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A Slack-Based Measures within Group Common Benchmarking using DEA for Improving the Efficiency Performance of Departments in Universitas Malikussaleh Dahlan Abdullah1*, Muhammad Zarlis2, Darmawan Napitupulu3, Hartono4, S Sriadhi5, Cut Ita Erliana6,
Rohman Dijaya7, Yulian Findawati7, Heri Nurdiyanto8, Robbi Rahim9, Ansari Saleh Ahmar10 1Department of Informatics, Universitas Malikussaleh, Aceh, Indonesia 2Department of Computer Science, Universitas Sumatera Utara, Medan, Indonesia 3Lembaga Ilmu Pengetahuan Indonesia, Jakarta, Indonesia 4Department of Computer Science, STMIK IBBI, Medan, Indonesia 5Department of of Electrical Engineering, Universitas Negeri Medan, Indonesia 6Department of Industrial Engineering, Universitas Malikussaleh, Aceh, Indonesia 7Department of Informatics, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia 8Department of Informatics, STMIK Dharma Wacana, Lampung, Indonesia 9School of Computer and Communication Engineering, Universiti Malaysia Perlis, Kubang Gajah, Malaysia 10Departement of Statistics, Universitas Negeri Makassar, Makassar, Indonesia Abstract. Measurement of the efficiency of the university performance.

Data Envelopment Analysis (DEA) is a data-based performance evaluation method used when multiple inputs and outputs are represented in the Decision Making Unit (DMU) set. 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 of surplus and the output of the short decision of the decision making unit (DMU).

DEA Structure usually apply in general settings, actually DMUs can fall into distinct groups whose members experience similar circumstances. The targets of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia

(KEMENRISTEKDIKTI), one of which is the measurement of the efficiency based on the number of lecturers research, the efficient use of resources.

This study will group each department at the Universitas Malikussaleh using the Group Common Benchmarking approach and then provide suggestions for improvements to each group by using Slack-Based Measures.

1 Introduction Data Envelopment Analysis (DEA) is an optimization framework proposed to measure the relative performance of a set of Decision Making Units (DMUs)[1].

In recent years, educational institutions such as universities have increasingly focused on improving quality as an effort to improve their prestige. Within the university, the study program is also increasingly focused on ranking especially related to the quality of publications and graduates[2]. The result of benchmarking that get from the DEA method in the form of benchmarking values can be studies as a pattern when there is a new data can be directly predicted[3].

Data Envelopment Analysis (DEA) is a mathematical model for evaluating Decision Making Units (DMUs) that have multiple inputs and multiple outputs. Note that adding or removing an inefficient DMU will not necessarily change the efficiency of DMU and efficient frontier. Inefficiency scores can only be changed if the efficient frontier is changed.

The performance of each DMU depends on the identification of the Efficient Frontier expressed through slack measurement[4]. In DEA, when there is a value of Non-Zero Input and Output Slacks then this often means inefficiency[5]. If there is a DMU with an efficiency score of one even if it has a zero slack value, it remains categorized as having the same efficiency level as an efficient DMU, even if it is inefficient[4].

Slack Based Measure can measure the efficiency of each department in 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[6]. In the DEA Method, we can identify the Efficient Frontier based on a certain subset of efficient DMU, which can be viewed as a common reference set and will minimize the pareto-efficient frontier[7]. From this new efficient frontier this will find the closest targets to each of DMU[8].

This study will group each department at the Universitas Malikussaleh using the Group Common Benchmarking approach and then provide suggestions for improvements to each group by using Slack-Based Measures. In grouping based on efficient frontier it is necessary to pay attention to the quality of grouping[9] and need to pay attention to the new patterns that will emerge based on the trend patterns that exist in the process of grouping[10].

The results of the study using Slack Based Measure and Group Common Benchmarking are expected to be the entire study program available at Malikussaleh University to be efficient. 2 Related Works Data Envelopment Analysis (DEA) is a method of performance

evaluation and benchmarking of a collection of Decision Making Units (DMU) that are settlement-based with mathematical programming methods[11]. O'Neal et al. [12] proposed DMU exclusion of indefinite data to calculate efficiency.

This affects the relative effectiveness of other DMU. Undetected data in DEA can use stochastic approaches. Stochastic programming has undergone many theoretical developments since the 1950s, beginning with the pioneering work in Dantzig[13]. A Common Set of Weights is the basis for comparing and ranking all decision-making units under the same conditions[14].

While CSW and DEA offer two "opposite" approaches to analyzing efficiency, in some situations would be desirable intermediate access between them. For example, Cook and Zhu [15] claim that in many real-world applications where DEA is used, DMUs can be grouped into groups whose members have similar circumstances, and therefore each DMU as a separate entity may not be suitable. Cook et al.

[7] develop models that are based on the idea of minimizing distance from the DMU group to the DEA effective limit. On the other side, Tone [5] proposed a method to evaluate the effectiveness based on the deceleration values, a measure based on free movement (SBM) was introduced. When using SBM to evaluate the context, we can have a reasonable stratification of the DMU performance levels.

3 Methodology Linear programming model of DEA proposed by CCR can be written as follows. _ Subject to _ (1) _ 3.1. Slack Based Measures 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} (2) We consider an expression for describing a certain DMU (x0, y0) as x0 = X?? + ?? - y0 = Y?? - ?? + (3) 3.2. Slack Based Measures 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 = ?? - (4) using s- and s+, we define an index ?? as follows, ??= 1- 1 ?? ??=1 ?? ?? ?? - / ?? ???? 1+ 1 ?? ??=1 ?? ?? ?? + / ?? ???? (5) It can be verified that ?? satisfies the properties P1 (unit invariant) and P2 (monotone). Furthermore from (5), it holds 0 < ?? = 1 (6) Then, Slack-Based Measure become the following linear program in t, S-, S+, and ? : ?????? ?? = ??- 1 ?? ??=1 ?? ?? ?? - / ?? ???? ????????????? ???? 1 = ?? + 1 ?? ??=1 ?? ?? ?? + / ?? ???? (7) ???? 0 =??? +

?? - ???? 0 =???- ?? + ? = 0, ?? - =0, ?? + =0, ?? > 0 3.3.

Group Common Benchmarking in Linear Programming Group common benchmarking model will finds the closest targets for the DMU in a given group by minimizing globally weighted distance to their actual inputs and outputs. ?????? ??? ?? ?? || ?? ?? , ?? ?? - ?? ?? , ?? ?? || 1 ?? ??.??.: ????? ?? ???? ?? ?? = ?? ?? ??? ?? ?? ????? ?? ???? ?? ?? = ?? ?? ??? ?? ?? - ?? ' ?? ?? + ?? ' ?? ?? + ?? ?? =0 ????? ?? ??= 1 ?? ?? ??= 1 ?? ?? ?? =?? ?? ?? ????? ??? ?? ?? ?? ???? =??(1- ?? ??) ????? ?? ?? =0, ?? ?? ?{0,1} ????? ?? ???? =0, ?? ?? = 0 ?? , ?? ?? = 0 ?? ???,?? (8) 4 Experimental Process 4.1.

Data Description Universitas Malikussaleh 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 _10 _467 _ _Medicine _30 _278 _4 _257 _ _Management _48 _1265 _5 _1302 _ _Economic Development _11 _853 _5 _290 _ _Accounting _23 _1127 _5 _417 _ _ Using (1), we can calculate the efficiency score of each DMU. The result can be seen in Table 2.

Using (1), we can calculate the efficiency score of each DMU. The result can be seen in Table 2. 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. The score of efficiency for all DMUs can be found in Table 2. Table 2: Efficiency Score of Each DMU Using 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 _ _ 4.2. Linear Programming with Slack Based Measures 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. Slack value for Infefficient DMU can be seen in Table 3.

Tabel 3: Slack Value for 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 _ _ 4.3.

Slack Based Measure within Common Group Benchmarking Using (8) we can calculate the distance to their paretto efficient frontier for each DMU. For each in efficient DMU, we calculate the distance for input and output. We assume that the DMU Information Technology as the best DMU. The Result can be seen in Table 4.

Tabel 4: Distance to Paretto Efficient Frontier DMU _Distance _Distance _ _ _Number of Lecturers _Number of Students _Number of Research _Number of Graduates _ _ _ _ _ _ _ _Civil Engineering _9 _159 _0 _77 _ _Architectural Engineering _2 _192 _0 _415 _ _Industrial Engineering _0 _121 _0 _310 _ _Chemical Engineering _8 _240 _0 _358 _

_Mechanical Engineering _6 _89 _0 _386 _ _Electrical Engineering _2 _168 _0 _284 _ _Agribusiness _0 _101 _0 _337 _ _Agro-Technology _17 _234 _0 _326 _ _Communication Science _6 _131 _0 _337 _ _Political Science _6 _326 _0 _427 _ _Sociology _4 _101 _0 _406 _ _Jurisprudence _33 _508 _5 _143 _ _Management _31 _677 _0 _692 _ _Accounting _6 _539 _0 _193 _ _According to (8) the minimum distance to paretto efficient frontier are Input Number of Lecturers and Output Number of Research.

For the input we use the maximum distance to subtract with its slack value and the output we use the minimum distance to add with its slack value. 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 The result of Recomendation of Input and Output for become efficient can be seen in Table 5.

Table 5: 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 _ _ 5 Conclusion First, the Common Group Benchmarking can be used to determine the minimum value of each input and the inefficient output to the paretto efficient frontier value so that it can be used as a basis for using slack based measure.

Second, slack based measure can be used to reduce the maximum value of inputs based on Common Group Benchmarking and can also increase the minimum value of output based on Common Group Benchmarking. Third, the results show that each department can be efficient if we increase the output and reduce the input according to the slack value.

Future research is expected that the developed DEA model can be applied to ensure quality of data in the process of efficiency measurement especially if there is a lot of uncertainty data. References [1] M. Ehrgott, A. Holder, and O. Nohadani, “Uncertain Data Envelopment Analysis,” Eur. J. Oper. Res., vol. 268, no. 1, pp. 231–242 (2018) [2] E. C. Rosenthal and H. J. Weiss, “A data envelopment analysis approach for ranking journals,” Omega, vol. 70, pp. 135–147 (2017) [3] D.

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