

# TECHNICAL EFFICIENCY OF INDONESIAN SHARIA BANKS: A Data Envelopment Analysis Approach

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**Abstract:** With the development of sharia banks, one of the effects that occurs is the existence of competition among sharia banks. The objective of this study is then to analyze the efficiency of Sharia banks in Indonesia. Understanding efficiency is important because if banks perform consistently with full efficiency, the fewer inputs they use, the larger the output they achieve. Total earning assets measure the output, while the inputs used are total deposit and total operating costs. A data envelopment analysis with input-oriented and variable returns-to-scale is used to accomplish the objective. The result shows that among twelve Sharia banks under-investigated, four of them are considered the most efficient.

**Abstrak:** Dengan berkembangnya bank syariah, salah satu dampak yang terjadi adalah adanya persaingan antar bank syariah. Tujuan dari penelitian ini kemudian untuk menganalisis efisiensi bank syariah di Indonesia. Memahami efisiensi penting karena jika bank berkinerja konsisten dengan efisiensi penuh, semakin sedikit input yang mereka gunakan, semakin besar output yang mereka capai. Output diukur dengan total aset produktif, sedangkan input yang digunakan adalah total deposit dan total biaya operasi. Analisis data envelopment dengan *input-oriented* dan variabel *returns-to-scale* digunakan untuk mencapai tujuan. Hasilnya menunjukkan bahwa di antara dua belas bank syariah yang kurang diselidiki, empat di antaranya dianggap paling efisien.

**Keywords:** data envelopment analysis, efficiency, Indonesia, Sharia bank.

## A. Introduction

With the amendment of the Indonesian Law (Undang-Undang) Number 7 of 1992 into Undang-Undang Number 10 of 1998 about Indonesian banking which allows conventional banks to operate by applying Sharia principles or conducting operations in Sharia and conventional ways (dual banking system), the growth of Islamic banks has experienced a significant acceleration since the sharia unit can offer separate sharia banking products. The basic difference between these two types of banking lies in the returns and profit sharing provided by customers to financial institutions and/or financial institutions to the customers. In conventional banking, the distribution of profits is based on the principle of interest, while in Sharia banking, the distribution of profits and losses is based on the principle of profit sharing.

With the development of Sharia banks and the strength of conventional banks, one of the effects that occurs is the existence of competition both between conventional banks and Sharia banks, as well as among Sharia banks. The concern now is how the performance of these banks. Bank performance is important for stakeholders because they can evaluate the performance while still applying prudential principles, complying with regulations, and implementing risk management. One of the important aspects of measuring bank performance is efficiency. Bank efficiency is considered to be very important at this time and in the future with increasingly fierce competition, problems that can arise due to lack of resources, and increasing standards of customer satisfaction.<sup>1</sup> The objective of this study is then to analyze the efficiency of Sharia banks in Indonesia. Understanding efficiency, which is simply defined as the ratio of output to input,<sup>2</sup> is important because if banks perform consistently with full efficiency, the fewer inputs they use, the larger output they achieve. A data envelopment analysis (DEA) with input-oriented and variable returns-to-scale (VRS) is used to accomplish the objective.

The rest of the paper is structured as follows. The following section shows the data used in this study, including inputs and output. The third

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<sup>1</sup> Arafat, W. (2006). *Manajemen Perbankan Indonesia: Teori dan Implementasi*. Jakarta: Pustaka LP3ES.

<sup>2</sup> Cooper, W. W., Seiford, L. M. and Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses: With DEA- solver Software and References*. Springer.

section describes the empirical model of this study, i.e., input-oriented DEA with the VRS approach. The fourth section shows the result of this study while the last section concludes.

## **B. THEORETICAL BASIS**

### **Sharia Bank**

The word bank comes from the Italian *banco* which means bench. This is the bench used by bankers to serve their operational activities to customers. In the 12th century, the word *banco* in Italy referred to a table, counter, or place of business money exchange (money changer). This meaning implies a transaction function, namely exchanging money or in a broader sense of business transactions, namely paying for goods and services. Then this term is used today to describe the place of transactions between banks and customers with various products and services offered. Dr. Husein Syahatah explained that the definition of a Sharia bank is a Sharia financial institution that provides banking and financial product services, and investments in various sectors following Sharia rules and aims to realize social and economic growth for Muslims. The aim of establishing a Sharia bank was to offer and expand the conventional implementation of Sharia rules, Islamic transactions, and various related matters. The main rules in Islamic law in the banking industry are 1. Prohibition of usury for carrying out various transactions 2. Carrying out business and trade based on legal profits 3. Giving zakat.

Sharia banks carry out operational activities based on Sharia principles, namely in the form of agreements guided by Islamic principles between the bank and other parties in storing funds and financing business activities and other activities that are considered valid based on Sharia values. Sharia business units (UUS) are Sharia business units formed by conventional banks to operate as Sharia banks but under the management of conventional banks, which means that UUS does not stand alone. The Sharia business unit (UUS) functions as a unit that operates based on Sharia principles or can be said to be a work unit of a branch office of a conventional bank that operates in another area and carries out conventional operations where the office functions as the main office of a sharia sub-branch office or sharia business unit.

The operational principles of sharia that are applied in collecting public funds are the principles of wadi'ah and Mudharabah.<sup>3</sup> 1. Wadi'ah Principle This principle has legal implications where the customer acts as the party lending money and the bank acts as the borrower. The wadi'ah principle applied is wadi'ah yad dhamanah as in checking account products. In contrast to wadi'ah amanah, which has the principle that the entrusted property cannot be used by the entrusted person, in wadi'ah dhamanah the entrusted party (bank) is responsible for the integrity of the entrusted property so that he may utilize the entrusted property. 2. Mudharabah Principles Savers or depositors in applying the mudharabah principles act as shahibul maal (capital owners) and banks as mudharib (managers). These funds are used to carry out murabahah, ijarah, or to carry out a second mudharabah by the bank, in which case the bank is fully responsible for the losses incurred.

This principle is applied in terms of time savings and time deposits. The principle of mudharabah is divided into three types, namely: mudharabah muqayyadah on the balance sheet and off the balance sheet and mudharabah mullah. Sharia banks in off-balance sheet mudharabah muqayyadah also play a role in providing capital to be managed by the mudharib and Sharia banks will get back their capital and share the profits from the projects carried out. Mudharabah muqayyadah is a direct distribution of funds to business implementers, where the bank acts as an intermediary that brings together the fund owner and the business implementer. Mudharabah mutlaqah can be in the form of savings and deposits, so there are two types of fund collection, namely: mudharabah savings and mudharabah deposits.<sup>4</sup>

## Data Envelopment Analysis

DEA is a mathematical method using linear programming techniques to convert inputs to outputs to evaluate the performance of comparable organizations or products. In DEA, each DMU is free to choose any combination of inputs and outputs to maximize its relative efficiency. The relative efficiency or efficiency score is the ratio of the total weighted output

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<sup>3</sup> Karim, A. A. (2004). *Bank Islam Analisis Fiqh dan Keuangan*. Jakarta: PT Raja Grafindo Persada

<sup>4</sup> Muhammad. 2005. *Sistem dan Prosedur Operasional Bank Syariah*, UII Press, Yogyakarta.

to the total weighted input<sup>5</sup>. DEA uses linear programming to estimate relative efficiency. The relative efficiency, denoted by  $\theta$ , is the efficiency score allocated to a decision-making unit as a result of the DEA. This relative efficiency is a non-negative value calculated based on linear relations between the inputs and outputs of the DMUs under analysis. In other words, it determines how efficient a DMU is in producing a certain level of output, based on the amount of input it uses, compared to similar DMUs.

DEA uses linear programming to estimate relative efficiency. The relative efficiency, denoted by  $\theta$ , is the efficiency score allocated to a decision-making unit as a result of the DEA. This relative efficiency is a non-negative value calculated based on linear relations between the inputs and outputs of the DMUs under analysis. In other words, it determines how efficient a DMU is in producing a certain level of output, based on the amount of input it uses, compared to similar DMUs.

In analyses of individual vessel efficiencies in a given fishery, inputs can be divided between ‘endogenous’ and ‘exogenous’ inputs. The former are physical inputs used directly to land the observed catch, such as fishing time, number of crewmembers, and engine size. The latter are non-physical inputs that may however still affect the catch and thus the efficiency of the vessel, such as vessel type, fishing ground, and year. Exogenous factors can be continuous (time), categorical (education level of skipper), or classificatory (fishing ground, vessel type).

Several methods exist for including all three types of exogenous factors directly in the DEA evaluation<sup>6</sup> but especially in the case of categorical and classificatory factors it is an often-encountered practice to employ so-called second-stage analyses, where the efficiency scores obtained by DEA are subsequently modelled against the exogenous variables. The most often encountered approach to modeling the DEA scores against exogenous variables is Tobit regression, which is suitable

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<sup>5</sup> O.L. Inman *et al.* (2006). Predicting US jet fighter aircraft introductions from 1944 to 1982: a dogfight between regression and TFDEA. *Technol Forecast Soc Change*

<sup>6</sup> Cooper, W. W., Seiford, L. M. and Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses: With DEA- solver Software and References*. Springer.

when the dependent variables are either censored or corner solution outcomes, of which DEA scores fall within the second category. A corner solution variable is continuous and limited from above below or both and takes on the value of one or both of the boundaries with a positive probability. As DEA efficiency scores are continuous on the interval  $]0; 1]$ , and take on the value 1 with positive probability, it seems obvious to use a two-limit Tobit technique for modeling the scores as a function of the exogenous variables.

Tobit has as such been adopted as the natural ‘choice’ for modeling DEA scores in second-stage evaluations. The two-limit Tobit technique is however miss-specified when applied to DEA scores, given that these only take on the value 1 with positive probability (and not the opposite limiting value 0). Even so, Tobit yields sensible results in second-stage DEA, and it has as such never been questioned whether Tobit is the most appropriate method, regarding the predictability of scores and effects of the exogenous variables. This paper aims to compare four different approaches to model DEA scores against exogenous influences, to investigate whether other models than Tobit yield more optimal predictions of the DEA scores.

DEA scores are limited to the interval  $]0; 1]$ , and the model used to reproduce the scores must thus also be limited to this interval, and accordingly non-linear. An introductory approach may, however, be to use an ordinary least squares (OLS) linear regression of the scores against the exogenous variables, as this represents a first-order Taylor approximation to the more complex non-linear models. The OLS model will predict scores outside the interval  $]0; 1]$  but if the effects (the regression parameters) predicted by this model do not differ significantly from the effects predicted from non-linear models, OLS is adequate for modeling these effects. The results of Tobit modeling of the DEA scores will thus be compared with the corresponding OLS results, and with two alternative non-linear approaches.<sup>7</sup>

## Data

The data used in this study consists of 12 Sharia Banks operated in Indonesia (10 national private banks and 2 local government banks). The

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<sup>7</sup> Cook, D.O., Kieschnick, R., McCullough, B.D., 2000. Specification errors in studies of the composition of corporate.

data is taken from quarterly financial reports (December 2021) published by the Financial Services Authority or Otoritas Jasa Keuangan (OJK) in Bahasa Indonesia.

The output and input used in this study follow the study of Masrizal et al. (2022). The output is measured by total earning assets (in million rupiahs). It is the total sum of placement accounts with Bank Indonesia, placements with other banks, receivables (murabahah, salam, istishna', qardh, and multiservice), ijarah, and mudharabah, musyarakah, and other financings. Murabahah is a scheme used for short-term financing. Under this scheme, the seller discloses the real cost and profit of the products to the buyer. Negotiation of a profit margin is possible and installment payments are common.<sup>8</sup>

Salam (bai') is a scheme similar to forward contracts. Under this scheme, the seller and buyer agree to a future transaction where the buyer pays the full amount of the price and the seller promises to deliver the goods. Quality, quantity, price, and time of delivery are determined at the time of the contract. Istishna' is a type of sale transaction where the buyer places an order with the seller to manufacture a certain asset and the sale is completed upon delivery of the asset to the buyer.<sup>9</sup>

Qardh (al Hashanah) is the only loan permissible under the Islamic finance scheme. This scheme is a zero-return loan. However, administration and transaction costs are permissible (as long as there is no relationship between the maturity and amount of the loan Ijarah is a (pure) lease transaction.<sup>10</sup> In a mudarabah contract, one party provides all the capital for the business which is called shahibul maal while the entrepreneurs or mudharib contribute effort and time to the project. The profits will be shared in a fixed ratio and losses will be borne by the financial institution.<sup>11</sup> In a

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<sup>8</sup> Dhumale, R. and Sapcanin, A. (1999). *An application of Islamic banking principles to microfinance*. Technical note, A study by the Regional Bureau for Arab States, UNDP, in cooperation with the Middle East and North Africa Region, World Bank, New York, NY.

<sup>9</sup> Ayub, M. (2007). *Understanding Islamic Finance*. John Wiley & Sons.

<sup>10</sup> Dhumale, R. and Sapcanin, A. (1999). *An application of Islamic banking principles to microfinance*. Technical note, A study by the Regional Bureau for Arab States, UNDP, in cooperation with the Middle East and North Africa Region, World Bank, New York, NY.

<sup>11</sup> *ibid*

musharakah contract, profits are shared based on an agreement, whereas losses are shared based on equity participation.<sup>12</sup>

The inputs used in this study are total deposit and total operating costs. The total deposit consists of the total sum of wadiah savings accounts, mudharabah savings, and mudharabah deposits. Total operating costs consist of the sum of personnel costs, advertising expenses, and other operational costs. Wadiah is trust or savings; the trusted party is not responsible for the loss unless the negligence stems from it.<sup>13</sup> The data of inputs and output used is shown in Table 1.

**Table 1. Data of inputs and output used (in million rupiahs)**

DMU	Total earning asset	Total deposit	Total operating costs
PT Bank Muamalat Indonesia	24,945,246	46,871,375	1,248,231
PT Bank Victoria Syariah	858,781	1,230,445	34,572
PT Bank Jabar Banten Syariah	7,384,535	7,883,355	377,739
PT Bank Syariah Indonesia	193,074,867	233,251,358	8,542,492
PT Bank Mega Syariah	10,234,188	11,394,777	447,709
PT Bank Panin Dubai Syariah (Tbk)	10,078,411	7,796,461	195,656
PT Bank KB Bukopin Syariah	5,233,540	4,595,068	154,003
PT Bank BCA Syariah	7,400,747	7,677,861	212,486
PT Bank BTPN Syariah (Tbk)	11,519,289	10,993,547	1,686,155
PT Bank Aladin Syariah (Tbk)	1,158,299	1,038,184	156,319
PT Bank Aceh	20,171,538	24,018,009	1,346,241
PT Bank NTB Syariah	8,846,589	8,143,058	383,701

In DEA, the influence of inputs on output cannot be investigated—whether the inputs significantly affect the output; thus, the selection of inputs only depends on the literature without knowing whether the selected inputs significantly influence the output. However, Ferrera et al.<sup>14</sup> argued

<sup>12</sup> Fianto, B. A., Gan, C., Hu, B., and Roudaki, J. (2018). Equity financing and debt-based financing: evidence from Islamic microfinance institutions in Indonesia. *Pacific-Basin Finance Journal*, 52, 163-172

<sup>13</sup> Ayub, M. (2007). *Understanding Islamic Finance*. John Wiley & Sons.

<sup>14</sup> Ferrera, J. M. C., Crespo-Cebada, E., Chaparro, F. P., and González, D. S. (2011). Exploring educational efficiency divergences across Spanish regions in PISA 2006. *Revista de Economía Aplicada*, 19(57), 117-145.



that inputs must fulfill the requirement of isotonicity (i.e., *ceteris paribus*, more input implies an equal or higher level of output); hence, the selected inputs should present a significant positive correlation with the output in addition to having theoretical support from previous work. Table 2 shows the correlation coefficients of all variables used. Notice that in Table 2, the output is strongly correlated with inputs.

**Table 2. Correlation coefficients of inputs and output**

	Total earning asset	Total deposit	Total operating costs
Total earning asset	1	1	1
Total deposit	0.99657013	0.9842390	
Total operating costs	0.98758628	3	

### C. RESEARCH METHOD

Efficiency refers to the ability of a decision-making unit, in this study, it is a sharia bank in Indonesia, to minimize input used in the production of a given output, or the ability to obtain maximum output from a given inputs.<sup>15</sup> Consequently, a DMU is fully technically efficient if it produces the maximum possible output from a fixed level of inputs (in an output orientation), or if it uses the minimum possible inputs to produce a given level of output (in an input orientation).

This study uses DEA to assess efficiency. It is a non-parametric approach that requires very few assumptions in estimating technical efficiency compared to the parametric approach such as the stochastic frontier analysis (SFA). In SFA, one has to define a functional form a priori and estimate the finite set of unknown parameters from the data. In addition, due to the use of the maximum likelihood method, the distribution of inefficiency must be defined a priori. In DEA, we do not consider those

<sup>15</sup> Cooper, W. W., Seiford, L. M. and Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses: With DEA- solver Software and References*. Springer.

issues. DEA has been widely used to assess efficiency across sectors, e.g., small and medium enterprises and,<sup>16</sup> the creative industry.<sup>17</sup>

Let  $M$  be the number of inputs and  $N$  be the number of DMUs, (in this study,  $M=2$  and  $N=12$ ). Efficiency can be estimated by solving the mathematical linear programming as follows

$$\begin{aligned}
 \text{Min} \quad & \theta \\
 \text{Subject to} \quad & \theta \mathbf{x}_o - \mathbf{X} \boldsymbol{\lambda} \geq \mathbf{0} \\
 & \mathbf{Y} \boldsymbol{\lambda} \geq y_o \\
 & \mathbf{e} \mathbf{Y} = \mathbf{1} \\
 & \boldsymbol{\lambda} \geq \mathbf{0},
 \end{aligned} \tag{1}$$

where  $1 \geq \theta \geq 0$  is the efficiency,  $\mathbf{X}$  represents the  $M \times N$  input matrix,  $\mathbf{Y}$  is the  $1 \times N$  output vector,  $\boldsymbol{\lambda}$  is the  $N \times 1$  vector of constants, and  $\mathbf{e}$  is the  $1 \times N$  vector of ones,  $\mathbf{x}_o$  and  $y_o$  are inputs and output of DMU under consideration. When the efficiency score is 1, the corresponding DMU is considered efficient; otherwise, when the efficiency score is less than 1, the corresponding DMU is considered inefficient.

The methodology is completely deterministic, in the sense that it attributes all the deviation from the frontier to inefficiency; there is no random error estimated.

The input-oriented model of DEA is used, where it attempts to minimize input while satisfying a given output level. In addition, the assumption of variable returns to scale (VRS) is used, as this assumption is relevant to be applied in the Indonesian economy which is characterized by many distortions.

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<sup>16</sup> Pramono, S. N. W., Ulkhaq, M. M., Pujotomo, D., & Ardhini, M. A. (2019, August). Assessing The Efficiency of Small and Medium Industry: An Application of Data Envelopment Analysis. In *IOP Conference Series: Materials Science and Engineering* (Vol. 598, No. 1, p. 012043). IOP Publishing.

<sup>17</sup> Handayani, N. U., Sari, D. P., Ulkhaq, M. M., Widharto, Y., & Fitriani, R. C. A. (2020). A data envelopment analysis approach for assessing the efficiency of sub-sectors of creative industry: A case study of batik enterprises from Semarang, Indonesia. In *AIP Conference Proceedings* (Vol. 2217, No. 1, p. 030038). AIP Publishing LLC.

## D. DISCUSSION

The result of the DEA is shown in Table 3. According to input-oriented VRS-DEA, four Sharia banks have an efficiency score of 1, indicating the most efficient DMUs. They are PT Bank Victoria Syariah, PT Bank Syariah Indonesia, PT Bank Panin Dubai Syariah (Tbk), and PT Bank Aladin Syariah (Tbk). The other Sharia banks are considered inefficient since their efficiency scores are less than one. We also provide a rank for each DMU.

PT Bank Syariah Indonesia which is located at the frontier has the highest value of total earning assets among others. Note that the high value of output does not guarantee the efficiency score will be 1 (one). The second to the fourth highest output values belong to PT Bank Muamalat Indonesia, PT Bank Aceh, PT Bank BTPN Syariah (Tbk), and PT Bank Mega Syariah, respectively. However, those banks have efficiency scores of less than 1, meaning that all of them are inefficient. It is of interest viewing banks having the two lowest output values (PT Bank Aladin Syariah (Tbk) and PT Bank Victoria Syariah) are located at the frontier. This indicates that to be the most efficient one, DMU does not have to have the highest output value, it also must have low values of inputs.

**Table 3. Efficiency result**

DMU	Efficiency	Rank	Reference set
PT Bank Muamalat Indonesia	0.700	12	$\lambda_4 = 0.081$ $\lambda_6 = 0.919$
PT Bank Victoria Syariah	1.000	1	$\lambda_2 = 1.000$
PT Bank Jabar Banten Syariah	0.730	10	$\lambda_6 = 0.698$ $\lambda_{10} = 0.302$
PT Bank Syariah Indonesia	1.000	1	$\lambda_4 = 1.000$
PT Bank Mega Syariah	0.701	11	$\lambda_4 = 0.00085$ $\lambda_6 = 0.99915$
PT Bank Panin Dubai Syariah (Tbk)	1.000	1	$\lambda_6 = 1.000$
PT Bank KB Bukopin Syariah	0.922	5	$\lambda_2 = 0.268$

			$\lambda_6 = 0.466$
			$\lambda_{10} = 0.266$
PT Bank BCA Syariah	0.761	9	$\lambda_2 = 0.183$
			$\lambda_6 = 0.706$
			$\lambda_{10} = 0.111$
PT Bank BTPN Syariah (Tbk)	0.871	6	$\lambda_4 = 0.0079$
			$\lambda_6 = 0.9921$
PT Bank Aladin Syariah (Tbk)	1.000	1	$\lambda_{10} = 1.000$
PT Bank Aceh	0.842	8	$\lambda_4 = 0.055$
			$\lambda_6 = 0.945$
PT Bank NTB Syariah	0.843	7	$\lambda_6 = 0.862$
			$\lambda_{10} = 0.138$

Table 3 also shows the reference set for each DMU for the sake of benchmarking. For instance, the reference set for PT Bank Muamalat Indonesia is  $\{4, 6\}$ , which is PT Bank Syariah Indonesia and PT Bank Panin Dubai Syariah (Tbk); and the values of are  $\lambda_4 = 0.081$  and  $\lambda_6 = 0.919$ . They show the proportions contributed by PT Bank Panin Dubai Syariah (Tbk) and PT Bank Syariah Indonesia to the point used to evaluate PT Bank Muamalat Indonesia. Hence, PT Bank Muamalat Indonesia is inefficient. Note that the reference set for the efficient DMUs is themselves.

## E. CONCLUSION

This study aims to measure the efficiency of Sharia banks in Indonesia. DEA with input-oriented and VRS approach is used to accomplish the objective of the study. The result shows that among twelve Sharia banks under-investigated, four of them are considered the most efficient, located at the frontier (see Table 3). The rank for each DMU is also provided.

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