 doi: 10.21831/cp.v38i2.22837

HOW COMPARISON OF EFFICIENCY SCHOOL PERFORMANCE BETWEEN NATURAL AND SOCIAL SCIENCES: A BOOTSTRAPPING DATA ENVELOPMENT ANALYSIS

Zaenal Mustakim[1*], Muhamad Chamdani[2], Umi Mahmudah[3]
[1,3]State Islamic Institute of Pekalongan, [2]Sebelas Maret University
*e-mail: zaenalmustakim@iainpekalongan.ac.id

Abstract: The main purpose of this study is to compare the efficiency performance of high school education in Indonesia based on its specialization groups, namely natural and social sciences. This study uses secondary data of high school published by Ministry of Education and Culture of Republic of Indonesia in 2016 which covers general description such as the numbers of schools, students, teachers, graduates, classes, et cetera. This study uses a bootstrap approach that is applied in Data Envelopment Analysis (DEA) method, which compares the efficiency of each Decision Making Unit (DMU). To compare its efficiency, as many as 34 provinces are used as DMUs by using six input variables, namely the number of participants of national exam, students, schools, teachers, libraries, and the number of classrooms. The output variables are the number of graduates, the average score of national exam in Indonesian, English, and mathematics.The results indicate that all provinces have very good performance in organizing high school education for both natural and social sciences where the average efficiency scores of the traditional DEA are .99 and .98 for natural and social sciences, respectively. Meanwhile, its average scores from bootstrapped DEA are .98 and .96 for natural and social sciences, respectively. The empirical results also reveal that bootstrapped DEA provides better accuracy of efficiency scores than the traditional DEA. Overall, the provinces in Indonesia have better performance in organizing natural science than social science.

Keywords: ***DEA, efficiency, high schools***

PERBANDINGAN EFISIENSI KINERJA SEKOLAH JURUSAN ILMU ALAM DAN SOSIAL: *BOOTSTRAPPING DATA ENVELOPMENT ANALYSIS*

Abstrak: Tujuan utama penelitian adalah untuk membandingkan efisiensi kinerja pendidikan sekolah menengah di Indonesia berdasarkan kelompok penjurusan, yaitu ilmu alam dan sosial. Penelitian ini menggunakan data sekunder sekolah menengah yang dipublikasikan oleh Kementerian Pendidikan dan Kebudayaan Republik Indonesia pada tahun 2016 yang mencakup gambaran umum seperti jumlah sekolah, siswa, guru, lulusan, kelas, dan lain-lain. Penelitian menggunakan pendekatan *bootstrap* yang diterapkan pada metode Data envelopment Analysis (DEA), yang membandingkan efisiensi tiap unit pengambilan keputusan (DMU). Untuk membandingkan efisiensi kinerja, sebanyak 34 provinsi digunakan sebagai DMU dengan menggunakan enam variabel input, yaitu jumlah peserta ujian nasional, siswa, sekolah, guru, perpustakaan, dan jumlah ruang kelas. Variabel output yang digunakan adalah jumlah lulusan, nilai rata-rata ujian bahasa Indonesia, bahasa Inggris, dan matematika. Hasilnya menunjukkan bahwa semua provinsi memiliki kinerja yang sangat baik dalam menyelenggarakan pendidikan sekolah menengah untuk ilmu alam dan sosial dengan skor rata-rata efisiensi DEA tradisional masing-masing 0,99 dan 0,98 untuk ilmu alam dan sosial. Hasil empiris juga mengungkapkan bahwa DEA *bootstrap* memberikan akurasi skor efisiensi yang lebih baik daripada DEA tradisional. Secara keseluruhan, provinsi-provinsi di Indonesia memiliki kinerja yang lebih baik dalam mengatur ilmu pengetahuan alam daripada ilmu sosial.

Kata Kunci: ***DEA, efisiensi, sekolah menengah***

INTRODUCTION

In order to improve quality education has launched Republic of Indonesia government regulation No. 47 of 2008 which is compulsory education program of at least 12 years. Indonesian citizens must undergo basic education for 6 years followed by junior high school for 3 years and senior high school for 3 years. High School is an educational institution that is very important for the community, especially the next generation because it is usually used to find the true identity. In fact, high school is indeed a very decisive period in human development. Mahmudah, Suhartono, & Rohayana (2018) state that high school is a period of preparation for both students and institutions to provide sufficient skills and knowledge so that they are able to adapt to the environment appropriately. Those who have high school diploma can be very helpful in navigating their lives, whether on campus life or work life. In fact, many agencies require the level of education in the recruitment of new workers. Therefore, it is very important in completing 12 years of education as required by the Indonesian government.

To help students focus on a scientific field, the high school education system in Indonesia carries out a policy of majors or specializations that are tailored to the conditions of each student. Unlike the previous curriculum (the 2006 Curriculum) where specializations are conducted in 11th grade, based on the 2013 curriculum, this policy is usually done in 10th grade. This is intended to direct students' interest so that it is more focused on a field of interest. The selection of specializations is based on students' grades and interests. Students can immediately choose their specializations when their grades are good. But, when their grades are not good enough then they must be seen correctly from the interview of the counseling teacher.

Generally, there are three specializations provided by high schools in Indonesia, namely natural sciences, social sciences and languages (depending on high school, usually only science and social sciences). It is important to note that according to the regulation of the minister of education and culture number 69 of 2013 regarding the basic framework and curriculum structure of senior high school, there are 9 (nine) compulsory subjects in high school curriculum in Indonesia where all students must take these subjects. They are religion and manner education, Civics and Citizenship education, Indonesian, Mathematics, History, English, Art and Culture, Physical Education, and Entrepreneurship education. Table 1 show subjects and hours per week that must be taken by high school students in Indonesia based on specializations.

Table 1. Subjects and Hours per Week

Subjects		Hours per Week		
		Grade 10	Grade 11	Grade 12
Mandatory subjects		24	24	24
Specializations				
Natural Sciences	Mathematics	3	4	4
	Biology	3	4	4
	Physics	3	4	4
	Chemistry	3	4	4
Social Sciences	Geography	3	4	4
	History	3	4	4
	Sociology	3	4	4
	Economics	3	4	4
Languages	Indonesian Language and Literature	3	4	4
	English Language and Literature	3	4	4
	Other Foreign Languages	3	4	4
	Anthropology	3	4	4
Choice of Special Groups		6	4	4
Number of Hours of available per week		68	72	72
Number of hours that must be taken per week		42	44	44

Source: Regulation of the minister of education and culture number 69 of 2013

The main objective of this study is to analyze the performance efficiency of all provinces in Indonesia in organizing high school education. This is important to do in order to compare their performance in the implementation of education in high school. Unfortunately, the efficiency measurement of high school performance in Indonesia is still very rare (Mahmudah, et al., 2018).

This study only focuses on two specializations in high school, namely science and social sciences specializations. In other words, this study compares the level of efficiency of all provinces in Indonesia in providing high school education services for natural and social sciences. This needs to be done in order to know which provinces can be used as role models for other provinces. Provinces that have efficient performance (or have the best performance) can be used as references for other provinces to improve their performance (Fatimah & Mahmudah, 2017). Thus, due to the efficiency performance of all provinces increase then it allows to improve quality education in Indonesia, especially at the high school level. According to Escardibul & Calero (2013), teaching staff and school autonomy have positive impact on the quality of education system.

This study uses data envelopment analysis model which is well known as a powerful method in measuring the level of efficiency of decision making units (Fatimah &Mahmudah, 2017). Efficiency measurement is introduced by Farrel (1957) which becomes the most widely used method by other researchers. Whereas data envelopment analysis (DEA) is introduced by Charnes, Cooper, & Rhodes (1978) where there are three main components, namely input, output and DMUs. Further, this method is developed by Banker, Charness, & Cooper (1984). Basically, DEA model compares DMUs to find out which units perform efficiently based on the input variables in producing the targeted outputs. Therefore, these units can be used as references for other units to improve their performance to the point of efficiency (Banker,et al., 1984). Data envelopment analysis uses a scale of 0 to 1 to representing the efficiency of each DMU where a unit is said to have efficient performance when the efficiency score is 1, otherwise, when its score is less than 1 then their performance is categorized as inefficient (Charnes, et al., 1978;Banker,et al., 1984).

Although this method is the most popular among other methods of measuring efficiency, in fact the researchers found that DEA is very sensitive to the existence of outliers which leads to less accurate results of efficiency scores (see Gstach (1998); Simar & Wilson (1998); Ben-Tal&Nemirovski (2000); Bertsimas&Sim (2003); Mahmudah, et al.(2018); et cetera). In addition, according to Simar & Wilson (1998) this method also requires input and output data with a high level of accuracy and precision, which is very difficult to obtain in real research.

In order to deal with problems of outliers that exist in the DEA method, researchers provide suggestions that can be used. Cooper, Huang, Lelas, & Olesen (1998) and Gstach (1998) use stochastic approach on DEA. Meanwhile, Bertsimas & Sim (2003) and Mahmudah, et al. (2018) use robust approach to reduce the impact of outliers in DEA method. However, this study applies bootstrap approach introduced by Efron (1979) to face the existence of outliers in the DEA traditional. This approach is a re-sampling method that is commonly used to other analytical methods to get better accuracy of the results. Further, this study also applies the algorithms of bootstrapped DEA introduced by Simar &Wilson (1998) to obtain bias-corrected efficiency score.

Based on the problems that have been mentioned above, this study aims to analyze the efficiency performance of high school education in Indonesiabased on its specialization groups, namely natural and social sciences. This study is very important to understand the level of efficiency performance of each province in organizing high schools education therefore we can determine which provinces have good performances.Province that has the best efficiency performance is entitled to be role model for other provinces to improve their performances.This study also provides a good overview of the performance of each province in organizing high schools specialization groups, namely natural and social sciences. Furthermore, this study is expected to improve the quality of Indonesian education by producing competitive students for both natural and social sciences.

METHOD

This study uses the statistics of general senior secondary school data in 2016, which is taken from the center for Education and cultural Data and Statistics, Ministry of Education and Culture of Republic of Indonesia. This study uses all provinces in Indonesia, which a total of 34 provinces as decision making units (DMUs) by using six input variables and four output variables. The input variables are the number of participants of national exam, the number of students, the number of schools, the number of teachers, the number of libraries, and the number of classrooms whereas the output variables are the number of graduates, the average score of national exam in Indonesian, English, and mathematics. In determining these variables are based on Fatimah & Mahmudah (2017) and Mahmudah, et al. (2018).

In order to produce the empirical results, which are the efficiency scores for each province based on the input and output variables,this study applies bootstrap approach on data envelopment analysis introduced by Simar &Wilson (1998), where sample replication has a very important role in providing better results.

Data envelopment analysis is a nonparametric method which is often used by researchers in analyzing technical efficiency of a unit or a program because of its simplicity. Besides, this method does not require statistical assumptions that usually exist in parametric approaches so that the results of the analysis depend only on the three categories in DEA, which are input and output variables and DMUs. Therefore, selection of these components is fundamental in applying this method due to accuracy and preciseness of input and output variables greatly influence the final conclusions. Unfortunately, in the sampling process researchers usually face difficulties in getting data that has a high level of accuracy. Besides, it is well known that one of the weaknesses of DEA is the difficulty of applying statistical inference to the DEA score (Simar &Wilson, 1998). Therefore, a bootstrap approach is applied in DEA which allows reducing the sensitivity of efficiency scores from the traditional DEA. Basically, bootstrapping DEA is based on data generating process (DGP) to produce the expected final results.

Generally, DEA estimator based on multiple inputs and outputs can be described as follows. Let X and Y are input and output variables are used in the production process Ψ where the input set represents the technology set $L(Y) = \{X{:}(X,Y) \in \Psi\}$. Then based on Farrel (1957) the technical efficiency is defined as $\theta(X,Y) = \min\{\theta{:}\theta X \in L(Y)\}$. Due to DEA is production frontier boundary then in generating samples is not straightforward but using smoothed bootstrap by drawing with replacement from the original estimates. Simar & Wilson (1998) use a kernel smoothing in order to generate pseudo efficiency scores, where this procedure is based on the reflection method (Silverman, 1986). Bootstrapping DEA according to Simar &Wilson (1998) can be described through the following algorithms:

Step 1:
Calculating efficiency scores using the traditional DEA, $\theta_i = \theta_1, \theta_3, ..., \theta_n$ where i = 1, 2 ,..., n

Step 2:
Generating random samples from the values from step 1 to produce $\theta_{bi} = \theta_{b1}, \theta_{b3}, ..., \theta_{bn}$ where i = 1, 2 ,..., n

Step 3:
Smoothing these samples in step 2 by using

$$\hat{\theta}_i^* = \begin{cases} \theta_{bi} + he_i^* & \text{if } \theta_{bi} + he_i^* \geq 1 \\ 2 - \theta_{bi} - he_i^* & \text{if} \theta_{bi} + he_i^* < 1 \end{cases}$$

where h represents the bandwidth parameter.

Step 4:
Calculating the final value of efficiency scores θ^* by using:

$$\theta_i^* = \bar{b} + \frac{\hat{\theta}_i^* - \bar{b}}{\left(1 + h^2/\hat{\sigma}_\theta^2\right)^{1/2}}$$

where $\bar{b}$ and $\hat{\sigma}_\theta^2$ represent the average and variance of efficiency score, respectively.

Step 5:
Adjusting the original output by using θ_1/θ_i^*

Step 6:
Recalculate the efficiency scores by using the values in step 5 to produce $\hat{\theta}_k^*$

Step 7:
Repeat step 2 – 6 as many as *b* times to obtain *b* times of estimates.

These algorithms are used in order to obtain bias-corrected efficiency scores from bootstrap DEA. To give a clear picture of the difference between the traditional DEA and the bootstrapped DEA then the efficiency scores for both methods are presented in this study. Besides that, the bootstrap bias estimates are also presented. Furthermore, this study provides confidence interval for the estimated efficiencies from bootstrapped DEA based on Efron (1979). Confidence interval of mean bootstrap 100(1 – α)% when α = .5 is defined as follows.

$$\hat{\theta} \pm z_{\alpha/2}se = \hat{\theta} \pm z(\frac{\alpha}{2})\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(\hat{\theta}_i - \hat{\theta}\right)^2}$$

However, this study uses several conditions in order to apply bootstrap approach on DEA. The numbers of bootstrap replication B=1000 and B=2000 while the value of alpha which is related to the confidence interval for the bias corrected efficiencies is .05. Further, this study uses input-oriented model of DEA which is applied to analyze whether a DMU under evaluation is able to reduce the existing inputs when the outputs are fixed.

FINDINGS AND DISCUSSION

Results

To obtain the expected results, this study uses secondary data based on statistical data of high school in Indonesia published by Ministry of Education and Culture of Republic of Indonesia in 2016. This study uses six input variables, namely the number of national exam participants, the number of students, the number of schools, the number of teachers, the number of libraries, and the number of classrooms. Meanwhile, there are four output variables are used, i.e., the number of graduates, the average score of national exam in Indonesian, English, and mathematics. It is important to note that these three subjects are mandatory subjects that are tested on both natural and social sciences. Furthermore, selection of the input and output are based on the National Education Standards (see Fatimah & Mahmudah, 2017). Further, there are 34 provinces in Indonesia are used as decision

Table 2. Statistics Descriptive of Natural Sciences

Variables	Minimum	Maximum	Mean	Std.Dev
*X*1	2056	105157	22296.09	26229.39
*X*2	14357	577605	126835.50	133009.90
*X*3	55	1441	373.21	348.14
*X*4	103	13979	2562.79	3417.38
*X*5	41	1016	277.88	253.76
*X*6	489	18261	4388.06	4338.48
*Y*1	64.54	82.79	73.28	4.98
*Y*2	49.83	85.66	63.20	7.67
*Y*3	32.03	80.74	54.42	11.75
*Y*4	4709	182795	41870.79	43196.72

Table 3. Statistics Descriptive of Social Sciences

Variables	Minimum	Maximum	Mean	Std.Dev
*X*1	2614	120098	25084.65	28307.40
*X*2	14357	577605	126835.50	133009.90
*X*3	55	1441	373.21	348.14
*X*4	103	13979	2562.79	3417.38
*X*5	41	1016	277.88	253.76
*X*6	489	18261	4388.06	4338.48
*Y*1	53.53	76.72	65.37	5.70
*Y*2	43.81	81.53	56.26	8.25
*Y*3	32.25	73.55	51.77	10.92
*Y*4	4709	182795	41870.79	43196.72

Table 4. Efficiency Scores of Natural Sciences

DMUs	theta	B=1000				B=2000			
		theta	bias	Low	Up	theta	bias	Low	Up
Aceh	1.00	.98	.02	.93	1.00	.98	.02	.94	1.00
Bali	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Bangka Belitung	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Banten	.94	.93	.01	.91	.94	.93	.01	.91	.94
Bengkulu	1.00	.99	.01	.96	1.00	.99	.01	.96	1.00
DI Yogyakarta	1.00	.99	.01	.94	1.00	.98	.02	.93	1.00
DKI Jakarta	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Gorontalo	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Jambi	.99	.99	.01	.97	.99	.99	.01	.97	.99
West Java	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Central Java	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
East Java	1.00	.99	.01	.93	1.00	.98	.02	.93	1.00
West Kalimantan	1.00	.98	.02	.94	1.00	.98	.02	.94	1.00
South Kalimantan	.98	.97	.01	.95	.98	.97	.01	.95	.98
Central Kalimantan	.96	.95	.01	.94	.96	.95	.01	.94	.96
East Kalimantan	.92	.91	.01	.90	.92	.91	.01	.90	.92
North Kalimantan	1.00	.98	.02	.94	1.00	.98	.02	.93	1.00
Riau Island	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Lampung	.96	.95	.01	.94	.96	.95	.01	.94	.96
Maluku	.99	.98	.01	.97	.99	.98	.01	.97	.99
North Maluku	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
West Nusa Tenggara	.96	.95	.01	.94	.96	.95	.01	.94	.96
East Nusa Tenggara	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Papua	.96	.96	.01	.95	.96	.96	.01	.95	.96
West Papua	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
Riau	1.00	.99	.01	.96	1.00	.99	.01	.96	1.00
West Sulawesi	1.00	.98	.02	.94	1.00	.98	.02	.93	1.00
South Sulawesi	1.00	.98	.02	.94	1.00	.98	.02	.93	1.00
Central Sulawesi	.96	.95	.01	.93	.96	.95	.01	.93	.96
Southeast Sulawesi	1.00	.98	.02	.93	1.00	.98	.02	.94	1.00
North Sulawesi	1.00	.99	.01	.96	1.00	.99	.01	.96	1.00
West Sumatra	1.00	.98	.02	.94	1.00	.98	.02	.93	1.00
South Sumatra	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00
North Sumatra	1.00	.98	.02	.93	1.00	.98	.02	.93	1.00

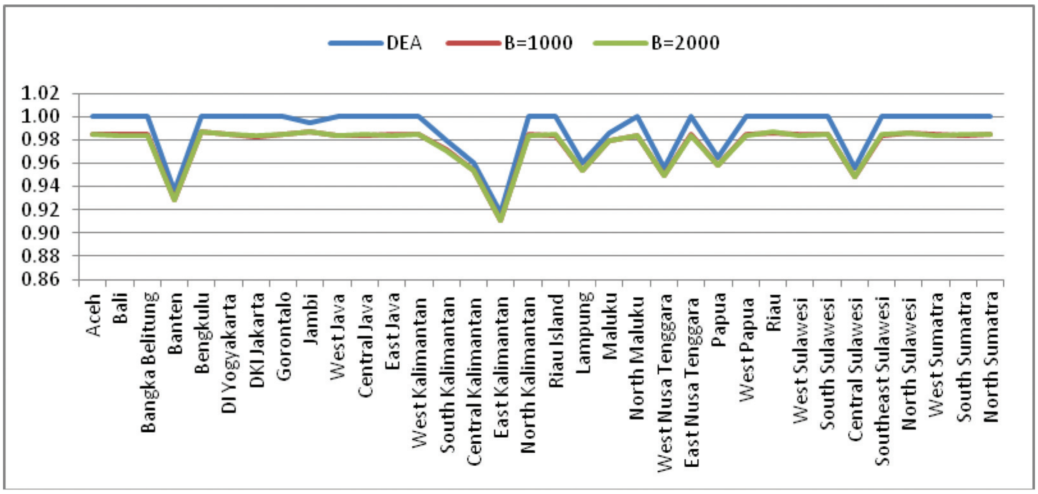

Figure 1. Efficiency Scores of Natural Sciences

Table 5. Efficiency Scores of Social Sciences

DMUs	theta	B=1000				B=2000			
		theta	bias	Low	Up	theta	bias	Low	Up
Aceh	1.00	.98	.02	.92	1.00	.97	.03	.92	1.00
Bali	1.00	.97	.03	.92	1.00	.98	.02	.92	1.00
Bangka Belitung	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
Banten	.93	.92	.01	.91	.93	.92	.01	.91	.93
Bengkulu	1.00	.98	.02	.95	1.00	.98	.02	.95	1.00
DI Yogyakarta	1.00	.97	.03	.92	1.00	.98	.02	.92	1.00
DKI Jakarta	1.00	.98	.02	.96	1.00	.98	.02	.95	1.00
Gorontalo	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
Jambi	.99	.98	.01	.95	.99	.98	.01	.95	.99
West Java	1.00	.98	.02	.92	1.00	.97	.03	.92	1.00
Central Java	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
East Java	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
West Kalimantan	.95	.94	.01	.92	.95	.94	.01	.92	.95
South Kalimantan	.92	.91	.01	.89	.92	.91	.01	.88	.92
Central Kalimantan	.93	.92	.01	.90	.93	.92	.01	.90	.93
East Kalimantan	.91	.90	.01	.88	.91	.90	.01	.88	.91
North Kalimantan	1.00	.97	.03	.92	1.00	.97	.03	.92	1.00
Riau Island	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
Lampung	.95	.94	.01	.93	.95	.94	.01	.93	.95
Maluku	.96	.95	.01	.93	.96	.95	.01	.93	.96
North Maluku	1.00	.97	.03	.92	1.00	.97	.03	.92	1.00
West Nusa Tenggara	.96	.95	.01	.93	.96	.95	.01	.93	.96
East Nusa Tenggara	.92	.91	.01	.87	.92	.91	.01	.88	.92
Papua	.95	.94	.01	.93	.95	.94	.01	.93	.95
West Papua	1.00	.97	.03	.92	1.00	.98	.02	.92	1.00
Riau	.99	.98	.01	.95	.99	.98	.01	.95	.99
West Sulawesi	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
South Sulawesi	1.00	.97	.03	.92	1.00	.97	.03	.92	1.00
Central Sulawesi	.96	.95	.01	.92	.96	.95	.01	.92	.96
Southeast Sulawesi	1.00	.97	.03	.92	1.00	.98	.02	.92	1.00
North Sulawesi	1.00	.99	.01	.95	1.00	.99	.01	.96	1.00
West Sumatra	1.00	.98	.02	.92	1.00	.98	.02	.92	1.00
South Sumatra	1.00	.98	.02	.95	1.00	.98	.02	.95	1.00
North Sumatra	1.00	.97	.03	.92	1.00	.98	.02	.92	1.00

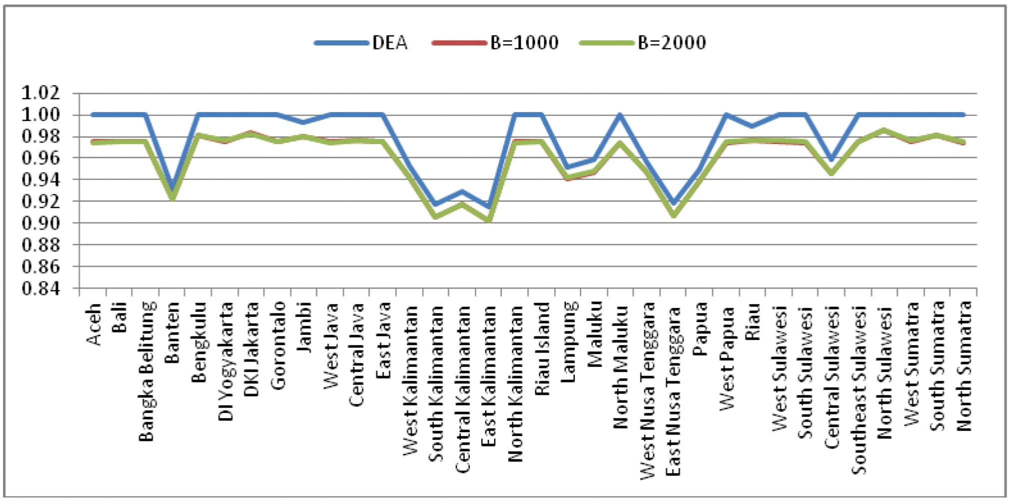

Figure 2. Efficiency Scores of Social Sciences

making units. Table 2 presents the general description of the input and output variables for natural science specializationswhereas Table 3 shows statistics descriptive of social science specializations that are used in this study.

From table 2 and Table 3, input variables are represented by X_i where *X*1 is the number of participants of national exam in 2016, *X*2 is the number of students, *X*3 is the number of schools, *X*4 is the number of teachers, *X*5 is the number of libraries, and *X*6 is the number of classrooms. Meanwhile, output variables are represented by $Y_i$where *Y*1 is the average score of national exam in Indonesian, *Y*2 is the average score of national exam in mathematics, *Y*3 is the average score of national exam in English, and *Y4* is the number of graduates.

To analyze technical performance of all provinces in organizing high school education for natural science specializations then the input and output data in table 2 are analyzed by using R studio. Table 4 shows the efficiency scores for both the traditional DEA and bootstrapped DEA of natural sciences specializations.

From Table 4, **theta** indicates the efficiency scores for the traditional DEA and bootstrapped DEA; **bias** represents the bootstrap bias estimates for the DMUs whereas **Low** and **Up** indicate the lower and upper bounds of confidence intervals, respectively. Further, B=1000 and B=2000 indicate the numbers of bootstrap replications. Table 4 indicates the efficiency scores for natural sciences where the average efficiency score of the traditional DEA is .99 while its average for bootstrapped DEA is .98 where both the numbers of replicates B=1000 and B=2000 produce similar value.Figure 1 shows the relationship of the efficiency scores from the traditional DEA and bootstrapped DEA for natural sciences.

From figure 1 it can be seen clearly that the efficiency scores from the traditional DEA has linear relationship with the efficiency scores from the bootstrapped DEA, where the scores of the traditional DEA are represented by blue line whereas the bias-corrected scores of the bootstrapped DEA are represented by red and green lines for the numbers of replications B=1000 and B=2000, respectively.

Furthermore, to measure the technical performance of these provinces in social science specializations then the input and output data in table 3 are analyzed. Table 5 shows the efficiency scores for both the traditional DEA and bootstrapped DEA of social sciences.

Table 5 indicates the efficiency scores for each DMU based on social sciences specializations where the average efficiency score of the traditional DEA is .98 while its average of bootstrapped DEA is .96 where both the number of replications B=1000 and B=2000 provide similar value. This indicates similar results to the natural sciences specializations where the traditional DEA produce higher average efficiency score than the bootstrapped DEA although the difference is not significant. Figure 2 shows the relationship of the efficiency scores from the traditional DEA and bootstrapped DEA for social sciences.

From figure 2 it also can be seen clearly that the traditional DEA and bootstrapped DEA have linear relationship where the efficiency scores of the bootstrapped DEA go along with the efficiency scores of the traditional DEA increase.

Discussion

This study applies bootstrap approach on data envelopment analysis in order to test the efficiency performance of high schools education in Indonesia. As mentioned earlier, bootstrap approach is expected to produce better accuracy than traditional DEA. Further, this study focuses on comparing its efficiency on natural and social sciences specializations, which are commonly offered by all high schools in Indonesia. There are six input variables and four output variables are used to analyzing the efficiency of 34 DMUs which are represented by all Indonesian provinces.

In order to obtain the efficiency scores which represent all of provinces efficiency performances, this study follows the algorithms that are suggested by Simar & Wilson (1998) where bias-corrected efficiency scores from bootstrapped DEA are analyzed to deal with the sensitivity of the traditional DEA.

The empirical results of the traditional DEA produce the following results. The average efficiency score of natural science is .99 and its standard deviation is .02, which means that the performance of all provinces in organizing high schools education in natural sciences specialization reaches 99%. Meanwhile, the average score of social sciences is .98 while the standard deviation is .03, which means that all provinces in Indonesia are able to support their activities by using 98% of their resources. Further, based on the idea of Thanassoulis, Dyson, & Foster(1987) of the discrimination phase then the provinces in Indonesia are expected to be able to support the activity by using 99% and 98% of the existing resources for natural and social sciences specializations, respectively.

These results indicate that all provinces in Indonesia have very good performance in organizing high school for both natural and social sciences specializations.This statement is also supported by the results also indicate for the two specializations produce more than 50% of provinces perform efficiently, where their efficiency scores are 1.00. Natural science produce as many as 24 provinces (70.59%) have efficient performance. Meanwhile, there are 21 provinces (61.76%) perform efficiently in organizing high school education for social science. Beside, the lowest scores of technical efficiency for both natural and social sciences are .92 and .91, respectively. It comes as no surprise that for the two specializations it was found that East Kalimantan province has the lowest performance efficiency.

Thus, we can safely conclude that overall all provinces in Indonesia have worked very well in carrying out their duties to organize high schools where both the average score and the lowest score of efficiency are more than 90%. This result is in line with the studies conducted by Gharakhani, Kazemi, & Haji (2011) and Mahmudah, et al. (2018) where all provinces have performance efficiency more than 90% in organizing high schools.

Summing it up, based on the traditional DEA the results show a slight difference in natural and social sciences where provinces in Indonesia has a slightly better performance in organizing high schools based on specialization of natural sciences. The results show that natural science has a higher average score of efficiency scores than social science. Further, the lowest score efficiency for natural science is higher than social science. Besides, natural science also produces more provinces that have efficient performance. These show excellent accuracy of the estimation results for the two specializations.

By using the algorithms of bootstrapped DEA proposed by Simar & Wilson (1998) then the bias-corrected scores are as follows. Based on table 4 and table 5 the bootstrap approach provides consistent results for both the numbers of replication B=1000 and B=2000 where they produce values whose differences are not significant. Further, they produce efficiency scores whose values are not far from the efficiency scores based on the traditional DEA. In fact, these values follow the efficiency scores of the traditional DEA continuously. It is important to note that both specializations produce consistent results.

Based on table 4 the average efficiency score for natural sciences specialization based on the bootstrap DEAis .98, which is smaller than the average score from the traditional DEA (.99). This result is consistent with the previous studies which suggest that bootstrapped DEA tend to produce smaller values of efficiency scores than the traditional DEA (see Simar & Wilson (1998); Ben-Tal&Nemirovski (2000); Bertsimas& Sim (2003); Mahmudah, et al. (2018), et cetera). Whereas the average of bias estimates is .01, which is very small. Further, the average range of lower and upper bounds is .05 which also indicate a very small range.

Furthermore, the average efficiency score for social science based on the bootstrapped DEA for both the number of replications B=1000 and B=2000 provide similar value, which is .96. For the same reason, this result also consistent with the previous studies because the average score based on the traditional DEA is .98. The bootstrapped DEA for social science also produce very small value for both the average of bias estimate and the range, which are .02 and .06. The results of the bootstrapped DEA also indicate provinces in Indonesia have better performance in organizing natural science than social science, which has no contradiction with the results published by Mahmudah, et al. (2018).

The results of the bootstrapped DEA also reveal that the province that has the lowest efficiency score in organizing natural and social sciences specializations is East Kalimantan where the scores are .91 and .90, respectively. Therefore, it is safe to conclude that the province of East Kalimantan has the worst performance among all provinces in organizing high school education of both natural and social sciences specializations. However, based on Thanassoulis, et al. (1987) East Kalimantan is expected to be able to support its activity regarding the existing resources by using 91% and 90% for both natural and social sciences, respectively. This shows that the province of East Kalimantan actually has good performance in organizing natural and social sciences specializations. Therefore, based on both the traditional DEA and bootstrapped DEA it can be said that all provinces in Indonesia perform well generally.

Furthermore, based on figure 1 and figure 2 also indicate that when the efficiency scores of the traditional DEA increase then the bias-corrected scores of bootstrapped DEA go up. On the contrary, when the efficiency scores in the traditional DEA decrease, its scores in the bootstrapped DEA go down. These figures illustrate clearlythe linear relationship between the traditional DEA and bootstrapped DEA, where the efficiency scores of the bootstrapped DEA go along with the efficiency scores of the traditional DEA.

Overall, the empirical results based on table 4 and table 5 reveal that bootstrap approach provides bias-corrected efficiency scores that do not conflict with the traditional DEA. These statements are in line with previous studies which state there is no contradiction between the traditional DEA and the bootstrap DEA because the second approach is to improve the traditional DEA (see Simar & Wilson (1998) and Bertsimas& Sim (2003); and Mahmudah, et al. (2018)). Most studies apply bootstrap or robust approach on DEA model in analyzing efficiency performance claim that the approaches provide better accuracy then the traditional DEA (seeSimar & Wilson (1998); Bertsimas& Sim (2003); Gharakhani, et al. (2011); Mahmudah, et al. (2018), et cetera).

Furthermore, the bias-corrected efficiency scores from bootstrapped DEA are always in the interval ranges where the scores of the traditional DEA tend to be the same as the upper limit of the confidence intervals of the estimated efficiencies from bootstrapped DEA. The results also indicate that bootstrap approach provides a narrow range of confidence intervals for both natural and social sciences specializations. This shows that bootstrap approach on DEA model provides consistent results while the traditional DEA tends to obtain over-estimate efficiency scores therefore the final results are less reliable.

To crown it all, bootstrap approach produces less uncertainty of the estimation results of efficiency scores in analyzing the performance of Indonesian provinces in organizing high schools for both natural and social sciences specializations. Thus, it can be said that the bootstrapped DEA produces better results than the traditional DEA because its accuracy is better.

CONCLUSION

This study measures the efficiency performance of Indonesian provinces in organizing high schools education for both natural and social sciences specializations by using data envelopment analysis. This method is one of the most popular methods in measuring technical efficiency of DMUs because its simplicity. However, bootstrap approach is applied on DEA in order to deal with the weakness of the traditional DEA where this method needs high level accuracy of input and output data. Besides, the existence of outliers tends to cause the traditional DEA produce over-estimate efficiency scores. The empirical results indicate that all provinces in Indonesia perform very well in organizing high school education for both natural and social sciences specializations. The results also reveal that all provinces in Indonesia have better performance in organizing natural sciences than social sciences where the traditional DEA produce as many as 70.59% and 61.76% of the provinces that perform efficiently based on natural and social sciences, respectively.

Furthermore, the results indicate that bootstrap approach provides consistent results where its efficiency scores follow the efficiency scores of the traditional DEA continuously. The results also indicate that bootstrap approach on DEA provide better accuracy of efficiency scores while the traditional DEA tends to produce over-estimate efficiency scores. Therefore, this study suggests that bootstrapped DEA is more appropriate to be implemented when measuring the efficiency performance due to it provides better precision results.

REFERENCES

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management*

Science, *3*(9), 1078-1092.doi:10.1287/mnsc.30.9.1078.

Ben-Tal, A. & Nemirovski, A. (2000). Robust solutions of linear programming problems contaminated with uncertain data. *Mathematical Programming*, *88*(3), 411-424. doi:10.1007/PL00011380.

Bertsimas, D. & Sim, M. (2003). Robust discrete optimization and network flows. *Mathematical Programming, 98*(1), 49-71. doi:10.1007/s10107-003-0396-4.

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429–444. doi:10.1016/0377-2217(78)90138-8.

Cooper, W. W., Huang, Z. M., Lelas, V, Xi, S. & Olesen, O. B. (1998). Chance constrained programming formulations for stochastic characterizations of efficiency and dominance in DEA. *Journal of Productivity Analysis*, *9*(1), 53-79.doi:10.1023/A:1018320430249.

Escardibul, J. & Calero, J. (2013). Two quality factors inthe education system: teaching staff and school autonomy. The current state of research. *Regional and Sectoral Economic Studies*, *13*(3), 1-14.

Efron, B. (1979). Bootstrap methods: Another look at the Jackknife. *Annals of Statistics*, *7*(1), 1-26.doi:10.1214/aos/1176344552.

Farrell, M.J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society Series*, *120*(3), 253-290.doi:10.2307/2343100.

Fatimah, S. & Mahmudah, U. (2017). Data Envelopment Analysis (DEA): Pengukuran efisiensi kinerja sekolah dasar. *Cakrawala Pendidikan*, *37*(2), 233-243. doi:10.21831/cp.v36i2.11511.

Gharakhani, M., Kazemi, I., & Haji, H. H. (2011). A robust DEA model for measuring the relative efficiency of Iranian high schools. *Management Science Letters*, *1*(3), 389–404. doi:10.5267/j.msl.2011.01.002.

Gstach, D. (1998). Another approach to data envelopment analysis in noisy environments: DEA+. *Journal of Productivity Analysis, 9*(2), 161-176. doi:10.1023/A:1018312801700.

Mahmudah, U. Suhartono, & Rohayana, A. D. (2018). A robust data envelopment analysis for evaluating technical efficiency of Indonesian high schools. *Indonesian Journal of Science Education*, *7*(1), 114-121.doi:10.15294/jpii.v7i1.9883.

RoI, Ministry of Education and Culture. (2016). *Statistik Sekolah Menengah Atas* (*SMA*) *2015/2016*. Center for Educational Data and Statistics and Culture 2016. Retrieved from http://publikasi.data.kemdikbud.go.id/uploadDir/isi_583FC30B-53E3-42F5-88EB-940540BB8E5A_.pdf.

RoI, Ministry of Education and Culture. (2016). *Nilai rata-rata sekolah UN*. Retrieved fromhttps://data.go.id/dataset/nilai-rata-rata-sekolah-un.

RoI, Ministrial Regulation of Education and Culture 2013 No. 69, Basic Framework and Curriculum Structure.

Silverman, B. W. (1986). *Density estimation for statistics and data analysis*. London: Chapman and Hall Ltd.

Simar, L. & Wilson, P. W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. *Management Science*, *44*(1), 49-61.doi:10.1287/mnsc.44.1.49.

Thanassoulis, E., Dyson, R. G., & Foster, M. J. (1987). Relative efficiency assessments using data envelopment analysis: an application to data on rates departments. *Journal of Operational Research*, *38*(5), 397-412. doi:10.2307/2582729.