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Multi-Stage Data Envelopment Analysis to Evaluate Inclusive-Based Elementary Schools in Indonesia

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Abstract

The main purpose of this study is to evaluate inclusive-based elementary schools in Indonesia by measuring the technical efficiency of these schools. Data envelopment analysis (DEA) was used to obtain the efficiency scores where there were two popular models; CRS and VRS model. As many as 38 primary schools in Central Jakarta in Indonesia in the period 2014/2015 were determined as decision making units (DMUs) with six inputs and four outputs. The results revealed that CRS (constant returns to scale) model produced as many as 9 schools with efficient performances while VRS (variable returns to scale) model produced as many as 25 schools that performed efficiently whereas there were 12 schools (31.58 percent) had the efficiency scores below the average scores for both CRS and VRS models. Further, the average scores of CRS and VRS models were 0.819 and 0.869, respectively. Overall, elementary schools which implemented inclusive education in Central Jakarta are suggested to improve their performances.

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INTRODUCTION

Education has a huge contribution to the knowledge, attitude, or skills of the community. Indonesia, as a developing country, should have continuous innovation to improve the education quality. Therefore, the implemented educational system will be capable to produce high-quality human resources to advance the competitiveness. In an effort to improve quality education, Indonesian government has a policy to support the impelementation of inclusive education. Inclusive schools in Indonesia aim to provide equal right for people who have physical, emotional, intellectual or social disabilities to obtain qualified education. it was reinforced by the Law Number 8 of 2016 on Disabilities which stated the persons with disabilities had the same rights to get qualified education in educational units of all types, paths, and levels of education inclusively as well as specially. Further, the regulation of Minister for National Education Number 70 Year 2009 defined inclusive education as a system of education that provide opportunities to all students who have disabilities and intelligence potential and/or special talents to participate into an educational environment along with students in general. Meanwhile, UNESCO (2009) described that inclusive education as a process to strengthen the capacity f system education to reach all students and it was fundamental strategy for achieving Education for All (EFA).

The establishment of inclusive education was based on a world conference on special needs education which was held in Salamanca, Spain in June 1994. It proclaimed that regular schools with an inclusive orientation was the most effective way to combat discriminatory attitudes, create a sociable society, build an inclusive society to achieve education for all (UNESCO, 2009). Therefore, the inclusive education allows students with disabilities obtained similar education services to other students. However, the implementation of inclusive education requires various preparations such as the existing facilities and infrastructures should properly support the activities of students with special needs. Other than that, it should be noted about the learning patterns of these students which were certainly different from other students. It is important to consider both of them because they were indicators used by the Indonesian government to measure the quality education. According to the National Education Standards Agency there were eight indicators; graduate competency standards, content standards, process standards, assessment standards, standards of teachers and education personnel, facilities and infrastructure standards, management standards and funding standards. Therefore, the quality education not only relies on results but also emphasizes the process of learning. Further, Primary and Secondary Education of the Republic of Indonesia (2016) stated that the success of education quality assurance by educational unit is measured through several indicators, namely process, output, outcome and impact.

Duke et al. (2017) explained that the development of inclusive education policy was expected to reflect the culture, values and vision of a country where the main priorities of this development were beliefs, skills, and practices. A study conducted by Miskolci et al. (2016) revealed that the practice of inclusive education at the levels of school and class could not be separated from the socio-political aspect. In addition, teachers and other school stakeholders had an important role in conceptualizing inclusive education. UNESCO (2009) described several important aspects of implementing inclusive education as shown in Figure 1.

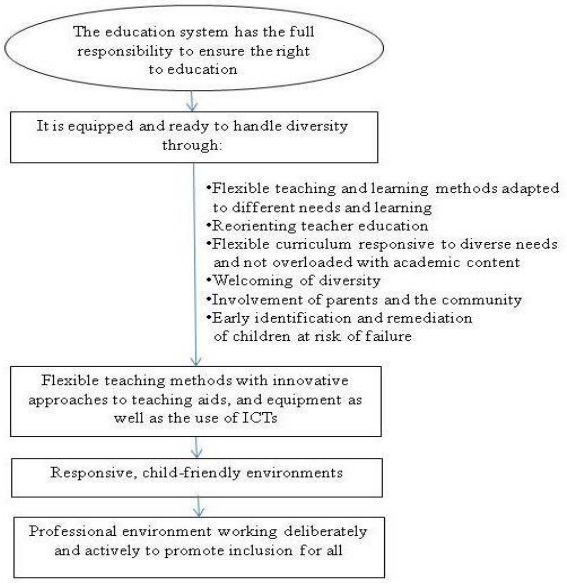

Figure 1. Inclusive Education (source: UNESCO, 2009)

Figure 1 indicates there are several things that need to be addressed in inclusive education; the use of flexible learning methods tailored to each student with special needs, preparation of inclusive-oriented educators, and the availability of flexible and responsive curriculum for various needs and not overloaded with academic content, capable of receiving diversity and the involvement of parents and community.

According to the Central Bureau of Statistics in Indonesia, the number of children with special needs in 2015 was 1.6 million. Further, the government rendered the education access for them by establishing and encouraging inclusive-based schools in the regions. Hereafter, there were 32 thousands inclusive schools in Indonesia and 299 thousands children with special needs participated in inclusive schools. Jakarta, a capital city of Indonesia was one of the regions that had a lot of inclusive schools at all level of educations, such as preschool, elementary school, junior high school and senior high school. Therefore, Jakarta was inaugurated as one of the provinces of inclusive education. Even though inclusive schools were applied in all level of education in Jakarta but elementary school level produced the largest number of inclusive schools, In 2015, there were 258 elementary school based on inclusive education.

Efficiency measurement of inclusive-based schools was important to be carried out because it is related cohesively to the education quality. The most popular method to measure efficiency performance is Data Envelopment Analysis (DEA) which defined as a methodology to evaluate the productivity of a decision-making unit (DMU) in producing the expected outputs using a number of inputs. There were two DEA models that were widely used by researchers in efficiency measurement analysis, first namely CRS (*Constant Returns to Scale*) model which was first introduced by Charnes, Cooper and Rhodes (1978) and it was commonly known by CCR model. Second VRS (*Variable Returns to Scale*) model was introduced by Banker, Charnes and Cooper (1984) so that it was also known as BCC model. However, this study presented both models in obtaining the efficiency scores to investigate which inclusive-based school that performed efficiently based on the existing input variables. Numerous studies used DEA method in measuring a unit, an organization or a program in education domain. Carrington, Coelli and Rao (2005) analyzed the efficiency performance of Australian Universities used DEA method. As there were 35 universities in the period 1996 to 2000 were investigated by utilizing both quantity and quality measurements. The results revealed that there was relatively efficient sector and there was excellent productivity growth of the most economy sectors. The efficiency measurement of higher education in Australia also studied by Duan and Deng (2016) in 36 universities since 2011 until 2015. The results indicated that all universities had relative efficient performance where the average efficiency scores in operation and research terms were 0.95 and 0.90 respectively.

Meanwhile, Kecek and Demirag (2016) measured primary schools efficiency in Turkey using DEA method and it was condutcted in 10 primary schools in the province of Kutahya as DMUs and three input also two input variables where the results revealed that only 40 percent of these primary schools performed efficiently. Fatimah and Mahmudah (2017) used two-stage data envelopment analysis to investigate the performance of elementary schools in Indonesia. They utilized all of 34 Indonesia's provinces where six inputs and three outputs were used. The results indicated that 17 provinces performed efficiently according to VRS model while there were only 12 provinces with efficient performances based on CRS model. Other studies investigated the efficiency performance of primary schools such as Hu, Zhang and Liang (2009), Zhang (2010), Yawe (2014). Although there were studies measuring elementary schools efficiency using DEA method but studies focusing on the efficiency of elementary schools that applying inclusive education was still rarely encountered. As mentioned above, inclusive based schools were important to be organized to render equality of rights to all Indonesian citizens. Therefore, a study on inclusive-based elementary schools was required to analyze which schools performed efficiently. Other than that, this study allows investigating the schools that needed to improve their performances in providing proper education for students with special needs.

METHODOLOGY

This study was an evaluation research towards the efficiency measurement of elementary schools in Indonesia which applied inclusive education. The documentation technique was implemented where sampling data were obtained from the official website of Jakarta education agency. Data envelopment analysis (DEA) method was used to obtain the technical efficiency scores of schools. This method was the most popular among the researchers in analyzing efficiency measurement. There were two models of DEA, namely CRS model that introduced by Charnes, Cooper, and Rhodes (1978) and VRS model which introduced by Banker, Charnes, and Cooper (1984). Multi-stage DEA carried out sequence of radial linear program to identify efficient projection point where possessed a mixture of input and output variables that as similar as possible with the inefficient projection point (Coelli, 1992). A basic model of DEA for the selected entity k was presented in the following equation (Charnes, Cooper and Rhodes, 1978).

$$\begin{aligned} &\max h_x = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \\ &\text{Subject to:} \\ &\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; \quad \forall j, j = 1,2,\dots,n \\ &u_r, v_i \geq 0; \quad r = 1,2,\dots,s \text{ and } i = 1,2,\dots,m \end{aligned} \tag{1}$$

where h_x represented the relative efficiency of DMU$_k$, u_r represented the weighted output r, v_i indicated the weighted input i, y_{rj} showed the quantity of output r produced by unit $j = 1,2,\dots,n$, x_{ij} showed the quantity of input i produced by unit $j = 1,2,\dots,n$, m was the number of input variables, s was the number of output variables, n indicated the number of entities. The equation (1) was equivalent with the following linear program:

$$\begin{aligned} &\max h_x = \sum_{r=1}^{s} u_r y_{rk} \\ &\text{Subject to:} \\ &\sum_{i=1}^{m} v_i x_{ij} = 1 \\ &\sum_{r=1}^{s} u_r y_{rk} - \sum_{i=1}^{m} v_i x_{ij} \leq 0; \quad j = 1,2,\dots,n \\ &u_r, v_i \geq 0; \quad r = 1,2,\dots,s \text{ and } i = 1,2,\dots,m \end{aligned} \tag{2}$$

For the simplicity, the equation (2) could be written as follows:

$$\begin{aligned} &\max(v,u) = uy_k \\ &\text{Subject to:} \\ &-vX + uY \leq 0 \\ &ux_k = 1 \\ &v \geq 0; u \geq 0 \end{aligned} \tag{3}$$

Further, the linear program in the equation (3) was converted into the dual problem for computational necessity and it was presented in the equation (4).

$$\begin{aligned} &\min(\theta,\lambda) = \theta \\ &\text{Subject to:} \\ &\theta x_k - X\lambda \geq 0 \\ &\lambda_j \geq 0 \end{aligned} \tag{4}$$

where θ indicate a real variable and $\lambda_j, j = 1,2,\dots,n$ showed a nonnegative vector. Moreover, BCC model of DEA was determined by adjoining the constraint of $\sum_{j=1}^{n} \lambda_j = 1$ which allowed the evaluation of return to scale impact (Banker, Charness and Cooper, 1984).

RESULTS AND DISCUSSION

This study used multi-stage VRS method to evaluate the performance of elementary schools in Indonesia which were based on inclusive education. There were three main steps in analyzing inclusive-based elementary schools efficiency measurement using DEA method as described as follow.

Step 1: Determining Decision Making Units (DMUs)

In this study, DMUs represented the primary schools which implemented inclusive education system in Indonesia. This study used primary schools in Central Jakarta, one of district in Jakarta region in the period 2014/2015 as the samples where 44 primary schools were implemented inclusive education. However, after selection model was applied, inaccurate and incomplete data was removed. As a result, there were 38 primary schools in Central Jakarta were appropriate to be used as DMUs in this study.

Step 2: Determining input and output variables

As mentioned before, efficiency measurement was the ratio of output and input variables. Therefore the determination of these variables was very important in order to get

empirical results accurately. However, the input and output variables in this study were adjusted to the National Education Standards which consisted of eight categories of quality education in Indonesia: competency standards, content standards, process standards, assessment standards, standards of teachers and education personnel, facilities and infrastructure standards, management standards and funding standards (National Education Standards Agency-*Badan Standar Nasional Pendidikan, BSNP*).

This study used six input variables which were the number of students, the number of students that participated in final exam, the number of teachers, the number of classes, the number of laboratories, and the number of libraries. Meanwhile, this study obtained four output variables the average test score of Indonesian language, the average test score of mathematics, the average test score of science and the average of national final exam.

Step 3: Calculating efficiency scores of each DMUs

This study used DEAP version 2.1 to obtain the expected results to evaluating inclusive-based elementary schools in Indonesia where the efficiency scores of two models of DEA, namely CRS and VRS models were produced. Further, slack values were determined by suing multi-stage method. By incorporating 38 elementary schools as decision making units with 6 inputs and 4 outputs descriptive statistics of the input and output variables analyzed in this study as shown in table 1.

Table 1. Descriptive Statistics

Variables	Min	Max	Ave	Std Dev
Output				
Y1	63.00	87.43	74.51	5.53
Y2	37.97	90.92	64.81	13.88
Y3	50.24	87.50	68.52	10.12
Y4	51.94	88.62	69.28	9.27
Input				
X1	141.00	779.00	326.53	131.25
X2	20.00	100.00	52.97	20.06
X3	8.00	31.00	16.11	5.75
X4	6.00	31.00	11.84	6.21
X5	0.00	3.00	0.68	0.81
X6	0.00	2.00	0.84	0.44

In Table 1, Y1 indicated the average test score of Indonesian Language, Y2 shows the average test score of Mathematics, Y3 represents the average test score of Science and Y4 is the average of national final exam. Further, X1 indicates the number of students, X2 shows the number of students who participate in final exam, X3 indicates the number of teacher, X4 shows the number of classes, X5 shows the number of laboratories and X6 shows the number of libraries. Thus, table 2 indicates the results from DEAP version 2.1. Both efficiency scores from CRS and VRS models were presented to see the comparison. However, it is important to note that all subsequent results were referred to VRS model results due to in general this model produced better efficiency scores than CRS model.

Table 2. Efficiency Scores

Schools	CRS	VRS	Scale		Schools	CRS	VRS	Scale	
1	0.991	1.000	0.991	drs	20	0.922	1.000	0.922	irs
2	1.000	1.000	1.000	-	21	1.000	1.000	1.000	-
3	1.000	1.000	1.000	-	22	1.000	1.000	1.000	-
4	0.612	0.654	0.935	drs	23	0.957	1.000	0.957	irs
5	0.943	1.000	0.943	irs	24	0.930	1.000	0.930	irs
6	1.000	1.000	1.000	-	25	0.896	1.000	0.896	irs
7	1.000	1.000	1.000	-	26	0.668	0.668	1.000	-
8	1.000	1.000	1.000	-	27	0.294	0.299	0.983	irs
9	0.728	0.778	0.936	irs	28	0.425	0.445	0.955	irs
10	1.000	1.000	1.000	-	29	0.686	0.778	0.882	irs
11	0.836	0.875	0.956	irs	30	0.855	1.000	0.855	irs
12	0.934	1.000	0.934	irs	31	0.959	1.000	0.959	irs

13	0.935	1.000	0.935	irs	32	0.820	1.000	0.820	irs
14	0.929	1.000	0.929	irs	33	0.396	0.430	0.919	irs
15	0.417	0.424	0.983	drs	34	0.731	0.800	0.914	irs
16	0.469	0.470	0.997	drs	35	0.832	1.000	0.832	irs
17	0.630	0.637	0.990	irs	36	0.859	1.000	0.859	irs
18	0.671	0.672	0.999	drs	37	1.000	1.000	1.000	-
19	0.963	1.000	0.963	irs	38	0.822	1.000	0.822	irs

In Table 2, CRS indicated technical efficiency from CRS DEA, VRS shows the technical efficiency from VRS DEA, scale indicates scale efficiency where CRS scores were divided by VRS scores. Meanwhile, irs (increasing return to scale) indicates that when a larger proportion of the outputs compared to the increased inputs in production process and drs (decreasing return to scale) occurred when the increased inputs produced less proportionate in the outputs.

The results indicated that the average technical efficiency scores of CRS and VRS models were 0.819 and 0.869, respectively whereas the average of scale efficiency was 0.947. Further, the minimum scores for CRS and VRS models were 0.294 and 0.299, respectively and they were held by 27th school, which indicated that its school had the lowest efficiency performance. Furthermore, the results also showed that in CRS model as many as 9 elementary schools (or 23.68 percent) based on inclusive education had efficient performance where their efficiency scores equaled to one. Thus, VRS model produced as many as 25 schools (or 65.79 percent) with efficient performances. From table 2 it could be seen that as many as 5 schools (or 13.16 percent) operated at decreasing returns to scale while as many as 23 schools (or 65.53 percent) operated at increasing returns to scale therefore there were 10 schools (or 26.32 percent) produced scale efficiency that presented neither increasing returns to scale or decreasing returns to scale. The results also showed that there were 12 schools had the efficiency scores less than the average scores for both CRS and VRS models or as many as 31.58 percent where it looked not good enough. The results indicated that elementary schools in Central Jakarta that implemented inclusive education needed to improve their performances to increase their efficiencies. Furthermore, according to the degree of discrimination proposed by Thanassoulis, Dyson and Foster (1988) the 4th school should be able to support its activity by using only 65.4 percent of the existing resources while the 9th school should be able to support its activity by using only 77.8 percent of the available inputs and so on.

Further, the schools that did not perform efficiently provide slacks which represent improvement required by a DMU to perform efficiently where it could be augmentation of the output variables or reduction of the input variables. Figure 2 shows summary of output slacks while figure 3 indicates summary of input slacks. However, slacks only occurred on inefficient DMUs of CRS model as well as VRS model. Therefore when one of these models produced efficiency scores equaled to one then the values of slack were zero for both input and output slacks. Based on table 2, the values of slacks of the 1st, 2nd and 3rd schools were zero for both input and output slacks. Contrary, the 4th and the 5th schools produced nonzero values of both input and output slacks.

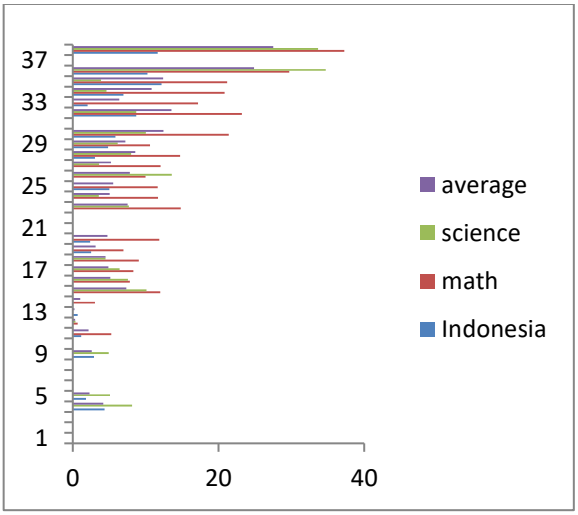

Figure 2. Output Slacks

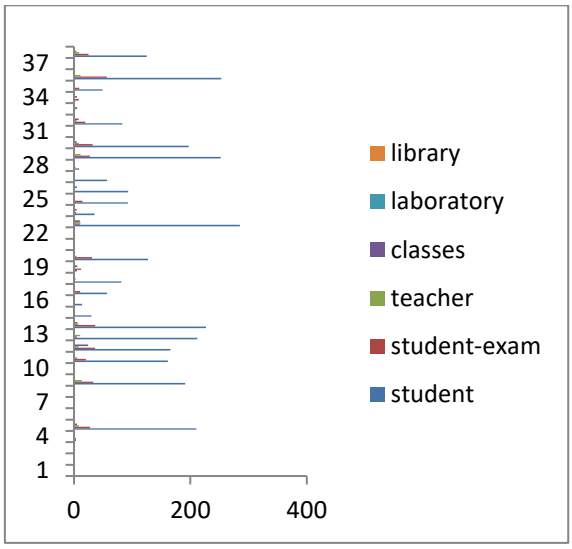

Figure 3. Input Slacks

Table 3 is utilized to understand the general overview of the input and output slack values since it showed descriptive statistics of both The slack values of output variable are described as foloows. The results showed that the largest slack of Indonesian language variable was 12.20 and it was taken place by the 35th school while its largest value of mathematics was 37.26 and it was occurred by the 38th school. Further, the 36th school required the largest slack of science variable by 34.72 whereas the 38th school needed the largest addition score of the average of national final exam. Meanwhile, the input slacks results indicated that the 23rd school was required for reducing its input with the largest value by 285 students while the 36th school needed to reduce the largest student who participated in final exam by 56 students. Further, the 9th school was required to decrease the largest number of teacher 14 teachers while the 12th school needed to decrease its number of classes with the largest number 25 classes. Moreover, the 20th school needed to reduce two laboratories while the 34th school required for reducing one library to obtain efficient performance.

Table 3. Descriptive Statistics of Slacks

Variables	Min	Max	Ave	Std Dev
Output				
Y1	0.00	12.20	2.27	3.52
Y2	0.00	37.26	8.45	9.55
Y3	0.00	34.72	4.88	7.98
Y4	0.00	27.53	5.20	6.41
Input				
X1	0.00	285	79	92
X2	0.00	56	11	15
X3	0.00	14	3	4
X4	0.00	25	2	5
X5	0.00	2	0	1
X6	0.00	1	0	0

As mentioned before, the 27th school had the lowest efficiency scores for both CRS and VRS models where the produced scale efficiency was 0.983. However, in order to achieve efficient performance this school needed slack movement where mathematics score had to increase by 12.033 points. Therefore, the projected value was 68.813 (56.780+12.033=68.813 where the original score of mathematics was 56.780). Further, this school also required to improve science score by 3.625 points from its original value of 64.350. As consequence, the projected value was 67.975 while the average of final score was needed to increase by 5.220 points from its original value of 64.490. Therefore, the projected value became 69.710. It was important to note that the results indicated there was no need to increase Indonesia language score. Furthermore, the projected values of input variables were as follows. The number of students had the projected value was 175.909 from its original value of 779.000 while the number of students which joined the final exam had the projected value was 29.870 where its original value was 100.000. Further, the number of teacher had projected value was 8.662 from its original value at 29.000 while the number of classes had projected value was 7.229 when the original value was 28.000. Overall, both of the number of laboratories and libraries had zero values of projection.

CONCLUSION

This study utilized data envelopment analysis (DEA) method in evaluating the efficiency of primary schools which applied inclusive education. As many as 38 primary schools in Central Jakarta were used as the decision making units (DMUs) by applying six inputs and four outputs. The results revealed that the average technical efficiency scores of CRS and

VRS models were 0.819 and 0.869, respectively. Further, CRS model produced as many as 23.68 percent elementary schools with efficient performances whereas there were 65.79 percent of elementary schools performed efficiently based on VRS model. The results also showed there were 12 schools (31.58%) had the efficiency scores less than the average scores for both CRS and VRS models.

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