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Bank Efficiency in Indonesia: An Analysis through Data Envelopment Analysis (DEA) Approach

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Abstract: The purpose of this study is to see the efficiency level of banks, and to see which units need to be increased or decreased. This study will look at the efficiency value of government-owned banks from 2017 to 2022 using the Data Envelopment Analysis (DEA) approach. The research findings show that only one bank is consistently efficient during the study period, while other banks need to further improve input utilization to produce optimal output. The existing literature has not discussed much about the in-depth discussion of technical and scale efficiency and how additional changes and adjustments are needed to reach the efficiency limit.

Keyword: Data Envelopment Analysis (DEA), Efficiency, State-Owned Banks

INTRODUCTION

Along with the rapid development of technology, the use of technology in various industries has led to a lot of automation in various aspects including in the banking industry. A series of automation developments have occurred since 2015 which at that time focused on automating routine tasks using Robotic Process Automation (RPA). Villar & Khan (2021) mentioned that RPA is a robot technology designed to execute business processes by looking at how humans behave using several applications.

On its webpage, McKinsey in 2017 said it has seen a second wave of automation and the emergence of Artificial Intelligence (AI) in the next few years, where machines will do 10-25 percent of the work across bank functions. Since decision-making in banking services will be done quickly and automatically, this increase in automation is expected to eventually lead to an increase in bank profits. Haabazoka (2019) and Bashayreh & Wadi (2021) also support this view, stating that technological innovation in the banking industry enhances financial performance.

The implementation of this automation has an impact on the use of human resources, based on data from the first quarter of 2022, there was a decrease in the number of bank employees, which then had an impact on the closure of a number of bank branch offices. According to data from the Infobank Research Bureau (BirI), the number of bank employees

in 2019 was 450,095 people shrinking to 437,292 people in 2020, in 2021 the number of bank employees was recorded as 437,413 people, and fell to 432,954 people in 2022, and in 2023 increased to 441,145 people. With a decrease in the number of bank employees, of course it will also affect the efficiency of the bank's performance itself, where due to the use of technology, employee productivity will increase and labor costs will be reduced. However, based on the bank's monthly reports during 2022, it can be seen that the 3 government-owned banks are still the banks with the highest labor cost budgets in Indonesia.

Therefore, it is necessary to investigate whether increased labor costs translate into higher bank output. Additionally, the impact of capital and intermediate costs on bank performance requires further examination. This study aims to determine the optimal combination of labor, capital, and intermediate costs for maximizing bank revenue and efficiency.

Mulyadi et al (2023) argues that efficiency is the ability to achieve goals by minimizing the use of resources such as time, money or energy. The goal of efficiency is to achieve maximum results with the available resources. The benefits of efficiency include increased productivity, cost savings, and better use of resources. Al-Hiyari et al (2013) state that efficiency is the ability to achieve optimal results by using available resources effectively and efficiently in a business context, efficiency often refers to the ability of a company to allocate resources such as capital, time and labor properly to achieve maximum company goals without waste or ineffective use (Siregar & Azzahra, 2022).

Dwijayantie & Mulyadi (2022) efficiency achievements include improved performance, increased customer satisfaction, and the ability to adapt to changes in the current environment, efficiency not only provides a competitive advantage, but also provides a foundation for sustainable growth and success in the company. Octrina & Priatmojo (2023) efficiency is the ability to use resources optimally in achieving the desired goals. Efficiency in the context of banking refers to the bank's ability to optimally manage resources and operational processes to achieve desired results, such as increasing profitability, reducing operational costs, and improving the quality of service to customers.

According to Nugraha (2022) the method often used to measure efficiency is the Data Envelopment Analysis (DEA) method, a mathematical programming technique used to evaluate the relative efficiency of a collection of decision-making units (DMUs) in managing resources (inputs) of the same type so that they become results (outputs) of the same type as well, where the relationship of the function form from input to output is known. Efficiency is the ability to achieve maximum results with minimal use of resources, both in the context of business and banking. Efficiency not only increases productivity and saves costs, but also provides a competitive advantage and a foundation for sustainable growth. Calculating efficiency using the Data Envelopment Analysis (DEA) method is often used.

The analysis technique used is using Data Envelopment Analysis (DEA) to determine the efficiency value of a company with the help of DEAP 21 software. Atina (2023) argues that the Data Envelopment Analysis (Computer) Program or DEAP is a program developed by Professor Tim Coelli from the Centre for Efficiency and Productivity Analysis University of Queensland, Australia. This program constructs DEA boundaries by calculating technical and cost efficiencies.

According to Simonovic & Breach (2023) DEA is a method that uses a linear program model to evaluate the relative efficiency of several objects, such as performance benchmarking. Through the calculation of comparative input and output ratios for units in a population, DEA helps identify the causes and solutions of inefficiency. Li et al (2022)argue that efficiency is measured by a value of 1 or 100 percent; if efficiency = 1, then the measurement is said to be efficient. Conversely, a DMU is considered relatively inefficient if the dual value < 1. Decision Making Units (DMUs) in DEA are units such as hospitals,

banks, units of factories, tax offices, universities, schools, power plants, police stations, departments, tax offices, prisons and anything that has similar operational characteristics.

The main advantage of DEA over other methods is its ability to handle a wide range of inputs and outputs without requiring the assumption of a particular functional form between them (Emrouznejad et al., 2023). DEA also allows the identification of efficient and inefficient DMUs and provides guidance for improvement (Yang & Fang, 2022). Atrasina (2023) stated that the advantages of DEA can process many inputs and outputs, do not need the assumption of a functional relationship between input and output variables, and have different units of measurement on outputs and inputs. The basic concept of using DEA has numerical data for each input and output, the data is considered positive for all DMUs and in principle, more inputs and outputs will result in a higher efficiency score. The size of each input and output need not be the same.

DEA calculations are determined based on two main assumptions, namely constant returns to scale (CRS) and variable returns to scale (VRS) (Kamarudin et al., 2019). The CRS assumption was developed by Charnes et al (1978) assuming that all banks operate at optimal scale. While the VRS assumption was introduced by Banker (1984), this model maximizes all outputs or minimizes all inputs. However, the most fundamental difference between these two assumptions is that the CRS model can be used to compare entities of different scales, while the VRS model is used for entities of the same size. In general, the DEA equation can be expressed as follows (Owusu Kwateng et al., 2020):

$$Max\ h = \frac{\sum_r U_r Y_{rjo}}{\sum_i V_i X_{ijo}}$$

Subject to:

$$\frac{\sum_r U_r Y_{rj}}{\sum_i V_i X_{ij}} \leq 1,\ \ j = 1 \ldots . n\ (for\ all\ j)$$

To prevent situations where certain inputs or outputs are ignored in efficiency calculations, the values of ur and vi are set to always equal a small positive number, ε.

$$U_r V_i \geq \varepsilon$$

Based on the equation above, if h = 1, then the bank is efficient, and if the value of h < 1, then the entity is inefficient. Many studies such as applied DEA model in banking and financial sector in various countries (Chang et al., 2017; Hada et al., 2017; Li et al., 2022; Yu et al., 2019; Zhu et al., 2017). However, there is a dearth of research providing detailed explanations for changes in technical efficiency and scale efficiency, as well as specific recommendations for achieving efficiency frontiers. Given that this study focuses on banks of similar scale, the Variable Returns to Scale (VRS) DEA model will be employed.

METHOD

This research is a descriptive study with the aim of seeing how government-owned banks utilize their inputs to produce their best output. The research sample is a government-owned bank totaling 4 banks, from 2017 to 2022. The analysis was conducted by testing the efficiency of banks with the Data Envelopment Analysis (DEA) approach. The following outputs and inputs are used in this study, namely:

a. Input Variables
   a) Labor Cost

Labor cost refers to the total cost incurred by a company to pay salaries and employee benefits in a certain period.

b) Capital cost
Capital costs or often referred to as capital costs are costs incurred by banks to acquire and maintain fixed assets and capital used in their operations.

c) Intermediate cost
Intermediate costs include various types of costs incurred in the day-to-day operations of service delivery.

b. Output Variables

a) Revenue
Revenue refers to the total amount of income earned by a company from the sale of products or services over a certain period of time. It includes all revenue generated from the sale of goods or services before deducting costs such as operating expenses, taxes, or other fees. Revenue or total sales is often a key measure in analyzing the financial performance of a company.

RESULTS AND DISCUSSION

Efficiency with Data Envelopment Analysis (DEA) measurement, there are several concepts that must be considered, namely the concept of Increasing Returns to Scale (IRS) occurs when an increase in the percentage of inputs results in a greater percentage increase in output. In other terms, efficiency increases with a larger scale of operations. The second concept Constant Returns to Scale (CRS) occurs when an increase in the percentage of inputs results in the same increase in the percentage of output. This means that efficiency does not change even if the scale of operations increases. The third concept Decreasing Returns to Scale (DRS) occurs when an increase in the percentage of inputs results in a smaller percentage increase in output. In this case, efficiency decreases as the scale of operations increases.

In analyzing efficiency using DEA, there are several important concepts, namely Original Value, Radial Movement, Slack Movement and Project Value. Original Value refers to the initial value of inputs and outputs used in the analysis. Radial Movement refers to uniform proportional changes in all inputs or outputs to achieve efficiency, i.e. increasing outputs or reducing inputs proportionally. Slack Movement is the additional change required in certain inputs or outputs to achieve efficiency after the application of Radial Movement, indicating imperfections in resource distribution. Project Value is the value generated after taking into account Radial and Slack Movement, reflecting the position of the company evaluated after efficiency improvements are made. The following are the efficiency results using DEA using inputs including: Labor cost, Capital cost and Intermediate cost, while the output includes: Revenue.

DEA Efficiency Analysis of BBNI

The efficiency of PT Bank Negara Indonesia (Persero) Tbk is measured using Data Envelopment Analysis (DEA) by assessing technical efficiency and efficiency scale, the following are the results of BBNI efficiency during 2017-2022:

Table 1. BBNI DEA Results in 2017

2017				
Technical efficiency: 78.10			Scala efficiency = 78.10 (irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	48,177,849,000	2,713,721,276	0,000	50,891,570,276
Input (1)	9,277,196,000	0,000	0,000	9,277,196,000
Input (2)	22,804,689,000	0,000	(3,531,869,507)	19,272,819,493

Input (3)	20,863,357,000	0,000	0,000	20,863,357,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

Technical efficiency measures how effectively inputs are converted into outputs, with a score of 78.10 indicating that PT Bank Negara Indonesia (Persero) Tbk in 2017 operated 78.10% of its potential efficiency. Scale efficiency measures the entity's ability to operate at an optimal scale. In Table 1, it can be seen that the return of scale increase (IRS) score of 78.10 indicates that BBNI in 2017 operates at a less optimal scale with increasing return of scale. In this year to achieve technical efficiency, output (Revenue) requires a slight increase (Radial Movement output) while on the input side (Capital cost) needs to make a reduction. While the input (Labor Cost) and input (Intermediate cost) remain unchanged after adjusting the radial (radial movement).

Table 2. 2018 DEA BBNI Results

2018				
Technical efficiency = 100.00			Scale efficiency = 74.50(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	54,138,613,000	0,000	0,000	54,138,613,000
Input (1)	9,518,738,000	0,000	0,000	9,518,738,000
Input (2)	26,126,508,000	0,000	0,000	26,126,508,000
Input (3)	21,782,961,000	0,000	0,000	21,782,961,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

In 2018 PT Bank Negara Indonesia (Persero) Tbk has perfect technical efficiency with a value of 100%, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 74.50% with increasing Returns to Scale (IRS) condition which means that this bank can improve its efficiency by increasing the scale of its operation. No radial movement or slack is required, indicating efficient use of resources.

Table 3. BBNI DEA Results 2019

2019				
Technical efficiency: 98.88%			Scale efficiency: 68.70% (irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	58,532,373,000	711,418,496	0,000	59,243,791,496
Input (1)	10,186,127,000	0,000	0,000	10,186,127,000
Input (2)	26,524,759,000	0,000	(1,738,445,109)	24,786,313,891
Input (3)	23,686,899,000	0,000	0,000	23,686,899,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

Technical efficiency measures how effectively inputs are converted into outputs with a score of 98.88 indicating that PT Bank Negara Indonesia (Persero) Tbk in 2019 operated 98.88% of its potential efficiency. Scale efficiency measures the entity's ability to operate at an optimal scale. In Table 3, it can be seen that the return of scale increase (IRS) score of 68.70 indicates that BBNI in 2019 operates at a less than optimal scale with increasing returns to scale.

To achieve technical efficiency, output (Revenue) requires a slight increase (Radial Movement output) while on the input side (Capital cost) needs to make a reduction, this needs to be done to achieve a new, more optimal project value. While the input (Labor Cost) and input (Intermediate cost) remain unchanged after radial adjustment (radial movement).

Table 4. BBNI DEA Results in 2020

2020				
Technical efficiency: 100.00			Scale efficiency: 68.30(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	56,172,871,000	0,000	0,000	56,172,871,000

Input (1)	9,750,781,000	0,000	0,000	9,750,781,000
Input (2)	27,362,400,000	0,000	0,000	27,362,400,000
Input (3)	24,213,756,000	0,000	0,000	24,213,756,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

PT Bank Negara Indonesia (Persero) Tbk in 2020 is considered to have perfect technical efficiency with a value of 100%, meaning that this bank uses its inputs optimally to produce outputs. However, the efficiency is only 68.30% with increasing Returns to Scale (IRS) which means that the bank has not reached its optimal scale. No radial movement or slack is required, indicating efficient use of resources

Table 5. BBNI DEA Results for 2021

2021				
Technical efficiency = 92.60			Scale efficiency: 74.70(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	50,025,887,000	3,997,259,755	0,000	54,023,146,755
Input (1)	11,195,268,000	0,000	0,000	11,195,268,000
Input (2)	26,882,982,000	0,000	(4,116,879,691)	22,766,102,309
Input (3)	24,800,952,000	0,000	(146,905,841)	24,654,046,159

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

The technical efficiency value with a score of 92.60 indicates that PT Bank Negara Indonesia (Persero) Tbk in 2021 operates 92.60% of its potential efficiency. Scale efficiency measures the entity's ability to operate at an optimal scale. In Table 5, it can be seen that the return of scale increase (IRS) score of 74.70 indicates that BBNI in 2021 operates at a less than optimal scale with increasing returns to scale. To achieve technical efficiency, output (Revenue) requires a slight increase (Radial Movement output) while on the input side (Capital cost) and input (Intermediate cost) need to reduce. Meanwhile, the input (Labor Cost) remains unchanged after adjusting the radial (radial movement).

Tabel 6. Hasil DEA BBNI Tahun 2022

2022				
Technical efficiency: 90.10			Scale efficiency: 81.70(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	54,658,681,000	6,019,736,667	0,000	60,678,417,667
Input (1)	12,456,022,000	0,000	(42,302,548)	12,413,719,452
Input (2)	26,548,893,000	0,000	(15,252,199)	26,533,640,801
Input (3)	27,059,149,000	0,000	0,000	27,059,149,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

Technical efficiency measures how effectively inputs are converted into outputs, with a score of 90.10 indicating that PT Bank Negara Indonesia (Persero) Tbk in 2022 operates 90.10% of its potential efficiency. Scale efficiency measures the entity's ability to operate at an optimal scale. In Table 6, it can be seen that the return of scale increase (IRS) score of 81.70 indicates that BBNI in 2022 operates at a less optimal scale with increasing return of scale. Achieving technical efficiency, output (Revenue) requires a slight increase (Radial Movement output) while on the input side (Labor cost) and input (Capital cost) need to reduce. While the input (Intermediate Cost) remains unchanged after adjusting the radial (radial movement).

Overall, PT Bank Negara Indonesia (Persero) Tbk is not yet efficient when viewed from the results of technical efficiency, only in 2018 and 2020 BBNI was able to achieve optimal technical efficiency values. This means that in that year (2018, 2020) BBNI was able to utilize existing inputs without doing so to produce optimal output. Although overall BBNI still has the potential to improve efficiency when viewed based on the results of the IRS

efficiency scale, meaning that banks can still increase output more than the proportion of increased input.

BMRI DEA Analysis Results

The efficiency of PT Bank Mandiri (Persero) Tbk is measured using Data Envelopment Analysis (DEA) by assessing technical efficiency and efficiency scale, the following are the results of BMRI's efficiency during 2017-2022:

Table 7. BMRI DEA Results 2017

2017				
Technical efficiency: 100.00			Scala efisiensi: 70.70(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	77,284,648,000	0,000	0,000	77,284,648,000
Input (1)	14,858,642,000	0,000	0,000	14,858,642,000
Input (2)	36,618,753,000	0,000	0,000	36,618,753,000
Input (3)	34,989,097,000	0,000	0,000	34,989,097,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

In 2017 BMRI has perfect technical efficiency with 100% value, meaning that the bank is able to use its input optimally to produce output. However, the efficiency scale is only 70.70% with increasing Returns to Scale (IRS) which means that the bank still needs to improve its efficiency by increasing the scale of its operations. There is no radial movement or slack required, indicating an efficient use of resources.

Table 8. BMRI DEA Results in 2018

2018				
Technical efficiency: 95.90			Scala efisiensi: 67.40(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	80,992,570,000	3,434,008,968	0,000	84,426,578,968
Input (1)	16,322,769,000	0,000	0,000	16,322,769,000
Input (2)	38,442,696,000	0,000	(11,900,522,850)	26,542,173,150
Input (3)	37,566,139,000	0,000	(5,128,685,341)	32,437,453,659

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

The score of 95.90 on technical efficiency indicates that PT Bank Mandiri (Persero) Tbk in 2018 operates 95.90% of its potential efficiency. The resulting efficiency scale to measure the entity's ability to operate at an optimal scale, shows that the return of scale increases (IRS) with a score of 67.40 meaning that BMRI in 2018 operates at a less than optimal scale with increasing returns to scale. Achieving technical efficiency, output (Revenue) requires a slight increase (Radial Movement output) while on the input side (Capital cost) and input (Intermediate cost) need to reduce. While the input (Labor Cost) remains unchanged after adjusting the radial movement.

Table 9. 2019 DEA BMRI Results

2019				
Technical efficiency: 100.00			Scala efisiensi: 62,70(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output	91.525.090.000	0,000	0,000	91.525.090.000
Input (1)	17.221.046.000	0,000	0,000	17.221.046.000
Input (2)	44.612.199.000	0,000	0,000	44.612.199.000
Input (3)	40.076.167.000	0,000	0,000	40.076.167.000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BMRI's technical efficiency has a perfect value with 100% meaning that this bank uses its input optimally to produce output. However, the efficiency is only 67.70% with increasing Returns to Scale (IRS) which means that this bank can improve its efficiency by increasing

its scale of operation. No radial movement or slack is required, indicating efficient use of resources.

Table 10. 2020 DEA BMRI Results

2020				
Technical efficiency: 100.00			Scala efisiensi: 58.60(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	87,321,117,000	0,000	0,000	87,321,117,000
Input (1)	17,770,433,000	0,000	0,000	17,770,433,000
Input (2)	46,728,153,000	0,000	0,000	46,728,153,000
Input (3)	40,646,791,000	0,000	0,000	40,646,791,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

BMRI has perfect technical efficiency with 100% value, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 58.60% with Increasing Returns to Scale (IRS) condition which means that this bank can improve its efficiency by increasing the scale of its operation. No radial movement or slack is required, indicating efficient use of resources.

Table 11. 2021 DEA BMRI Results

2021				
Technical efficiency: 100.00			Scala efisiensi: 68.20(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	97,749,086,000	0,000	0,000	97,749,086,000
Input (1)	22,677,112,000	0,000	0,000	22,677,112,000
Input (2)	49,144,792,000	0,000	0,000	49,144,792,000
Input (3)	49,140,167,000	0,000	0,000	49,140,167,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost.

BMRI in 2021 has perfect technical efficiency with a value of 100%, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 68.20% with Increasing Returns to Scale (IRS) conditions, which means that this bank can improve its efficiency by increasing the scale of its operations. No radial movement or slack is required, indicating an efficient use of resources.

Table 12. BMRI DEA Results in 2022

2022				
Technical efficiency: 100.00			Scala efisiensi: 76.90(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	112,382,118,000	0,000	0,000	112,382,118,000
Input (1)	24,641,746,000	0,000	0,000	24,641,746,000
Input (2)	56,540,566,000	0,000	0,000	56,540,566,000
Input (3)	53,260,058,000	0,000	0,000	53,260,058,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BMRI has a perfect technical efficiency value of 100%, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 76.90% with Increasing Returns to Scale (IRS) which means the bank can still improve its efficiency by increasing the scale of its operations. There is no radial movement or slack required, indicating efficient use of resources. Overall, PT Bank Mandiri (Persero) Tbk has achieved optimal technical efficiency except in 2018. With a technical efficiency value of 100, it means that BMRI has succeeded in overcoming waste or deficiency in utilizing available resources, meaning that no resources are wasted, and each input unit is used effectively.

BBRI DEA Analysis Results

The efficiency of PT Bank Rakyat Indonesia (Persero) Tbk is measured using Data Envelopment Analysis (DEA) by assessing technical efficiency and efficiency scale, the following are the results of BBRI efficiency during 2017-2022:

Table 13. 2017 DEA BBRI Results

2017				
Technical efficiency: 100.00			Scala efisiensi: 96.90(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	102,912,375,000	0,000	0,000	102,912,375,000
Input (1)	20,440,958,000	0,000	0,000	20,440,958,000
Input (2)	24,752,035,000	0,000	0,000	24,752,035,000
Input (3)	38,614,076,000	0,000	0,000	38,614,076,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with a value of 100%, meaning that this bank uses its input optimally to produce output. The efficiency scale is 96.90% with Increasing Returns to Scale (IRS) condition which means the bank is already good enough in increasing its output and can still improve its efficiency by increasing its scale of operation. No radial movement or slack is required, indicating efficient use of resources.

Table 14. 2018 DEA BBRI Results

2018				
Technical efficiency: 100.00			Scala efisiensi: 80.67(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	111,582,804,000	0,000	0,000	111,582,804,000
Input (1)	22,423,271,000	0,000	0,000	22,423,271,000
Input (2)	26,914,859,000	0,000	0,000	26,914,859,000
Input (3)	41,990,284,000	0,000	0,000	41,990,284,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with 100% value, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 80.67% with Increasing Returns to Scale (IRS) condition which means the bank can still improve its efficiency by increasing the scale of its operation. No radial movement or slack is required, indicating an efficient use of resources.

Table 15. 2019 DEA BBRI Results

2019				
Technical efficiency: 100.00			Scala efisiensi: 79.10(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	121,756,276,000	0,000	0,000	121,756,276,000
Input (1)	24,243,276,000	0,000	0,000	24,243,276,000
Input (2)	31,432,629,000	0,000	0,000	31,432,629,000
Input (3)	44,965,625,000	0,000	0,000	44,965,625,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with 100% value, meaning that this bank uses its input optimally to produce output. The result of scale efficiency is only 79.10% with Increasing Returns to Scale (IRS) condition which means the bank can still improve its efficiency by increasing its scale of operation. There is no radial movement or slack required, indicating an efficient use of resources

Table 16. 2020 BBRI DEA Results

2020				
Technical efficiency: 100.00			Scala efisiensi: 78.30(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**

2020				
Technical efficiency: 100.00			Scala efisiensi: 78.30(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	116,932,512,000	0,000	0,000	116,932,512,000
Input (1)	26,319,791,000	0,000	0,000	26,319,791,000
Input (2)	32,185,160,000	0,000	0,000	32,185,160,000
Input (3)	49,931,359,000	0,000	0,000	49,931,359,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with 100% value, meaning that this bank uses its input optimally to produce output. The efficiency scale is only 78.30% with Increasing Returns to Scale (IRS) condition which means the bank can still improve its efficiency by increasing its scale of operation. No radial movement or slack is required, indicating an efficient use of resources.

Table 17. 2021 BBRI DEA Results

2020				
Technical efficiency: 100.00			Scala efisiensi: 66.50(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	143,523,329,000	0,000	0,000	143,523,329,000
Input (1)	38,047,126,000	0,000	0,000	38,047,126,000
Input (2)	47,970,187,000	0,000	0,000	47,970,187,000
Input (3)	75,918,108,000	0,000	0,000	75,918,108,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with 100% value, meaning that this bank uses its input optimally to produce output. However, the efficiency scale is only 66.50% with Increasing Returns to Scale (IRS) condition, which means that this bank can improve its efficiency by increasing its scale of operation, meaning that there is still potential to increase the output produced. There is no radial movement or slack required, indicating an efficient use of resources.

Table 18. BBRI DEA Results in 2022

2020				
Technical efficiency: 100.00			Scala efisiensi: 67.40(irs)	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	151,874,816,000	0,000	0,000	151,874,816,000
Input (1)	39,390,133,000	0,000	0,000	39,390,133,000
Input (2)	55,216,047,000	0,000	0,000	55,216,047,000
Input (3)	82,191,967,000	0,000	0,000	82,191,967,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBRI has perfect technical efficiency with a value of 100%, meaning that this bank uses its input optimally to produce output. However, the efficiency is only 67.40% with Increasing Returns to Scale (IRS) condition, which means that this bank can improve its efficiency by increasing its scale of operation, to further increase the output produced. There is no radial movement or slack required, indicating efficient use of resources. The results of Data Envelopment Analysis (DEA) as a whole show that PT Bank Rakyat Indonesia (Persero) Tbk has not been able to manage its operations well or classified as inefficiency in the period 2017 to 2022. This analysis is carried out by assessing the efficiency scale of government-owned financial companies listed on the Indonesia Stock Exchange.

BBTN DEA Analysis Results

The efficiency of PT Bank Tabungan Negara (Persero) Tbk is measured using Data Envelopment Analysis (DEA) by assessing technical efficiency and efficiency scale, the following are the results of BBTN efficiency during 2017-2022:

Tabel 19. Hasil DEA BBTN Tahun 2017

2017				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	19,271,582,000	0,000	0,000	19,271,582,000
Input (1)	2,554,429,000	0,000	0,000	2,554,429,000
Input (2)	4,837,319,000	0,000	0,000	4,837,319,000
Input (3)	6,170,567,000	0,000	0,000	6,170,567,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2017 has perfect technical efficiency with a value of 100%, meaning that the bank uses its input optimally to produce output, with an efficiency scale of 100%, meaning that the bank already has an optimal efficiency scale, where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources

Tabel 20. Hasil DEA BBTN Tahun 2018

2018				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	2,285,1758,000	0,000	0,000	2,285,1758,000
Input (1)	2,876,562,000	0,000	0,000	2,876,562,000
Input (2)	5,017,694,000	0,000	0,000	5,017,694,000
Input (3)	6,852,544,000	0,000	0,000	6,852,544,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2018 has perfect technical efficiency with a value of 100%, meaning that the bank uses its input optimally to produce output, with an efficiency scale of 100%, meaning that the bank already has an optimal efficiency scale where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources.

Table 21. 2019 DEA BBTN Results

2019				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	25,719,874,000	0,000	0,000	25,719,874,000
Input (1)	2,863,955,000	0,000	0,000	2,863,955,000
Input (2)	5,400,658,000	0,000	0,000	5,400,658,000
Input (3)	7,063,215,000	0,000	0,000	7,063,215,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2019 has perfect technical efficiency with a value of 100% meaning that the bank uses its inputs optimally to produce outputs, with an efficiency scale of 100% meaning that the bank already has an optimal efficiency scale where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources.

Table 22. 2020 BBTN DEA Results

2020				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**

2020				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	25,116,488,000	0,000	0,000	25,116,488,000
Input (1)	2,977,208,000	0,000	0,000	2,977,208,000
Input (2)	5,818,445,000	0,000	0,000	5,818,445,000
Input (3)	6,846,610,000	0,000	0,000	6,846,610,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2020 has perfect technical efficiency with a value of 100%, meaning that the bank uses its inputs optimally to produce outputs, with an efficiency scale of 100%, meaning that the bank already has an optimal efficiency scale where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources.

Table 23. BBTN DEA Results for 2021

2021				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	25,794,958,000	0,000	0,000	25,794,958,000
Input (1)	3,782,925,000	0,000	0,000	3,782,925,000
Input (2)	5,736,791,000	0,000	0,000	5,736,791,000
Input (3)	8,846,522,000	0,000	0,000	8,846,522,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2021 has perfect technical efficiency with a value of 100%, meaning that the bank uses its inputs optimally to produce outputs, with an efficiency scale of 100%, meaning that the bank already has an optimal efficiency scale where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources.

Table 24. BBTN DEA Results in 2022

2022				
Technical efficiency: 100.00			Scale efficiency: 100.00	
Variable	**Original Value**	**Radial Movement**	**Slack Movement**	**Project Value**
Output (1)	25,907,368,000	0,000	0,000	25,907,368,000
Input (1)	4,190,298,000	0,000	0,000	4,190,298,000
Input (2)	6,353,803,000	0,000	0,000	6,353,803,000
Input (3)	9,438,880,000	0,000	0,000	9,438,880,000

Description: Input 1: Labor Cost, Input 2: Capital Cost, Input 3: Intermediate Cost

BBTN in 2022 has perfect technical efficiency with a value of 100% meaning that the bank uses its inputs optimally to produce outputs, with an efficiency scale of 100% meaning that the bank already has an optimal efficiency scale where an increase or reduction in the scale of operations will not increase efficiency further. No radial movement or slack is required, indicating efficient use of resources.

The results of the Data Envelopment Analysis (DEA) as a whole show that PT Bank Tabungan Negara (Persero) Tbk has been able to manage its operations well or classified as efficient in the period 2017 to 2022. This means that the bank managed to maximize its output by using inputs without any waste. All input and output variables are optimal so they do not require further adjustment. In this research period the bank has been very good at managing its resources.

CONCLUSION

Overall, it was found that only BBTN was efficient during the observation period, while other banks were not optimal in utilizing the available inputs. Overall, the suggestion that can be given is that banks need to maintain and strengthen the operational process, banks need to increase process optimization in units that are not optimal. In terms of revenue, banks need to increase the diversification of products and services by offering more innovative financial products, so as to increase revenue. Improvement or utilization of manpower needs to be optimized, one of which is by providing training, especially in the use of technology. Banks also need to optimize the use of fixed assets and capital investment by conducting audits to see which assets are not or less productive. In addition, banks can also review the financing structure and look for other sources of financing that are lower in cost. Banks need to re-evaluate the operational costs used, one of which is by using a technology-based procurement system to manage expenses more efficiently.

REFERENCES

Al-Hiyari, A., Al-Mashregy, M. H. H., Mat, N. K. N., & Alekam, J. M. (2013). Factors that affect accounting information system implementation and accounting information quality: A survey in University Utara Malaysia. *American Journal of Economics*, *3*(1), 27–31.

Atina, A. G. (2023). *Pengukuran Tingkat Efisiensi Aktivitas Proses Produksi Menggunakan Metode Data Envelopment Analysis (DEA)(Studi Kasus: CV. Mandiri Sejahtera Garment)*. Universitas Islam Sultan Agung.

Banker, R. D. (1984). Estimating most productive scale size using data envelopment analysis. *European Journal of Operational Research*, *17*(1), 35–44.

Bashayreh, A., & Wadi, R. M. A. (2021). The effect of Fintech on banks' performance: Jordan case. *The Importance of New Technologies and Entrepreneurship in Business Development: In the Context of Economic Diversity in Developing Countries: The Impact of New Technologies and Entrepreneurship on Business Development*, 812–821.

Chang, M., Jang, H. B., Li, Y. M., & Kim, D. (2017). The relationship between the efficiency, service quality and customer satisfaction for state-owned commercial Banks in China. *Sustainability (Switzerland)*, *9*(12). https://doi.org/10.3390/su9122163

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, *2*(6), 429–444.

Dwijayantie, R., & Mulyadi, J. M. V. (2022). Efisiensi Perusahaan Manufaktur dengan Data Envelopment Analysis. *JIAFE (Jurnal Ilmiah Akuntansi Fakultas Ekonomi)*, *8*(2), 253–270.

Emrouznejad, A., Marra, M., Yang, G., & Michali, M. (2023). Eco-efficiency considering NetZero and data envelopment analysis: a critical literature review. *IMA Journal of Management Mathematics*, *34*(4), 599–632.

Haabazoka, L. (2019). A study of the effects of technological innovations on the performance of commercial banks in developing countries-A case of the zambian banking industry. *The Future of the Global Financial System: Downfall or Harmony 6*, 1246–1260.

Hada, S. S., Zhu, N., & Tamang, G. (2017). Frontier Analysis of Nepalese and Chinese Commercial Banks : DEA Approach. *International Journal of Operational Research/Nepal - IJORN*, *6*(1).

Kamarudin, F., Sufian, F., Nassir, A. M., Anwar, N. A. M., & Hussain, H. I. (2019). Bank efficiency in Malaysia a DEA approach. *Journal of Central Banking Theory and Practice*, *8*(1), 133–162.

Li, Z., Feng, C., & Tang, Y. (2022). Bank efficiency and failure prediction: a nonparametric and dynamic model based on data envelopment analysis. *Annals of Operations Research*, *315*(1), 279–315.

Mulyadi, M., Hatta, H., Umiyati, H., Amane, A. P. O., Santosa, S., Novianti, R., Liniarti, S., Nasution, R. S. A., Kalsum, E. U., & Ismainar, H. (2023). *Model-Model Pelatihan dan Pengembangan SDM*. Penerbit Widina.

Nugraha, M. (2022). Analisis Determinan Efisiensi Perbankan Dengan Data Envelopoment Analysis: Sebuah Kajian Literatur. *Jurnal GICI Jurnal Keuangan Dan Bisnis*, *14*(1), 66–73.

Octrina, F., & Priatmojo, H. E. (2023). Islamic bank efficiency: an efficiency method with SFA. *Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah*, *10*(6), 379–394.

Owusu Kwateng, K., Osei-Wusu, E. E., & Amanor, K. (2020). Exploring the effect of online banking on bank performance using data envelopment analysis. *Benchmarking: An International Journal*, *27*(1), 137–165.

Simonovic, S. P., & Breach, P. A. (2023). System context: Global change and the food-energy-water nexus. *Journal of Water Resources Planning and Management*, *149*(11), 4023064.

Siregar, M., & Azzahra, K. (2022). The Effect Of Corporate Social Responsibility, Company Size And Capital Intensity On Tax Avoidance. *MARGINAL : Journal Of Management, Accounting, General Finance And International Economic Issues*, *1*(4). https://doi.org/10.55047/marginal.v1i4.309

Villar, A. S., & Khan, N. (2021). Robotic process automation in banking industry: a case study on Deutsche Bank. *Journal of Banking and Financial Technology*, *5*(1), 71–86.

Yang, J., & Fang, L. (2022). Average lexicographic efficiency decomposition in two-stage data envelopment analysis: an application to China's regional high-tech innovation systems. *Annals of Operations Research*, *312*(2), 1051–1093.

Yu, Y., Huang, J., & Shao, Y. (2019). The sustainability performance of Chinese banks: A new network data envelopment analysis approach and panel regression. *Sustainability (Switzerland)*, *11*(6). https://doi.org/10.3390/su11061622

Zhu, N., Liu, Y., Emrouznejad, A., & Huang, Q. (2017). An allocation Malmquist index with an application in the China securities industry. *Operational Research*, *17*(2). https://doi.org/10.1007/s12351-016-0249-6