FACTORS AFFECTING THE TECHNICAL EFFICIENCY OF STATE-OWNED COMMERCIAL BANKS: AN EMPIRICAL STUDY OF BANK GOVERNANCE

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Abstract

The study examined the technical efficiency and its influencing factors within state-owned commercial banks in Vietnam during the period from 2013 to 2022. Deploying data envelopment analysis (DEA) (Banker et al., 1984) and the Tobit regression model, this study revealed that the technical efficiency and scale efficiency of these banks experienced various fluctuations and reached optimal levels in multiple years. The analysis highlights positive relationships between technical efficiency and ratios such as return on equity (ROE), earnings per share (EPS), and loan-to-deposit (LD). Conversely, the loan-to-asset (LOTA) ratio and gross domestic product (GDP) growth rate were found to have negative effects on technical efficiency. Notably, the 100 percent state-owned variable has shown a statistically significant negative influence. These findings underscore the importance of resource allocation, including the optimisation of outputs based on inputs, and emphasise the necessity of assessing factors influencing technical efficiency. Formulating strategies aimed at improving business efficiency and fostering sustainable bank development is crucial. This comprehensive analysis provides valuable insights for policymakers and bank managers to enhance the operational performance of state-owned banks in Vietnam, ensuring their long-term sustainability and contribution to the national economy.

Keywords: Efficiency, Technical Efficiency, Commercial Bank, Data Envelopment Analysis, Tobit Models

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1. INTRODUCTION

Commercial banks face the challenge of ensuring efficiency in their operations as their roles are businesses that operate in the financial sector. Their primary functions include capital raising, capital consumption and other services with the dual aims of profit maximisation and financial stability (Wheelock & Wilson, 1995). Evaluating the technical efficiency of these banks involves the production of outputs from inputs and the assessment of outcomes achieved and consumed resources (Banker, 1993). Efficiency, in this context, is the correlation between the utilisation of resources as inputs and the outputs that are goods and services. Business operations play a significant role in assessing a bank's ability to meet its obligations both historically and prospectively.

Various methods have been developed to measure the business operation efficiency in commercial banks such as financial ratios and the CAMELS model (Samad, 2017). Alternatively, the method using the margins requires calculating the relative efficiency indices by comparing the banks' performances against a top-performing bank in the industry. The operational efficiency of any organisation reflects the relationship between minimum input and achievable maximum output. This analytical framework was developed by and subsequently refined by Banker (1993). Henceforth, this model includes technical efficiency, allocation efficiency, cost efficiency and scale efficiency in evaluating the operational efficiency of commercial banks, thus allowing managers to assess their performance in time series or compare to their counterparts within the industry.

Improving business efficiency remains a paramount goal for commercial banks, necessitating efforts to strengthen financial abilities, operational capability, business opportunities seizing and informed decisions in input and output selection (Hughes & Mester, 2008). Therefore, the evaluation of factors influencing business efficiency is increasingly necessary within the bank sector. These factors are interrelated, having multidimensional impacts on efficiency that necessitate the managers to manage and prioritise properly. Therefore, for banks, to thrive in the recent dynamic landscape, it is crucial to examine, measure and evaluate the influence of these factors on business efficiency in the bank's development strategies while considering the overall economic development conditions.

As considered the largest state-owned commercial banks in Vietnam (Vietinbank, Vietcombank, Joint Stock Commercial Bank for Investment and Development of Vietnam — BIDV, and Agribank), these four play the most paramount role in capital support for all sectors and industries in the economy. Their positions as well as significance are underscored by extensive branch networks, solidified capital bases, and internal management capabilities. Following the privatisation of the three banks (Vietinbank, Vietcombank, and BIDV), these banks have utilised their strengths to drive innovation, maintain their market positions, and enhance service quality. However, the banking industry also faces difficulties and challenges in recent competitive dynamics. Therefore, achievements in recent years compared to the potential, position, and reputation of banks are still modest, and operational efficiency, technical efficiency have not reached desired levels. To keep pace with trends and effectively navigate new challenges, it is imperative to delve into research on technical efficiency and its influencing factors. This research is essential for formulating both short-term tactical plans and long-term strategic initiatives. Through generalising topics and studies related to the thesis, it is realised that there are still research gaps:

1) Most empirical studies about the business efficiency of commercial banks covered financial indicator analysis. There are no studies about business efficiency in relation to banking resources or proposals of a theoretical model for business efficiency for commercial banks.

2) Most studies about the business efficiency of commercial banks used quantitative models with the scope of study for the whole system of Vietnamese commercial banks or specific commercial banks with data collected on a quarterly basis. The literature reviews show that there has been no research in Vietnam on the business efficiency of state-owned commercial banks using the data envelopment analysis (DEA) and Tobit models in the past 10 years.

To clarify viewpoints of business efficiency, criteria for evaluation, measures of business efficiency for commercial banks or affecting business efficiency, and the model for measuring such factors for commercial banks. This study also aims to answer the question of how the technical efficiency of banks has been recently, and what factors affect the technical efficiency of banks. The results show positive/negative relationships between technical efficiency and ratios.

The structure of this paper is as follows. Section 2 reviews the relevant literature. Section 3 analyses the methodology used to conduct empirical research on technical efficiency and the factors influencing it. Section 4 presents the results of the factors influencing technical efficiency using the Tobit model in state-owned commercial banks in Vietnam. Sections 5 and 6 cover the discussion and conclusion, respectively.

2. LITERATURE REVIEW

The topic of banks' efficiency has gained considerable attention from scholars worldwide. Researchers have employed various methods to assess technical efficiency, with the utilisation of DEA that considers specific sets of input and output variables outlined by Banker (1993). Subsequently, Berger et al. (1987) also adopted the same method of analysis to assess the technical efficiency of both state-owned and non-state-owned commercial banks (Berger & Humphrey, 1997). These studies are considered a solid foundation of technical efficiency research using the DEA model that has paved the way for further research. This topic has been examined by the trends in competition and efficiency by Vittas and Neal (1992), or linked with risk factors, as demonstrated by Laeven (1999) with a sample of banks in Southeast Asia, also using the DEA model.

Several studies have employed both stochastic frontier analysis (SFA) and DEA, using input-output variables to estimate the technical efficiency of commercial banks and analyse Malmquist indices. Besides, some studies on the relationship between efficiency and risk in commercial banks have opted for a non-parametric DEA approach, as demonstrated by Laeven (1999). To measure technical efficiency during banking restructuring post-crises, DEA has been utilised with specific inputs (interest expenses, employee expenses, operating expenses) and outputs (loans, securities). For instance, a study on the efficiency of Emporiki bank branches in Greece during 2001–2002 employed the goal programming (GP) model alongside DEA. Input variables included $x1$ (salary, overtime payment costs), $x2$ (branch operation and office rental costs), as well as $x3$ (other operating expenses like telephone, electricity, stationery, and insurance). Output variables comprised $y1$ (deposits), $y2$ (loans), $y3$ (other activities), $y4$ (average loan value), $y5$ (average deposit value), and $y6$ (non-interest income). Specifically, in this study, variables $y1$, $y2$, and *y3* were assigned to GP Model A, while *y4, y5*, and *y6* were allocated to GP Model B (Tsolas & Giokas, 2012). Additionally, some studies have used the DEA model to evaluate technical efficiency combined with financial indicators to assess the profit efficiency of commercial banks. Scholars Isik and Hassan (2002) combined the analysis of bank efficiency through financial indicators with the DEA model. The efficiency of state-owned commercial banks in Turkey was evaluated by combining input and output factors to assess the impact, ownership characteristics, and management proficiency of banks on profit targets during the period 1988–1996.

Recent studies on technical efficiency have included the impact of the COVID-19 pandemic. Intriguing findings indicate that the technical efficiency of banks tends to increase during the pandemic period, suggesting resilience to economic fluctuations (Patra et al., 2023). Adopting a two-stage DEA model, Kumar and Kar (2023) have compared the internal technical efficiency of two categories of banks: 1) the private sector and 2) the public sector. Moreover, some research has revealed a positive relationship between technical efficiency and a bank's scale, which drives banks to expand their operations and increase their total assets as well as revenue (Ravirajan & Shanmugam, 2023).

Several studies have employed the Tobit model after considering the DEA model (Ullah et al., 2023; Delis & Papanikolaou, 2009; Ravirajan & Shanmugam, 2023; Grigorian & Manole, 2006; Sufian & Shah Habibullah, 2010). Various factors, including financial capacity and structure, influence technical efficiency. The financial capacity is defined as the asset and capital values owned by banks, indicating their ability to engage in business activities. For commercial banks, financial capacity primarily consists of equity, representing shareholder capital. Notably, studies have revealed that shareholder capital and profits positively affect technical efficiency (Istaiteyeh et al., 2024; Ullah et al., 2023). Therefore, the evaluation of factors influencing business efficiency is increasingly necessary within the bank sector (Mhaibes et al., 2024; Begum et al., 2023).

Developing a reasonable financial framework is essential to improve the operational efficiency of commercial banks. Therefore, for banks, to thrive in the recent dynamic landscape, it is crucial to examine, measure and evaluate the influence of these factors on business efficiency in the bank's development strategies while considering the overall economic development conditions (Hafez, 2023; Michael et al., 2023).

Financial structure pertains to the capital arrangement that banks raise to support their activities, often evaluated using metrics like the debt-to-equity ratio, self-financing ratio, or debt-to-equity ratio. In many instances, banks strive to optimise efficiency by either maximising output from limited input or minimising input usage with predetermined outputs. Assuming that decision-making units (DMU) — banks operate in similar market conditions (market, price, technology, etc.), those demonstrate higher efficiency than others by effectively combining input factors to generate output factors (Tamatam et al., 2019). Different combinations of input and output factors will result in different efficiencies. To assess how input-output combinations impact output outcomes, some studies adopted equity ratio on total capital (EQRE), loan-to-asset ratio (LOTA) (Sufian & ShahHabibullah, 2010), loan-to-deposit ratio (LD) (Sulaeman et al., 2019)., and non-performing loans (NPL) (Sufian & Shah Habibullah, 2010; Ullah et al., 2023).

Commercial banks assess their technical efficiency through internal restructuring outcomes. Effective restructuring across all levels, in both short and long terms, enhances the overall operational efficiency of these banks. Moreover, technical efficiency is also assessed during the process of mergers and acquisitions (M&A), as explored by (Sufian & Shah Habibullah, 2010). Findings suggest that M&A activities lead to the formation of high-quality bank groups, although the extent of efficiency scalability remains unclear. Some research indicates that M&As can enhance the efficiency of banks (Grigorian & Manole, 2006). Additionally, the ownership structure, whether a bank is listed or unlisted, influences its technical efficiency (Nguyen & Pham, 2020).

The technical efficiency of commercial banks is influenced by changes in economic cycles, inflation rates, gross domestic product (GDP) growth rates, capital flows in the economy, prospects of economic sectors using bank capital, structural shifts between economic regions, price stability, interest rates, unemployment rates, integration pathways (Delis & Papanikolaou, 2009). Stable macroeconomic growth rates will positively support the business operations of enterprises, including commercial banks (Istaiteyeh et al., 2024). Specifically, during periods of economic growth, industries expand production, and capital demand increases, helping banks effectively use input factors to achieve optimal outputs, and manage customer loans to be fully and timely paid, thereby contributing to improving technical efficiency. Conversely, during economic downturns, business activities are narrowed, and economic entities face difficulties, and minimise expenses, leading to decreased demand for capital and bank loans. Customers facing difficulties in repaying principal and interest to the bank may cause banks to face risks, increased bad debts, and potential asset loss.

3. RESEARCH METHODOLOGY

3.1. Model for determining technical efficiency

The technical efficiency of a bank is determined by the following equation:

$$Max\ E_s = \frac{\sum_{i=1}^{m} u_i y_{is}}{\sum_{j=1}^{n} v_j x_{js}} \tag{1}$$

where,

- y_{is} is output *i* of bank *s*;
- x_{js} is input *j* used by bank *s*;
- u_i is the output weight;
- v_j is the input weight;
- E_s is maximized to select optimal weights, subject to the following conditions:

$$\frac{\sum_{i=1}^{m} u_i y_{is}}{\sum_{j=1}^{n} v_j x_{js}} \leq 1 \tag{2}$$

where, $r = 1, \dots n;\ v_j\ and\ u_i \geq 0$.

However, there are difficulties in finding the solution to the problem, so Charnes et al. (1994) added the following constraint:

$$\sum_{j=1}^{n} v_j x_{js} = 1 \quad (3)$$

Then, technical efficiency can be considered as in Eq. (4) with three constraints presented below.

$$\underset{u,v}{Max}\, z_s = \sum_{i=1}^{m} u_i y_{is} \quad (4)$$

$$\begin{cases} \sum_{j=1}^{n} v_j x_{js} = 1 \\ \sum_{i=1}^{m} u_i y_{is} - \sum_{j=1}^{n} v_j x_{jr} \le 0, r = 1, \dots n \\ u_i \ge 0, v_j \ge 0, \forall i, j \end{cases} \quad (5)$$

Constraint 1. Requires the total weight of input variables at the bank to be 1.

Constraint 2: Banks (banks in different years) are operating either within or on the production frontier.

Constraint 3. The weights u_i and v_j are unknown and are computed from the software. To solve the linear problem, we convert it to a dual problem to find the optimal values. The dual function of the original linear function is as follows in Eq. (6) with constraints.

$$\underset{\theta\lambda}{Min}\, z_s = \theta_s \quad (6)$$

$$\begin{cases} \theta_s x_{js} - \sum_{r=1}^{n} \lambda_r x_{ir} \ge 0, j = 1,2, .. m \\ \sum_{r=1}^{n} \lambda_r y_{ir} - y_{is} \ge 0, r = 1,2, \dots s \\ \lambda_r \ge 0, r = 1,2, \dots n \end{cases} \quad (7)$$

where,

- x_{js} and y_{is} are the input and output of bank s being evaluated;
- λ_r is the weight of the bank;
- θ_s is the pure technical efficiency of the evaluated bank;
- θ_s is the technical efficiency of the bank, with a value of 1 if it lies on the frontier.

Therefore, Banker (1993) proposed an additional assumption of bank efficiency when there is scale impact or the assumption of scale efficiency (VRS). The model is further supplemented with the assumption = 1, so we have another efficiency indicator which is scale efficiency (Banker et al., 1984), then we have Eq. (6), where:

$$\begin{cases} \theta_s x_{js} - \sum_{r=1}^{n} \lambda_r x_{ir} \ge 0, j = 1,2, \dots m \\ \sum_{r=1}^{n} \lambda_r y_{ir} - y_{is} \ge 0, r = 1,2, \dots s \\ \lambda_r \ge 0, r = 1, 2, \dots n; \sum_{1}^{n} \lambda_r = 1 \end{cases} \quad (8)$$

Cooper et al. (2011) further developed the study to calculate the excess input or the shortfall in output scale efficiency of the bank.

$$Min\theta_s - \varepsilon(\sum_{j=1}^{n} s_j^- + \sum_{i=1}^{m} s_i^+ \theta, \lambda, s_j^-, s_i^+ \quad (9)$$

where,

$$\begin{cases} \sum_{r=1}^{n} \lambda_r x_{ir} + s_j^- \ge \theta_s x_{js}, j = 1,2, .. m \\ \sum_{r=1}^{n} \lambda_r y_{ir} - s_i^+ = y_{is}, i = 1,2, \dots s \\ \lambda_r, s_j^-, s_i^+ \ge 0, r = 1,2, \dots n \end{cases} \quad (10)$$

s_j^-, s_i^+, respectively, are the surplus input and deficient output of the bank. When the bank achieves optimal efficiency $\theta_z = 1, s_j^- = s_i^+ = 0$.

The Charnes, Cooper, and Rhodes (CCR) model is built on the assumption of constant returns to scale, but in reality, bank efficiency varies depending on the scale of operations. Therefore, Banker et al. (1984) proposed to add the assumption of efficiency when the scale factor impacts, additionally incorporating the assumption $\sum_1^n \lambda_r = 1$, hence the model is called Banker, Charnes and Cooper (BCC) and the input orientation model for the bank s is as follows (Banker et al., 1984):

$$Min\theta_s - \varepsilon(\sum_{j=1}^{n} s_j^- + \sum_{i=1}^{m} s_i^+ \theta, \lambda, s_j^-, s_i^+ \quad (11)$$

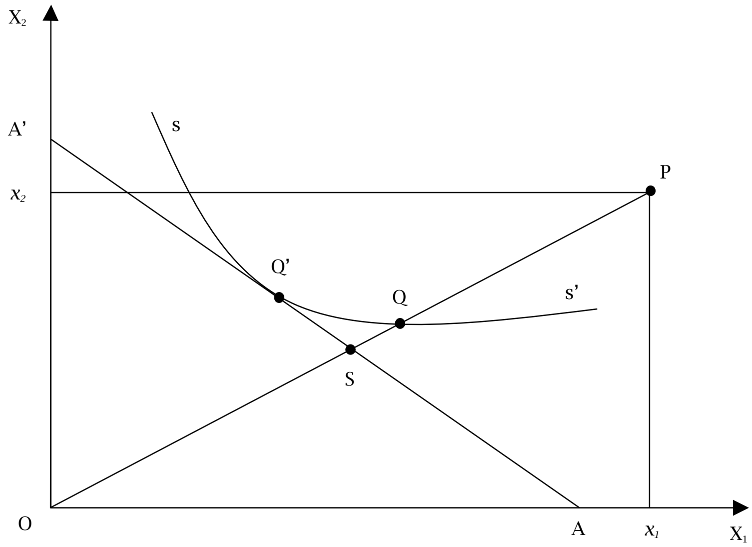
where,

$$\begin{cases} \sum_{r=1}^{n} \lambda_r x_{ir} + s_j^- \ge \theta_s x_{js}, j = 1,2, \dots m \\ \sum_{r=1}^{n} \lambda_r y_{ir} - s_i^+ = y_{is}, i = 1,2, \dots s \\ \lambda_r, s_j^-, s_i^+ \ge 0, r = 1,2, \dots n; \sum_{1}^{n} \lambda_r = 1 \end{cases} \quad (12)$$

The value of θ_s represents the pure technical efficiency of the BCC model with the assumption of scale-dependent efficiency.

Simulating technical efficiency in Figure 1 is as follows. The model with two inputs "x_1", "x_2" and output "y", along with the assumption of constant returns to scale. The isoquant curve of overall efficient banks is *ss'*. Therefore, the optimal cost to produce output on the *ss'* curve, units lying on the *ss'* curve are considered the best combination, and the most cost-saving input. If the bank uses predetermined inputs at point *P* to produce one unit of output, then the technical inefficiency of the bank is determined by the distance *QP*. In this case, the level of inefficiency is represented by the ratio *QP/OP* (this ratio is less than 1). Efficiency according to the model is measured by the ratio: $TE_i = OQ / OP$ and takes values ranging from 0 to 1. When efficiency has a value of 1, the bank is maximally efficient, point *Q* is efficient because it lies on the isoquant curve (Sengupta, 1988).

Figure 1. Technical efficiency and allocation efficiency



Source: Farrell (1957), Sengupta (1988).

Allocation efficiency (*AE*). The allocation efficiency of the bank at point *P* is determined by $AE_i = OS / OQ$. The distance *SP* represents the reduction in production costs if production occurs at the allocation-efficient point and technical or overall economic efficiency *Q'*.

Economic efficiency (*CE*). Overall economic efficiency or cost efficiency is the combination of input factors x_1 and x_2 with the lowest cost. Cost efficiency is determined by the ratio of actual costs to minimum costs, where $CE = OS / OP$. *CE* consists of two components: 1) technical efficiency and 2) allocation efficiency.

The equation for determining *CE* is as follows:

$$(CE)\frac{OS}{OP} = (TE)\frac{OQ}{OP} * (AE)\frac{OS}{OQ} \tag{13}$$

Scale efficiency. Unlike *AE* and *CE*, scale efficiency measures the ratio of output changes when input factors change with unchanged production technology and management at the optimal production scale.

Three cases may occur:

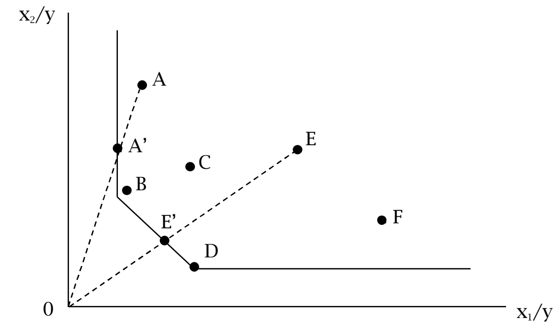
1) Increasing returns to scale (IRS) occur when the output scale of the bank increases and the input scale increases less than the corresponding increase in output scale.

2) Decreasing returns to scale (DRS) occur when the rate of increase in input costs of the production process is greater than the increase in the scale of the corresponding output.

3) Constant returns to scale (CRS) when the rate of increase in output scale and the rate of increase in input costs are equal.

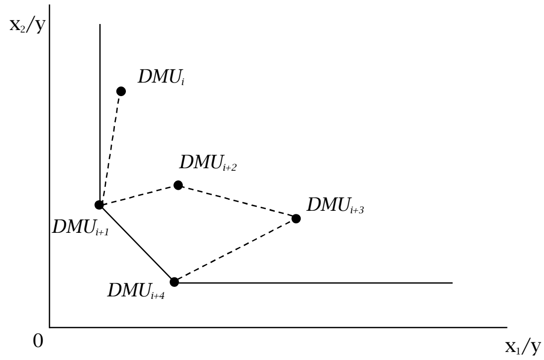
DEA models are used to evaluate the efficiency of a bank relative to other banks in the sample or to examine the efficiency of a unit over time. The result generates a frontier set of efficient banks and compares it with inefficient banks (see Figure 2). Examination of a bank in different years, comparing efficient years with inefficient years (see Figure 3).

Figure 2. Technical efficiency of commercial banks



Source: Charnes et al. (1994).

Figure 3. Technical efficiency of a bank follow-time



Source: Charnes et al. (1994) and Ngo (2012).

With this model, a bank's optimal operational efficiency will have a value of 1. The indices of inefficient units are calculated by comparing the inefficient units against the efficient frontier, or by analysing the efficiency over time of a bank using the DEA model to see how efficiency changes over time, with years of optimal efficiency having a technical efficiency value of 1, compared to less efficient years with a value less than 1.

The DEA model in analysing the technical efficiency of commercial banks needs to specify the approach to commercial banks with which functions to select appropriate input and output factors for the research context. There are five approaches: 1) production approach, 2) asset approach, 3) intermediate approach, 4) value-added approach, and 5) cost approach. Among them, the intermediate approach is the most widely used, considering commercial banks as financial intermediaries, establishing and utilising funds for lending and services.

For the DEA method, there is no requirement for the shape of the best frontier and constraints on the distribution of inefficient factors. There is no need to specify the form of the function. In many cases, specifying the wrong form of the function will distort the research results. The DEA model constructs the efficient frontier based on actual research samples, so the results of DEA analysis are closer to reality. The content of the method is consistent with the concept of technical efficiency of commercial banks as proposed by Banker (1993). As a comprehensive efficiency analysis model, based on many input and output factors in the operations of commercial banks, it is suitable for the business characteristics of Vietnamese commercial banks. The results of the model can be used as a dependent variable in evaluating factors affecting the technical efficiency of commercial banks. It is easy to handle technically, and simple to operate using software to run the model.

The study collected data from four state-owned commercial banks in Vietnam over 10 years, from 2013 to 2022. Based on the overall research results, and the theoretical basis of technical efficiency, especially the theory of the intermediate approach to commercial banks' functions, the DEA model evaluates the technical efficiency of state-owned commercial banks in Vietnam as shown in Table 1. The model measures technical efficiency based on input and output variables, including technical efficiency, scale efficiency, and pure technical efficiency.

Table 1. Input and output of the DEA model

Input variables		***Output variables***	
X1: Operating expenses	Bhattacharyya et al. (1997), Laeven (1999), Kasman (2002), Tsolas and Giokas (2012), Istaiteyeh et al. (2024)	*Y1*: Net income	Denizer et al. (2000), Laeven (1999)
X2: Total asset		*Y2*: Earning per share	
X3: Equity			

Source: Authors' elaboration.

3.2. Model of technical factors affecting the technical efficiency of state-owned commercial banks

The study uses the Tobit regression model, where the dependent variable takes values in the range (0, 1), to analyse the factors affecting the technical efficiency of state-owned commercial banks, as introduced by Tobin in 1958. The Tobit regression model is also called the censored regression model, designed to estimate the linear relationship between variables when the dependent variable is censored on the left or right (also known as censoring from below and above). This model is considered the most appropriate for evaluating the factors influencing the technical efficiency of state-owned commercial banks after determining the efficiency of each bank or a bank over time (Tobin, 1958).

In addition to the DEA model and Tobit model, some studies use ordinary least squares (OLS) regression methods, or Federal reference method (FRM) and Federal equivalent method (FEM) to evaluate the impact of factors on bank business performance. However, the Tobit model is still considered the best suitable for the dependent variable censored between 0 and 1.

Right censoring occurs when the dependent variable cases have values equal to or greater than some threshold, but all take the value of that threshold (even though the actual value may be equal to the threshold, it could also be higher). In the case of left censoring, the value of the dependent variable is also assigned the lowest threshold value (even though that dependent variable could have even lower values). The Tobit model can be used to predict an outcome censored from above, from below, or both. In the current study, different efficiency points estimated through DEA fall within the range from 0 to 1 and can be considered dependent variables in the Tobit model (Ullah et al., 2023).

The form of the model is as follows:

$$Y_i = \beta' x_i + \varepsilon_i \tag{14}$$

where, x_i and β' are explanatory variables and unknown parameters. Y' is the dependent variable constrained within the range of 0 and 1.

Below is the formula for determining the value of β':

$$L = \prod_{y_i=0}(1-F_i)\prod_{y_i>0}\frac{1}{(2\Pi\sigma^2)^{1/2}} \times e^{-\left[\frac{1}{2\sigma^2}\right](y_i-\beta x_i)^2} \tag{15}$$

$$F_i = \int_{-\infty}^{\beta x_i/\sigma}\frac{1}{(2\Pi)^{1/2}}e^{-t^2/2}dt \tag{16}$$

The Tobit model can be simplified as follows:

$$\xi_{it} = \gamma_0 + \sum_{j=1}^{n}\gamma_j D_{jit} + \sum_{j=1}^{m}\gamma_j Z_{jit} \tag{17}$$

where,

- ξ_{it} is the technical efficiency of bank i in year t, technical efficiency is analysed using DEA or SFA methods;
- D_{jit} are dummy variables (bank type, before and after restructuring, etc.);
- Z_{jit} are variables (market factors, scale, market share, risk, etc.).

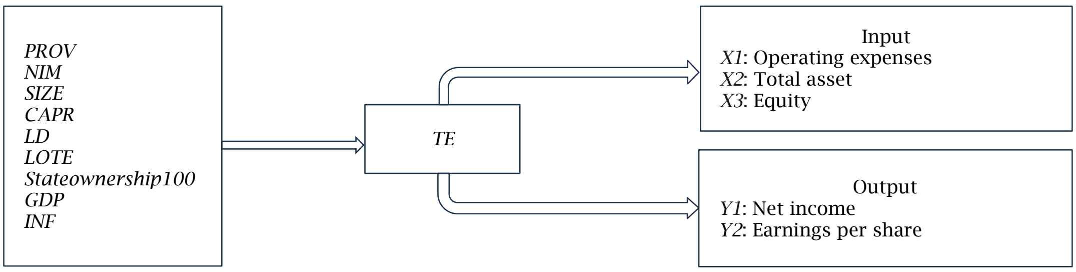
The variables affecting the study are presented in detail in Table 2.

Table 2. Detailed description of variables in the Tobit regression model

Variables	*Description*	*Source*	*Expectation (+/-)*
	Dependent variable		
TE	Technical efficiency		
	Independent variable		
EPS	Earnings per share	Financial report	+
ROE	Return on common equity	Balance sheet	+
PROV	Risk provisions	Balance sheet, financial statement	-
NIM	Net interest margin	Profit and loss statement, balance sheet	+
SIZE	Bank size	Balance sheet, financial statement	-/+
CAPR	Equity/asset ratio	Balance sheet	+
LD	Loan/deposit ratio	Balance sheet, financial statement	+/-
LOTA	Loan/asset ration	Balance sheet	+/-
Stateownership100	100% state-owned	0, 1	+/-
GDP	Gross domestic product	General Statistics Office	+
INF	Inflation rates	General Statistics Office	-

Source: Authors' elaboration.

Figure 4. Factors affecting technical efficiency



Source: Authors' elaboration.

4. EMPIRICAL RESULTS

4.1. Technical efficiency based on the DEA model

Analysing *TE* according to the DEA model is based on input variables and output variables. These variables are calculated from the business resources of commercial banks.

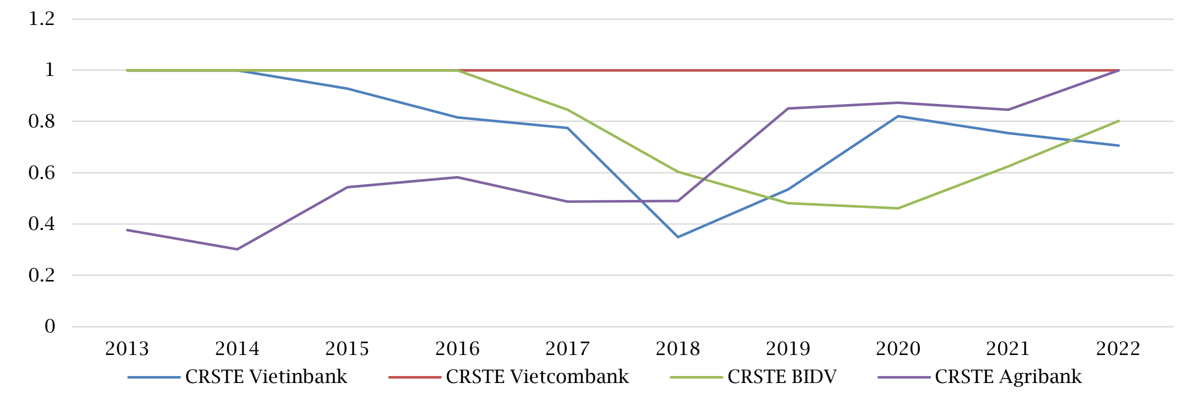
The data presented in Table 3 indicates considerable fluctuations in the technical efficiency of state-owned commercial banks from 2013 to 2022. Initially, Vietinbank, Vietcombank, and BIDV achieved maximum technical efficiency scores of 1 in the first two years, but this trend declined in subsequent years. Specifically, Vietinbank's efficiency dropped to 0.349 in 2018, fluctuating between 0.5 and over 0.9 in the following years. Notably, Vietcombank maintained a consistent optimal efficiency score of 1 throughout the entire decade. BIDV initially reached optimal technical efficiency levels in the first four years but experienced significant fluctuations afterwards. In contrast, Agribank started with the lowest technical efficiency, yet demonstrated a gradual improvement. While achieving only 0.376 in 2013, Agribank's technical efficiency eventually reached optimal levels of 1 by 2022.

Table 3. Technical efficiency of state-owned commercial banks in the period of 2013–2022

Year	*Vietinbank*				*Vietcombank*				*BIDV*				*Agribank*			
	CRSTE	*VRSTE*	*Scale*	*IRS/DRS*	*CRSTE*	*VRSTE*	*Scale*	*IRS/DRS*	*CRSTE*	*VRSTE*	*Scale*	*IRS/DRS*	*CRSTE*	*VRSTE*	*Scale*	*IRS/DRS*
2013	1.000	1.000	1.000	-	1.000	1.000	1.000	-	1.000	1.000	1.000	-	0.376	0.855	0.439	IRS
2014	1.000	1.000	1.000	-	1.000	1.000	1.000	-	1.000	1.000	1.000	-	0.302	0.841	0.359	IRS
2015	0.928	0.948	0.978	DRS	1.000	1.000	1.000	-	1.000	1.000	1.000	-	0.544	0.996	0.546	IRS
2016	0.815	0.831	0.981	IRS	1.000	1.000	1.000	-	1.000	1.000	1.000	-	0.582	0.998	0.583	IRS
2017	0.774	0.945	0.819	IRS	1.000	1.000	1.000	-	0.846	1.000	0.846	IRS	0.487	1.000	0.487	IRS
2018	0.349	0.966	0.361	IRS	1.000	1.000	1.000	-	0.604	1.000	0.604	IRS	0.490	0.973	0.504	IRS
2019	0.535	1.000	0.535	IRS	1.000	1.000	1.000	-	0.481	0.982	0.489	IRS	0.851	1.000	0.851	IRS
2020	0.820	1.000	0.820	IRS	1.000	1.000	1.000	-	0.462	1.000	0.462	IRS	0.873	1.000	0.873	IRS
2021	0.755	1.000	0.755	IRS	1.000	1.000	1.000	-	0.625	1.000	0.625	IRS	0.846	1.000	0.846	IRS
2022	0.706	1.000	0.706	IRS	1.000	1.000	1.000	-	0.802	0.985	0.814	IRS	1.000	1.000	1.000	-

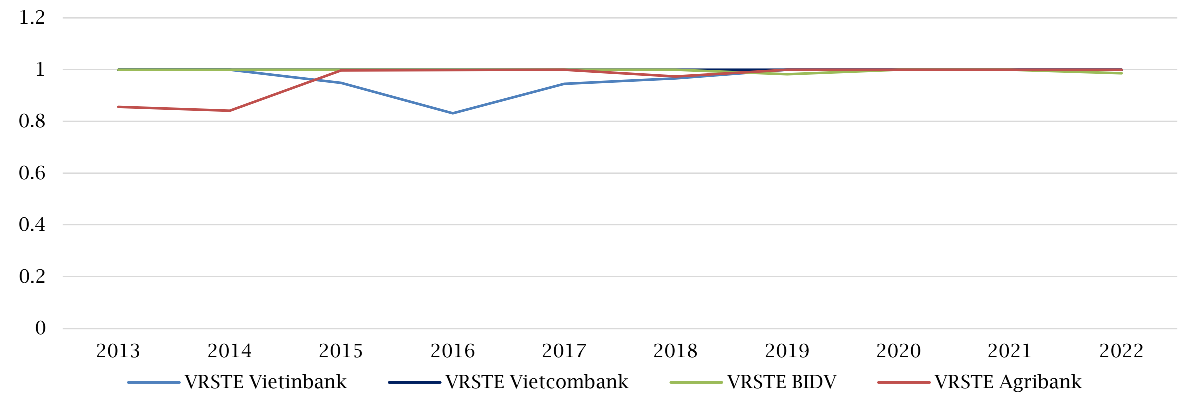
Note: CRSTE — technical efficiency from CRS DEA, VRSTE — technical efficiency from VRS DEA.
Source: Authors' elaboration using DEAP 2.1 software.

Figure 5. Technical efficiency (CRSTE)



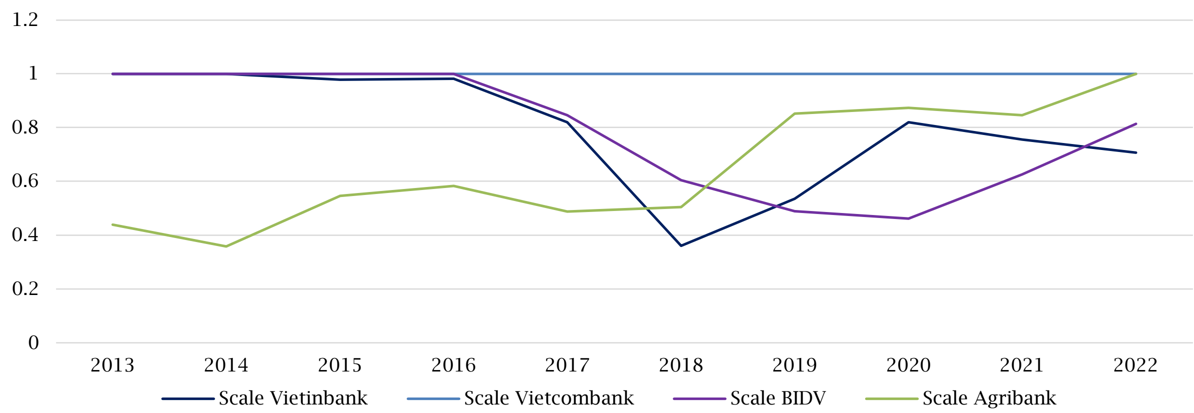
Source: Authors' elaboration using DEAP 2.1 software.

Figure 6. Technical efficiency (VRSTE)



Source: Authors' elaboration using DEAP 2.1 software.

Figure 7. Scale efficiency



Source: Authors' elaboration using DEAP 2.1 software.

The scale efficiency for each bank is displayed in Figure 5. Notably, Vietcombank is the sole bank that reached a score of 1 during the entire ten-year period. Vietinbank achieved that score in the year of 2013 and 2024. However, Figure 6 fluctuated from 2014 onwards, indicating the scale effects. Particularly, Vietinbank experienced a decrease in efficiency in 2015, followed by an upward trend from 2016 to 2022, which suggests the growth rate of input increased less than the growth rate of the corresponding output scale. This analysis revealed Vietcombank's consistent optimal efficiency position among state-owned commercial banks in Vietnam throughout the 10 years. The efficiency of the remaining banks remains relatively positive, underscoring the dominant positions of the top four banks in Vietnam.

4.2. Tobit model regression results

Technical efficiency scores range from 0 to 1. To evaluate the factors affecting these scores, the study utilised the Tobit regression model.

Table 4. Descriptive statistics of variables in the model

Variable	Obs.	Mean	Std. dev	Min	Max
TE	40	0.8955	0.1892116	0.5	1
NIM	40	0.0276653	0.0028252	0.0197717	0.0336694
ROE	40	0.1408021	0.0526944	0.0428192	0.2598597
CAPR	40	0.0582164	0.0134807	0.0406177	0.094189
LOTA	40	0.6995952	0.0720806	0.5249087	0.8006246
NPL	40	0.0160919	0.0085435	0.0062272	0.0468
PROV	40	12,600,000,000.000	7,420,000,000.000	3,520,000,000.000	29,500,000,000.000
LD	40	0.9333297	0.1048976	0.7658343	1.153829
EPS	40	2,521.781	1,419.836	597.6047	6,317.783
Stateownership100	40	0.75	0.438529	0	1
SIZE	40	34.61646	0.3889393	33.78161	35.29048
GDP	40	0.05921	0.0178996	0.0258	0.0852
INF	40	0.03195	0.0119965	0.0063	0.048

Source: Authors' elaboration using Stata 17 software.

The findings reveal that over 10 years, the *TE* ranged from a high of 1 to a low of 0.5. The *ROE* averaged 0.14, with a minimum of 0.04 and a maximum of 0.25. In terms of *EPS*, the highest recorded value was 6,317.78 Vietnamese dong, while the average stood at 2,521.78 Vietnamese dong, with a low of 597.6 Vietnamese dong. The average *GDP* growth rate was 0.05, reaching a peak of 0.08 and a maximum of 0.02. Conversely, *INF* fluctuated from a high of 0.048 to a low of 0.0063, averaging at 0.03.

Prior to performing the regression analysis, we assessed multicollinearity among the variables in the model using the variance inflation factor (VIF). The findings revealed that the highest VIF observed was 2.21, with an average value of 1.62. This indicates the absence of multicollinearity issues among the variables in the model. Furthermore, the Tobit model underwent validation through Wald and Likelihood ratio (LR) tests, both yielding exceptionally low p-values of 0.0000, suggesting the suitability of the Tobit model with the independent variables. Wald $Chi^2(6) = 123.89$, Log-likelihood = 13.944088, Prob > chi2 = 0.0000. Regression results are shown in Table 5.

Table 5. Tobit model regression results

TE	Coef.	Std. err	Z	P > |z|	95% conf. interval	
ROE	6.797301	1.426286	4.77	0.000	4.001832	9.592771
LOTA	-5.094863	0.7033735	-7.24	0.000	-6.47345	-3.716277
Stateownership100	-0.4296935	0.0976721	-4.40	0.000	-0.6211273	-0.2382597
EPS	0.0000974	0.000052	-1.87	0.061	-0.0001993	4.50e-06
LD	1.35283	0.4812992	2.81	0.005	0.4095007	2.296159
GDP	-5.18572	1.285967	-4.03	0.000	-7.706169	-2.66527
_cons	3.128981	0.4238976	7.38	0.000	2.298157	3.959805
/sigma_u	3.93e-09	0.0224089	0.00	1.000	-0.0439206	0.0439206
/sigma_e	105098	0.0159797	6.58	0.000	0.0737782	0.1364177
Rho	1.40e-15	1.60e-08			0	1
Obs. summary: 0 left-censored observations; 23 uncensored observations; 17 right-censored observations.						

Source: Authors' elaboration using Stata 17 software.

5. DISCUSSION

The technical and scale efficiency of state-owned commercial banks in Vietnam have experienced various fluctuations and reached optimal levels in multiple years. Notably, Agribank, which had struggled to achieve optimal technical efficiency for an extended period, finally reached a score of 1 by 2022. Among these banks, Vietcombank stands out for consistently maintaining the highest efficiency throughout the entire 10-year span. To sustain their positions as Vietnam's leading banks, state-owned commercial banks must implement comprehensive strategies to efficiently allocate and manage input resources, thereby minimising costs, optimising output, and ultimately enhancing profitability. These findings are corroborated by research conducted by (Ullah et al., 2023). Furthermore, efficiency tends to rise with scale when examined on a bank-by-bank basis. However, collectively across state-owned commercial banks and over time, efficiency does not vary significantly with scale. Thus, as banks approach saturation points, they should prioritise investments in technology and improvements in service quality, adjusting their business models towards sustainable growth. The findings also underscore the correlation between the efficiency of state-owned commercial banks and the substantial influence of technological progress. This emphasises the necessity of technological investment for the development of digital banking products and contemporary banking services, which warrant further encouragement.

The model examining factors influencing technical efficiency identifies six variables with statistical significance. Among these, *ROE*, *EPS*, and *LD* ratio demonstrate positive effects, while *LOTA* ratio, *GDP* growth rate, and *Stateownership100* exhibit negative effects. These findings imply that organising resources, including input factors, to achieve proposed output factors, may reduce financial efficiency, and an increase in lending over deposits may lower technical efficiency. This result is in line with research by Samad (2017) and Ullah et al. (2023). State-owned commercial banks should manage input costs to optimise output, and they must implement effective credit growth policies alongside a certain level of deposit mobilisation. The *LOTA* ratio negatively impacts technical efficiency, underscoring the need for banks to control credit growth at the asset level and refrain from aggressive lending in the presence of significant risk factors. State-owned banks with 100% foreign capital ownership exhibit lower technical efficiency compared to those with less than 100% state ownership, suggesting that state-owned banks operate more efficiently post-privatisation. The *GDP* growth rate negatively affects *TE*, similar to the findings of Istaiteyeh et al. (2024) indicate that macroeconomic factors do not support increased business efficiency for state-owned commercial banks. Therefore, the government requires macroeconomic solutions to support related parties (businesses, individuals) in developing business activities, which will positively impact bank business results. Developing a reasonable financial framework is essential to improve the operational efficiency of commercial banks (Ikhwan et al., 2023). Additionally, through regulations and policies issued by the State Bank of Vietnam regarding mobilisation, lending, risk control, etc., direct support can be provided to bank business operations.

6. CONCLUSION

Improving business efficiency is always the primary goal of commercial banks. To achieve this, analysing technical efficiency and considering the factors affecting it play an important role. Despite the results mentioned above, the study has some limitations. Due to a lack of information, the analysis was conducted quantitatively based only on data sets from 2013 to 2022. The data is not long enough to fully and objectively evaluate the bank's business performance. Especially for banks doing business in the monetary sector, long data series can reflect the business situation and business results. The data span is not long enough to apply a more complex model, which may result in some assessments not being comprehensive. This study plays a crucial role in the following research because in this study theories are established, efficiency is measured, and in particular, factors that affect the technical efficiency of commercial banks are established. The initial research was conducted for the group of state-owned commercial banks, and then we will carry out for all commercial banks. This will reduce errors and select a measurement variable suitable for the studies in the banking industry. In future studies, the project will expand the scope of research and refine the research model to provide more accurate assessments of technical efficiency and continue to propose practically significant solutions.

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