Efficiency Measurement in Halal Inspection Agency for Foods, Cosmetics, and Pharmaceuticals Sectors Using Data Envelopment Analysis

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Abstract. Consuming halal products has become part of today's lifestyle. In addition, product halal assurance is one of the basic requirements for Indonesian products to penetrate the global halal market. The government continues to encourage the existence of a new Halal Inspection Agency as a form of strengthening halal product guarantees as well as accelerating the development of the halal industry in Indonesia. The purpose of this research is to evaluate the efficiency of performance in each product group segment at one of the Halal Inspection Agency using Data Envelopment Analysis. Performed for 9 segments of the main product groups using input and output variables. The finding shows that of 9 product segments as Decision Making Units (DMU), 2 DMUs were identified as 100% efficient and 7 DMUs are still inefficient with efficiency score below 100%. By using the CCR model, this research proposed the cause of inefficiency. This research also provides slack and radial movement analysis
Keywords: Halal, Efficiency Measurement, DEA, Indonesia

Introduction

Currently, Indonesia is on a mission to become the centre of the World's Halal industry by 2024, referred as the Global Halal Hub [1]. The global halal industry market has the potential to accelerate the Indonesian economy. To be able to support the sector in the Islamic economy is through the Halal industry. A Halal certificate is one of the requirements for entrepreneurs to be able to market and distribute their products domestically or internationally. Currently, a few institutions contribute to the Halal certification process, such as Halal Product Assurance Organizing Agency (which operates under the Ministry of Religious Affairs), the Indonesian Ulema Council, and the Halal Inspection Agency.

As the level of competition in the industrial world increases, and the uncertainty in today's business world, organization needs to be able to continuously improve its performance, especially performance efficiency. This can be evaluated through the development of innovation and services that are expected to increase customer satisfaction and loyalty from all industries. The government through the Ministry of Religious Affairs also planned to have 10 million products Halal Certified, especially food and beverages at least in 2024. Through this regulation, organizational efficiency related to the Halal certification process is very influential and has big effect. Generally, the measurement of company performance uses conventional methods, namely financial and accounting-based methods [2]. However, many difficulties are found when using performance measurement in a conventional way [3], according to [4], performance is usually focused on individual units, not measured, and interpreted holistically. In addition, [5] argues that accounting measurements such as ROA (Return on Assets) can generate uncertainty in the results of performance measurements if these measurements use specific measurements and can also be influenced by non-value-added factors.

An approach to measure efficiency is based on [6] Frontier Approach which is divided into Parametric Frontier and Non-Parametric Frontier. The parametric approach can be measured using a parametric statistical test such as the Stochastic Frontier Approach (SFA) and Distribution Free Approach (DFA). While a non-parametric frontier approach is measured using Data Envelopment Analysis. Along with the development of research related to measuring company performance, the appropriate approach is through the linear programming methods, namely Data Envelopment Analysis (DEA), which is a method of measuring the comparative efficiency of operating units or homogeneous decision-makers [7]. Parametric testing requires data to have assumptions first such as normal distribution. Whilst DEA does not require such assumptions. With DEA, it is possible to measure efficiency involving multiple inputs and outputs. DEA does not require a functional relationship between inputs and outputs. Another advantage is that it can provide input projections that should be used or outputs that should be produced so that inefficient decision-making units become efficient. DEA can show the efficiency value of an organization (Decision Making Units (DMU)). In DEA, the most efficient DMU will be used as a benchmark for other DMUs. The application of the DEA method has been widely used by previous studies. The banking sector dominates the use of the DEA method [8].

The field *of management and public management has successfully used DEA. Even though DEA hasn't been used as much in non-profit management, there have been certain studies where it has been utilized as a variable that is rely on performance yet. Since the lack of reliable output-based performance measurements has occasionally plagued some researchers, this research becomes important.* [9]. *In recent years, research about DEA in a non-profit setting, has recently emerged for evaluating and controlling the efficiency of an organization or company. Previous research on performance efficiency analysis in Indonesia National Zakat Amil Agency has been done* [10]. *The variables used for input are operating cost and personnel cost. The output variable is the amount of zakat distributed. Other research* [11] *was proposed to measure the efficiency in a university using Data Envelopment Analysis.* The variables used in this research are total lecturers, total students, and amount of expenditure realization for input variables. For output variables, the amount of income from educational services, and the total number of alumni. A different use of DEA, known as joint DEA maximization, is also used in [12] to assess the relative efficacy of universities' teaching and research programs. University spending (in USD), the number of researchers, their average credentials, the number of research students, and research funds make up the input variables (Million USD). While the results are measured by the number of research graduates, publications, honors, and intellectual properties. By employing Data Envelopment Analysis, research done by [13] also offers models for analysing the effectiveness of fundraising initiatives and programs for non-profit organizations in Korea (DEA).This research is using non-parametric DEA method to analyze and get insight from data.

The purpose of this research is to measure the efficiency of the main product segments in the Halal Inspection Agency and analyzed using DEA model. To pursue the validity of the analysis, the research focused on analyzing 9 segments of products. The data were based on the internal report of the non-profit organization. The following is the research's contribution: the non-profit organization’s effectiveness in the halal sector is first presented in this study. It is important to measure the results of the product of non-profit organization. Secondly, this research gives the ineffective DMUs their reference set of effective DMUs.. Inefficient DMU can be improved by referring to the peer DMUs. Researchers can utilize the techniques and findings of this study as a guide when assessing effectiveness in the non-profit sectors.

Methodology

DEA is one of linear programming techniques developed by A. Charnes, W.W. Cooper, and E. Rhodes to evaluate non-profit organizations and the public sector [14]. It measures the performance efficiency of a group of organization units that have input and output variables that are identic to generate a set of outputs called DMU. DMU participates in the process of making product purchase decisions, both goods, and services, within an organization. It can be a store branch, university, hospital, institution, or even occupation such as doctors or lecturers. There are basic concepts of DEA that must be complied [15] such as all inputs and outputs should be numerical and have positive values for all DMU. For organizations with the characteristics of a multi-site company, DEA will compare each service provider unis, as well as to calculate the efficiency rating based on the ratio of resource input to output. DEA is used to find the points with the lowest unit cost for any given output, connecting the points to form an efficiency limit by making use of selected variables, such as unit cost and output. In the process, some units achieve 100% efficiency and are referred to as relatively efficient units, while other units with an efficiency rating of less than 100% are referred to as inefficient units. Numerical coefficients are assigned to each firm to define its relative efficiency.

The strategic value of DEA-based analysis depends on the inputs and outputs chosen. To avoid findings that are often much less helpful for strategic reasons, input and outputs must be carefully chosen. DEA has a weak discriminating power, so with weight restriction there is an additional limit formulation regarding weights to ensure that all factors are considered in the efficient value and a maximum limit to keeping a factor from being overrepresented. Third, DEA does not follow conventional statistical methods. According to [16], the statistical inference's of probabilistic assumptions do not model error components, therefore researchers cannot rely on them to boost validity. As a result, the performance scores produced by DEA are more tangible, emphasizing inputs and outputs should be carefully chosen. Additionally, measurement errors should be thoroughly checked for in the data by researchers because erroneous outliers may encompass and affect other scores. Finally, since outliers are created by calculating the separation between each DMU and its most effective peers, DEA is also very sensitive to them. As a result, attention should be taken to the selection of inputs and outputs to guarantee that each DMU is homogeneous and comparable.

The DEA calculation was formulated by Charnes, Cooper, and Rhodes in 1978 on a linear programming model and is referred to as the CCR model. The CCR model is also called the Constant Return to Scale (CRS) model because CCR has the assumption that the addition to the input and output is the same (constant) [16]. This will affect the addition of input where if there is an additional input of n, then the resulting output will also increase by n. The results of the CCR model measurement are reflected by the Technical Efficiency (TE) value. TE acts as an independent variable in this research. The calculation of the CCR model is in equation (1).

$$Max\ Ee = \frac{u1O1e + u2O2e + \cdots + uMOMe}{v1I1e + v2I2e + \cdots + vNINe} \quad (1)$$

E = Efficiency Ratio
u_i = Coefficient/Weight for Outputs
O_{jk} = Output
v i = Coefficient/Weight for Input
I_{ik} = Input

1.12.3. This function has a limit of efficiency values less than or equal to 1 and all values are positive and not zero as shown in equations (2) and (3)

1.12.4.

$$\frac{u1O1k+ u2O2k+\cdots+ uMOMk}{v1I1k+ v2I2k+\cdots+ vNINk} \leq 1 \; k = 1, 2, \ldots, n \tag{2}$$

or

$$u_1O_{1k}+ u_2O_{2k}+\cdots+ u_MO_{Mk}-(v_1I_{1k}+ v_2I_{2k}+\cdots+ v_NI_{Nk}) \leq 0 \; k = 1, 2, \ldots, n \tag{3}$$

where,

$$u_j \geq 0 \; j = 1, 2, \ldots, M \tag{4}$$

$$v_i \geq 0 \; i = 1, 2, \ldots, N \tag{5}$$

To measure efficiency using the DEA method, the input and output variables must be defined first based on the approach used. In this research, authors chose to use the production approach at the Halal Inspection Agency. The Halal Inspection Agency is an institution that conducts inspection and testing activities on the Halal status of products and resulting in a Halal decree for each product registered based on the definition of the Indonesian Ministry of Religion (2022). The data taken is data from January – March 2022 from 9 standard segments that have been determined internally, with an Input-Oriented approach. According to [17] Input-oriented is efficiency that aims to reduce the number of inputs but can produce the same amount of output. The variables used as inputs and outputs in the production approach can be seen in the following Table 1.

Table 1. Input and Output Variables.

	Definition	Data Sources
Input 1 (X_1)	Number of registrations	Sales Monthly Report
Input 2 (X_2)	Number of Auditor	Auditor Monthly Report
Output (Y_1)	Registration Fee	Financial Statement

The total Decision-Making Unit (DMU) analyzed amounted to 9 segments are groups that are examined for their Halal Status. These segments consist of food segments, additives segments, food services segments, services, cosmetics segments, slaughterhouse segments, pharmaceutical segments, flavor segments, and product segments from overseas. The research methodology is depicted in Figure 1.

Result and Discussion

In the DEA method, an organization is considered to be efficient if it has achieved an efficiency score of 100%. The more a DMU moves away from 100% or close to 0%, the more inefficient it is. The efficiency score generated by the DEA method is obtained by comparing the output achievement with the input used from each segment so that the resulting efficiency score is relative. The calculation of efficiency data is carried out using the DEAP Version 2.1 software used to construct DEA frontiers for the calculation of technical efficiencies. DEA analysis also produces data in the form of benchmarks, or called peers. Benchmark values are only owned by efficient segments. The benchmark value shows how many inefficient segments make an efficient segment a benchmark in achieving efficiency. The results of efficiency scores and benchmark values for DMU using the DEA method are shown in Table 2.

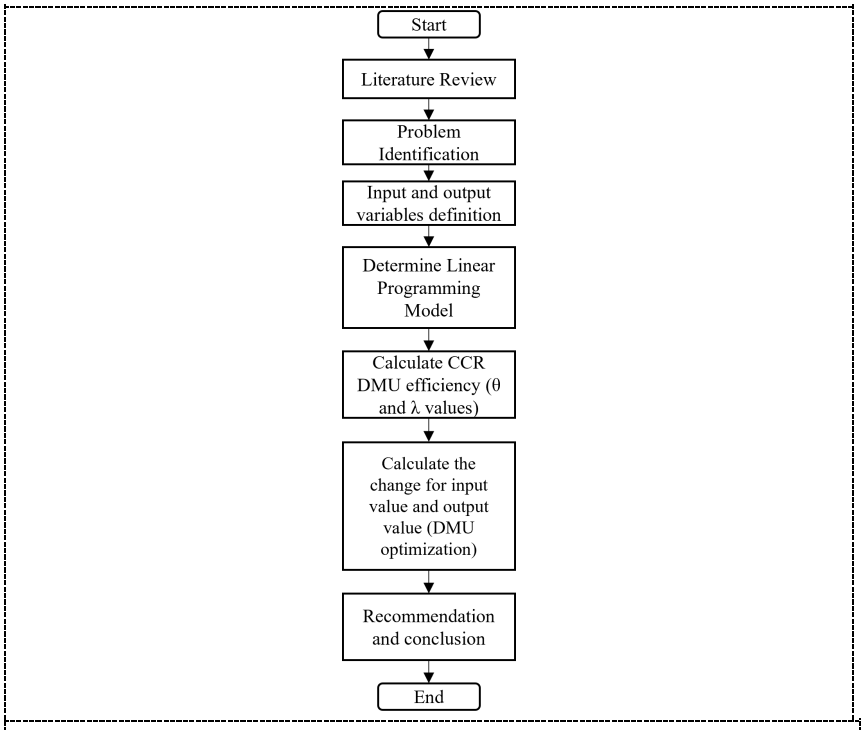

Figure 1. Flow Diagram of Research Methodology.

Table 2. DEA Computation Results (*Cont.*)

DMU	*Efficiency*	*Variable*	*Original Value*	*Radial Movement*	*Slack Movement*	*Projected Value*	*Listing of Peers*	
							Peer	*Lambda Weight*
1 (Food)	1	No of Registrations	364	0	0	364	1	1
		No of auditors	345	0	0	345		
		Registration Fee (in Mio)	5769	0	0	5769		
2 (Additives)	0.85	No of Registrations	179	0	0	179	1	0.425
		No of auditors	197	-29.09	0	167.91	8	0.275
		Registration Fee (in Mio)	3873	-571.87	0	3301.13		
3 (Food Services)	0.53	No of Registrations	79	0	0	79	1	0.217
		No of auditors	172	-81.78	-15.34	74.88		
		Registration Fee (in Mio)	2387	-1134.94	0	1252.063		
4 (Services)	0.63	No of Registrations	10	0	0	10	8	0.112
		No of auditors	14	-5.24	0	8.76		
		Registration Fee (in Mio)	1152	-430.84	-372.73	348.43		
5 (Cosmetics)	0.92	No of Registrations	111	0	0	111	1	0.31
		No of auditors	136	-10.801	-19.993	105.206		

		Registration Fee (in Mio)	1911	151.772	0	1759.228		

Table 2. DEA Computation Results (*Cont.*)

DMU	*Efficiency*	*Variable*	*Original Value*	*Radial Movement*	*Slack Movement*	*Projected Value*	*Listing of Peers*	
							Peer	*Lambda Weight*
6 (Slaughterhouse)	0.53	No of Registrations	3	0	0	3		
		No of auditors	5	-.2371	0	2.63	8	0.034
		Registration Fee (in Mio)	7000	-3319.101	-3576.371	104.53		
7 (Pharmaceutical)	0.71	No of Registrations	52	0	0	52		
		No of auditors	69	-20.198	0	48.802	8 1	0.076 0.124
		Registration Fee (in Mio)	1347	-394.292	0	952.708		
8 (Flavour)	1	No of Registrations	89	0	0	89	8	1
		No of auditors	78	0	0	78		
		Registration Fee (in Mio)	3101	0	0	3101		
9 (Overseas)	0.76	No of Registrations	297	0	0	297	8	3.337
		No of auditors	341	-80	0	260.292		
		Registration Fee (in Mio)	16019	-3791.376	-1879.343	10348.281		

In Table 2, DMU 1 and DMU 8 are the most efficient segments. These two DMUs are in the efficient category and DMUs that are in the best practices category due to the utility of inputs in producing the best results among other DMUs. Peer is one or more DMUs that have the most efficient conditions so that they can be used as a reference for inefficient DMUs to increase their efficiency values [18]. DMU 1 (food segment) and 8 (flavor segment) become peers for other DMUs. When DEA calculates performance scores and compares those scores to those of high-performing peers, the top-performing firms establish a frontier based on their input/output combinations, providing helpful targets for more qualitative or contextual best practices for organizational learning according to [16]. It must be kept in mind that, in the end, DEA is a mechanism for performance evaluation and benchmarking against best practices, as [19] emphasize. The method for finding peers used by DEA contributes significantly to its appeal as a benchmarking tool. According to [20], Organizations are grouped by DEA by using data analysis to find those that share the most similar situations as identified by the gathering of inputs and outputs.

In Table 3, it is also found that DMUs have a TE score below 100%. These seven DMUs are in the relatively inefficient category because there is a deviation from the maximum efficient value of 100%. This deviation is because the input utility to produce output cannot match the DMU which is in the efficient category. DMU with the smallest deviation is DMU 5, which is 8%, so in general, DMU 5 (cosmetic segment) can increase its efficiency value up to 100% if it can reduce input use by 8%. This research uses the DEA method with input-oriented with input target is divided into 2 types, namely Slack movement, and Radial Movement. Slack Movement is an output target where the DMU experiences a deficiency or weakness compared to other DMUs, so to increase it, the appropriate output criteria must be added. Meanwhile, Radial Movement is an excess input target, so the DMU must reduce the input by Radial Movement to achieve relative efficiency.

In the DEA method, improvements to the efficiency score can be obtained through the magnitude of the slack value in each DMU. Slack will have a value if the DMU is in the inefficient category. This makes slack information important to find out which DMUs can improve efficiency improvements. Slack is a target that must be achieved by DMU if it wants to increase its efficiency.

Table 3. Inefficient DMU.

DMU	Efficiency	Deviation
2	85%	15%
3	53%	47%
4	63%	37%
5	92%	8%
6	53%	47%
7	71%	29%
9	76%	24%

Conclusions

This paper has presented a DEA application in one of Halal Inspection Agency in Indonesia. The inputs and outputs had been carefully selected which consists of 2 inputs and 1 output to measure the efficiency of 9 product segments. The variables closely related to the effectiveness of the Halal Inspection Agency's product are used to choose the input and output variables. The input variables selected for this study is the number of registrations and number of auditors whereas output variables considered in this study is registration fee. The model has demonstrated a strong discriminatory power in differentiating between efficient and inefficient segments. Based on the result, Food segment and Flavor segment have highest efficiency. Those segments become the peer for other DMUs. The other seven DMUs are in the relatively inefficient category because there is a deviation from the maximum efficient value of 100%. This deviation is because the input utility to produce output cannot match the DMU which is in the efficient category. DMU with the smallest deviation is DMU 5, which is 8%, so in general, DMU 5 (cosmetic segment) can increase its efficiency value up to 100% if it can reduce input use by 8%.

Further research might be done in more than one stage of organizational performance efficiency assessment using DEA. This would give more informative and holistic efficiency measurement. Also, more than 1 branch of the Halal Inspection Agency can be used to give a better understanding of efficiency performance. In addition to the recommended solution, future studies may include suggestions for improvement values in inputs and outputs. If a new DMU needs to be known its efficiency score, DEA analysis would have to be recalculated since it has a relative score. Therefore, a combination of machine learning algorithms and DEA can be applied to future studies.

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