# EFFICIENT COMPARISON OF THE TOP 10 LARGEST COMMERCIAL BANKS IN INDONESIA: DEA (DATA ENVELOPMENT ANALYSIS)

**Ari Christianti**

Universitas Kristen Duta Wacana, Yogyakarta

ari@staff.ukdw.ac.id

**Abstract.** Banking efficiency is very important in supporting the success of macro policies specifically, maintaining the sustainability of development that affects economic growth and social welfare. This study discusses the efficiency of commercial banks for the 2015-2019 period using data from the 10 largest commercial banks in Indonesia. The methodology used is non-parametric, Data Envelopment Analysis, to analyze technical efficiency. The results showed that 7 banks had a maximum efficiency level consistently during the study period and there were still 3 banks that did not reach the maximum efficiency but during certain periods or periods. Based on the results of the DEA, inefficient banks in a certain period can achieve maximum efficiency by reducing inputs such as labor costs, net fixed assets, and the number of deposits. This might be attributed that the competition in the banking industry and because not all inputs could be controlled by management, some large banks cannot maintain their level of efficiency consistently.

**Keywords:** DEA analysis, efficiency, input, output

**Abstrak.** Efisiensi perbankan sangat penting dalam mendukung keberhasilan kebijakan makro yakni menjaga keberlangsungan pembangunan yang berpengaruh pada pertumbuhan ekonomi dan kesejahteraan masyarakat. Penelitian ini membahas tentang efisiensi bank umum periode 2015-2019 dengan menggunakan data 10 bank umum terbesar di Indonesia. Metodologi yang digunakan adalah non parametrik, Data Envelopment Analysis, untuk menganalisis efisiensi teknikal. Hasil penelitian menunjukkan terdapat 7 bank yang memiliki tingkat efisiensi maksimum secara konsisten selama periode penelitian dan masih terdapat 3 bank yang tidak mencapai efisiensi maksimum namun pada periode atau beberapa periode tertentu saja. Berdasarkan hasil DEA, bank yang tidak efisien secara maksimum pada periode tertentu bisa mencapai efisiensi maksimum dengan mengurangi input seperti biaya tenaga kerja, aset tetap bersih dan jumlah simpanan. Kemungkinan, karena kompetisi dalam industri perbankan dan karena tidak semua input bisa dikendalikan oleh manajemen menyebabkan beberapa bank besar tidak bisa mempertahankan tingkat efisiensinya secara konsisten.

**Kata kunci:** Analisis DEA, effisiensi, input, output

## INTRODUCTION

Banking efficiency is very important in the development of the banking industry, especially in countries with bank-based financial systems such as Indonesia. The role of banks as intermediary institutions in transferring funds from the surplus side to the deficit side plays

a very important role in economic growth. Thus, the banking industry must be able to operate efficiently because bank efficiency affects the determination of credit interest rates which can have a direct impact on financing in the real sector (Christianti, 2020). In addition, other benefits of an efficient banking sector are supporting the success of macro policies, maintaining sustainable development that affects economic growth and social welfare (Iršová, 2009).

The concept of efficiency in general could be defined as the success of activities associated with minimal use of resources. The fewer resources used to achieve the desired results, the more efficient the activity. Alber, Elmofty, Walied, & Sami (2019) in their article stated that improving banking efficiency is a challenge that has long been faced by banks. This is because management is faced not only with how to reduce costs but also how to generate more revenue for each unit cost incurred. Lindley & Sealey (1977) in their research explained that there are 2 approaches in the banking efficiency concept, namely the production approach and the intermediation approach. The production approach assumes that the bank as a service provider for debtors (depositors) processes funds from depositors to become loans or credits to customers in need. Furthermore, the intermediation approach assumes that the bank as an intermediary party has a major role to raise funds from depositors and as a return for depositors who have deposited their funds in the bank, the bank will provide loans to creditors to generate profits including giving returns to depositors.   Alber et al. (2019) in their article also stated that in the intermediation approach, banks act as intermediaries for depositors and creditors. Thus, banks are seen as buyers of labor, assets, and savings funds that produce output in the form of savings and investment.

This study aims to measure the efficiency of the top 10 largest commercial banks in Indonesia based on assets. The following table is the 10 larger banks in Indonesia in 1st quartal 2020,

**Table 1.** The top 10 largest commercial banks based on assets in Indonesia

| No. | Name of bank | Assets size (in billion rupiah) |
|---|---|---|
| 1. | Bank Rakyat Indonesia | 1,287.09 |
| 2. | Bank Mandiri | 1,130.70 |
| 3. | Bank Central Asia | 953.70 |
| 4. | Bank Negara Indonesia | 803.20 |
| 5. | Bank Tabungan Negara | 308.10 |
| 6. | Bank CIMB Niaga | 271.80 |
| 7. | Bank OCBC NISP | 191.50 |
| 8. | Bank Pan Indonesia | 190.20 |
| 9. | Bank BTPN | 184.90 |
| 10. | Bank Danamon | 169.90 |

There is an assumption that the greater the assets owned by the bank, the more efficient the bank. Grigorian & Manole (2002) and Muljawan et al. (2014) stated that the greater the assets owned by a bank, the more efficient the bank is because banks that have a larger asset value tend to be able to pay lower input costs than their competing banks and can increase returns to scale through fixed cost allocations. This statement is supported by Hauner (2005) that found that bank size is related to market forces. This means that a larger bank has lower input cost.

However, Asongu & Biekpe (2018), find that large banks continue to be inefficient compared to smaller banks. Asongu & Odhiambo (2019), also states that larger banks become more efficient, more unrivaled, make banks abuse their power to exploit customers by creating monopolistic practices. Therefore, the existence of large banks in their development must be regulated and supervised so that monopolistic practices do not occur. It proves that there is a role for bank size in increasing efficiency in the banking sector (Karray & Chichti, 2013).

Furthermore, this study will measure the efficiency with an intermediation approach because it is considered more appropriate to be used to evaluate financial institutions as a whole (Berger & Humphrey, 1997). Bank efficiency research with an intermediation approach has been carried out, such as research conducted by Kamarudin, Sufian, Nassir, Anwar, & Hussain (2019) and Singh & Bansal (2017). Meanwhile, the measurement of efficiency in this study uses a non-parametric approach, namely Data Envelopment Analysis (DEA). Epstein & Henderson (1989) stated that the advantage of using DEA is that it is an efficiency measure to identify the units used that can be used as a reference to help find the causes of inefficiency. In contrast to parametric approaches such as SFA (Stochastic Frontier Analysis), DEA can use multiple inputs and outputs. In addition, DEA can also produce more detailed information on the value of unit efficiency, not only relative to the efficiency frontier line, but also to more specific efficient units to serve as a comparison (Hawdon, 2003). The advantages of using DEA in measuring banking efficiency are supported by Bhattacharyya, Lovell, & Sahay (1997) who state that imperfect regulations and markets in developing countries can change input-output prices so that it can be difficult to measure the cost or profit function using a parametric approach. This is what makes the non-parametric DEA method a popular methodology in evaluating the relative efficiency of the decision-making unit (DMU).

## LITERATURE REVIEW

The importance of efficiency in increasing economic growth causes research on efficiency to continue. In addition to measuring banking efficiency, research on efficiency also links efficiency with bank performance factors and examines what factors can increase banking efficiency, both internal and external.

Research on measuring efficiency was conducted by Zaini Abd Karim (2001) using the Stochastic Cost Frontier approach to test whether there were significant differences in efficiency in ASEAN countries such as Indonesia, Malaysia, the Philippines, and Thailand. The conclusion from this study is that large banks tend to have higher cost-efficiency than small banks.

Researches on efficiency also conducted to examine what factors could increase banking efficiency both internally and externally, including Thi My Phan, Daly, & Akhter (2016). Their study compared bank efficiency in 6 Asian countries (Bangladesh, India, Indonesia., Malaysia, Philippines, and Vietnam) in the 2005-2012 period. The results show that the size of the bank has a positive effect on efficiency. This founded was supported by Jiménez-Hernández, Palazzo, & Sáez-Fernández (2019) and Jiménez-Hernández et al. (2019) and Ruslan, Pahlevi, Alam, & Nohong (2019). Furthermore, Alber et al. (2019) researched the efficiency of banks in Greece stated that the efficiency score differs according to the size of the bank (size), age, and ownership. Small banks, which have been operating with private ownership for a long time, are more efficient than large banks that have only recently operated with public ownership. Sufian, (2016) on his research in efficiency with the DEA method showed that production efficiency had a positive effect on bank size, capital, and bank ownership.

Research on testing the factors that affect efficiency associated with internal and external factors was conducted by Goswami, Hussain, & Kumar (2019) using bank size, capital, liquidity risk, ROA, interest rates, market risk, market concentration, and GDP. The regression results of the fixed effect model panel show that liquidity risk, ROA, credit risk, market concentration, and GDP affected the level of efficiency.

Other efficiency studies related to bank internal conditions were also conducted by Uchida & Satake (2009). Their research stated that banks with large deposits were more efficient in terms of costs even though they had a small effect on profit efficiency. It concluded, depositors that provide funding to banks play an important role in disciplining bank management. It directly forces the efficient use of inputs. Furthermore, the research of Assaf, Berger, Roman, & Tsionas (2017) tested bank efficiency under normal conditions that affected bank sustainability, risk, and profitability. The results show that cost efficiency is better in measuring management quality when profit efficiency reflects high returns from risky investments under normal conditions. This study also calls on policymakers, regulators, supervisors, and managers to focus on cost efficiency during normal conditions to survive in a financial crisis

**METHOD**

The population used in this research were commercial banks. The sample was the top 10 largest banks in Indonesia based on their asset value in the 1st quarter of 2020. The period of this research is 5 years start from 2015-2019. The following were ten commercial banks used as research samples (Ciptaining, 2020).

**Table 2.** Sample of the Research

| No | Name of bank | Bank code | Categories based on ownership | Categories based on BUKU |
|----|--------------|-----------|-------------------------------|--------------------------|
| 1 | PT. Bank Rakyat Indonesia Tbk | BBRI | state-owned banks | BUKU 4 |
| 2 | PT. Bank Mandiri Tbk | BMRI | state-owned banks | BUKU 4 |
| 3 | PT. Bank Central Asia Tbk | BBCA | foreign exchange national private commercial banks | BUKU 4 |
| 4 | PT. Bank Nasional Indonesia Tbk | BBNI | state-owned banks | BUKU 4 |
| 5 | PT. Bank Tabungan Negara Tbk | BBTN | state-owned banks | BUKU 3 |
| 6 | PT. Bank CIMB Niaga Tbk | BNGA | foreign exchange national private commercial banks | BUKU 3 (in March 2019, BNGA migrated to BUKU 4 category) |
| 7 | PT. Bank OCBC NISP Tbk | NISP | foreign exchange national private commercial banks | BUKU 3 |
| 8 | PT. Bank Pan Indonesia Tbk | PNBN | foreign exchange national private commercial banks | BUKU 3 (in March 2019, BNGA migrated to BUKU 4 category) |
| 9 | PT. Bank Tabungan Pensiunan Nasional Tbk | BTPN | non-foreign exchange national private commercial bank | BUKU 3 |
| 10 | PT. Bank Danamon Indonesia Tbk | BDMN | foreign exchange national private commercial banks | BUKU 3 |

The efficiency score in this research used the DEA with the assumption of output-oriented with VRS methods. The meaning of this assumption is how much the output value must be generated using the same number of inputs that the bank becomes efficient. The data used in this research is secondary data taken from the publication of commercial bank annual reports available on individual bank websites.

The measurement of efficiency in this study uses the DEA with an intermediation approach. The intermediation approach was used because the intermediation approach is more appropriate for evaluating financial institutions while, the production approach is better used for evaluating branches of financial institutions (Berger & Humphrey, 1997). Besides, the intermediate approach is used because it is related to the basic function of the bank as an intermediary institution such as research conducted by Yannick, Hongzhong, & Thierry

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(2016) and Ouenniche & Carrales (2018). The input and output variables with the intermediation approach used in this study were taken from the research variables used by Lindley & Sealey (1977), which consisted of,

**Table 3.** Input and Output Variables

| Symbol | Variable | Source of data |
|--------|----------|----------------|
| | **Input** | |
| $x_1$ | Cost of labor | Income statement |
| $x_2$ | Net fixed assets | Balance sheet |
| $x_3$ | Deposits | Balance sheet |
| | **Output** | |
| $y_1$ | Loans | Balance sheet |
| $y_2$ | Liquid Assets and Investments in Securities | Balance sheet |
| $y_3$ | Other Operating Income | Income statement |

This research was started by collecting data from input and output variables to measure efficiency using DEA. In summary, the following were the stages of the research,

**Pearson Correlation of Input-Output Variables.** Pearson correlation is used to test the relationship between input and output variables. This Pearson correlation is performed to fulfill the following hypothesis,
Ho:     There is no correlation (correlation) between the input variables (x1, x2, x3) and the output variables (y1, y2, y3).
H1:     There is a relationship (correlation) between the input variables (x1, x2, x3) and the output variables (y1, y2, y3).
Basic decision making:
If the probability > 0.01 mean Ho is accepted
If the probability < 0.01 mean Ho is rejected

**Efficiency Measurement with DEA.** DEA is a linear programming model that includes many inputs and outputs without determining weights for each variable and without an explicit explanation of the functional relationship between input and output. According to Cooper, Deng, Huang, & Li (2002), DEA calculates efficiency measures on a scale and determines the efficient input and output levels for the unit being evaluated. DEA is also used to measure the level of relative efficiency, especially based on technical efficiency and is linear programming to estimate the frontier.

DEA was first introduced by Charnes, Cooper, & Rhodes (1978) by using an input model assuming a constant rate of return (Constant Return to Scales-CRS). The approach is then developed using an output model. Another approach is using the assumption of Variable Return to Scales (VRS) introduced by Banker, Charnes, & Cooper (1984). The relationship between relative efficiency and efficiency measures can be described technically based on output-oriented can be described as follows,
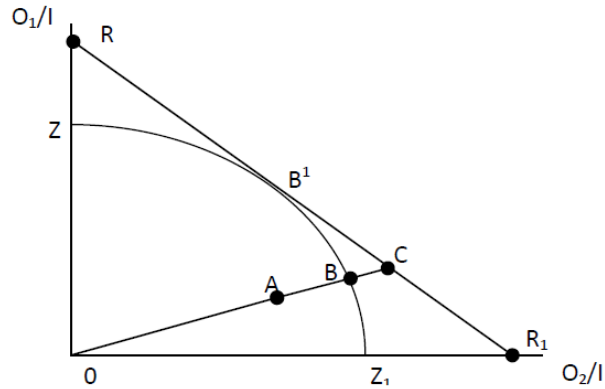
**Figure 1.** Output-Oriented Efficiency Illustration

Source: Zaini Abd Karim, M., 2001

Based on Figure 1, assume there are two outputs (O1 and O2) and input (I). If a constant return to scale is assumed, it can be described by a production possibility curve in two dimensions. In Figure 1, the $ZZ_1$ curve is a Production Possibility Curve (PPC) which describes the relative production function based on two outputs and one input. The level of output relative to input along this curve is an efficient level of the output-input combination. Therefore, the combination at point A is inefficient because it is under the production possibilities curve.

The AB distance represents a technical inefficiency which is the level of outputs that should be increased by not adding inputs. Therefore, a measure of technical efficiency based on output-oriented is the ratio,

Technical Efficiency (TE) = OA/OB                                      (1)

If we have information on the prices of O1 and O2, we will get the isorevenue (RR1) line, and we can define the efficiency of the allocation as,

Allocation Efficiency (AE) = OB/OC                                     (2)

Furthermore, economic efficiency will also be defined as a product of the two efficiencies, so that,

Economic Efficiency = (OA/OC) = (OA/OB) x (OB/OC) = TE x AE            (3)

Generally, the measurement of technical efficiency can be done based on input (input-oriented) or output (output-oriented). In other words, efficiency can be measured by minimizing input to achieve a certain output or maximizing output by using certain inputs, to obtain alternative calculations,

$$\text{Efficiency} = \frac{\text{Input}}{\text{Output}} \text{ Or Efficiency} = \frac{\text{Output}}{\text{Input}}$$                (4)

The calculations in this study focus on the second alternative or better known as input-based efficiency so that by using multiple outputs and multiple inputs, it will obtain,

$$\text{Efficiency} = \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots}{v_1 x_{1j} + v_2 x_{2j} + \cdots}$$                (5)

With

$u_1$ = weighed against output i,

$y_{1j}$ = output size 1 from unit j,

$v_1$ = weighed against input i, and

$x_{1j}$ = input size 1 from unit j.

The DEA model which allows for the return to scale variable condition with the input orientation for DMU can be formally written as follows:

$$\min z_0 = \Theta_0 \tag{6}$$

with constraints:

$$\sum_{j=1}^{n} \lambda_j\, y_{rj} \geq y_{ro}, \qquad r = 1,2,....,s$$
$$\Theta_0 x_{i0} - \sum_{j=1}^{n} \lambda_j\, x_{ij} \geq 0,\ i = 1,2,....,m$$
$$\sum_{j=1}^{n} \lambda_j = 1 \tag{7}$$
$$\lambda_j \geq 0, \qquad\qquad\qquad j = 1,2,....,n$$

Where $\Theta$ is the technical efficiency (BCR), xij is the number of i-th type inputs from the j-th DMU and yrj is the r-th type outputs from the j-th DMU. The value of $\Theta$ is always less or equal to 1. DMU whose value $\Theta < 1$ means inefficient, whereas, DMU whose value $\Theta = 1$ means efficient.

DEA is a non-parametric approach that is often used in efficiency measurement research. Because it is non-parametric, this approach does not require the initial assumption of the production function. The data used are input and output variables which are then processed to produce a certain efficiency score for each Decision-Making Unit (DMU). The efficiency score with DEA is the relative efficiency score between each DMU in the research object. With this efficiency score, analysis can be carried out related to efficiency in the transformation process from input to output in the banking industry. Efficiency scores from measurement results using DEA are generated from calculations using the Efficiency Measurement System (EMS) software.

Based on the DEA approach, a DMU that is both input and output-oriented is efficient if it gets a score equal to 100% or 1. A bank is efficient in input orientation if it has an efficiency score equal to 100%, and a bank is not efficient if the efficiency score is less than 100%. If the resulting score is less than 100%, it means that the DMU is still taking wasteful actions using its input.

**Kruskal Wallis Test.** The Kruskal Wallis test in this study was used to test the difference in efficiency between bank groups according to ownership and BUKU. Test whether the top 10 largest commercial banks based on assets grouped by ownership come from the same population or not. If the Kruskal Wallis test is significant at alpha =5%, the efficiency analysis can be analyzed based on ownership and BUKU categories.

The hypothesis used in the Kruskal Wallis test is:

Ho: Bank groups come from the same population (identical).

H$_1$: Bank groups come from unequal (not identical) populations.

Basic decision making:

If the probability > 0.05 mean Ho is accepted

If the probability < 0.05 mean Ho is rejected

**Efficiency Comparative Analysis.** Comparative analysis was performed after the Kruskal Wallis test. The Wallis Crucifix test was conducted to test whether the 10 commercial banks

sampled came from the same population or not. If the Kruskal Wallis test results show that the H0 decision is rejected, then the bank group does not come from the same population and practices different technologies so it is not appropriate to conclude all banks into one sample. Thus, a bank efficiency analysis needs to be differentiated based on ownership and BUKU. On the other hand, if the Kruskal Wallis test results show the decision to accept Ho, the efficiency analysis is not differentiated based on ownership and BUKU groups, because they come from the same population.

## RESULTS AND DISCUSSION

**Pearson Correlation Input-Output.** Before analyzing bank efficiency with the DEA approach, the isotonic relationship between the input and output variables will be tested using the Pearson correlation. The following is a summary result of the Pearson Correlation test between input and output variables used to measure the bank's efficiency with DEA.

**Table 4.** Coefficient of Pearson Correlation Input-Output

|     | X1 | X2 | X3 | Y1 | Y2 | Y3 |
|-----|----|----|----|----|----|----|
| X1  | 1.000000 | | | | | |
| X2  | 0.804907<br>t stat =<br>9.397619<br>0.0000 | 1.000000 | | | | |
| X3  | 0.967574<br>t stat<br>=26.53946<br>0.0000 | 0.879086<br>t stat<br>=12.77735<br>0.0000 | 1.000000 | | | |
| Y1  | 0.951600<br>t stat<br>=21.45156<br>0.0000 | 0.907840<br>t stat<br>=14.99983<br>0.0000 | 0.991708<br>t stat<br>=53.46440<br>0.0000 | 1.000000 | | |
| Y2  | 0.954148<br>t stat =<br>22.08395<br>0.0000 | 0.844411<br>t stat<br>=10.92087<br>0.0000 | 0.948053<br>t stat<br>=20.64775<br>0.0000 | 0.953084<br>t stat<br>=21.81384<br>0.0000 | 1.000000 | |
| Y3  | 0.950286<br>t stat<br>=21.14392<br>0.0000 | 0.890506<br>t stat<br>=13.56046<br>0.0000 | 0.971762<br>t stat<br>=28.53245<br>0.0000 | 0.977010<br>t stat<br>=31.74986<br>0.0000 | 0.929046<br>t stat<br>=17.39789<br>0.0000 | 1.000000 |

Based on table 4 shows that the results of statistical tests between the input variables (labor costs, net fixed assets, and total savings) and the output variables (total loans, liquidity assets, and securities, and other operating costs) are all significant (probability value $<0.01$). The conclusion is that Ho is rejected, which means that there is a positive and strong relationship

between the input variable and the output variable. This implies that the isotonicity principle has been successfully fulfilled. Therefore, the DEA approach can be used to evaluate bank efficiency.

**Efficiency Measurement Results.** The study aims to compare the efficiency among the top 10 largest commercial banks in Indonesia based on assets. The following was a summary table of descriptive statistics from DEA analysis,

**Table 5.** Statistics Descriptive of Efficiency

| | |
|---|---|
| Mean | 0.9912 |
| Minimum | 0.8550 |
| Maximum | 1.0000 |
| Standard Deviasi | 0.0281 |

Based on the level of efficiency in the table 5. It can be seen that the maximum value of efficiency was 1. This score was owned by several banks namely BBRI, BMRI, BBTN, NISP, PNBN, BTPN, and BDMN had an efficiency value of 1 consistently. Next year BBCA 2015 was not efficient, but in 2016-2019 the efficiency value was 1. In contrast to BBNI and BNGA whose efficiency values were less than 1 for 3 years. Furthermore, the minimum value of efficiency was 0.8550 owned by BNGA in 2019. The average and standard deviation of the efficiency scores was 0.0281. A small standard deviation value means that the diversity of data on the level of efficiency is small.

**Kruskal Wallis Test Based on Ownership.** This study used a sample of the top 10 largest commercial banks in Indonesia, grouped into three ownership: state-owned banks, foreign exchange national private commercial banks, and non-foreign exchange national private commercial bank. The purpose of the analysis was made in groups was to get depth analysis of efficiency in the top 10 largest banks in Indonesia. The stages in the analysis were as follows,
a. Test whether the top 10 largest commercial banks based on assets grouped by ownership come from the same population or not by using the nonparametric test, namely Kruskal Wallis.
b. If the Kruskal Wallis test results are significant at alpha = 5%, the conclusion was a commercial bank efficiency analysis based on ownership can be carried out.
The following are the results of the Kruskal Wallis test using SPSS.

**Table 6.** Kruskal Wallis Test Based on Ownership

| | Efficiency |
|---|---|
| Chy Square | 0.896 |
| df | 2 |
| Asymp.Sig. | 0.639 |

The Kruskal Wallis test results showed that the probability value was greater than 5%, so H0 was accepted. This means that the bank group comes from the same population and

practices the same technology. Therefore, it would be appropriate to analyze all the banks into one sample. For further analysis, the banks are not separated by frontier based on ownership.

**Kruskal Wallis Test Based on BUKU.** This study used a sample of the top 10 largest commercial banks in Indonesia, grouped into two: BUKU 4 and BUKU 3. BUKU is a grouping of banks based on core capital (tier 1) which is regulated by Bank of Indonesia (BI). Based on core capital, Bank are grouped into 2 groups consist of BUKU 3: Banks with core capital of 5 Trillion rupiah up to less than 30 Trillion rupiah and BUKU 4: Banks with core capital at least 30 Trillion rupiah. The purpose of the analysis was made in groups was to get depth analysis of efficiency in the top 10 largest banks in Indonesia. The stages in the analysis were as follows,
The following are the results of the Kruskal Wallis test using SPSS.

**Table 7.** Kruskal Wallis Test Based on BUKU

|            | Efficiency |
|------------|------------|
| Chy Square | 0.896      |
| df         | 2          |
| Asymp.Sig. | 0.639      |

The Kruskal Wallis test results showed that the probability value was greater than 5%, so H0 was accepted. This means that the bank group comes from the same population and practices the same technology. Therefore, it would be appropriate to analyze all the banks into one sample. For further analysis, the banks are not separated by frontier based on BUKU.

**Efficiency Comparative Analysis.** Based on the results of the Kruskal Wallis test, the analysis and discussion of the efficiency of commercial banks in this study did not differentiate between ownership and BUKU because the samples had the same characteristics and came from the same population. The following is a table of the efficiency values of the 10 commercial banks that were the research samples,

**Table 8.** Efficiency Score of the Top 10 Largest Commercial Banks in Indonesia 2015-2019

| Bank Code | 2015   | 2016 | 2017   | 2018   | 2019   |
|-----------|--------|------|--------|--------|--------|
| BBRI      | 1      | 1    | 1      | 1      | 1      |
| BMRI      | 1      | 1    | 1      | 1      | 1      |
| BBCA      | 0.8850 | 1    | 1      | 1      | 1      |
| BBNI      | 0.9570 | 1    | 0.9340 | 1      | 0.9830 |
| BBTN      | 1      | 1    | 1      | 1      | 1      |
| BNGA      | 1      | 1    | 0.9860 | 0.9590 | 0.8550 |
| NISP      | 1      | 1    | 1      | 1      | 1      |
| PNBN      | 1      | 1    | 1      | 1      | 1      |
| BTPN      | 1      | 1    | 1      | 1      | 1      |
| BDMN      | 1      | 1    | 1      | 1      | 1      |

Based on table 8 it could be concluded that BBRI, BMRI, BBTN, NISP, PNBN, BTPN, and BDMN have achieved an efficiency score of 1 during the 2015 to 2019 period, which means that these banks had reached full efficiency. This indicates that the banks were able to use available inputs to produce optimal output. Overall, there was one period in 2016 in which all commercial banks in the sample had an efficiency score of 1.

Overall, it could be explained that in 2015 there were 80% of commercial banks in the sample had reached maximum efficiency. Evenly, in 2016 all commercial banks in the sample had reached full efficiency. Furthermore, in 2017, the proportion of efficient banks decreased by 20% to 80%, then in 2018 increased to 90%, and in 2019 decreased to 80%. This means that there are still 10% -20% of banks that experience fluctuation inefficiency, meaning that there are still 1-2 banks during the research period had a fluctuating performance. However, there was one bank (BBCA) that succeeded in improving its performance so that in the following periods, BBCA was able to achieve maximum efficiency consistently. In contrast to BBNI and BNGA, the efficiency values fluctuate. However, if compared, BBNI was better than BNGA. This was because BNGA consecutively for the last three years had an efficiency value that had continued to decline, from 0.9860 in 2017 to 0.8550 in 2019.

Next, it would be discussing the potential deterioration amount of commercial bank input. Potential deterioration is an amount of input that the bank can reduce input to achieve a maximum efficiency value by optimizing input.

**Potential Decrease in Inputs in Banks.** The following are some of the potentials for input reductions at the largest commercial banks in Indonesia consisting of labor costs, net fixed asset value, and total deposits, especially in inefficient banks based on table 8,
a. Potential Reduction in Labor Cost

**Table 9.** Potential Reduction in Labor Cost

| Bank code | Potential Reduction in Labor Cost (million rupiahs) | | | | |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| BBRI | 0 | 0 | 0 | 0 | 0 |
| BMRI | 0 | 0 | 0 | 0 | 0 |
| BBCA | - | 0 | 0 | 0 | 0 |
| BBNI | 1,115,187.310 -319,286.829 | 0 | -616,135.007 | 0 | -176,826.354 |
| BBTN | 0 | 0 | 0 | 0 | 0 |
| BNGA | 0 | 0 | -56,789.101 | -164,231.870 | -672,526.965 |
| NISP | 0 | 0 | 0 | 0 | 0 |
| PNBN | 0 | 0 | 0 | 0 | 0 |
| BTPN | 0 | 0 | 0 | 0 | 0 |
| BDMN | 0 | 0 | 0 | 0 | 0 |

Based on the results by DEA data, it showed that labor costs as an input that must be reduced to achieve efficiency values. The number 0 in table 8 shows that the bank has optimized its labor costs to achieve an efficiency score. Meanwhile, a number other than 0 shows the number of labor costs that can still be reduced to produce maximum efficiency. Table 8 shows that in 2015 there are two banks (BBCA and BBNI) that still able to reduce labor costs as one way to achieve maximum efficiency values. BBCA still had to reduce labor costs in the amount of 1,115,187.310 (millions of rupiahs) to achieve an optimal output. Similarity with BBNI, which in the same period was also able to reduce labor costs in the amount of 319,286.829 (millions of rupiahs).

It was different from 2016 where all banks have reached the maximum efficiency value of 1, which means that all banks could optimize output and input so that banks in that period have optimized their labor costs. However, in 2017 BBNI still had to reduce labor costs, however, in 2018, BBNI was able to optimize labor costs. Finally, in 2019, BBNI still has to reduce labor costs to achieve its efficiency. It is different from BNGA, which from 2017-2019 must continue to strive to reduce labor costs to achieve the maximum level of efficiency because it appears that the amount of labor costs that must be reduced by BNGA has also increased during 2017-2019.

b. Potential Reduction in Net Fixed Assets

**Table 10.** Potential Reduction in Net Fixed Assets

| Bank code | Potential Reduction in Net Fixed Assets (million rupiahs) | | | | |
| --- | --- | --- | --- | --- | --- |
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| BBRI | 0 | 0 | 0 | 0 | 0 |
| BMRI | 0 | 0 | 0 | 0 | 0 |
| BBCA | -1,113,297.277 | 0 | 0 | 0 | 0 |
| BBNI | -899,736.143 | 0 | -1,514,548.924 | 0 | -460,457.290 |
| BBTN | 0 | 0 | 0 | 0 | 0 |
| BNGA | 0 | 0 | -73,642.189 | -223,800.468 | -908,821.390 |
| NISP | 0 | 0 | 0 | 0 | 0 |
| PNBN | 0 | 0 | 0 | 0 | 0 |
| BTPN | 0 | 0 | 0 | 0 | 0 |
| BDMN | 0 | 0 | 0 | 0 | 0 |

In addition to labor costs, the amount of net fixed assets was also an input that must be reduced to achieve efficiency values. Similar to the potential reduction in labor cost input, the number 0 in table 9 indicates that the bank has optimized its net fixed assets to achieve an efficiency score. Furthermore, a number other than 0 showed that the number of fixed assets can still be reduced to produce maximum efficiency. Two banks in 2015 must be reduced the number of fixed assets, namely BBCA and BBNI. To achieve efficiency, BBCA can still reduce its net fixed assets in the amount of 1,113,297.277 (millions of rupiahs), and BBNI can still reduce its net fixed assets in the amount of 899,736.143 (millions of rupiahs).

2016 is because all banks have reached their maximum efficiency, which means that all banks can optimize output and input so that banks in that year have optimized the amount of net fixed assets. However, in 2017-2019 there were still banks that had to reduce the amount of net fixed assets to achieve efficiency.

c. Potential Reduction in Savings Input

**Table 11.** Potential Reduction in Savings

| Bank code | Potential Reduction in Savings (million rupiahs) | | | | |
|---|---|---|---|---|---|
| | **2015** | **2016** | **2017** | **2018** | **2019** |
| BBRI | 0 | 0 | 0 | 0 | 0 |
| BMRI | 0 | 0 | 0 | 0 | 0 |
| BBCA | -54,813,487.293 | 0 | 0 | 0 | 0 |
| BBNI | -15,526,243.591 | 0 | -33,504,640.431 | 0 | -10,313,727.715 |
| BBTN | 0 | 0 | 0 | 0 | 0 |
| BNGA | 0 | 0 | -2,822,064.418 | -7,948,503.492 | -28,648,823.819 |
| NISP | 0 | 0 | 0 | 0 | 0 |
| PNBN | 0 | 0 | 0 | 0 | 0 |
| BTPN | 0 | 0 | 0 | 0 | 0 |
| BDMN | 0 | 0 | 0 | 0 | 0 |

The amount of savings was the third input that must be reduced to achieve efficiency values. According to table 11, in 2015, there were two banks (BBCA and BBNI) that had to reduce the number of deposits. To achieve efficiency, BBCA and BBNI still reduce the amount of savings respectively in the amount of 54,813,487.293 and 15,526,243.591 (millions of rupiahs). Further, 2016 was a period when all the banks in the sample have reached the maximum efficiency value of 1, which means that all banks have optimized the number of deposits. Similar to the explanation for the potential reduction in labor costs and the number of deposits, in 2017-2019 of the largest commercial bank group, there were still 1 to 2 banks that had not

This study aims to measure and compare the score of efficiency at the top 10 largest commercial banks in Indonesia. Are there differences in score efficiency in large banks according to the statement of (Grigorian & Manole, 2002) and Muljawan, Hafidz, Astuti, & Rini Oktapiani (2014) which states that the greater the assets owned by a bank, the more efficient the bank is? The results showed that overall, almost all banks in the sample have reached maximum efficiency, and there are many banks that have been able to optimize input and output. This study support Ersangga & Atahau (2019) which states that bank size has a positive effect on efficiency (DEA score).

In addition, the results of the study show that inefficient banks can achieve maximum efficiency scores by reducing inputs consisting of labor costs, total net fixed assets, and total deposits. This can be seen from the results of DEA data processing related to the potential for input reduction. The results of this study support (Hauner, 2005) who found that bank

size is related to market forces. Therefore, a larger bank has lower input costs, which means that a larger bank has achieved maximum efficiency by reducing their input costs.

## CONCLUSION

This research purpose was measure and compare efficiency score from the top 10 largest commercial banks in Indonesia. Based on the research results, it can be concluded that, the Kruskal Wallis test showed there was no significant difference in efficiency between the top 10 largest commercial banks in Indonesia both on ownership and BUKU. Therefore, it would be appropriate to analyse all the banks into one sample and not separated by frontier based on ownership and BUKU. From efficiency score, there were 7 banks that had maximum efficiency throughout the research period, namely BBRI, BMRI, BBTN, NISP, PNBN, BTPN, and BDMN. Next, according to DEA analysis, it showed that inefficient banks could achieve maximum efficiency by reducing inputs, namely labour costs, total net fixed assets, and total deposits. Banks that have reached maximum efficiency are expected to continue to improve and maintain their performance due to increasingly fierce competition.

The limitations of this study were not all banks can be directly efficient by reduced inputs because they not always can be controlled by management. The DEA analysis tool is a logarithmic mathematical application that does not consider bank conditions and bank limitations. Therefore, it is still necessary to consider the conditions and limitations of the bank in making decisions related to achieving an efficient bank.

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