Study program’s evaluation using data envelopment analysis

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Abstract: The aim of this research was to find the determinant’s efficiency of study program in the State Polytechnic of Malang. This research analysed the efficiency of D-3 study program in 2010 to 2014. The efficiency level was measured by data envelopment analysis. The input variables used in this research were number of student, number of lecture, and the budget of fund, while the output were number of research and number of graduate student. Furthermore, each input and output variables were regressed on the efficiency level, in order to know the impact of the variables on the efficiency level. The result showed that number of student gave negative impact on efficiency, while the number of lecture, the number graduate students, the amount of budget of fund, and the number of research gave positive impact.

Keywords: level of efficiency; determinant’s of efficiency; study programs; data envelopment analysis; DEA.

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1 Introduction

Input and output management in college is a critical process. Input for learning process used to produce outputs as expected. There are some resources used as input in college. Misallocate resources could result in students’ dissatisfaction with the college, for example, potential students going to other education providers or passing negative remarks about the university through word-of-mouth (Ong and Nankervis, 2012). Meanwhile, the process of knowledge transfer can show how the learning process quality and the lectures have a big part on it. Good working environment and salary has positive impact on lecture job satisfaction (Bilal, 2012).

Usually, college concern about the quantity and quality of graduates, but ignore that they have other input and output that should managed efficiently. Some university or polytechnic have do performance evaluation, but the performance evaluation only based on the accreditation point that usually use ratio analysis. The performance evaluation should analyse the level of efficiency in each study program as decision-making units (DMU). It should be not only evaluate performance of the quantity and quality of graduates, but need to see how the process of education and teaching was done efficiently. It could be achieved high output by using high input, whereas there are maybe at the other unit or other institutions capable to produce the same level of output with a lower input. Then, the performance best practice needs to be assessed with the form of efficiency.

There are some previous researches about the efficiency in university. Selim and Bursalıoğlu (2013) conducted research in some universities in Turkey. They use data input and output for measuring the efficiency of that is revenue from the central government, income, the allocation of the project, and the allocation of the project scientific research project), the number of graduates scholar, the number of graduates post graduate, the number of students a doctoral program, the number of publication, the number of employees with the approach of data using envelopment analysis. The next, data input and output analysed their influence on the level of efficiency.

Moreover, Agasisti and Jones (2009) used data envelopment analysis (DEA) to compute the technical efficiency of Italian and English higher education institutions. The result shows that, institutions in England are more efficient than those in Italy.

2 Theoretical review

2.1 Performance measurement and efficiency

Performance measurement is the foundation to conduct a performance assessment. It can be used to assess the success of an organisation, program or activity. Performance refers to something related to the activities of doing the work, included the results that achieved (Otley, 1999). Performance is a construct that has multidimensional aspects, the way to measures also varies depending on the complexity of the factors of the performance.

The measurement of the performance is not limited on the achievement of the objectives and the targets which have been determined. But, including information on how high the level of efficiency in producing goods and services, the quality of goods and services, the comparison between the activities and the target, and the effectiveness
in achieving its objectives. So, a measurement instrument of the company performance becomes the important tool. It should be used by the management as the basis of decision making and to evaluate the performance management in each unit of the organisation.

Productivity is one of a performance measure. The definition of the process of production according to Frisch (2010, p.3) is a process of transformation, directed by human beings, which is considered desirable by some individuals. Meanwhile, Sealey and Lindley (1977) stated that the transformation is a process when the goods or services (input) processed were produced become the new form of goods or services (output).

The basic principle to know the level of productivity is by comparing the number of outputs produced with the number of input used.

\[
\text{productivity} = \frac{\text{outputs}}{\text{inputs}}
\]

(1)

There are three main factors that are very important in productivity improvement, namely labour, capital and management [Heizer and Render, (2009), p.23]. The production process, generally involving more than one input and output. If the number of the input were many, it takes a method to find the aggregate value of all the inputs. So, it can obtained single index that can be used to measure productivity. The same things done when the production process involving more than one output.

2.2 Cost efficiency

According to Berger and DeYoung (1997), cost efficiency is the way to make a calculation of how big is the difference between the expenses incurred by DMU against best practice of the cost that is supposed to be issued by DMU to produce a bunch of output on equal conditions. Before to calculate the cost efficiency, cost minimisation needs to be counted first. It can be calculated using the DEA. The formula of DEA of cost minimisation as follows [Coelli et al., (1997), p.184]:

\[
\begin{align*}
\text{Min} & \quad \lambda^* x^* w^i / x^i \\
& -q_i + Q\lambda \geq 0, \\
& x^*_i - X\lambda \geq 0, \\
& 1^T\lambda = 1 \\
& \lambda \geq 0
\end{align*}
\]

(2)

where

\[w^*_i\] NX1 vector of input prices for DMU-i
\[x^*_i\] cost minimising vector of input quantities of DMU-i.

Then, the total cost efficiency of a DMU is as follows [Coelli et al., (1997), p.184]:

\[
\text{CE} = w^* x^*_i / w^* x
\]

(3)

The ratio of cost efficiency, according to Berger and DeYoung (1997), is the proportion of costs or resources that were used efficiently. In more details, when a DMU produce cost efficiencies of 70%, it means that there has been a waste of 30% of the costs when
compared with the same conditions of best practice. The range of the efficiency is 0 to 1, if the result is equivalent to 1, it indicate that DMU has reached best practice.

2.3 Previous research

Selim and Bursalioglu (2013), in their research, use central government budget appropriations, the university own revenue, the project allocations, and the total academic as input data for measuring the efficiency in the research. Furthermore, output data used are number of graduates’ students, number of post graduate students, number of doctorate students, number of publication, and number of employment. Moreover, Selim and Bursalioglu (2013) employ the input and output data as independent variables and analyse the impact on the university efficiency level. The results of research show that the number of publications and the number of employees have a positive influence on the level of efficiency.

There are some data of input used by Agasisti and Johnes (2009), the number of students, the number of funding sources, the number of PhD students, and the number of academic staff in their research. While the output data used is the number of graduates (Bachelor and Master), and the amount of external research grants or contracts.

This study measures the efficiency of courses at the Polytechnic of Malang by using multiple input data. The input data is the number of students of the program, the number of faculty, and the amount of funds. While the output used is the number of graduates and the number of research done. This research will also analyse the effect of the input and output of data to the score of efficiency, as is done by Selim and Bursalioglu (2013).

Based on the explanations, the research hypothesis is:

H1 There is an influence of the number of students, the amount of funds, the number of graduates, and the number of research on the efficiency of the study program.

3 Research methodology

The object of this research was study programs in State Polytechnic of Malang. There are nine study programs in this research, Teknik Elektronika (TE), Teknik Listrik (TL), Teknik Telekomunikasi (TT), Manajemen Informatika (MI), Teknik Mesin (TM), Teknik Sipil (TS), Teknik Kimia (TK), Akuntansi (AK) and Administrasi Niaga (AN).

The analysis step of this research starts with classical assumption test. There are several points in classical assumption test that must be tested, multicollinearity, heterocedasticity, normality, and auto correlation. Linear regression analysis used to measure the influence of between more than one independent variables on dependent variable.

Here,

\[ Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 \]

Y  efficiency score
a  constants
b_1, b_2, b_3, b_4  regression coefficient
X_1 \text{ number of student}
X_2 \text{ number of lecture}
X_3 \text{ number of fund}
X_4 \text{ number of graduates}
X_5 \text{ number of research}

There are two kinds variables used in this research, independent and dependent variable. Both types of variable in this research can be explained as follows:

1. **Independent variables:**
   - number of student
   - number of lecture
   - number of fund
   - number of graduates
   - number of research

2. **Dependent variable:** the efficiency score

DEA is a tool to count the score of efficiency in the first stage of analysis. DEA is a method of non-parametric program that uses linear model to calculate a comparison of the ratio of output and input to all units compared in a population. The aim of the DEA is to measure the degree of the relative efficiency of DMU, when all these units are on a curve efficient frontier. So this method used to evaluate the relative efficiency of some object (benchmarking of the performance). Using DEA, the technical efficiency of overall unit can be calculated. The score for each unit is relative depends on the level of efficiency of the others in the samples. Each unit in samples assumed to have the positive value, and the values between 0 and 1 with the provisions of the efficiency that indicate imperfectly.

Furthermore, data of input and output variable will be put in the formulation of the DEA to obtain the technical efficiency. The formulation of DEA is as follows (Cooper et al., 2000):

\[
\begin{align*}
\text{FPO max } \theta = & \frac{U_1 Y_{10} + U_2 Y_{20} + U_3 Y_{30} + \ldots + V_s X_{so}}{V_1 X_{10} + V_2 X_{20} V_3 X_{30} + \ldots + V_m X_{mo}} \\
\text{Subject to } & \frac{U_1 Y_{10} + U_2 Y_{20} + U_3 Y_{30} + \ldots + U_s Y_{so}}{V_1 X_{10} + V_2 X_{20} + V_3 X_{30} + \ldots + V_m X_{mo}} \leq 1 \\
V_1, V_2, V_3, \ldots, V_m & \geq 0 \\
U_1, U_2, U_3, \ldots, U_s & \geq 0
\end{align*}
\]

whereas
- m \quad \text{ number input used}
- s \quad \text{ number output produced}
- \theta \quad \text{ weighted average input } 1
\( V_m \) weighted average input \( m \)

\( U_1 \) weighted average output 1

\( U_s \) weighted average output 2

\( X_{10} \) the amount of input 1 used by the study program

\( Y_{10} \) the amount of output 1 used by the study program

\( \theta \) optimal value as relative efficiency indicator of DMU tested.

The technical level of efficiency can be divided into two major groups, parametric and non-parametric. The method will be used in this research are parametric. The DEA employed to count the score of efficiency.

Before counting the score, input and output should be determined first, using intermediary approach. Inputs are the number of students, budget funds, the amount of D3, while the output that is used is the number of graduates and the number of research.

### 4 Result and discussion

Table 1 shows that in 2010, TT study program has the highest efficiency, while the TK study program has the lowest efficiency. In 2011, TE study program got highest efficiency, while TL program study has lowest efficiency.

<table>
<thead>
<tr>
<th>Study program</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE</td>
<td>83.60</td>
<td>98.20</td>
<td>86.90</td>
<td>82.80</td>
<td>92.20</td>
</tr>
<tr>
<td>TL</td>
<td>84.75</td>
<td>57.30</td>
<td>54.20</td>
<td>69.10</td>
<td>72.30</td>
</tr>
<tr>
<td>TT</td>
<td>100.00</td>
<td>86.70</td>
<td>60.70</td>
<td>74.30</td>
<td>77.00</td>
</tr>
<tr>
<td>MI</td>
<td>93.70</td>
<td>86.50</td>
<td>98.30</td>
<td>85.80</td>
<td>95.60</td>
</tr>
<tr>
<td>TM</td>
<td>78.90</td>
<td>67.80</td>
<td>53.40</td>
<td>67.00</td>
<td>74.40</td>
</tr>
<tr>
<td>TS</td>
<td>89.70</td>
<td>81.20</td>
<td>70.30</td>
<td>86.20</td>
<td>88.30</td>
</tr>
<tr>
<td>TK</td>
<td>69.40</td>
<td>78.80</td>
<td>63.00</td>
<td>80.20</td>
<td>67.50</td>
</tr>
<tr>
<td>AK</td>
<td>95.30</td>
<td>60.30</td>
<td>45.20</td>
<td>70.10</td>
<td>85.60</td>
</tr>
<tr>
<td>AN</td>
<td>90.40</td>
<td>78.80</td>
<td>63.00</td>
<td>80.20</td>
<td>67.50</td>
</tr>
</tbody>
</table>

On 2012, the MI program study reaches highest level of efficiency at 96.2%, while the AK program study had the lowest efficiency. Throughout the year 2013, the TS study program reaches highest level of efficiency, while the TM study program efficiency has the lowest score. In 2014, the MI study program reaches highest efficiency and AN study program had the lowest efficiency.

Multiple linear regression analysis was employ to know the influence of the number of students at \( X_1 \), the number of lecturers \( X_2 \), the amount of funds \( X_3 \), the number of graduate \( X_4 \), and the number of research \( X_5 \) on the efficiency of study program \( Y \).

Based on Table 2, the value of the coefficients R-square shows value of 0.712 or 71.2%. It means that to a variable degree of efficiency influenced 71.2% by the number
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of student \((X_1)\), the number of lecturers \((X_2)\), the amount of funds \((X_3)\), the number of graduates \((X_4)\), and the amount of research \((X_5)\). While the rest 28.8% influenced by other variables outside independent variables that investigated in this study.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Regression analysis result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Coefficient</td>
</tr>
<tr>
<td>Constant</td>
<td>83.201</td>
</tr>
<tr>
<td>Number of student ((X_1))</td>
<td>–0.097</td>
</tr>
<tr>
<td>Number of lecture ((X_2))</td>
<td>0.387</td>
</tr>
<tr>
<td>Funds ((X_3))</td>
<td>0.475</td>
</tr>
<tr>
<td>Number of graduates ((X_4))</td>
<td>0.372</td>
</tr>
<tr>
<td>Number of research ((X_5))</td>
<td>0.535</td>
</tr>
<tr>
<td>(T) table</td>
<td>2.132</td>
</tr>
<tr>
<td>(R)-square</td>
<td>0.712</td>
</tr>
<tr>
<td>(F)</td>
<td>16.287</td>
</tr>
<tr>
<td>Sig (F)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The influence of independent variables which are the number of students, number of lecturers, the amount of the funds, number of graduates, and the number of research on dependent variables simultaneously using \(F\) test, show the value of significance \(f = 0.000\). It means independent variables have significant impact on dependent variable simultaneously.

Moreover, \(t\)-test show that each variable give partial effect on efficiency score. The number of student gives negative effect, while the number of lecture, fund and research give positive effect. It means that the bigger number of student decrease the efficiency. On the contrary, the number of lecturers, fund and research can make the efficiency of the program study increase. Thus, the research hypothesis formulated is accepted.

From this research, each study program has to consider the increase in the number of students. If it cannot be followed by the increase of another input (lecturers, fund), it can affect the amount of output produced (the number of research). Thus, the efficiency of the study program would be decrease.

References


