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/ _International Journal of Engineering & Technology, 5 (x) (2017) xxx-xxx International Journal of Engineering & Technology Website: www.sciencepubco.com/index.php/IJET doi: Research paper, Short communication, Review, Technical paper _/ _ _ A Slack-Based Measures for Improving the Efficiency
Performance of Departments in Universitas Malikussaleh _ _ _ _Dahlan Abdullah1,2*, Tulus3, Saib Suwilo3, Syahril Efendi2, Hartono2 _ _ _ _1Department of Informatics, Universitas Malikussaleh, Aceh, Indonesia 2Department of Computer Science, Universitas Sumatera Utara, Medan, Indonesia 3Department of Mathematics, Universitas Sumatera Utara, Medan, Indonesia *Corresponding author E-mail:dahlan@unimal.ac.id _ _ Abstract Data Envelopment Analysis (DEA) is a data-oriented performance evaluation method that has a very satisfactory performance when there are multiple inputs and outputs presented in the form of set of peer Decision Making Units (DMU).

In the discussion of DEA, basically measures the efficiency of each DMU in specific performance based on DEA Efficiency Scores. In DEA, when there is a value of Non-Zero Input and Output Slacks then this often means inefficiency. This scalar measures directly with the input surplus and the output of the short decision of the decision making unit (DMU).

Universitas Malikussaleh as one of the State Universities in Indonesia, it is necessary to follow the regulations of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia (KEMENRISTEKDIKTI), one of which is the measurement of efficiency based on the number of lecturers research, the efficient use of resources included in the number of lecturers and employees, as well as students who can be accommodated based on efficiency measurements using DEA.

This paper will measure the efficiency of each department in Malikussaleh University and if there is an inefficient department then it will be measured based on slack-based measures to advise aspects that need attention so that the department can be efficient.
Keywords: Data Envelopment Analysis, Decision Making Units, Input and Output Slack, Slack-Based Measures

Introduction Research on benchmarking is now evolving as a follow-up to the process of improvement, quality assurance, evaluation and performance improvement [1].

[2] have used DEA CCR for measuring the relative efficiency of capital and resource placement. DEA has become one of the most appropriate methods for comparing the various Decision Making Units (DMUs) associated with public services such as universities [3]. Measuring the efficiency of college performance is very important to do, but it is difficult to do considering the characteristics of each different college especially if the college is viewed as a non profit organization with multiple outputs generated from multiple inputs.

Research conducted by [4] there are 2 (two) main outputs that can be used to measure the performance of universities, namely: the number of graduates and the number of publications. [5] has develops a method to evaluate efficiency for all departments in Universitas Malikussaleh using DEA with bounded output. A main objective of DEA is to measure the efficiency of a Decision Making Unit (DMU) by a scalar measure, ranging between zero (the worst) and one (the best) [6].

This scalar value is measured through a linear programming model. Specifically, the Charnes-Cooper-Rhodes (CCR) model deals with the ratio of multiple inputs and outputs in an attempt to gauge the relative efficiency of the DMUs. This fractional program is solved by transforming it into an equivalent linear program .

The optimal objective value (?? *) is called the ratio (or radial) efficiency of the DMU. The optimal solution reveals the existence, if any, of a surplus in inputs and a shortage in outputs (called slacks). A DMU with the full ratio efficiency, ?? * = 1, and with no slacks in any optimal solution is called CCR-efficient.

Otherwise, the DMU has a disadvantage against the DMUs in its reference set. Therefore, in discussing total efficiency, it is important to observe both the ratio efficiency and the slacks [6]. Universitas Malikussaleh as one of the State Universities in Indonesia, it is necessary to follow the regulations of the Ministry of Research, Technology and Higher Education (KEMENRISTEKDIKTI), one of which is the measurement of efficiency based on the number of lecturers research, the efficient use of resources included in the number of lecturers and employees, as well as students who can be accommodated based on efficiency measurements using DEA.

This paper will measure the efficiency of each department in Universitas Malikussaleh and if there is an inefficient department then it will be measured based on slack-based measures to advise aspects that need attention so that the department can be efficient.

The rest of this paper is organized as follows. In Section 2 we will provide related works in DEA.

In Section 3 we describe the methodology used in this research and in Section 4 we provide the experimental process performed in this research. Results and discussion are given in Section 5 and finally, we conclude the research in Section 6. Related Works Research conducted by [7] is necessary to measure the relative efficiency of the Decision Making Unit (DMU) in cases involving multiple inputs and outputs.

This can be done by analyzing the unctrollable input by using the return to scale variable in the efficiency scale, where it is assumed that the input is not in the convex state. [6] and [8] using Slack-Based Measure in the terms to get full ratio efficiency, ?? * = 1, and with no slacks in any optimal solution is called CCR-efficient.

[9] proposes a slack-based context-dependent DEA which allows a full evaluation of inefficiency in a DMUs performance. Methodology The mathematical model of DEA proposed by CCR is a fractional programming aimed to measure the efficiency of any DMU. The objective function of the model is to maximize a ratio of the sum of weighted output and the sum of weighted input with constraints of the similar ratio for every DMU which should be at most one. The fractional programming model can be expressed as follows [10].

???????????????? ? = ??=1 ?? ?? ?? ?? ??0 ??=1 ?? ?? ?? ?? ??0 (1) Subject to (1)_ _ In the model, there are n number of DMUs with k number of outputs resulting from 1 number of inputs. Yrj (>0) are the number of ouput of the jth DMU and Xsj (<0) are the number of input of the jth DMU. ur and vs are the variable weights to be determined after solving the model.

The model (1) is in the form of fractional programming, it would be computationally intractable particularly when the number of DMUs is large. Therefore it is necessarily to convert the model (1) into a linear programming problem, as proposed by [10], which can be written as follows (output oriented). _ Subject to _ (2) _ 3.1.

Definition and Computational Scheme of Slack-Based Measure We will deal with n DMUs (Decision Making Units) with the input and output matrices ?? = (?? ????) ? ?? ?????? and ?? = (?? ????) ? ?? ?????? , respectively. We assume that the data set is positive, i.e., X > 0 and Y > 0. The production possibility set P is defined as ??={(??,??) | ?? =????, ??= ????, ??=0} (3) We consider an expression for describing a certain DMU (x0, y0) as x0 = X?? + ?? - y0 = Y?? - ?? + (4) 3.2. Slack-Based Measure in Linear Programming With ?? = 0, ?? - =0 and ?? + =0.

The values ?? - ? ?? ?? and ?? + ? ?? ?? indicate the input surplus and output shortage of this expression, respectively, and are called slacks. From the conditions X > 0 and ?? =0, it holds ?? 0 = ?? - (5) using s- and s+, we define an index ?? as follows, ??= 1- 1 ?? ??=1 ?? ?? ?? - / ?? ???? 1+ 1 ?? ??=1 ?? ?? ?? + / ?? ???? (6) It can be verified that ?? satisfies the properties P1 (unit invariant) and P2 (monotone).

Furthermore from (5), it holds 0 < ?? = 1 (7) Then, Slack-Based Measure become the following linear program in t, S-, S+, and ? : ?????? ?? = ??- 1 ?? ??=1 ?? ?? ?? - / ?? ???? ????????????? ???? 1 = ?? + 1 ?? ??=1 ?? ?? ?? + / ?? ???? (8) ???? 0 =??? + ?? - ???? 0 =???- ?? + ? = 0, ?? - =0, ?? + =0, ?? > 0 Experimental Process 4.1. Data Description Universitas Malikussaleh is a state university located at Lhokseumawe city of Aceh province, Indonesia.

The name Malikussaleh comes from the name of the first king of the well known kingdom Samudra Pasai. This university has 30 Departments with around 20000 students. The data of 19 Departments (DMU) with two outputs and two inputs is shown in Table1. There are 11 departments are still new, therefore they do not have graduates yet. As a consequence, these 11 departments are not included in Table 1.

Table 1: List of DMU with input and output data DMU _INPUT _OUTPUT _ _ _Number of Lecturers _Number of Students _Number of Research _Number of Graduates _ _ _ _ _ _ _ _Information Technology _17 _588 _5 _610 _ _Civil Engineering _26 _747 _5 _533 _ _Architectural Engineering _15 _396 _5 _195 _ _Industrial Engineering _17 _467 _5 _300 _ _Chemical Engineering _25 _348 _5 _252 _ _Mechanical Engineering _23 _499 _5 _224 _ _Electrical Engineering _19 _420 _5 _326 _ _Agribusiness _17 _689 _5 _273 _ _Agro-Technology _34 _822 _5 _284 _ _Aquaculture _10 _501 _5 _204 _ _Communication Science _11 _719 _5 _273 _ _Political Science _11 _262 _5 _183 _ _Sociology _13 _487 _5 _204 _ _Anthropology _9 _173 _5 _116 _ _Jurisprudence _50 _1096 _5 _467 _ _Medicine _30 _278 _4 _257 _ _Management _48 _1265 _5 _1302 _ _Economic Development _11 _853 _5 _290 _ _Accounting _23 _1127 _5 _417 _ _ 4.2. Testing Using (2) we can find the score of efficiency.

For example for DMU1 (Department of Information Technology), the linear programming model can be written as follows. Maximize 610 U1 + 5 U2 Subject to 17 V1 + 588 V2 = 1 610 U1 + 5 U2 - 17 V1 - 588 V2 <= 0 533 U1 + 5 U2 - 26 V1 - 747 V2 <= 0 195 U1 + 5 U2 - 15 v1 - 396 V2 <= 0 300 U1 + 5 U2 - 17 V1 - 467 V2 <= 0 252 U1 + 5 U2 - 25 V1 - 348 V2 <= 0 224 U1 + 5 u2 - 23 V1 - 499 V2 <= 0 326 U1 + 5 U2 - 19 V1 - 420 V2 <= 0 273 U1 + 5 U2 - 17 V1 - 689 V2 <= 0 284 U1 + 5 U2 - 34 V1 - 822 V2 <= 0 204 U1 + 5 U2 - 10 V1 - 501 V2 <= 0 273 U1 + 5 U2 - 11 V1 - 719 V2 <= 0 183 U1

+ 5 U2 - 11 V1 - 262 V2 <= 0 204 U1 + 5 U2 - 13 V1 - 487 V2 <= 0 116 U1 + 5 U2 - 9 V1 - 173 V2 <= 0 467 U1 + 5 U2 - 50 V1 - 1096 V2 <= 0 257 U1 + 5 U2 - 30 V1 - 278 V2 <= 0 1302 U1 + 5 U2 - 48 V1 - 1265 V2 <= 0 290 U1 + 5 U2 - 11 V1 - 852 V2 <= 0 417 U1 + 5 U2 - 23 V1 - 1127 V2 <= 0 U1, U2, V1, V2 >= 0 END We use software LINDO Release 6.1 Demo Version.

The expression (3) is in LINDO format. The result is as follows. OBJECTIVE FUNCTION VALUE 1) 1.000000 VARIABLE VALUE REDUCED COST U1 0.001639 0.000000 U2 0.000000 0.000000 V1 0.058824 0.000000 V2 0.000000 0.000000 It can be seen that DMU1 is efficient, as the value of ß is 1.0.The score of efficiency for all DMUs can be found in Table 2.

Table 2: Result of efficiencies for each DMU using output-oriented DEA NO _DMU _DEA SCORE _ _1 _Information Technology _1.0 _ _2 _Civil Engineering _0.6982436 _ _3 _Architectural Engineering _0.6818709 _ _4 _Industrial Engineering _0.7045490 _ _5 _Chemical Engineering _0.8069085 _ _6 _Mechanical Engineering _0.5265533 _ _7 _Electrical Engineering _0.8263003 _ _8 _Agribusiness _0.6639550 _ _9 _Agrotechnology _0.3810771 _ _10 _Aquaculture _1.0 _ _11 _Communication Science _0.9912544 _ _12 _Political Science _0.9152225 _ _13 _Sociology _0.7845375 _ _14 _Anthropology _1.0 _ _15 _Jurisprudence _0.4226586 _ _16 _Medical _1.0 _ _17 _Management _0.9921286 _ _18 _Economic Development _1.0 _ _19 _Accounting _0.5871874 _ _ From Table 2 we would be able to observe that DMU1, DMU10, DMU14, DMU16, and DMU18 are efficient.

For DMU 2, DMU 3, DMU 4, DMU5, DMU6, DMU7, DMU8, DMU11, DMU12, DMU13, DMU15, DMU17, and DMU19 we can use Slack-Based Measure in determining the input surplus dan the output shortage. The slack value of each DMU can be seen in Table 3. Table 3: Slack Value for The Inefficient DMU NO _DMU _SLACK VALUE _ _1 _Civil Engineering _0.301756 _ _2 _Architectural Engineering _0.318129 _ _3 _Industrial Engineering _0.295451 _ _4 _Chemical Engineering _0.228036 _ _5 _Mechanical Engineering _0.473447 _ _6 _Electrical Engineering _0.173700 _ _7 _Agribusiness _0.336045 _ _8 _Agrotechnology _0.618923 _ _9 _Communication Science _0.008746 _ _10 _Political Science _0.084778 _ _11 _Sociology _0.215462 _ _12 _Jurisprudence _0.577341 _ _13 _Management _0.007871 _ _14 _Accounting _0.412813 _ _ According to the Slack value we can determine the input surplus and the output shortage.

For example we can see the DMU Civil Engineering with the slack value 0.301756. We can increase the output of U2 (Number of Research) according to the slack value using (4) U2 = 5 + 5*0.301756 = 7 We can decrease the input of V2 (Number of Students) according to the slack value using (4) V2 = 747 - 747*0.301756 = 522 Using Slack-Based Measure We can provide recommendations for improving the efficiency of each

department at the Universitas Malikussaleh that can be seen in Table 4.

Table 4: Recomendation of Input and Output for Every DMU to Become Efficient DMU _INPUT _OUTPUT _ _ _Number of Lecturers _Number of Students _Number of Research _Number of Graduates _ _ _ _ _ _ _ _Civil Engineering _26 _522 _7 _533 _ _Architectural Engineering _15 _270 _8 _195 _ _Industrial Engineering _17 _329 _7 _300 _ _Chemical Engineering _25 _268 _6 _252 _ _Mechanical Engineering _23 _262 _8 _224 _ _Electrical Engineering _19 _347 _6 _326 _ _Agribusiness _17 _407 _9 _273 _ _Agro-Technology _34 _313 _8 _284 _ _Communication Science _11 _712 _6 _273 _ _Political Science _11 _239 _6 _183 _ _Sociology _13 _382 _7 _204 _ _Jurisprudence _50 _463 _8 _467 _ _Management _48 _1255 _6 _1302 _ _Accounting _23 _561 _10 _417 _ _ Using Slack-Based Measures, Inefficient DMU can become efficient according to the input and output for every DMU. The result of using Slack-Based Measures, all of inefficient DMU become efficient that can be seen in Table 5.

Table 5: The Result of Slack-Based Measures for Inefficient DMU NO _DMU _DEA Score _ _1 _Civil Engineering _1.0 _ _2 _Architectural Engineering _1.0 _ _3 _Industrial Engineering _1.0 _ _4 _Chemical Engineering _1.0 _ _5 _Mechanical Engineering _1.0 _ _6 _Electrical Engineering _1.0 _ _7 _Agribusiness _1.0 _ _8 _Agrotechnology _1.0 _ _9 _Communication Science _1,0 _ _10 _Political Science _1,0 _ _11 _Sociology _1.0 _ _12 _Jurisprudence _1.0 _ _13 _Management _1.0

_ _14 _Accounting _1.0 _ _ Result and Discussion The results show that we can use Slack-Based Measure in determining the input surplus and the output shortage. This method can give advise aspects that need attention so that the department can be efficient. The results of this study indicate that the suggestion for improvement of efficiency in general is in line with the provisions of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia (KEMENRISTEKDIKTI), that the number of lecturers research should be improved and also need to consider the ratio between the ratio of the number of lecturers and students.

Where most of the results of Slack-Based Measure is largely the increase in output in the form of the number of research faculty and reduce the input of the number of students received to improve the quality of education. Conclusion First, when there is a value of Non-Zero Input and Output Slacks then this often means inefficiency. Second, we can use Slack-Based Measure in determining the input surplus and the output shortage.

This method can give advise aspects that need attention so that the department can be efficient. In the future, we should find different benchmarks for inefficient DMUs.

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