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Efficiency Measurement of Operations Management of Clean Water Company using DEA

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Abstract. Clean water is the most fundamental need for humans, it can be said to be the source of life. Water is an important factor in the future development process, if the management of water resources is wrong, it can cause a socio-economic development crisis for all countries. In 2017, water needs for residents of the city of Jakarta only reached 60% that served by clean water. The problem that arises is the lack of clean water supply, therefore research is needed to measure the level of efficiency, so that companies become a reference for overcoming unserved areas. Therefore DEA method is needed to measure the efficiency relative of a company. DMUs based on annual data comparisons from 2014 to 2018 refer to homogeneous data. Efficiency measurements of clean water companies show a positive trends every year. In 2017 and 2018, the company showed extraordinary achievements with a relative level of efficiency reaching 100% or a value of 1, so that it can be a reference for the following years.

Keywords: Data Envelopment Analysis, Effisiensi, Clean Water

1. Introduction

Clean water is the most fundamental need for humans, it can be said to be the source of life. Water is an important factor in the future development process, if the management of water resources is wrong, it can cause a socio-economic development crisis for all countries [3]. It is very useful for drinking water, cooking, washing and many activities that require clean water for daily needs. Jakarta is currently the centre of attention for migrants outside Jakarta to find work, do business, trade and study education, so that population growth will continue to increase, because Jakarta as the capital of Indonesia is the centre of government, trade and economy of the country. This impacts on increasing consumption of clean water to meet the needs or supply of water in the region.

With the level of consumers increasing, indicates that the consumption of clean water also increasing, the production costs incurred by water supply companies are increasing to produce a production capacity of clean water that is balanced with the number of consumers or customers who need it. In 2017, water needs for residents of the city of Jakarta only reached 60% that served by clean water (wartakota.tribunnews.com). In November 2019, residents affected by the water crisis in East Jakarta still depend on water supply assistance provided by the DKI Jakarta Provincial Government to meet their daily needs (republika.co.id). The problem that arises is the lack of clean water supply, therefore research is needed to measure the level of efficiency, so that companies become a reference for overcoming unserved areas. Therefore DEA method is needed to measure the efficiency relative of a company. Data Envelopment Analysis (DEA) is a method based on application of linear programming,

which is used to measure performance efficiency of organizational units called Decision Making Units (DMUs) [2].

2. Efficiency Measurement Using Data Envelopment Analysis (DEA) Method

2.1. Efficiency

The Efficiency is an important factor in the analysis in the economic field, where the process has a single input process and a single output, then efficiency is determined as [5]:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \quad (1)$$

2.2. Data Envelopment Analysis (DEA)

The nonparametric approach, which is the DEA method used to assess the entity's performance set, is called Decision Making Units (DMUs) that convert inputs into outputs [4]. Charnes, Cooper and Rhodes (CCR) were the first to propose the DEA Model in 1978 [6].

In measuring efficiency, it is assumed that there are n DMUs, each with m inputs and s outputs. The efficiency relative value of DMU p is obtained through the proposed model [1]:

$$\text{Max } Z_p = \frac{\sum_{r=1}^s U_{rp} \cdot Y_{ro}}{\sum_{i=1}^m V_{ip} \cdot X_{io}} \quad (2)$$

Subject to constraints:

$$\frac{\sum_{r=1}^s U_{rp} \cdot Y_{ro}}{\sum_{i=1}^m V_{ip} \cdot X_{io}} \leq 1 \quad (3)$$

$$U_{rp}, V_{ip} \geq 0 \quad (4)$$

The Objective functions (2) and constraints (3) are converted to linear forms so that the model can be solved using simple linear programming methods [7]. Mathematically, non negativity constraints (4) has a positive value. Then replace the Fractional Program (FP) by Linear Programming Problem (LPP), Optimal solution (V^*, U^*, Z^*) and The Reference set Z_p is the Primal Problem [5]. The Primal Problem becomes:

$$\text{Maximize } Z^*(V^*, U^*) = \sum_{r=1}^s U_r \cdot Y_{rp} \quad (5)$$

Subject to constraints:

$$\sum_{r=1}^s U_r \cdot Y_{ro} - \sum_{i=1}^m V_i \cdot X_{io} \leq 0 ; o = 1, \dots, n \quad (6)$$

$$\sum_{i=1}^m V_i \cdot X_{io} = 1 \quad (7)$$

$$U_r \geq 0; V_i \geq 0 \quad (8)$$

3. Methodology

Data collection is based on secondary data that has been published by one water supply company. From the data it is processed to get the inputs and outputs as needed. Data that will be used as a comparison between units is the result of annual performance reports from 2014 to 2018.

DMUs based on annual data comparisons from 2014 to 2018 refer to homogeneous data. Can be seen in Table 1 below.

Table 1. DMUs Input and Output

DMUs	INPUT			OUTPUT		
	Non Revenue Water (%)	Production Cost (Rp/m ³)	Human Resources	Number of Costumer	Volume Bill (Million m ³)	Revenue (Rp Million m ³)
2014	41.94	622	1,248	407,644	161.81	1,172
2015	41.08	680	1,178	426,088	170.06	1,245
2016	43.77	635	1,097	435,777	175.08	1,278
2017	44.12	628	1,034	445,442	178.49	1,304
2018	42.51	663	968	456,049	183.80	1,377

From the table above the inputs and outputs indicator to measure efficiency are as follows:

- Three Inputs: non revenue water, production cost (raw water, electricity and chemical) and human resources.
- Three Outputs: number of costumer, volume bill and revenue.

4. Result Analysis

The results obtained by the Data Envelopment Analysis (DEA) method using the DS for Windows program, namely there are 3 (three) DMUs that have not been efficient from the 5 (five) existing DMUs. The three DMUs can be seen in the following table:

Table 2. DEA Tabulation Results

DMUs	Efficiency Relative	Efficient Reference Set	Multipliers
2014	94%	2017	0.50
		2018	0.40
2015	97%	2018	0.93
2016	98%	2017	0.77
		2018	0.20
2017	100%	Nothing	Nothing
2018	100%	Nothing	Nothing

5. Conclusion

Efficiency measurements of clean water company show a positive trends every year. In 2017 and 2018, the company showed extraordinary achievements with a relative level of efficiency reaching

100% or a value of 1, so that it can be a reference for the following years. This proves that the company works hard every year to get efficient company management, so that it can serve underserved communities.

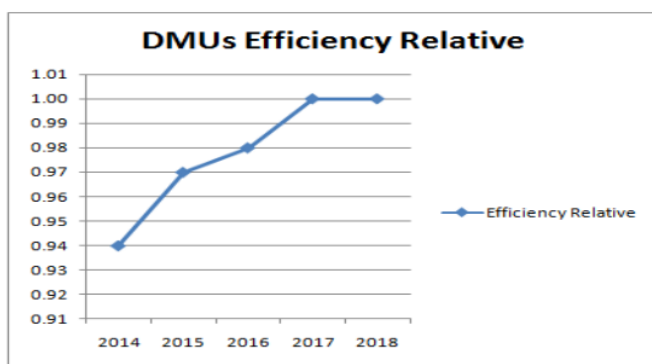


Figure 1. DMUs Efficiency Relative Chart

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