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Capital structure and profitability of Vietnamese commercial banks: Evidence from Monte Carlo simulation via the Bayes

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ABSTRACT

The objective of this study was to investigate the existence of an optimal capital structure for commercial banks. The authors employed a Bayesian regression approach to analyze the data gathered from 24 listed commercial banks in Vietnam from 2011 to 2021. The findings prove the existence of the optimal capital structure of banks. Furthermore, the study underscores the significance of bank size in enhancing overall bank performance and reveals that inflation positively affects bank profitability. Leveraging the advantages of the Bayesian methodology for small sample data analysis, the authors introduced a framework for estimating the optimal capital structure for individual banks. In this context, two banks were selected for case studies: Asia Commercial Bank (ACB) and Vietnam Joint Stock Commercial Bank for Industry and Trade (CTG). The analysis indicated that both banks maintain a deposit-to-total assets ratio that exceeds the optimal threshold and should consider adjustments to bring this ratio down. Conversely, the non-deposit to total assets ratio for both banks remains relatively low, suggesting a potential for an increase in order to optimize their financial performance.

Contribution/Originality: The study identifies an optimal capital structure, defined by deposit and non-deposit ratios, to enhance bank profitability. Additionally, by utilizing Bayesian methods to address challenges associated with small sample sizes, the study has introduced a methodology for estimating the optimal capital structure tailored to the unique characteristics of individual banks.

1. INTRODUCTION

In contemporary finance, banks are vital to the financial system. This is especially appropriate for countries with economies in transition, where financial systems often depend heavily on banks (Berglof & Bolton, 2002). It is not surprising that banks play an increasingly important role in the financial intermediation sector in Vietnam. The ratio of banking sector assets to Gross Domestic Product (GDP) increased from 37.13% in 2000 to 162.76% of GDP in 2021[1]. The stability in the operation of the banking system not only supports the economy in supplying capital continuously but also ensures sustainable economic growth in the long term. One of the critical factors in ensuring the sustainable operation of the banking industry is capital.

The function of capital for banks is similar to that of other businesses. The primary functions of capital for the

[1] Data collected at https://www.theglobaleconomy.com/rankings/bank_assets_GDP/.

banking sector can be listed explicitly as follows: (i) it operates as a buffer to mitigate economic shocks, (ii) it enhances depositor confidence, and (iii) it signifies the degree of risk that shareholders are prepared to assume. (Ayaydin & Karakaya, 2014). One of the most controversial topics regarding a bank's capital is how the financial structure of the bank affects its costs and performance (Fungáčová & Poghosyan, 2011). Numerous studies have assessed how capital affects bank performance, but the research results are inconsistent. Moreover, according to the studies that the authors have reviewed, there is a relationship between capital structure and the performance of banking institutions; however, they do not analyze whether a mechanism exists for an optimal capital structure for the bank. This may introduce bias into the proposed policies. A significant limitation of prior studies is their tendency to apply methodologies for measuring the capital structure of non-financial enterprises to the banking sector. It is important to recognize that the capital structure of banks differs markedly from that of non-financial enterprises, particularly given that banks have a considerably higher financial leverage ratio. This fundamental distinction can result in inaccuracies when analyzing the capital structure of banks (Gropp & Heider, 2010). Data from the financial statements of 24 listed commercial banks from 2011 to 2021, along with control variables, are bank size, liquid assets ratio, foreign equity ratio, and factors in macroeconomics, including economic growth and inflation. The study provides evidence of the optimal financial leverage ratio threshold for the banks' performance. Another difference in this study is that, via the Bayesian approach, the authors propose a method to calculate the threshold for the deposit to total assets and non-deposit to total assets ratios for each specific bank. Hence, we could offer a capital structure suitable to the characteristics of each bank to optimize the performance of these banks.

2. LITERATURE REVIEW

The theory often mentioned when discussing capital structure is the pecking order theory, proposed by Myers and Majluf (1984). This theory stated that because of the problem of information asymmetry, business managers often prioritize the use of capital from retained earnings, followed by debt and equity, to finance business investment opportunities. Myers and Majluf (1984) argued that managers are not trying to find the optimal capital structure but instead determine the order of priority in selecting capital sources in financing decisions. The pecking order theory provides a framework for understanding the inverse relationship that exists between a firm's profitability and its debt ratios; highly profitable firms tend to have less debt, not because they set goals with a low debt structure, but because they do not need external capital. In the case of having to use external capital when the financial resources of enterprises are not enough to finance their operations, the managers of these enterprises often prefer to use debt, and issuing new shares is a last resort. This can be attributed to the fact that managers understand the value and risks of the business; if managers believe that the company is performing better than the market assessment, they would not want to issue shares. On the contrary, when a company issues shares, investors could interpret this as a signal that the company is having difficulty in capital and has low prospects for development. Therefore, issuing shares to finance corporate activities would convey more unfavorable information than using debt. However, this theory also has some limitations as it ignores the effects of taxes, costs of issuing new securities, agency costs, and costs of financial distress. In addition, this theory fails to account for the success of certain businesses that continue to thrive and generate favorable results despite maintaining low levels of debt. Additionally, it does not address instances where companies with high stock prices still seek external capital; they are more likely to issue shares than to borrow. Because of these limitations, the pecking order theory could only be deemed complementary to the trade-off theory (Butt, Khan, & Nafees, 2013).

Trade-off theory was developed by Modigliani and Miller (1963). This theory states that, as firms increase their use of debt, firm value can increase thanks to the savings from the interest tax shield. An increase in debt, however, may also increase the financial risk, and the cost of financial distress may also rise. This reduces the benefit the business receives from the tax savings on interest. Therefore, Modigliani and Miller (1963) argued that there exists an optimal capital structure at which the average cost of capital of the firm is minimum and firm value is maximized;

if the debt ratio exceeds this point, the value of the business could begin to decrease.

When discussing the role of capital structure on firm profitability, researchers often rely on the second proposition of the Modigliani and Miller theorem. This proposition suggests that the relationship between the required return on market equity and the debt-to-equity ratio is inversely related because the higher the financial leverage, the higher the required return on equity. Most researchers agree that the development of this theory is quite suitable for banks; banks with an optimal capital structure could maximize shareholder value (Buser, Chen, & Kane, 1981). The vital aspect of this theory is that the advantage of tax shielding from interest and government "guarantees" could reduce the cost of the trade-off between the expected cost of default associated with the rate of low equity (Osborne, Fuertes, & Milne, 2012). Therefore, banks tend to use the financial leverage ratio to take advantage of the above advantages to increase the bank's profitability. However, the effect of market discipline has controlled banks in using financial leverage because investors are very vulnerable to the risk of the bank defaulting, which implies that banks that are deemed to have a high likelihood of financial distress may incur significantly elevated costs associated with uninsured funding (Covitz, Hancock, & Kwast, 2004; Gropp & Heider, 2010; Nier & Baumann, 2006). Flannery and Rangan (2008) have claimed that government guarantees have overshadowed the role of market discipline. When the government was deemed to have withdrawn its guarantees, as it did in the United States during the early 1990s when the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991 limited guarantees for banks' default costs unsecured deposits and the Omnibus Budget Reconciliation Act of 1993 demoted the unsecured deposits believed to have caused the mass banking failures of this period in the United States.

Studies by Holmstrom and Tirole (1997); Mehran and Thakor (2011) and Allen, Carletti, and Marquez (2011) have shown that a high capital ratio could help overcome agency problems arising from the asymmetry of information between depositors and borrowers. They argued that banks with high capital ratios are more likely to survive, have more incentives to monitor loans, and investors consider this when valuing banks. This makes it possible for banks to achieve higher marginal interest rates thanks to mobilising capital at a lower cost.

The above analysis showed that structured capital could positively or negatively affect the bank's profitability, depending on the scope of the studies. Studies concluded that equity capital enhances bank performance, including (Berger & Di Patti, 2006; Iannotta, Nocera, & Sironi, 2007; Naceur & Kandil, 2009). On the other hand, Saona (2010) studied the effect of capital structure on the profitability of US banks from 1995–2007. The research results show a negative relationship between increasing the ratio of equity capital and banks' profitability, which means that banks that tend to take advantage of financial leverage would have a higher rate of return. Similarly, Ayalew (2021), with a dataset of banks from 2013 to 2019 in Ethiopia, provided evidence that banks using high financial leverage are more efficient.

A substantial body of research is currently exploring the relationship between capital structure and bank performance; however, the findings have been inconsistent, often influenced by each study's specific scope and timeframe. Furthermore, many existing studies primarily examine the linear effects of capital structure on performance, neglecting the potential existence of an optimal capital structure that could enhance the profitability of banking operations.

Second, current research predominantly evaluates the capital structure of banks through ratios such as equity to total assets and total debt to total assets, similar to practices used for non-financial enterprises. However, Gropp and Heider (2010) highlight that the capital structure of banks fundamentally differs from that of non-financial firms. They emphasize that customer deposits constitute the most significant source of capital for banks, warranting a separate analysis of this vital funding source. Their study, based on data from banks in the United States and Europe, demonstrates the necessity of categorizing a bank's debt on the balance sheet into deposits and non-deposits. This differentiation is crucial for conducting a thorough examination of the capital structure of banks.

Third, many studies on capital structure predominantly utilize a frequency approach. However, this method presents a significant limitation, as it is unable to analyze smaller sample sizes. As a result, researchers often evaluate all commercial banks as a collective group to ensure an adequate sample size. It is essential to recognize that each bank possesses distinct characteristics, which means that the optimal capital structure is not uniform across institutions. To overcome this challenge, the authors propose a method that integrates prior information with available data to estimate the posterior distribution, thereby enabling the determination of the optimal capital structure for each specific bank. This approach marks a notable advancement in comparison to previous studies in the field.

3. RESEARCH MODEL AND HYPOTHESES

As mentioned, in this study, the authors would test whether there is an optimal capital structure for commercial performance in Vietnam. To address this question, the authors would test two main hypotheses.

Hypothesis 1: The financial leverage ratio has a positive impact on bank performance.

Hypothesis 2: The financial leverage squared has a negative impact on bank performance.

Gropp and Heider (2010) asserted that the capital structure of banks is different from that of non-financial enterprises, whereby the most critical capital source of a bank is formed from customer deposits; therefore, the role of this capital source needs to be analyzed separately. Based on bank data from the United States and Europe, Gropp and Heider (2010) demonstrated that it is necessary to divide the debt on the bank's balance sheet into two parts, namely deposits and non-deposits, for studies on the capital structure of banks. Therefore, to comprehensively evaluate the influence of capital structure on the performance of banking institutions in this study, the authors divided the bank's debt structure into two parts: the ratio of deposits to total assets and non-deposits to total assets. Therefore, hypothesis 1 of the study is developed as follows.

Hypothesis 1a: The ratio of deposits to total assets positively affects bank performance.

Hypothesis 1b: The ratio of non-deposits to total assets positively affects bank performance.

Similarly, hypothesis 2 of the study was rewritten as follows:

Hypothesis 2a: The square of the ratio of deposits to total assets has a negative effect on bank performance.

Hypothesis 2b: The square of the ratio of non-deposits to total assets has a negative effect on bank performance.

Besides considering the impact of capital structure on bank performance, the authors also test other hypotheses, including:

Hypothesis 3: Bank size improves bank performance.

Elsas, Hackethal, and Holzhäuser (2010) and Chiorazzo, Milani, and Salvini (2008) stated that large bank sizes would support banks in diversifying their activities, thereby improving their profitability.

Hypothesis 4: Foreign capital ratio improves bank profitability.

Another issue that needs attention is the trend of cooperation with foreign investors of Vietnamese banks. The sale of shares to foreign strategic partners of domestic banks has been very active in recent years. With the participation of foreign managers, domestic banks are expected to improve their governance capacity and enhance product quality thanks to substantial financial resources and modern financial technology from foreign financial institutions, which would help improve the performance of domestic banks. Based on a dataset with more than 50,000 observations from the banking systems of 119 countries between 1995 and 2002, Micco, Panizza, and Yanez (2007) found the benefits of the foreign capital ratio for the operational efficiency of domestic banks.

Hypothesis 5: Liquid assets reduce bank profitability.

According to Shim and Siegel (2000) liquid assets would enhance banks' ability to pay short-term deposits. To minimize liquidity risk, banks need to maintain a sufficiently large amount of liquid assets, which means they need to accept a reduction in loan size, which reduces the bank's profitability.Pasiouras and Kosmidou (2007) found evidence of a negative relationship between liquid assets and bank performance.

Hypothesis 6: Economic growth improves bank performance.

Albertazzi and Gambacorta (2009) have demonstrated that when economic conditions improve, it increases the demand for loans and improves borrowers' financial capacity, positively impacting financial intermediaries' operations. The studies by Goddard, Molyneux, and Wilson (2004) and Flamini, McDonald, and Schumacher (2009) found a positive relationship between the economic growth rate and the profitability of commercial banks.

Hypothesis 7: Inflation hurts bank performance.

Naceur and Kandil (2009) argued that high inflation would increase instability and reduce the economic demand for borrowing. Afanasieff, Lhacer, and Nakane (2002) also found evidence of the negative impact of inflation on marginal interest rates and reduced bank profitability.

To measure bank performance, researchers could use indicators such as Tobin's q or firm market value (Berger & Di Patti, 2006). However, these indicators are measured through market capitalization, which often fluctuates. Therefore, researchers could use other indicators such as return on equity (ROE), return on assets (ROA), and net interest margin (NIM). Among the above criteria, the two most commonly used indicators are ROA and ROE when discussing the performance of banks due to their accessibility and relative comprehensiveness in measuring corporate performance (Ercegovac, Klinac, & Zdrilić, 2020; Obamuyi, 2013; Zeitun & Goaied, 2022). ROA measures the effectiveness of asset management in generating profits for the banks, while ROE measures the return on equity (Obamuyi, 2013). It can be recognized that ROA and ROE are two accessible indicators, and they also comprehensively evaluate the bank's performance. Hence, in this study, ROA and ROE are the two indicators selected to assess the bank's performance.

Thus, the research models have the form.

Model 1.1: $ROA_{i,t} = \alpha_1 + \alpha_{11}DEP_{i,t} + \alpha_{12}DEPS_{i,t} + \alpha_{13}CT_{i,t} + \varepsilon_{i,t}$ (1)

Model 1.2: $ROA_{i,t} = \alpha_{20} + \alpha_{21}NON\_DEP_{i,t} + \alpha_{22}NON\_DEPS_{i,t} + \alpha_{23}CT_{i,t} + \varepsilon_{i,t}$ (2)

Model 2.1: $ROE_{i,t} = \beta_{10} + \beta_{11}DEP_{i,t} + \beta_{12}DEPS_{i,t} + \beta_{13}CT_{i,t} + \varepsilon_{i,t}$ (3)

Model 2.2: $ROE_{i,t} = \beta_{20} + \beta_{21}NON\_DEP_{i,t} + \beta_{22}NON\_DEPS_{i,t} + \beta_{23}CT_{i,t} + \varepsilon_{i,t}$ (4)

Where i is the i^{th} bank and t is the t^{th} year; DEP is the ratio of deposits to total assets, and NON_DEP is the ratio of non-deposits to total assets. CT includes controlling variables such as bank size, foreign capital ratio, economic growth, and inflation rate.

Table 1 outlines the variable symbols, the influence of these variables within the model, and the corresponding data sources.

Table 1. Variables in the model.

Notation	Variables of the model	Expected sign.	Data source
Dependent variable			
ROA	Return on assets		Financial statement of banks
ROE	Return on equity		Financial statement of banks
Independent variable			
DEP	Deposits to total assets	+	Calculate from the financial statement of banks
DEPS	Deposits to total assets square	-	Calculate from the financial statement of banks
NON_DEP	Non-deposits to total assets	+	Calculate from the financial statement of banks
NON_DEPS	Non-deposits to total assets square	-	Calculate from the financial statement of banks
SIZE	Bank size: Natural logarithm of total assets	+	Calculate from the financial statement of banks
FOREIGN	Foreign capital ratio: Foreign capital to total equity	+	Calculate from the financial statement of banks
LIQ	Liquid assets ratio: Liquid assets to total assets	+	Calculate from the financial statement of banks
INF	Inflation	-	World Bank national accounts data.
GDP	Economic growth	+	World Bank national accounts data.

4. METHODOLOGY

According to the author's literature review, studies on the issue of profitability were usually carried out according to the frequentist approach; however, many researchers argued that the frequentist inference to in numerous circumstances, it is becoming increasingly evident that interpreting statistical results may no longer be suitable (Briggs & Nguyen, 2019). One of the crucial assumptions of this approach is that the process of generating observed patterns must repeat continuously; this is considered inappropriate in practice, especially in scientific society. It is difficult to convince policymakers that the effect of capital structure on bank performance is an experiment repeated many times under exactly the same conditions. The Bayesian approach need not be based on this assumption; the Bayesian model's regression coefficients are a random quantity, and the fluctuations of these coefficients would be affected by confounding factors; for example, in this model, the confounding factors are characteristic of each specific bank. However, the fluctuations of the coefficients would decrease as the number of observations increases. This made the Bayesian statistical interpretation more suitable than the frequentist method in practice.

Furthermore, this study seeks to present a method for estimating the optimal capital structure for a particular bank. While the frequency approach may be limited in its effectiveness with small research samples, the Bayesian method is capable of overcoming the challenges posed by such limitations. The conditional distribution rule governs the formulation of Bayesian analysis.

$$p(B) = \frac{p(A,B)}{p(B)} \qquad (5)$$

Bayes' theorem is set up as follows.

$$p(A) = \frac{p(A|B)p(B)}{p(A)} \qquad (6)$$

A and B are random vectors.

The model will be reconstructed using a rational function, operating under the assumption that the data vector y is a sample from a model with the unknown parameter vector θ.

$$L(\theta; y) = f(y;\theta) = \prod_{i=1}^{n} f(y_i|\theta), \quad (7)$$

Where $f(y_i|\theta)$ is the probability density function of y for a given θ.

By applying the Bayesian rule, it is possible to derive the characteristics of a random variable θ from the available data and the model.

A Bayesian analysis entails defining a posterior model to represent the probability distributions of the parameters. This model, derived from a combination of research data and prior information, is an essential component of Bayesian analysis. The rational function, containing pertinent information regarding model parameters derived from observed data, merges with the prior distribution, encompassing available information on the model parameters to establish the posterior distribution.

$$\text{Posterior distribution} \propto \text{Likelihood} \times \text{prior information}$$

We may use Bayes' theorem to determine the posterior distribution of θ for a given y since y and θ are both random variables.

$$p(y) = \frac{p(y|\theta)p(\theta)}{p(y)} = \frac{f(y;\theta)\pi(\theta)}{n(y)} \qquad (8)$$

$n(y) \equiv p(y)$ is the marginal distribution of y and has the following form:

$$n(y) = \int f(y;\theta)\pi(\theta)d\,(\theta) \qquad (9)$$

Where $n(y)$ is the posterior probability distribution, $f(y;\theta)$ is the likelihood function of y under the given condition θ, $\pi(\theta)$ is the prior distribution of θ.

Hence, the Bayesian statistical method offers a solution to the challenge of small sample sizes in research by allowing the results to be interpreted as a probability distribution of the parameter values independently of the sample size (van Toor Mariëlle et al., 2017). The advantages and disadvantages of the Bayesian approach have been thoroughly researched (Gelman & Pardoe, 2006; Lynch, 2007). Van De Schoot, Winter, Ryan, Zondervan-Zwijnenburg, and Depaoli (2017) noted a fivefold increase in empirical studies employing the Bayesian method between 2010 and 2015. For this reason, the authors utilized the Bayesian approach to assess the impact of commercial banks' capital structure on their risk. Furthermore, this research would fully leverage the Bayesian approach to address challenges related to data processing from small sample sizes.

For this reason, the authors would apply Bayesian econometrics to evaluate the impact of capital structure on the performance of commercial banks. In particular, this study would take full advantage of the Bayesian approach in small sample processing by using Bayesian simulation results from 24 commercial banks for prior information to evaluate the impact analysis of capital structure for each specific bank. In this study, two banks were selected: Vietnam Joint Stock Commercial Bank for Industry and Trade (CTG), which has a majority of state-owned capital, and Asia Commercial Bank (ACB), which is 100% owned by private investors.

This study evaluates the influence of capital structure on the profitability of Vietnamese commercial banks from 2012 to 2022. This period is significant as it represents when Vietnam began restructuring its banking sector, characterized by a notable increase in mergers and acquisitions. Additionally, during this time, there was a heightened focus on regulatory standards pertaining to capital safety, which were more rigorously enforced and monitored. Since most previous studies were performed mainly using the frequentist method, prior information is not available. In this case, Nalborczyk, Batailler, Lœvenbruck, Vilain, and Bürkner (2019) proposed defining the standard Gaussian distributions N(0, 10) for the parameters in the model and the Cauchy(0, 5) distribution for variance.

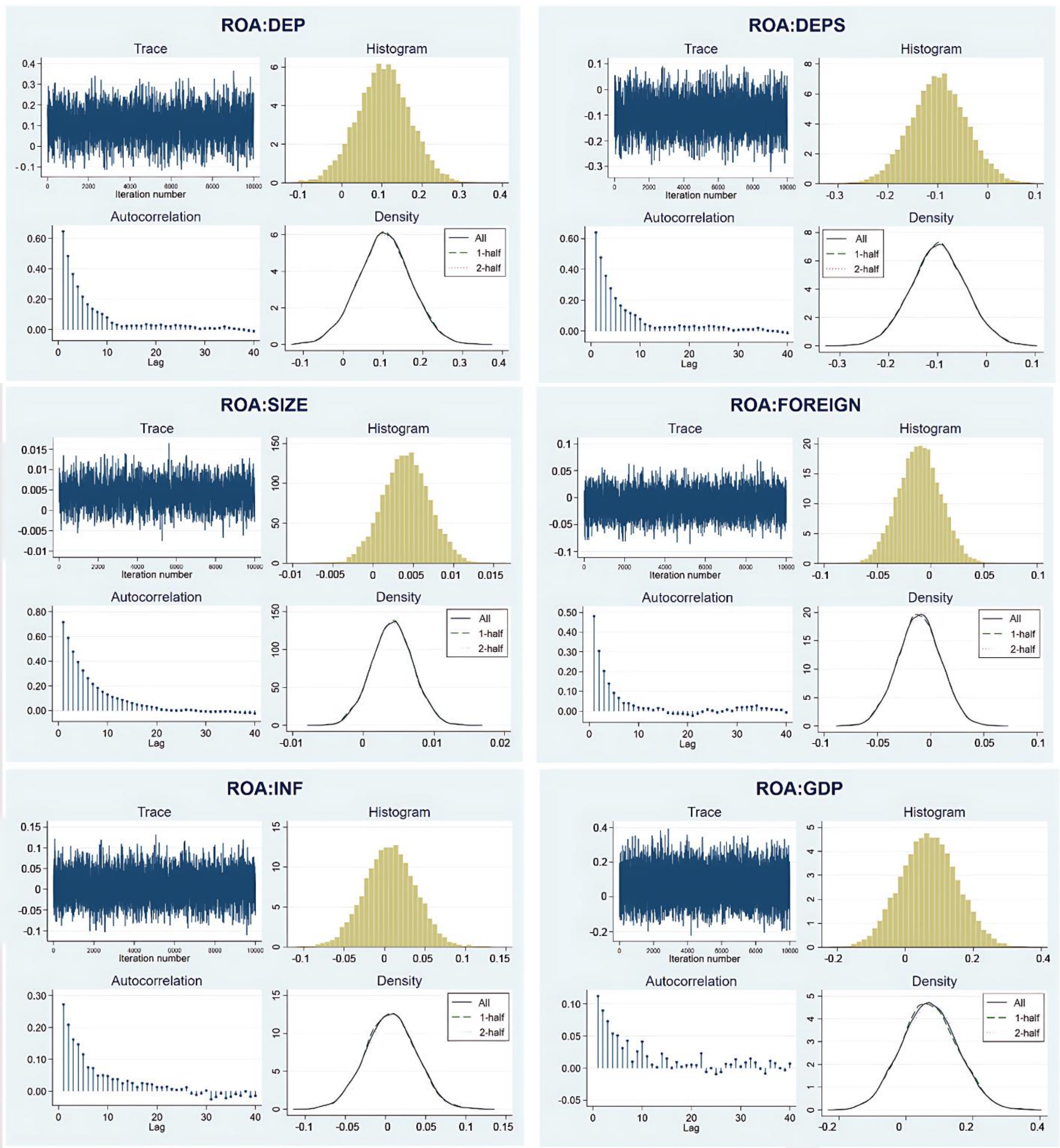
Table 2. Descriptive statistics.

Variables	Obs.	Mean	Std. dev.	Min.	Max.
ROA	288	0.010	0.009	0.000	0.0817
ROE	288	0.103	0.078	0.000	0.303
DEP	288	0.650	0.122	0.292	0.894
NON_DEP	288	0.156	0.088	0.001	0.468
DEPS	288	0.437	0.154	0.085	0.799
NON_DEPS	288	0.032	0.034	0.000	0.219
SIZE	288	9.453	1.177	6.712	12.079
FOREIGN	288	0.112	0.115	0.000	0.300
LIQ	288	0.140	0.086	0.007	0.497
INF	288	0.055	0.047	0.006	0.186
GDP	288	0.058	0.015	0.026	0.071

Table 2 provides a comprehensive overview of key metrics analyzed during the study period. The mean ROA is at 0.01, with a standard deviation of 0.009. The maximum ROA is 0.08, while the minimum value is 0. The mean ROE stands at 0.103, with a standard deviation of 0.078. The maximum recorded ROE is 0.303, with a minimum value of 0. Regarding the DEP ratio, the mean is 0.639, with a standard deviation of 0.156. The max DEP ratio is 1, and the minimum is 0.061. The mean NON_DEP ratio is 0.177, with a standard deviation of 0.135, ranging from a minimum of 0.061 to a maximum of 0.785. Regarding foreign capital, the mean ratio is 0.112, with a standard deviation of 0.115. The max foreign capital ratio is 0.3, and the min is 0. The mean inflation rate during this study period is 5.5%, with a standard deviation of 0.047. Inflation rates ranged from a minimum of 0.6% to 18.6%. Moreover, the average growth rate is recorded at 5.8%, with a standard deviation of 0.015, fluctuating from 2.6% to 7.1%. The logarithm of average total assets is 9.453, with a standard deviation of 1.177, where the maximum total assets recorded is 12.08 and the minimum is 6.7. Finally, the average value of the DEPS variable is 0.432, with a standard deviation of 0.18, ranging from a minimum of 0.004 to a maximum of 1. In contrast, the average value of the NON_DEPS variable is 0.049, with a standard deviation of 0.095, ranging from 0 to 0.616.

5. RESEARCH RESULTS AND DISCUSSION

The Monte Carlo Markov chain (MCMC) simulates the Bayesian result; To maintain the stability of Bayesian regression, it is essential for the MCMC chains to converge. This convergence necessitates that the chains achieve stationarity. According to the Stata Bayesian Analysis Reference Manual[2], the convergence of MCMC chains can be evaluated through the use of a diagnostic graph designed for convergence analysis. This method provides a clear visual representation of the chains' performance and helps ensure their reliability.



[2] https://www.stata.com/manuals16/bayes.pdf.

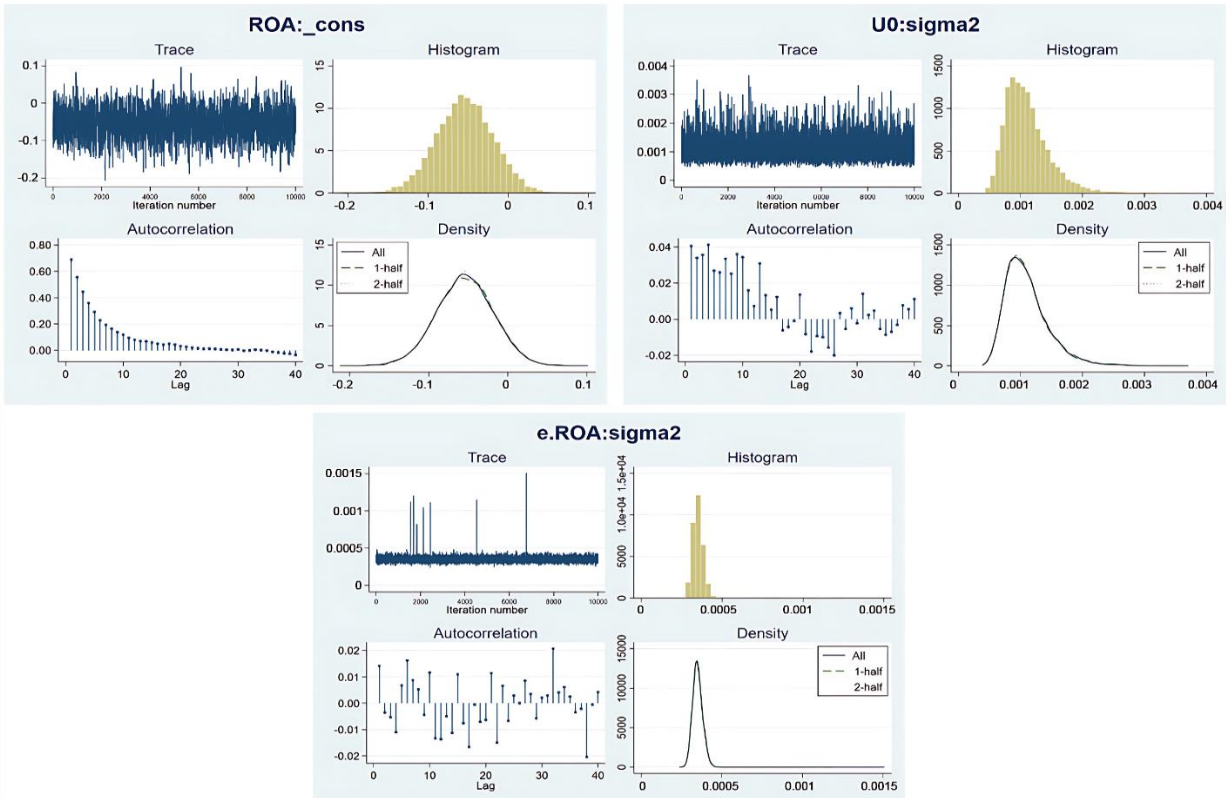


Figure 1. The convergence diagnostic graph for model 1.

This figure was drawn using Stata 16 software.

The Stata Bayesian Analysis Reference Manual instructs that visualized MCMC chain convergence diagnostics will be performed through analyzing graphs, including trace plots, histograms, autocorrelation, and density plots. Figure 1 shows that the trace plot fluctuates around the mean, indicating that the MCMC chains are stationary. Additionally, the autocorrelation drops rapidly to below 0.02 after 20 lags, reflecting that all delays of chains are within the effective limit. The distribution plot and density estimate show the shape of the normal distribution, and the histogram shape is uniform. It can be concluded that the Bayesian inference is steady. Thus, the results from Figure 1 show that the MCMC chains satisfy the convergence condition. The remaining models also had similar results.

Table 3. Bayesian simulation results of model 1.

ROA	Model 1.1			Model 1.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
DEP	0.102	0.069	0.004			
DEPS	-0.097	0.059	0.003			
NONDEP				0.114	0.040	0.001
NONDEPS				-0.159	0.059	0.002
SIZE	0.004	0.003	0.000	0.004	0.003	0.000
FOREIGN	-0.012	0.020	0.001	-0.016	0.020	0.001
LIQ	-0.007	0.019	0.000	-0.030	0.022	0.001
INF	0.011	0.033	0.001	0.011	0.032	0.001
GDP	0.066	0.083	0.002	0.051	0.083	0.002
_cons	-0.051	0.035	0.002	-0.038	0.030	0.002
U0: Sigma2	0.001	0.000	0.000	0.001	0.000	0.000
Sigma2	0.000	0.000	0.000			
Number of groups	24			24		
Obs. per group:	12			12		
Acceptance rate	0.820			0.825		
Efficiency: Min	0.026			0.024		

Table 4. Bayesian simulation results of model 2.

ROE	Model 2.1			Model 2.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
DEP	0.533	0.185	0.010			
DEPS	-0.514	0.158	0.008			
NONDEP				0.270	0.115	0.003
NONDEPS				-0.450	0.163	0.005
SIZE	0.054	0.008	0.000	0.054	0.008	0.000
FOREIGN	-0.015	0.056	0.002	-0.017	0.058	0.002
LIQ	-0.028	0.052	0.001	-0.051	0.063	0.002
INF	0.512	0.093	0.003	0.557	0.089	0.003
GDP	-0.160	0.235	0.005	-0.198	0.237	0.005
_cons	-0.536	0.098	0.006	-0.441	0.079	0.004
U0: Sigma2	0.004	0.002	0.000	0.004	0.002	0.000
Sigma2	0.003	0.000	0.000	0.003	0.000	0.000
Number of groups	24			24		
Obs. per group:	12			12		
Acceptance rate	0.820			0.821		
Efficiency: Min.	0.026			0.025		

Tables 3 and 4 showed that the lowest average acceptance rate (Avg acceptance rate) achieved is 0.820, which exceeds the required threshold of 0.1. Furthermore, the minimum efficiency (Avg efficiency: min) of the models is recorded at 0.024, surpassing the acceptable limit of 0.01. These results indicate that the model satisfactorily meets the necessary convergence requirements. The Monte-Carlo Standard Error (MCSE) for all parameters is notably low. As indicated by Flegal, Haran, and Jones (2008), a value closer to 0 suggests a higher robustness of the MCMC chains. Furthermore, the authors assert that an MCSE value below 6.5% of the standard deviation is acceptable, while a value under 5% of the standard deviation is deemed optimal. Thus, the analysis results in Table 10 show that all the maximum Rc values of the coefficients are 1, so it can be concluded that the MCMC chains meet the convergence requirements. In addition, the simulation results in Tables 3 and 4, when the variable of DEP and DEPS is replaced by NON_DEP and NON_DEPS, show that the regression coefficients of the control variables do not differ significantly. Thus, we can conclude that the Bayes simulation results are robust.

Unlike the frequentist method, we can only test the statistical results indirectly through the null hypothesis. For example, in this study, we can hypothesize H0: Deposits to total assets do not improve bank performance. Then we calculate the p-value; we can interpret the p-value as the probability that the observed deposit to total assets does not improve the bank's performance under the condition that H0 is true. We would reject hypothesis H0; that is, deposits to total assets improve the bank's performance if the p-value is less than 1%, 5%, or 10%. However, we cannot calculate the probability that the deposit to total assets ratio improves the bank's performance. Meanwhile, with the Bayesian approach, we can directly calculate the probability that this effect occurs. Thus, for the Bayesian approach, we can not only determine the impact but also estimate the probabilities of these impacts occurring, which is considered an advantage of the Bayesian method over the frequentist method.

Table 5. Interval test model 1.

Probability	Model 1.1			Model 1.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
{ROA:DEP} > 0	0.925	0.263	0.010			
{ROA:DEPS} < 0	0.944	0.229	0.008			
{ROA:NON_DEP} > 0				0.997	0.059	0.001
{ROA:NON_DEPS} < 0				0.996	0.062	0.001
{ROA:SIZE} > 0	0.922	0.268	0.010	0.926	0.262	0.011
{ROA:FOREIGN} < 0	0.722	0.448	0.013	0.797	0.402	0.012
{ROA:LIQ} < 0	0.638	0.481	0.009	0.719	0.273	0.004
{ROA:INF} > 0	0.630	0.483	0.014	0.642	0.480	0.015
{ROA:GDP} > 0	0.789	0.408	0.007	0.726	0.446	0.008

Table 6. Interval test model 2.

Probability	Model 2.1			Model 2.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
{ROE:DEP} > 0	0.999	0.033	0.000			
{ROE:DEPS} < 0	1.000	0.014	0.000			
{ROE:NON_DEP} > 0				0.991	0.095	0.001
{ROE:NON_DEPS} < 0				0.997	0.056	0.001
{ROE:SIZE} > 0	1.000	0.000	0.000	1.000	0.000	0.000
{ROE:FOREIGN} < 0	0.604	0.489	0.015	0.617	0.486	0.015
{ROE:LIQ} < 0	0.705	0.456	0.009	0.789	0.408	0.007
{ROE:INF} > 0	1.000	0.000	0.000	1.000	0.000	0.000
{ROE:GDP}< 0	0.752	0.432	0.008	0.799	0.401	0.007

Tables 5 and 6 show the probability of the impact of independent variables on dependent variables ROA and ROE in the model. Accordingly, both capital structure models have an inverted U-curve shape when the impact probability of the Deposits to total assets (DEP) and the Non-deposits to total assets (NON_DEP) to the dependent variable are all positive with the probability of 92.5% and 99.7% respectively in model 1 (ROA) and in model 2 (ROE) this value is 99.9% and 99.1% respectively. ; while the impact of the variable DEPS (squared the ratio of deposits to total assets) and NON_DEPS (the square of the ratio of non-deposits to total assets) on the dependent variable has a negative sign with probability 94.4% and 99.6% in model 1 (ROA); 100% and 99.7% in model 2 (ROE).

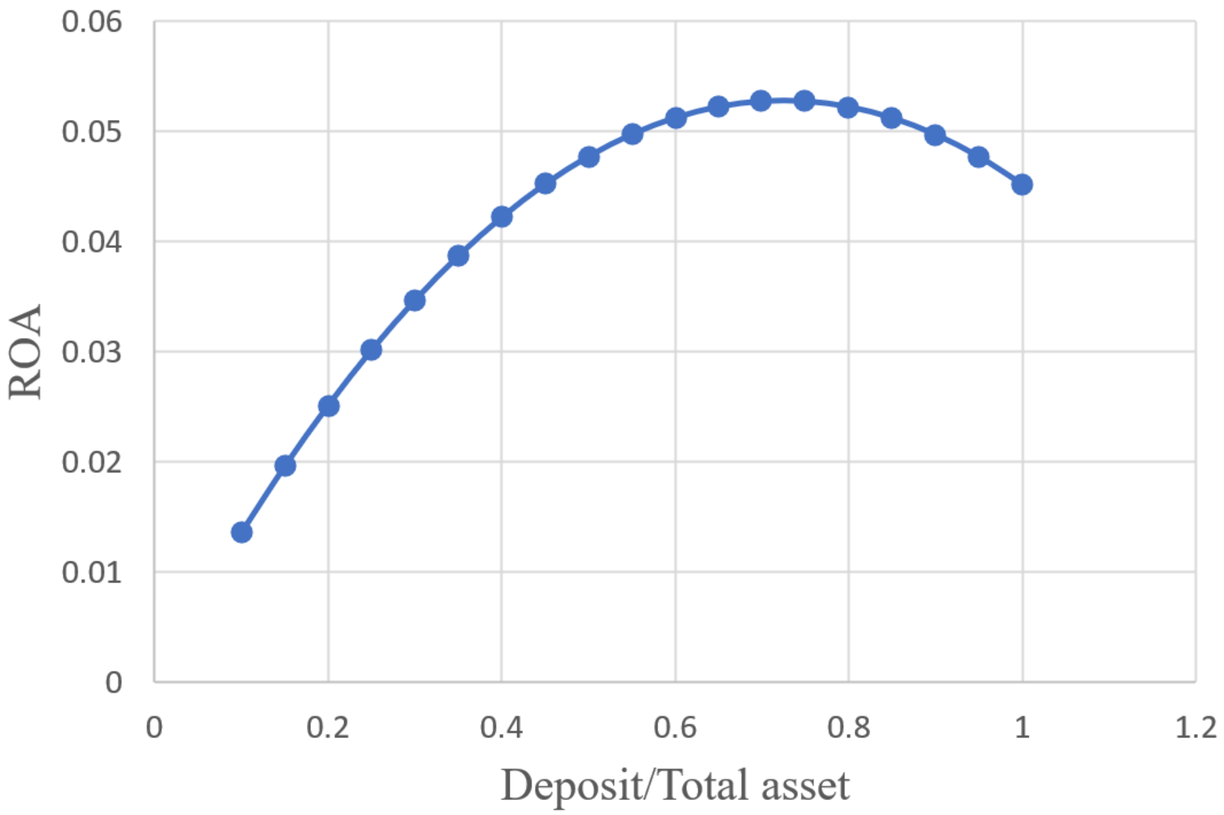


Figure 2. Relation between deposit/Total asset ratio and ROA.

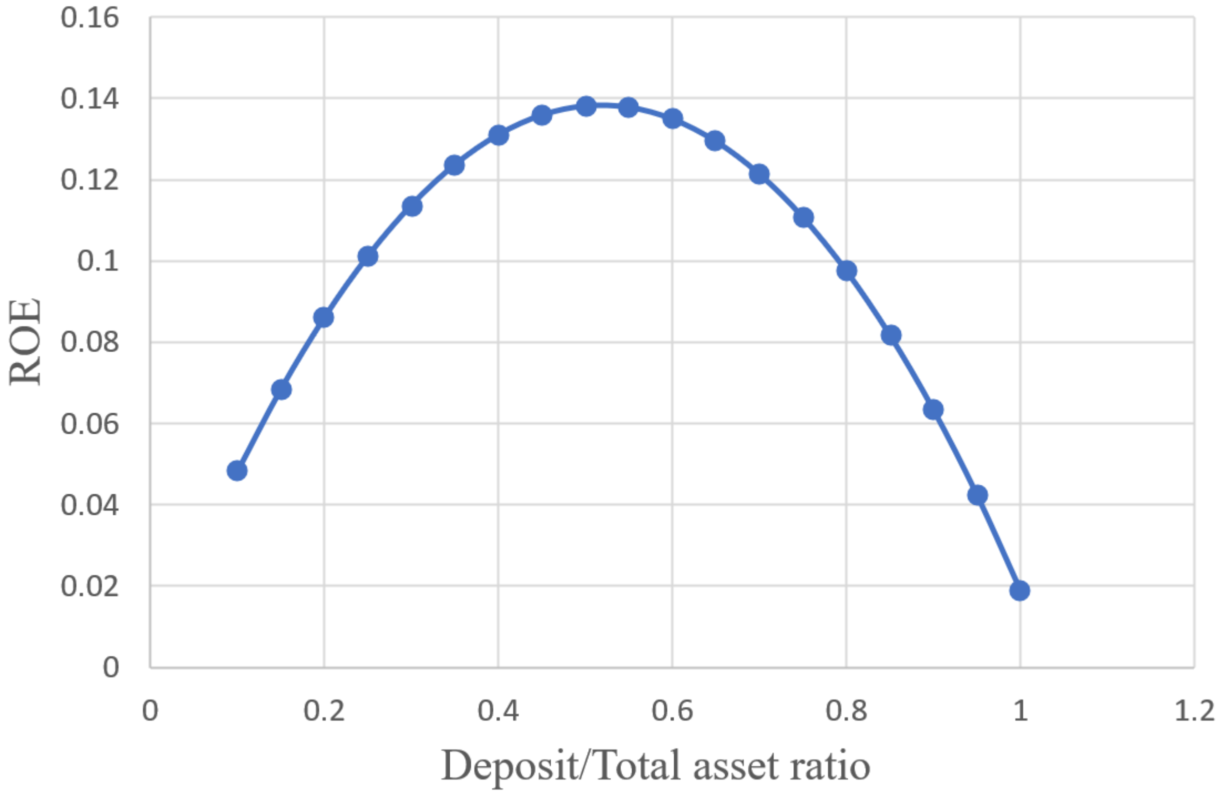


Figure 3. Relation between deposit/Total asset ratio and ROE.

Figure 2 illustrates the relationship between deposits to total assets and return on assets (ROA), while Figure 3 depicts the relationship between deposits to total assets and return on equity (ROE). In Figure 2, the optimal ratio of deposits to total assets for Model 1 is approximately 70%, where the ROA reaches its highest level. For Model 2, as shown in Figure 3, the optimal ratio is around 50% for achieving the highest ROE. Therefore, the bank's deposits to total assets ratio fluctuates between 50% and 70%, which can enhance the bank's operational efficiency. However, exceeding this range may lead to an increase in the bank's cost of capital and a decrease in operational efficiency.

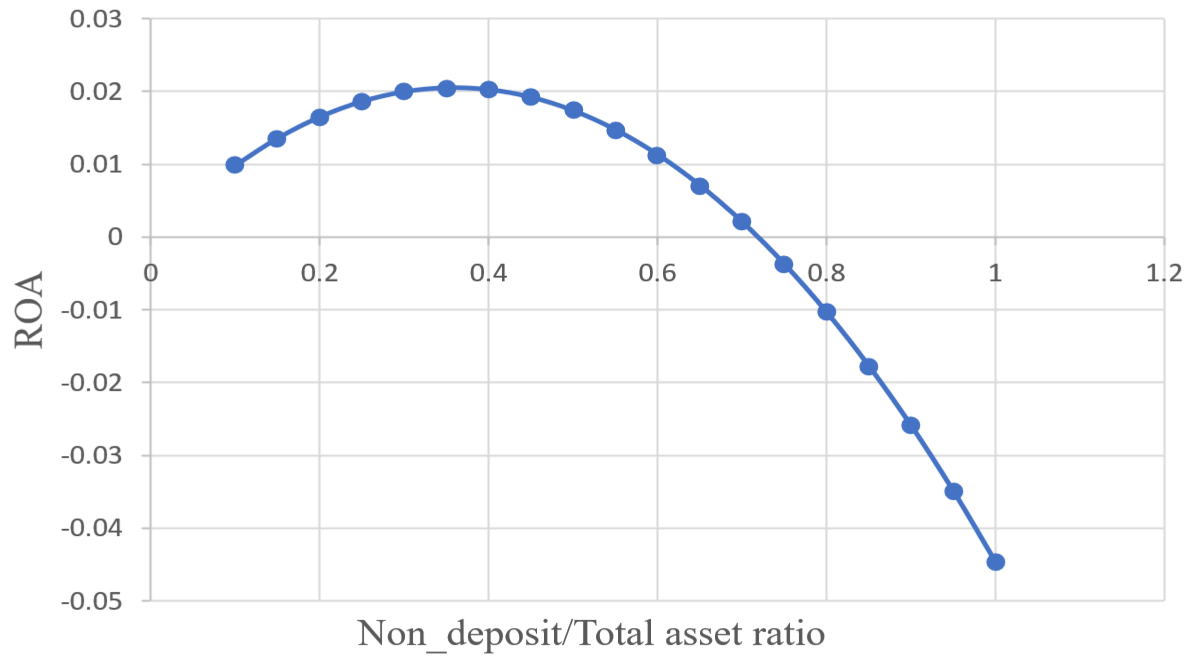


Figure 4. Relation between Non_Deposit/Total Asset ratio and ROA.

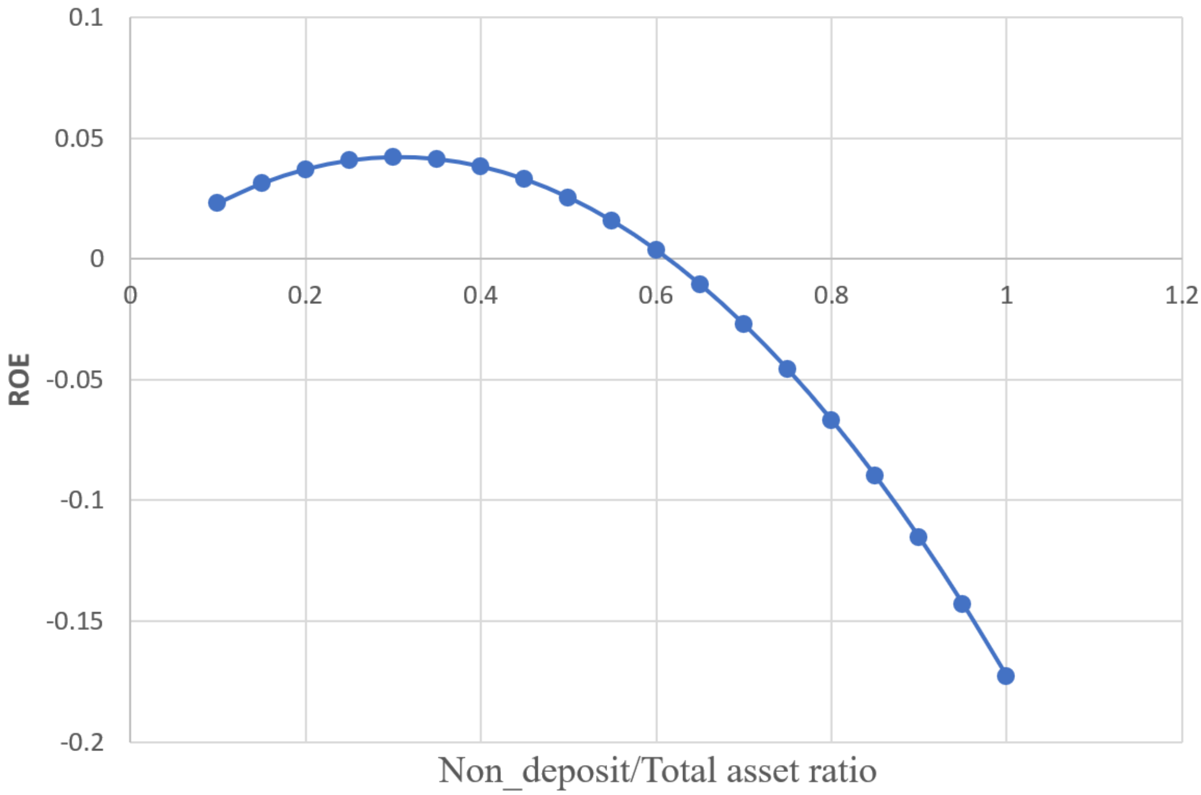


Figure 5. Relation between non-deposit/Total asset ratio and ROE.

Figure 4 illustrates the relationship between non-deposits to total assets and Return on Assets (ROA), while Figure 5 depicts the relationship between non-deposits to total assets and Return on Equity (ROE).

For non-deposit capital sources, the optimal non-deposits to total assets ratio does not differ much between the two models. In model 1, this ratio would reach 35%, at which point the return on assets (ROA) would achieve the highest level. In model 2, this ratio is about 30%, where the return on equity (ROE) would reach its highest level. Thus, it can be concluded that if the non-deposit to total assets ratio fluctuates between 30% and 35%, the bank's operational efficiency could be optimal.

This study aims to evaluate capital structure by analyzing key indicators, specifically the ratios of deposits to total assets and non-deposits to total assets, as described by Gropp and Heider (2010). Employing a Bayesian econometric regression approach, this research seeks to address the question of whether an optimal capital structure exists for banks to sustain operational efficiency. This work represents a notable contribution to the academic discourse, as prior studies have recognized the influence of capital structure on operational efficiency but have not established a definitive optimal threshold necessary to enhance efficiency within banking operations.

5.1. Control Variables

As for the internal factors of the bank, the results in the simulation table and the Interval test showed that the bank size (SIZE) plays a crucial role in improving the bank's performance. Accordingly, the probability of a positive effect of this variable on ROA is about 93%, while the probability of a positive impact on ROA is up to 100%, which was consistent with the hypothesis initially. Large banks would have resources to diversify activities to stabilize their income; this result was similar to the study of Elsas et al. (2010) and Chiorazzo et al. (2008). The ratio of foreign capital (FOREIGN) and liquid assets (LIQ) has a relatively light effect. The probability of impact of the FOREIGN variable on ROA is just over 70%, and ROE is only at 60%. Similarly, the probability of the impact of the LIQ variable on ROA and ROE is just over 70%.

The economic growth rate has a vaguer impact when the probability of the effect of the GDP variable on ROE and ROA is just over 70%. However, the inflation factor tends to improve the bank's performance. Although the impact of the variable INF on ROA is only about 63%, the effect of this variable on ROE is up to 100%. Research by Dung et al. (2020) for Vietnamese commercial banks also had similar results; Dung et al. (2020) explained that Vietnam has fast economic growth; to achieve this result, macroeconomic policies are often directed towards economic growth, especially monetary policy is often loosened to accomplish this goal. When monetary policy is loosened, the policy interest rate will decrease, and the cost of capital will decrease, which has contributed to improving the operational efficiency of enterprises, thereby enhancing the bank's profitability. However, Dung et al. (2020) also stated that this is only a short-term impact. In the long term, when inflation rises too high, the central bank will implement tight monetary policies to help curb inflation; at the same time, the economy's capital cost will also increase, resulting in a reduction in the bank's profitability.

5.2. The Impact of Capital Structure on the Performance of CTG and ACB

As mentioned in the research methods section, after performing Bayesian model simulations for 24 commercial banks, the authors would use the information obtained from the simulation results to make prior information to analyse the impact of capital structure on the performance of two banks, CTG and ACB. Although Bayesian methods could handle the small sample issue, it also has a particular sample size limitation. According to Van de Schoot, Broere, Perryck, Zondervan-Zwijnenburg, and Van Loey (2015) in Bayesian analysis, if there are only three observations for an independent variable, the simulation results may be biased; from 5 observations or more for an independent variable, the simulation of the results can be used for analysis. In this study, the research period is 2011-2021, which means we have 11 observations for each bank. With this number of observations, the simulation results are only reliable when analyzing a model that consists of only two independent variables. The study was conducted to evaluate the impact of capital structure on bank performance; the maximum number of independent variables in the model is only 2; therefore, the authors would choose two main variables that is financial leverage (measured through the ratio of deposits to total assets and the ratio of non-deposits to total assets) and the square of financial leverage. Thus, the model of the impact of capital structure on the performance of CTG and ACB has the form:

Model 3.1: $ROA_{j,t} = \gamma_{10} + \gamma_{11}DEP_{i,t} + \gamma_{12}DEPS_{i,t} + \varepsilon_{i,t}$ (9)

Model 3.2: $ROA_{j,t} = \gamma_{20} + \gamma_{21}NON\_DEP_{i,t} + \gamma_{22}NON\_DEPS_{i,t} + \varepsilon_{i,t}$ (10)

Model 4.1: $ROE_{j,t} = \delta_{10} + \delta_{11}DEP_{i,t} + \delta_{12}DEPS_{i,t} + \varepsilon_{i,t}$ (11)

Model 4.2: $ROE_{j,t} = \delta_{20} + \delta_{21}NON\_DEP_{i,t} + \delta_{22}NON\_DEPS_{i,t} + \varepsilon_{i,t}$ (12)

Where j = 1 is ACB and j = 2 is BID; t is year t. From the simulation results in Tables 4 and 5, we have prior information for the coefficients in the models as follows.

Table 7. Prior information for models 3 and 4.

Model 3.1	**Model 3.2**
Likelihood: $ROA \sim N\ (\mu, \sigma)$	
Priors:	
$\gamma_{10} \sim N\ (-0.051,\ 0.035)$ $\gamma_{11} \sim N\ (0.102,\ 0.069)$	$\gamma_{20} \sim N\ (-0.038,\ 0.030)$ $\gamma_{21} \sim N\ (0.114,\ 0.040)$
$\gamma_{12} \sim N\ (-0.097,\ 0.059)$	$\gamma_{22} \sim N\ (-0.159,\ 0.059)$
Model 4.1	Model 4.2
Likelihood: $ROE \sim N\ (\mu, \sigma)$	
Priors:	
$\delta_{11} \sim N\ (-0.536,\ 0.098)$ $\delta_{11} \sim N\ (0.533,\ 0.185)$ $\delta_{12} \sim N\ (-0.514,\ 0.158)$	$\delta_{11} \sim N\ (-0.441,\ 0.079)$ $\delta_{21} \sim N\ (0.270,\ 0.115)$ $\delta_{22} \sim N\ (-0.450,\ 0.163)$

Table 7 presents the prior information for models 3 and 4. Before simulating the Bayesian model with this prior information, the authors would perform a descriptive statistical analysis to gain an overview of the variables included in the regression model.

Table 8. Descriptive statistics of variables in models 3 and 4.

Variables	Obs.	Mean	Std. dev.	Min.	Max.
ACB					
ROA	12	0.011	0.006	0.003	0.020
ROE	12	0.169	0.088	0.064	0.277
DEP	12	0.764	0.129	0.506	0.886
NON_DEP	12	0.064	0.040	0.010	0.137
CTG					
ROA	12	0.010	0.003	0.005	0.015
ROE	12	0.150	0.055	0.083	0.268
DEP	12	0.659	0.069	0.559	0.759
NON_DEP	12	0.120	0.035	0.088	0.192

Table 8 summarizes the statistical data for the variables utilized in Models 3 and 4. In general, the ratio of deposits to total assets of ACB and CTG does not differ significantly, with the average value of this ratio at the two banks being 76.4% and 65.9%, respectively. However, there is a difference in the ratio of non-deposits to total assets between the two banks; this ratio for ACB is only 6.4%, while that of CTG is 12%. Regarding operational efficiency, the profitability of ACB is higher than that of CTG, with the average ROA of ACB being 0.011 and ROE being 0.169, while the figures for CTG are 0.01 and 0.15, respectively.

Table 9. Bayesian simulation results of model 3.

ROA	Model 3.1			Model 3.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
ACB						
DEP	0.126	0.199	0.012			
DEPS	-0.097	0.156	0.007			
NONDEP				0.113	0.173	0.005
NONDEPS				-0.164	0.243	0.008
_cons	-0.027	0.086	0.006	0.005	0.018	0.001
var	0.002	0.001	0.000	0.002	0.001	0.000
Optimal threshold for DEP	0.648					
Optimal threshold for NON_DEP				0.344		
Acceptance rate	0.547			0.653		
Efficiency: Min	0.021			0.096		
CTG						
DEP	0.120	0.200	0.008	0.668	0.324	0.012
DEPS	-0.101	0.176	0.006	-0.675	0.281	0.010
NONDEP				0.003	0.164	0.007
NONDEPS				0.006	0.003	0.000
_cons	-0.025	0.097	0.004			
var	0.002	0.001	0.000			
Optimal threshold for DEP	0.591					
Optimal threshold for NON_DEP				0.495		
Acceptance rate	0.583			0.591		
Efficiency: Min	0.055			0.054		

Table 10. Bayesian simulation results of model 4.

ROE	Model 4.1			Model 4.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
ACB						
DEP	0.730	0.305	0.011			
DEPS	-0.663	0.251	0.009			
NONDEP				0.514	0.314	0.012
NONDEPS				-0.423	0.417	0.014
_cons	0.003	0.148	0.005	0.133	0.036	0.001
var	0.010	0.006	0.000	0.010	0.006	0.000
Optimal threshold for DEP	**0.551**					
Optimal threshold for NON_DEP				0.607		
Acceptance rate						
Efficiency: Min.						
CTG						
DEP	0.668	0.324	0.012			
DEPS	-0.675	0.281	0.010			
NONDEP				0.432	0.290	0.010
NONDEPS				-0.395	0.404	0.017
_cons	0.003	0.164	0.007	0.099	0.040	0.001
var	0.006	0.003	0.000	0.006	0.003	0.000
Optimal threshold for DEP	0.494					
Optimal threshold for NON_DEP				0.547		
Acceptance rate	0.591			0.619		
Efficiency: Min.	0.054			0.059		

Table 11. Interval test model 2.

Probability	Model 3.1			Model 3.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
ACB						
{ROA:DEP} > 0	**0.758**	0.428	0.014			
{ROA:DEPS} < 0	**0.743**	0.437	0.014			
{ROA:NON_DEP} > 0				0.749	0.434	0.015
{ROA:NON_DEPS} < 0				0.738	0.440	0.014
CTG						
{ROA:DEP} > 0	**0.729**	0.445	0.018			
{ROA:DEPS} < 0	**0.729**	0.444	0.016			
{ROA:NON_DEP} > 0				0.744	0.436	0.013
{ROA:NON_DEPS} < 0				0.751	0.432	0.013

Table 12. Interval test model 3.

Probability	Model 2.1			Model 2.2		
	Mean	Std. dev.	MCSE	Mean	Std. dev.	MCSE
ACB						
{ROE:DEP} > 0	0.999	0.033	0.000			
{ROE:DEPS} < 0	1.000	0.014	0.000			
{ROE:NON_DEP} > 0				0.991	0.095	0.001
{ROE:NON_DEPS} < 0				0.997	0.056	0.001
CTG						
{ROE:DEP} > 0	0.983	0.131	0.004			
{ROE:DEPS} < 0	0.987	0.114	0.004			
{ROE:NON_DEP} > 0				0.930	0.255	0.007
{ROE:NON_DEPS} < 0				0.842	0.365	0.012

Table 9 and Table 10 provide the results of the Bayesian simulation, illustrating the effects of the ratios of deposits to total assets and non-deposits to total assets on return on assets (ROA) and return on equity (ROE) at BID and CTG. Meanwhile, Table 11 and Table 12 present the estimated probabilities associated with these effects. The simulation results in Table 9 show that the impact of capital structure on ROA has the form of an inverted U-curve in both selected banks, specifically for ACB, the optimal threshold of the ratio deposit to total assets for maximum ROA is 68.4%, and the ratio of non-deposit to total assets is 34.4%; for CTG, these figures are 59.1% and 49.5%, respectively. However, this threshold effect is not apparent when the probability of the impact of the variables DEP and NON_DEP on ROA in both banks is only about 70%. Meanwhile, the threshold effect of financial leverage on ROE is evident when the probability of impact of DEP and NON_DEP on ROE is mostly above 90%; even for ACB, this number was above 99%. The optimal threshold of the DEP ratio for ROE of ACB is 55.1%, and NON_DEP is 60.7%, while this figure for CTG is 49.4% and 54.7%, respectively. The optimal threshold for financial leverage of these two banks is not much different; however, in general, the optimal point for financial leverage of CTG is lower than that of ACB. This can be explained by the fact that CTG, being a state-owned bank with a majority share, has the advantage of cheap capital compared to other banks, so it may have less need to take advantage of financial leverage for optimal profitability. Through the example of two specific banks, ACB and CTG, the authors have outlined a method for determining the optimal capital structure for each bank, even with a relatively small data set consisting of only 11 observations. This represents a significant empirical contribution of the study and marks a key distinction from previous research, as no prior studies have focused on the capital structure of a single bank due to insufficient research sample sizes.

6. CONCLUSION AND POLICY IMPLICATIONS

The Bayesian simulation analysis results have provided evidence of an optimal capital structure to maximize the bank's operational efficiency. This research effectively addresses the limitations of prior studies that focused solely on the linear relationship between capital structure and bank performance. Accordingly, for the overall sample, the performance of commercial banks would be optimal when the ratio of deposits to total assets ranges from 50% to 70%. For the ratio of non-deposits to total assets, this number ranges from 30% to 35%. The study presents compelling evidence regarding the optimal capital structure threshold that enhances the performance of commercial banks. This finding provides valuable empirical support for the established theory of capital structure within the banking sector. For the control variable, the interval test results show that bank size has an essential role in bank performance; this result is similar to the studies of Elsas et al. (2010) and Chiorazzo et al. (2008). Meanwhile, the ratio of foreign capital and the ratio of liquid assets have a relatively vague impact. Regarding the macroeconomic factors, economic growth does not significantly impact the bank's performance, while inflation positively impacts the bank's performance. However, according to Dung et al. (2020), this is only a short-term impact. By combining the available prior information and the collected data to compute the posterior distribution, the Bayesian approach allows us to conduct quantitative analysis with a small number of observations. Taking advantage of this, the authors evaluated the impact of capital structure on the performance of 24 commercial banks and analyzed each specific bank in the sample. The two banks selected for analysis are ACB, which is a 100% privately owned bank, and CTG, which has a majority share capital held by the state. This distinction represents a significant departure from prior studies. Furthermore, it offers practical contributions by referencing a method to ascertain the optimal capital structure threshold tailored to the unique characteristics of each bank, ultimately enhancing their operational efficiency.

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