scale efficiency. Thus, large commercial banks earn NIM more. Our result is compatible with that of Raharjo et al. (2014).

There is a probability that the profitability variable (ROA) positively affects the NIM of 100% (Table 4 and Table 5). The posterior mean coefficients are  $\beta = 1.2117$  (Table 4) and  $\beta = 1.2326$  (Table 5). Similar to the study by Endri and Marlina (2020) and Raharjo et al. (2014), we detected strong evidence regarding the positive influence of profitability on NIM. According to the results of this analysis, a high NIM is more attainable for a bank with a higher ROA. Bank profitability indicates the ability of banks to generate income exceeding costs in relation to the bank capital base. A high ROA of banks reflects that such banks have had reasonable policies and plans to make optimal use of assets in generating revenue, increasing profits, and at the same time helping NIM increase.

Our results demonstrate that the operational cost to operating income ratio (BOPO) positively affects the NIM. In particular, the mean coefficient of BOPO variable is  $\beta = 0.0484$  (Table 4) or  $\beta = 0.0505$  (Table 5). There is a probability that the BOPO variable has a positive influence of 90.03% (Table 4) or 90.64% (Table 5). The research result illustrates that the operational cost to operating income ratio has a strong and positive impact on the NIM. From 2008 to 2020, Vietnamese commercial banks modernized the banking system and administration following international standards. Banks also altered their operations for safety and health. Bank management and administration have become more professional, approaching global banking governance requirements. Our result agrees with the conclusions of Mustafa-Zatriqi and Ahmeti (2022), Lestari et al. (2021), Lee and Isa (2017), and Raharjo et al. (2014).

The mean coefficient of the GWM variable is  $\beta = -1.1504$  (Table 4) or  $\beta = -0.9291$  (Table 5), and there is a probability that the GWM variable has a negative effect of 92.21% (Table 4) or 87.39% (Table 5). The research result indicates that liquidity negatively impacts the NIM. For banks with high liquidity, public trust will be maintained, and liquidity risks are also limited. However, maintaining a high rate of liquidity also imposes a significant opportunity cost on banks and reduces their NIM. Our result is consistent with the conclusion of Raharjo et al. (2014) and Hussain (2014).

LDR variable has a mean coefficient of  $\beta = 0.0067$  (Table 4) or  $\beta = 0.0098$  (Table 5), and there is a probability that the LDR variable has a positive influence of 81.66% (Table 4) or 89.58% (Table 5). The research result demonstrates that the loan-to-deposit ratio has a strong and positive impact on the NIM. This result refers to the efficiency with which a bank can turn customer deposits into interest income, hence expanding its NIM. A high loan-to-deposit ratio results in greater conversion of customer deposits into loans, as observed by its positive effect on the NIM. As a result of this efficiency, the LDR may raise its NIM. Our result is in accordance with the conclusions of previous studies by Mustafa-Zatriqi and Ahmeti (2022), Endri and Marlina (2020), Asmar (2018), and Raharjo et al. (2014).

Similar to the studies of Mustafa-Zatriqi and Ahmeti (2022), Raharjo et al. (2014), and Tarus et al. (2012), we detected that the NPL ratio had a positive

and strong effect on NIM. In particular, NPL variable has a mean coefficient of  $\beta = 0.1286$  (Table 4) or  $\beta = 0.1482$  (Table 5), and there is a probability that the NPL variable has a positive influence of 87.12% (Table 4) or 90.01% (Table 5).

For the bank's loans market power variable, the mean coefficient of the MPR variable is  $\beta = -0.0054$  (Table 4) or  $\beta = -0.0078$  (Table 5). There is a probability that the MPR variable has a negative influence on the NIM of banks of 76.11% (Table 4) and 84.66% (Table 5). The research result demonstrates that the higher a bank's lending market power is, the lower the bank's NIM is. This result is similar to those of Mustafa-Zatriqi and Ahmeti (2022), Khan and Jalil (2020), Islam and Nishiyama (2016), Khanh and Tra (2015), and Tarus et al. (2012). As part of the roadmap to restructure the national financial system of the SBV, mergers and acquisitions (M&A) activities between large banks and inefficient banks have been strongly encouraged in recent times. When the number of players decreases, the market share is still in the hands of the four largest banks in Vietnam, namely, Vietcombank, Vietinbank, Agribank, and BIDV. Consequently, the government can quickly seize the industry and impose restrictions on the NIM.

Secondly, we consider the effect of macroeconomic variables on NIM. Consistent with previous empirical studies (Gul et al., 2011; Raharjo et al., 2014; Tarus et al., 2012; Hussain, 2014; Khanh & Tra, 2015; Pham et al., 2018; Hanzlík & Teplý, 2022), we found that the inflation ratio had a positive influence on NIM. Table 5 presents that the mean coefficient of the INFL variable is  $\gamma = 0.0021$ . Thus, the level of inflation, measured by CPI, had a positive effect on the NIM of the bank. This result implies that inflation was anticipated. Hence, the bank management had a chance to adjust interest rates accordingly, further increasing the spread between interest revenue and interest expense, leading to a positive effect on NIM. However, there is a probability that the INFL variable has a positive effect of 50.02%. The probability of this influence implies that the impact of the inflation rate on the NIM is relatively low.

For the economic growth variable, the mean coefficient of the GDP variable is  $\gamma = -0.3026$ . There is a probability that the GDP variable had a negative impact on the NIM of 98.09% (Table 5). The research result demonstrates that economic growth has a strong and negative impact on NIM. Our result is consistent with those of Islam and Nishiyama (2016), Tarus et al. (2012), and Gul et al. (2011).

Similar to the GDP variable, we also found a negative and strong effect of money supply growth on NIM. In particular, variable M2 has a mean coefficient of  $\gamma = -0.0339$ , and there is a probability that variable M2 has a negative effect of 87.49% (Table 5). Our result contradicts that of Khan and Jalil (2020).

**Table 5:** Regression of bank-specific and macroeconomic variables on the NIM

Dependent variable: NIM				
Independent variables	Posterior mean	Posterior probability	Efficiency	Rc
LNSIZE	0.1858	0.9950*	0.9802	1.0000
	[0.0422; 0.3290]			
ROA	1.2326	1.0000*	0.9877	1.0000
	[0.8016; 1.6534]			
BOPO	0.0505	0.9064*	1.0000	1.0000
	[-0.0258; 0.1258]			
GWM	-0.9291	0.8739**	0.9863	1.0000
	[-2.5406; 0.6644]			
LDR	0.0098	0.8958*	1.0000	1.0000
	[-0.0054; 0.0251]			
NPL	0.1482	0.9001*	1.0000	1.0000
	[-0.0772; 0.3733]			
MPR	-0.0078	0.8466**	1.0000	1.0000
	[-0.0228; 0.0071]			
INFL	0.0021	0.5302*	0.9565	1.0000
	[-0.0517; 0.0556]			
GDP	-0.3026	0.9809**	1.0000	1.0002
	[-0.5872; -0.0160]			
M2	-0.0339	0.8749**	1.0000	1.0000
	[-0.0913; 0.0243]			
constant	0.6458	0.7506*	1.0000	1.0001
	[-1.2338; 2.5384]			
var	8.2900	—	0.9163	1.0003
	[7.0689; 9.7420]			

Notes: 95% credible interval in brackets. \*Probability of mean > 0. \*\*Probability of mean < 0.

### MCMC Diagnostics

As presented in Section 3.3 (Empirical Strategy), the posterior distribution is created based on the MCMC technique. Thus, the quality of the sample generated by the MCMC algorithm must accurately estimate the target distribution (Roy, 2020). Therefore, MCMC diagnostics are necessary to test the convergence of Markov chains and MCMC sampling cessation. In the current article, we utilized the Gelman-Rubin statistic, also known as the Rc coefficient, to test the convergence of the Markov chain and efficiency index to consider MCMC sampling cessation.

Tables 4 and 5 display that the coefficient Rc of all parameters is less than 1.1. According to Roy (2020), the Rc coefficient of less than 1.1 is evidence that the MCMC algorithm has generated representative samples. That is, Markov chains have converged. Meanwhile, the efficiency index of

all Markov chains greater than 0.01 indicates that MCMC-based estimates are more accurate and stable in terms of the characteristics of the posterior distribution. Thus, MCMC diagnostics through the  $R_c$  coefficient and the efficiency index demonstrate that the sample quality generated by the MCMC algorithm has provided an accurate estimate of the posterior distribution.

## CONCLUSION

The present article analyzes the factors affecting the NIM of 24 joint-stock commercial banks in Vietnam from 2008 to 2020. Although several previous studies examined factors, including bank-specific and macroeconomic factors affecting banks' NIM, these studies were carried out based on the frequentist approach. The current study utilizes the Bayesian approach, specifically Bayesian linear regression, to discover the relationship. Our result indicates that LNSIZE, ROA, BOPO, LDR, and NPL positively affect the NIM of banks while GWM, MPR, GDP, and M2 negatively affect NIM. The effect of the INFL on NIM is ambiguous.

The result of our article has provided important information for bank managers by showing the effect of bank-specific and macroeconomic factors on the NIM so that they give solutions to enhance the operational efficiency of banks. Furthermore, our findings provide investors with investment opportunities based on the factors affecting a bank's NIM. However, the study has limitations as follows. Future research may consider comparing NIMs of domestic and foreign capital banks in Vietnam. Furthermore, our study only examined one country for a limited period, implying that future research needs to investigate this association in other emerging markets with different banking structures. For instance, future studies can be extended by comparing and analyzing the determinants of NIM of banks among other countries in Southeast Asia. The comparison result may provide more insight for governments to plan their monetary policies.

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