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Analysis of Efficiency and Productivity with Data Envelopment Analysis and Malmquist Productivity Index at as Syafiiyah Islamic University

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Abstract

Efficiency is important in the assessment of a performance on an institution or organization. After assessment of efficiency is continued with measurement of assessment in its productivity. The purpose of this paper is to analyse the efficiency and productivity of 7 study programs at as Syafi'iyah Islamic University. The results obtained for the value of efficiency on 7 study programs of 2017/2018-2018/2019 academic year using the Data Envelopment Analysis method is there are 6 study programs as Decision Making Unit (DMU) for 2 years consecutive have a technical efficiency value reach 100% on each DMU. As for the productivity measurement of 7 study programs using the Malmquist Productivity Index method which achieved the highest productivity is Islamic Religious Education Program (PAI) with a Total Factor Productivity (TFP) value of 1.124.

Keywords: Efficiency, productivity, data envelopment analysis, DMU, malmquist productivity index

1. Introduction

The implementation of education conducted by a college institution should be evaluated for assessment of the performance of the study program. Through evaluation, there can be any things from the activities of a company or organization that has reached and has not achieved efficiency and can be evaluated also the value of productivity. Measurement in higher education assessment is generally done with accreditation system. This analysis of efficiency and productivity complements the accreditation system that has not measured and calculates and compares performance efficiencies between the courses. Evaluation conducted to measure the performance of the education implementation, including by calculating the value of efficiency and productivity. Efficiency and productivity measurements can be done using the Data Envelopment Analysis and Malmquist Productivity Index methods. Development of this method can improve the quality in the measurement of work evaluation. According to Diana (Marieta, 2010) states that the economic situation at that time around 2010 was determined by the effects of the crisis which caused the governments of countries around the world to streamline their processes in terms of collecting revenues from the state budget and then redistributing the principles of economic performance and efficiency. The role of efficiency, effectiveness and performance related to economic governance in the use of resources by public management need to be re-studied to achieve the medium and long term goals of economic recovery and sustainable development of the national economy. Research on efficiency and productivity has been carried out among them by (Baykut, 2016) conducted a study with DEA Malmquist to analyze the reasons for inefficiency in government companies in Turkey. The research was conducted on 21 companies and the results are companies that have achieved efficiency as many as 10 company in 2010, 13 companies in 2011, 18 companies in 2012 and 5 companies in 2013. (Milana, 2013) used DEA to measure the productivity of 31 companies in industry in Italy. (Afiatun, 2010) measured efficiency and productivity at 13 banks in Indonesia in 2004-2009. Three banks are Sharia banks and 10 conventional banks. The results of the efficiency measurements are known Sharia banks have lower efficiency compared to conventional banks while the productivity of Muamalat banks, Syariah Mandiri banks and Mega Syariah banks ranks 3rd, 10th and 13th. (Javarov & Gunarson, 2008) state that technical efficiency is a combination or combination of the

capacity and can produce up from input to output to the maximum level. Along with its development the use of efficiency measures is not only used for companies today but also measures the performance of the government or other public sectors. The opinion of (Evans, 2010) in his book Applied Production and Operation Management says that low production can have consequences such as increasing difficulties in selling products both domestically and in international markets also complicate the achievement of health, education goals and social welfare. Meanwhile, according to Hasibuan in (Amin, 2022) efficiency is an increase in output that is in line with the input. Refer to (Nicholson, 2002) notions of efficiency are divided into technical efficiency and cost efficiency. According to (Rusli, 1991) there are 3 types of productivity, namely total productivity, two factor productivity and partial productivity.

Based on previous research, this study aims to examine the efficiency and productivity of performance at as Syafiiyah Islamic University. This test uses Data Envelopment Analysis, and productivity testing uses the Malmquist Productivity Index. The difference from this study is that testing efficiency and productivity with different inputs and outputs. In this study, inputs and outputs were used from higher education organizations. The results of this research are expected to be useful and support decisions for higher education management.

2. Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI)

The research method in this paper uses the Data Envelopment Analysis and Malmquist Productivity Index methods. DEA was first discovered by Farrel in 1957 and later popularized by Charnes, Cooper, and Rhodes (1978), here in after known as DEA-CCR. One technique for measuring performance efficiency is Data Envelopment Analysis (DEA) which maximizes efficiency by taking into consideration input and output. DEA is a mathematical programming technique that calculates the relative efficiency of several decision-making units or Decisions Making Units (DMUs) on the basis of observed inputs and outputs. Measurement of efficiency is an important aspect of measuring company performance and can provide solutions to difficulties in calculating performance measures. (Mokhtar, 2008) measured the efficiency of sharia and conventional banking in Malaysia. The results show that the average overall efficiency has increased during the period 1997-2003 while conventional banks have remained stable over time while the level of efficiency of Shariah banking is still lower than conventional banks. In addition, the concept of efficiency according to (Oscan, 2008) is divided into 4 types, namely technical efficiency, price efficiency, allocative efficiency and scale efficiency.

According to (Coelli, 2005), there are two DEA models, namely the Charnes, Chooper, and Roodes (CCR) model and the Banker, Charnes and Cooper (BCC) model. CCR Model Developed by Charnes, Cooper and Rhodes in 1978. The DEA model with this assumption means that adding inputs by n times will increase output by n times, also called the Constant Return to Scale (CRS) and assumption while the BCC / VRS model developed by Banker, Charnes and Cooper in 1984. They stated that competition and financial constraints could cause companies not to operate at their optimal scale and to overcome this problem, they propose the assumption of Variable Return to Scale (VRS). VRS if there is an input increase of n times, it will not necessarily cause output to increase by n times, it can be bigger or smaller. The condition where the input is used can produce a larger output is called Increasing Return to Scale (IRS). If the input produces smaller output it is called Decreasing Return to Scale (DRS). The efficiency calculated by assuming VRS is called Pure Technical Efficiency (PTE).

Calculate the value of efficiency and productivity, the authors use DEAP software version 2.1. This software has been tested by many people as a tool to determine the value of relative efficiency with various calculation models on various samples. This software is used to find the efficiency value of a sample that has more than one output and input variable. This program can also be used to calculate the Malmquist total factor production index. These three program mode options include, (1) Standard CRS and VRS DEA models used to measure engineering efficiency and scale. (2) Development of the DEA model above to calculate cost and allocative efficiency. (3) Application of the Malmqusit method to calculate the index of changes in total production factors, changes in technology, changes in engineering efficiency and scale efficiency.

Table 1: Characteristics of efficiency and productivity according to (Baykut,2016).

	Efficiency	Productivity
$0 < Eff < 1$	inefficiency	decreasing in productivity
1	efficient	Productivity has the same result compare last year
>1		increasing in productivity

The way to be efficient is, first, to maximize output by keeping inputs constant or second, minimizing inputs by keeping outputs constant. The results of the measurement of efficiency are produced with the DEA model from 0 to 1 with the most efficient by calculating the total weight output divided by the total weight input. Changes in the total production of a DMU are said to be good if the DMU uses inputs efficiently to produce goods-services and companies use technological processes in the production process. MPI value > 1 from one indicates that the DMU has increased in total productivity (increasing return to scale) if the value of MPI $= 1$ indicates the current productivity has not increased from before but if the MPI value < 1 then the value indicates that the DMU has decreased in total productivity (decreasing return to scale).

The use of the Malmquist Productivity Index can and has been widely applied in analyzing productivity in various sectors. This method can also measure changes in performance over several time periods. The Malmquist Productivity Index (MPI) uses a non-parametric linear programming technique, taking into account all inputs and outputs.

The stages of the research carried out are as follows:

1. Identification of the problem, namely the formulation of problems that occur in the tertiary institution so that a problem can be defined that will be studied in research. The problems to be studied are efficiency, productivity using the Data Envelopment Analysis (DEA) method and the Malmquist Productivity Index at As Syafi'iyah Islamic University in Jakarta in the 2017/2018 and 2018/2019 academic years.

2. Identification of the model, namely by formulating an efficiency and productivity model that will be used in this study and adjusted to the data that has been obtained from the results of secondary research data.

3. Secondary research data was obtained from archived report recapitulation data and administrative data in each Study Program at the As Syafi'iyah Islamic University in the 2017/2018 and 2018/2019 academic years.

4. Literature study, looking for references that can help solve the problem under study can come from reference books that support research, scientific journals and the results of previous research. Literature study can also be used to obtain data that can be used.

5. Running data using DEAP Software version 2.1 to determine efficiency and productivity values

Model Formulation

Refer to (Banker, 1989) measurement efficiency of the DMU (Decisiun Making Unit) is the ratio of the total output weight yrk and the total input weight xik as follows:

$$Max\ Ef_k = \frac{\sum_{r=1}^{s} \mu_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} x_{ik}} \tag{1}$$

$$s.t\ \ 0 < \epsilon \leq \mu_{rk}\ , r = 1,2,3, \cdots, s$$

$$0 < \epsilon \leq v_{ik}\ , i = 1,2,3, \cdots, m$$

$$Ef_k = \frac{\sum_{r=1}^{s} \mu_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} x_{ik}} \leq 1$$

Where : $k: DMU, k = 1,2,3, \cdots, s$

$DMU_s = Decision\ Making\ Units$

$r: output, r = 1,2,3, \cdots, n$

$i: Input, i = 1,2,3, \cdots, m$

$\mu_{rk}: Weight\ of\ output\ r - th\ for\ DMU_k$

$Y_{rk}: output\ r - th\ for\ DMU_k$

$v_{ik}: Weight\ of\ output\ i - th\ for\ DMU_k$

$x_{ik}: intput\ i - th\ for\ DMU_k$

$\varepsilon: 10^{-6}\ , small\ quantity\ non - Archimedean\ entity$

In this study there are 7 DMU_s with 3 outputs and 5 inputs to obtain:

$$Max\ E_{fa} = \frac{\sum_{r=1}^{3} \mu_{rk} y_{rk}}{\sum_{i=1}^{5} v_{ik}\, x_{ik}} \tag{2}$$

$$s.t\ \ \mathrm{E}_{fk} = \frac{\sum_{r=1}^{4} \mu_{rk} y_{rk}}{\sum_{i=1}^{5} v_{ik}\, x_{ik}} \leq 1$$

where : r = 1,2,3

$k = 1,2,3, \ldots..7$

DMU 1

$$E_{f1} = \frac{\mu_{11} y_{11} + \mu_{21} y_{21} + \mu_{31} y_{31}}{v_{11} x_{11} + v_{21} x_{21} + v_{31} x_{31} + v_{41} x_{41} + v_{51} x_{51}} \leq 1$$

Where : $\mu_{11} y_{11}$= weight of output 1^{th} for DMU 1 times output 1^{th} for DMU 1
$\mu_{31} y_{31}$= weight of output 3^{th} for DMU 1 times output 3^{th} for DMU 1
$v_{11} x_{11}$ = weight of input 1^{th} for DMU 1 times input 1^{th} for DMU 1
⋮
$v_{15} x_{15}$ = weight of input 1^{th} for DMU 1 times input 5^{th} for DMU 1
Continue until DMU 7.

The Productivity measurement follows (Milana, 2013) stated by Fare et. al (1994) are:

$$MFP_M(\mathrm{y}^0, \mathrm{x}^0, \mathrm{y}^1\ \mathrm{x}^1) = EC \cdot TC = \frac{d^1(y^1,x^1)}{d^0(y^0,x^0)} \cdot \left[\frac{d^0(y^1,x^1)}{d^1(y^1,x^1)} \cdot \frac{d^0(y^0,x^0)}{d^1(y^0,x^0)}\right]^{\frac{1}{2}} \tag{3}$$

Where : $EC : \frac{d^1(y^1,x^1)}{d^0(y^0,x^0)}$

$TC : \left[\frac{d^0(y^1,x^1)}{d^1(y^1,x^1)} \cdot \frac{d^0(y^0,x^0)}{d^1(y^0,x^0)}\right]^{\frac{1}{2}}$

$d^0(y^1,x^1)$: output $y^1$and input x^1 at time d^0
$d^0(y^0,x^0)$: output y^0 and input x^0 at time d^0
$d^1(y^1,x^1)$: output y^1 and input x^1 at time d^1
$d^1(y^0,x^0)$: output y^0 and input x^0 at time d^1

3. Result

The object of this research is the Education Study Program or S1 level, 7 Study Programs from 3 Faculties at As Syafiiyah Islamic University namely Management and Accounting Departments (Faculty of Economics), PAI Department, KPI and PBS (Faculty of Islamic Religion) and Department of Diploma of Nursing and Bachelor of Nursing (Faculty of Health Sciences). This research is quantitative descriptive. Descriptive research aims to test existing data and conduct an analysis of the actual conditions. Whereas in this study using a quantitative analysis approach to get the results of efficiency and productivity. According to (Lazaraton, A. 2005) Quantitative descriptive research is reasearch conducted to be able to find a picture of the object to be examined through data samples or populations as they are without making generalizations. Quantitative research is research by obtaining data in the form of numbers or quantitative data that are made into numbers.

The variables in this study are the variables used as input and output that will be done by the Data Envelopment Analysis and Malmquist Productivity Index methods, refer to equations (1) and (3). Data analysis was carried out using DEAP 2.1 software, as input and output variables are given in Table 2.

Table 2: Variables *input – output*

No	Input Variable	Output Variable
1	Sum of College Students *(X_1)*	Sum of graduate *(Y_1)*
2	Sum of permanent lecturer *(X_2)*	Sum of research *(Y_2)*
3	Sum of temporary lecturer *(X_3)*	Sum of article *(Y_3)*
4	Lecturer with Master Degree *(X_4)*	
5	Lecturer with Doctor Degree *(X_5)*	

Referring to Table 2, input and output variables are then used to collect data. Based on the results of data collection obtained from interviews and data in the academic section as well as in each Study Program obtained variables that will be measured include, input: (1) the number of students, (2) the number of permanent lecturers, (3) the number of temporary lecturers (4) lecturer with Master degree, (5) lecturer with Doctor degree and output: (6) number of graduates (7) number of researches, (8) number of articles. The input and output data that have been collected are presented in Table 3.

Table 3: Data of year 2017/2018

No.	**DMU**	***Input***				***Output***			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	KPI	102	9	4	10	3	17	5	2
2	PAI	449	7	6	13	2	72	3	5
3	PBS	108	9	6	16	2	17	3	5
4	MANAGEMENT	639	14	6	22	1	134	13	13
5	ACCOUNTING	309	12	4	17	2	72	12	12
6	DIPOMA OF NURSING	178	5	2	8	1	62	10	2
7	BACHELOR OF NURSING	344	8	4	13	1	17	8	14

In addition to input output data of year 2017/2018 given in Table 3, data of year 2018/2019 is also required which is presented in Table 4.

Table 4: Data of year 2018/2019

No.	**DMU**	***Input***				***Output***			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	KPI	101	10	3	10	3	18	5	2
2	PAI	481	8	7	13	2	99	3	6
3	PBS	106	11	7	16	2	20	3	5
4	MANAGEMENT	637	16	7	22	1	107	13	14
5	ACCOUNTING	310	14	5	17	2	93	12	12
6	DIPOMA OF NURSING	177	6	2	8	1	27	5	2
7	BACHELOR OF NURSING	342	9	4	13	1	64	5	5

Calculation of efficiency and productivity the Study Program at As Syafi'iyah Islamic University uses DEAP 2.1 software. Data from Table 3 and Table 4 were then analyzed using DEAP 2.1 software, as shown in Figure 1.

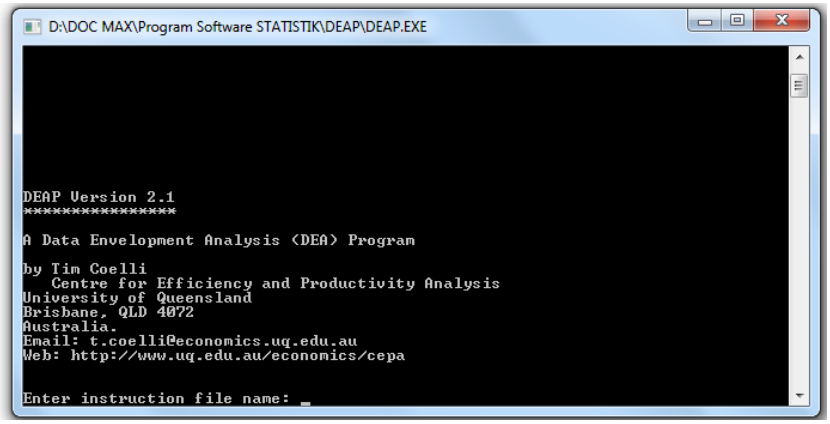

Figure 1: Software DEAP 2.1

As for the results of data processing carried out as in Figure 1, the results are given in Table 5.

Tabel 5: Result of Efficiency Year 2017/2018-2018/2019

No.	DMU	Technical Efficiency 2017/2018	Technical Efficiency 2018/2019	Mean of Technical Efficiency
1	KPI	1	1	1
2	PAI	0.988	1	0.994
3	PBS	1	1	1
4	MANAGEMENT	1	1	1
5	ACCOUNTING	1	1	1
6	DIPOMA OF NURSING	1	1	1
7	BACHELOR OF NOURSING	1	1	1
	Mean	**0.998**	**1**	**0.999**

Based on Table 5 above, it is known that the study programs that have the highest efficiency values from 2017/2018 to 2018/2019 among 7 undergraduate study programs are KPI, PBS, MANAGEMENT, ACCOUNTING, DIPLOMA OF NURSING, and BACHELOR OF NURSING with an average efficiency of 1,000 or 100%. A value of 100% indicates that the 6 DMUs have technically efficient values. In the calculation of productivity, the method used is the Malmquist index, which compares the value of productivity with the distance of the school year. The results of using DEAP 2.1 software can be seen in Table 6.

Table 6: Result of Productivity 2017/2018-2018/2019

No.	DMU	Productivity 2017/2018 - 2018/2019
1	KPI	0.988
2	PAI	1.124
3	PBS	1.008
4	MANAGEMENT	0.862
5	ACCOUNTING	0.967
6	DIPLOMA OF NURSING	0.502
7	BACHELOR OF NURSING	0.616
	Average	**0.837**

Based on Table 6 above it has been found that the malmquist method obtained the highest productivity value is the PAI study program with TFP > 1 which is equal to 1,124. There are 5 conditions in the malmquist method, if the TFP value < 1 then what happens is a decrease in the level of productivity that is KPI, MANAGEMENT, ACCOUNTING, DIPLOMA OF NURSING, and BACHELOR OF NURSING. TFP value = 1, what happens is the result of last year's productivity with the current year is the same. TFP value > 1 means an increase in productivity results compared to the previous year, and an increase in productivity is in the PAI and PBS study programs

Factors that cause productivity to increase are learning activities that run smoothly and a balance between the number of active students and the number of teaching lecturers, both permanent and non-permanent lecturers. Efforts to be made for study programs that are not yet productive are to carry out learning activities even better by allocating sufficient permanent and non-permanent lecturers and increasing research and articles for these lecturers.

The efficiency and productivity carried out at As Syafi'iyah Islamic University are:

Efficiency:

1. Combining the same general courses in each study program.
2. The ratio of lecturers is in accordance with the ratio of students.
3. Lecturers remain in teaching according to the credit load.
4. The teaching load for permanent lecturers for academic year 2017/2018 and 2018/2019 is 12 credits consisting of 6 credits for teaching, 2 credits for research, 2 credits for academic guidance and 2 credits for community service.

Productivity:

1. Teaching according to teaching load 6 credits.
2. There is research output. A lecturer must conduct research once in one semester.
3. There is community service. A lecturer must also do community service one time in one semester and be able to collaborate in a team.

In practice, this university also implements service management, namely full service, excellence service in serving customers. This is done because it is beneficial for the growth of the industry or the user community. There are 3 things in service management in this college, namely college management, customers and employees. Customers consist of actors (parents and students) and users (factories, companies, institutions, etc.). This tertiary institution began implementing a treasury study by tracing its graduates. Search to record and measure graduates who have entered into user customers both working in companies, factories, hospitals, institutions or entrepreneurs.

4. Conclusion

From the above research it can be concluded that measurement of the value of efficiency in 7 study programs in the academic year 2017/2018 - 2018/2019 using the Data Envelopment Analysis method to obtain results in the form of 6 study programs (DMU) which during the academic year 2017/2018 - 2018/2019 have technical efficiency at each DMU is 100%.Measuring the productivity value of 7 study programs in the academic year 2017/2018 - 2018/2019 using the Malmquist Productivity Index method to obtain results in the form of a study program that has the highest productivity is PAI with a TFP value of 1,124

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