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Two-Stage Data Envelopment Analysis (DEA) for Measuring the Efficiency of Elementary Schools in Indonesia

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ABSTRACT

Data Envelopment Analysis (DEA) is the most popular method for efficiency measurement of decision making units (DMUs). DEA compares several homogeneous DMUs based on a number of input and output variables. The main purpose of this study is to measure the performance efficiency of elementary schools in Indonesia in the period 2014/2015 by applying two-stage DEA method. The first step is to calculate the scores of efficiency by using DEA approach while the second step uses econometric approach to analyze the impact of environmental variables on the school efficiency. In order to obtain efficiency scores, as many as 34 provinces in Indonesia are defined as DMUs by using six inputs and three outputs. The results reveal that VRS model of DEA produces better results than CRS model in the first stage for measuring the performance efficiency of elementary school in Indonesia. Furthermore, there are 12 provinces in Indonesia with efficient elementary schools on CRS model, whereas there are 17 provinces with elementary schools perform efficiently on VRS model. Moreover, there are three environmental variables significantly influence the efficiency of elementary school in Indonesia; the repetition rate, the average of science of national exam and the qualified teachers' rate.

KEYWORDS
school efficiency, two-stage DEA, robust regression

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Introduction

Education is an important pillar in improving the quality of human resources in a country where its quality can be seen from the performance of educational units. The role of education is crucial to enhance the capabilities and competitiveness of a country in order to face the rapidly changing times. Educational backwardness is a serious obstacle in the process of society development. Qualified education may produce both moral and character that

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are capable of being a milestone of the country to improve its influence on the world. It is important to note that most modern society looks at educational institutions as a key role in achieving social objectives. In other words, countries with qualified people tend to have high-quality education institutions.

Primary Education of Bantul District in Special Region of Yogyakarta (2014) reports that according to the Program for International Student Assessment (PISA) in 2012, Indonesia is ranked 64 out of 65 countries whereas *Trends in Mathematics and Science Study (TIMSS) in 2011, Indonesia is in 40th place out of 42 countries, which indicate that the quality of education in Indonesia is very low, especially in the fields of mathematics, science, and reading. Furthermore, based on Education for All (EFA) in 2011, the education development index (EDI) is 0.934, which put Indonesia in 69th place out of 127 countries. Whereas based on the Learning Curve in 2013 on education quality, Indonesia was in 40th out of 40 countries. Overall, quality of education in Indonesia needs to be improved in all aspects to yield better human resources with the ability to compete internationally.* Therefore, efficiency measurements of educational units need to be done in order to provide a valid reference to the authorities in determining better programs in the future for upgrading education institutions in Indonesia. According to the National Education Standards Agency (Badan Standar Nasional Pendidikan, BSNP) of Indonesia there are eight indicators of education quality; competency standards, content standards, process standards, assessment standards, standards of teachers and education personnel, facilities and infrastructure standards, management standards and funding standards (bsnp-indonesia.org).

Education at the primary level is the first foundation in an effort to improve the quality of education in Indonesia. Due to elementary school is education unit which organizes the process of basic education and later become the basis for further education process by giving basic skills of reading, writing, and arithmetic which are the basic knowledge as well as skills are useful for students. Indonesia has 34 provinces with the number of both public and private elementary schools in the year 2014/2015 are as many as 147,513 and14,904, respectively. A large number of elementary schools are expected to have a good quality, both in the terms of products (results and achievements) and established character of students.

The main purpose of this study is to measure the performance efficiency of elementary schools in Indonesia as well as to analyze the influence of the environmental variables may affect the school's efficiency by using two-stage Data Envelopment Analysis (DEA). As many as 34 Indonesia's major political subdivisions are defined as DMUs. There are six input variables are used, i.e., the number of schools, the number of permanent teachers, the number of teachers certified more than the degree of bachelor, the number of students, the number of classes, and the number of libraries. Whereas there are three output variables are used, i.e., the number of elementary schools graduates, the number of schools is A-accredited and the average of national exam. Selection of input and output variables is in accordance with the quality standards of education. The first stage of this approach is to determine the efficiency scores of each DMU by using DEA approach, which yields two models; CRS (constant return to scale) model and VRS (variable return to scale) model. In the second stage,

robust regression instead of OLS regression is used to analyze the factors may affect the efficiency of DMUs due to the existence of outliers in the data are used in this study.

A large number of studies that are concerned with the education institutions efficiency have been studied by researchers (see Carrington et al (2005), Kong and Fu (2012) , Demir (2014), Nazarko and Saparauskas (2014), Mikusova (2015), Goksen, Dogan and Ozkarabacak (2015)). Agha et al (2011) uses DEA method to evaluate the relative technical efficiencies of 30 academic departments at the Islamic University of Gaza (IUG) during the academic period 2004-2006. The results reports that the average of efficiency score is 68.5 percent. Furthermore, there are 10 departments perform efficiently. Duguleana and Duguleana (2015) evaluate departments' performances at Transilvania University during the year 2014-2015. By using 30 departments are considered as DMUs with two inputs and four outputs the results report there are 12 departments with efficient performances.

Moreover, efficiency measurements on primary schools are widely investigated. Zhang (2010) uses 140 elementary schools in Taiwan to investigate the relative efficiency by using two-stage DEA. The school size and student characteristics are used as the environmental variables in the second stage. The results reveal that small schools have the highest efficiency score despite they have more resources. Further, the average of efficiency scores for both CRS and VRS models are different at every stage and school size. Borge and Naper (2005) investigate the efficiency potential in the lower secondary schools in Norway by using grades in the core subjects such as Mathematics and English as the output variables. The results show that the average of efficiency score is 0.78 which means that the average municipality may reduce the input variables by 22% without reducing the outputs. Kecek and Demirag (2016) apply 10 primary schools in Kutahya, a province in Turkey, to measure the relative efficiency by using DEA approach with three inputs (student/teacher, student/classroom, and student/section) and two outputs (total score in 2014 and the number of graduates). The results show there are four primary schools with efficient performances while the remaining schools are needed to improve their performances to achieve the efficiency point.

Based on the above issues, the measurement of performance efficiency of elementary schools in the provinces in Indonesia should be done in order to determine which province has elementary schools with the efficient performance by using the existing resources. Elementary school with the highest level of efficiency can be used as a role model in improving other schools level efficiency. It is expected to contribute to the Indonesian education to enhance the quality in creating human resources are highly competitive.

In order to produce empirical results, this study uses two-stage Data Envelopment Analysis (DEA) method, which the first step calculates the efficiency score by using the input and output variables as well as the DMUs are defined. Whereas the second step is carried out robust regression process of these efficiency scores and the environmental variables, which the factors may influence the efficiency of DMUs. Usually, these variables are different from the ones are used in the first step of the method and usually out of control of the DMUS but may have effects of DMUs to perform efficiently. The two-stage

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approach is very popular among researchers due to its simplicity in implementation.

Methodology

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Data Envelopment Analysis (DEA)

Data Envelopment Analysis is the most well-known method to measure the performance efficiency, which is a nonparametric approach based on linear programming to measure a unit, an organization or a program, which is often called Decision Making Units (DMUs), with similar characteristics. The most advantage of this method is that it is able to perform effectively with a lot of input and output variables. DMUs has efficient performances when the efficiency score equal to one (or efficiency value equals to 100 percent), otherwise when the efficiency score is less than one then the DMU has not efficient performance. This method consists of two models; CRS model which is developed by Charnes, Cooper, and Rhodes (1978) so it is also known as CCR model and VRS model is developed by Banker, Charnes, and Cooper (1984) and is also known as BCC model, which is a development of the first model. Generally, the framework of DEA method is as follows. Let x_{ij} denote the observed of input i for entity j where $x_{ij} > 0,\ i = 1,2,\dots,m;\ j = 1,2,\dots,n$ and denote y_{rj} as the observed output r for entity j where $y_{rj} > 0,\ r = 1,2,\dots,s;\ j = 1,2,\dots,n$. The k-line, i.e. X_k and Y_k, of these matrixes shows quantified inputs/outputs of unit DMU$_k$. Then the mathematical form of CCR model for the selected entity k can be written as follow:

$$\max h_x = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \tag{1}$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; \quad \forall j, j = 1,2,\dots,n$$

And

$$u_r, v_i \geq \epsilon; \quad r = 1,2,\dots,s \text{ and } i = 1,2,\dots,m$$

Where$h_x$represent the relative efficiency of DMU$_k$, $u_r$is the weighted output r, $v_i$represents the weighted input iy_{rj}represents the quantity of output r produced by unit $j = 1,2, \dots, n$, $x_{ij}$is the quantity of input i produced by unit $j = 1,2, \dots, n$, $m$is the number of inputs, $s$is the number of outputs, $n$is the number of entities and ϵrepresents small positive value. Equation 1 is nonlinear with fractional programming problem which has intractable nonlinear and non-convex properties (Charnes, Cooper, and Rhodes, 1978). A transformation of equation (1) into a linear programming form is given as follows:

$$\max h_x = \sum_{r=1}^{s} u_r y_{rk} \tag{2}$$

Subject to

$$\sum_{i=1}^{m} v_i x_{ij} = 1$$

$$\sum_{r=1}^{s} u_r y_{rk} - \sum_{i=1}^{m} v_i x_{ij} \leq 0\,; \quad j = 1,2, \dots, n$$

Or

$$\sum_{r=1}^{s} u_r y_{rk} \leq \sum_{i=1}^{m} v_i x_{ij}$$

$$u_r, v_i \geq \epsilon; \quad r = 1,2, \dots, s \text{ and } i = 1,2, \dots, m$$

The model above is a linear program that can be solved with the regular program for linear equation systems. This study uses DEAP Program to obtain the efficiency scores of each province in Indonesia related to the performance efficiency of their elementary schools. Due to this method is based on frontiers or boundaries then data accuracy and preciseness are needed to produce good results because a slight change of the data can change the measurement efficiency significantly. Therefore, the selection of DMUs and the indicators of input and output should provide valid and accurate data.

Robust Regression

The second stage is to analyze the factors may influence the school efficiency in the first step by applying robust regression. It is common to use ordinary least square (OLS) regression to determine the relationship between dependent variable and independent variables. Although the method is very popular and widely used in various fields of research, however, this method should not be applied to the data are contaminated with outliers because it can provide inaccurate results. Robust regression is an alternative approach to OLS regression to deal with outliers and at the same time is able to yield more accurate results. Other than that, this method can be applied when basic assumptions are unfulfilled by the original data. Generally, there are several

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methods of estimation in robust regression, i.e., Least Trimmed Square (LTS), M-Estimator, S-Estimator, and MM-Estimator. However, this study uses MM-estimator to provide the empirical results of a relationship between the efficiency scores of elementary schools of each province in Indonesia and the environmental variables that may influence the efficiency. MM-Estimator is a special type of M-Estimator where the regression parameter is estimated by using S-Estimator in order to minimize the scale of the residual from M-Estimation and then determine the regression parameters by using M-Estimator. MM-Estimation is defined as follows:

$$\hat{\beta}_{MM} = \underset{\beta}{\operatorname{argmin}} \sum_{i=1}^{n} \rho\left(\frac{e_i}{s}\right) \tag{3}$$

Where $\rho(\cdot)$ is objective function, which contributes to each residual e_i, s is the scale of robust estimation. Whereas M-Estimation and S-Estimation are defined as follows:

$$\hat{\beta}_M = \min_{\beta} \sum_{i=1}^{n} \rho\left(\frac{y_i - x_i'\hat{\beta}}{s}\right) \tag{4}$$

$$\hat{\beta}_S = \underset{\beta}{\operatorname{argmin}}\, s \sum_{i=1}^{n} (e_1, e_2, \ldots, e_k)$$

Where y_i represents dependent variable, x_i represents independent variable and β represent coefficient parameter. Generally, the steps of MM-estimator are as follows:

a. Calculate residual value of S-Estimation, $e_i = y_i - \hat{y}_i$ from robust regression with high breakdown point and Tukey bi-square weight.

b. Calculate the S-Estimation scale by using e_i and then calculate the initial weight,

$$w_i = \begin{cases} \left[1 - \left(\frac{e_i}{4.685}\right)^2\right]^2 & \text{if} |e_i| \leq 4.685 \\ 0 & \text{if} |e_i| > 4.685 \end{cases}$$

c. Calculate the regression coefficient where e_i with the scale of S-Estimation are used as initial iteration of Weight Least Square (WLS) estimation.

d. Calculate new weight value uses estimation scale of the WLS initial iteration. Whereas regression coefficient is calculated by using $\hat{\beta}^{(m+1)} = (X' W^m X)^{-1} X' W^m y$.

e. Repeat step 2 to step 4 to obtain a convergent value of $\hat{\beta}^{(m+1)}$.

Results and Discussion

In order to analyze the performance of elementary schools in all of Indonesia's major political subdivisions, this study uses two-stage DEA

approach, which in the first step is applied DEA approach to produce efficiency score of each DMU by using the input and the output variables while the second step is analyzed the relationship of school efficiency and the environmental variables that probably have influence on these efficiency scores.

Calculating the Efficiency Scores

This study applies DEA method to obtain efficiency scores of elementary schools of all provinces in Indonesia in period 2014/2015 by using DEAP version 2.1. The two models of DEA, namely CRS model and VRS model are compared. The empirical results are based on input oriented of DEA model with VRS model as scale assumption while slack values are calculated using multi-stage method. The steps to obtain efficiency scores are as follows:

a. Determination of input and output variables

Efficiency is defined as the ratio between output and input. Efficiency measurement of Elementary school performance refers to the National Education Standards, which consists of eight categories as mentioned above. The following variables of input and output are adjusted to those standards. Standard of graduate competence is represented by both the number of elementary school students' graduate and the number of students in all provinces in Indonesia. Assessment standard is represented by the average of national exam and schools with A-accredited certificates whereas the number of teachers and teachers with more than bachelor degree represent the standard education personnel. Further, the standard of facilities and infrastructure are represented by the number of schools, the number of classes and the number of libraries.

b. Determination of DMUs

Decision-Making Unit (DMU) represents a unit is analyzed its performance, which is all provinces in Indonesia. There are 34 provinces in Indonesia, namely Special Capital Region of Jakarta, West Java, Banten, Central Java, Special region of Yogyakarta, East Java, Special Region of Aceh, North Sumatra, West Sumatra, Riau, Riau Islands, Jambi, South Sumatra, Bangka Belitung Islands, Bengkulu, Lampung, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, North Sulawesi, Gorontalo, Central Sulawesi, South Sulawesi, West Sulawesi, Southeast Sulawesi, Maluku, North Maluku, Bali, West Nusa Tenggara, East Nusa Tenggara, Papua, and West Papua.

c. Calculation of Efficiency Score

This study uses 34 provinces in Indonesia as DMUs with six inputs and three outputs to produce efficiency scores. Input variables are the number of schools, the number of permanent teachers, the number of teacher with more than bachelor degree, the number of students, the number of classes and the number of libraries while output variables are the number of elementary schools with A-accredited certification, the number of graduates and the average of national exam. The descriptive statistics of these variables are presented in table 1.

Table1. Descriptive Statistics of Input and output Variables

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Variables	Minimum	Maximum	Mean	Std. Dev
Variabel *Output*				
y_1	13	3188	396	704
y_2	10979	767720	128511	166566
y_3	16,98	22,66	20,457	1,499
Variabel *Input*				
x_1	451	19817	3970	5111
x_2	3423	150400	29767	39047
x_3	3663	201362	36829	5210
x_4	77694	4611703	741986	969539
x_5	128	139525	23897	30757
x_6	243	11973	2292	2862

Where y_1 represents the number of school with A-accredited certificates, y_2 represents the number of elementary student graduates, and y_3 represents the average of the national exam. Further, x_1 represents the number of schools, x_2 describes the number of permanent teachers, x_3 represents the number of teachers with more than the bachelor degree, x_4 represents the number of students, x_5 describes the number of classes and x_6 describes the number of libraries. Table 2 shows efficiency scores of 34 provinces by using the determined input and output variables. However, there are two models of DEA; CRS model and VRS model are presented while scale indicates the comparison of these two models.

Table 2. Efficiency Scores

DMUs	CRS	VRS	SCALE
Jakarta Special Capital Region	1.000	1.000	1.000
WestJava	0.999	1.000	0.999
Banten	1.000	1.000	1.000
Central Tengah	1.000	1.000	1.000
Special Region of Yogyakarta	0.935	1.000	0.935
EastJava	0.947	1.000	0.947
Special Region of Aceh	0.953	0.953	1.000
North Sumatra	0.903	0.969	0.932

West Sumatra	0.889	0.948	0.938
R i a u	0.865	0.869	0.995
Riau Islands	0.883	0.909	0.972
J a m b i	0.900	0.901	0.999
South Sumatra	0.869	0.878	0.990
Bangka Belitung Islands	1.000	1.000	1.000
Bengkulu	0.936	0.945	0.991
Lampung	1.000	1.000	1.000
West Kalimantan	0.851	0.878	0.970
Central Kalimantan	0.940	0.941	0.999
South Kalimantan	0.910	0.910	0.999
East Kalimantan	0.832	0.833	0.998
North Kalimantan	1.000	1.000	1.000
North Sulawesi	0.898	0.899	1.000
Gorontalo	1.000	1.000	1.000
Central Sulawesi	0.794	0.795	0.999
South Sulawesi	0.893	0.901	0.991
West Sulawesi	0.951	0.957	0.994
Southeast Sulawesi	0.875	0.877	0.998
M a l u k u	1.000	1.000	1.000
North Maluku	1.000	1.000	1.000
B a l i	0.888	1.000	0.888
West Nusa Tenggara	0.932	0.939	0.992
East Nusa Tenggara	1.000	1.000	1.000
Papua	1.000	1.000	1.000
West Papua	1.000	1.000	1.000

The results reveal there are 12 provinces (35.29%) with efficient performances of elementary schools on CRS model, i.e., Special Capital Region of Jakarta, Banten, Jawa Central java, Bangka Belitung Islands, Lampung, North

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Kalimantan, Gorontalo, Maluku, North Maluku, East Nusa Tenggara, Papua, and West Papua. The average of efficiency score is 0.937 with standard deviation 0.0600. Further, the results indicate that there are 17 provinces (50%) with elementary schools' performances are below the score average while the lowest score is 0.794 and it is obtained by the province of Central Sulawesi, which indicates that this province should be able to support its activity levels with only 79.4% of its resources. According to the description of discrimination phase introduced by Thanassoulis, Tyson and Foster (1987) then it can be said that province of West Java should be able to support its activity levels by using only 99.9% of its existing resources (input variables) whereas province of Aceh Special Region and West Sulawesi should be able to maintain their activities levels with only 95.3% and 95.1% of the existing inputs, respectively.

Moreover, VRS model produce as many as 16 provinces (47.06%) have efficient performances of their elementary schools, i.e.Special Capital Region of Jakarta, West Java, Banten, Central Java, Special Region of Yogyakarta, East Java, Bangka Belitung Islands, Lampung, North Kalimantan, Gorontalo, Maluku, North Maluku, Bali, East Nusa Tenggara, Papua, and West Papua. Further, the average of VRS model efficiency score is 0.950 with standarddeviation is 0,058. Like on CRS mode, Central Sulawesi also provides the lowest score on VRS model (0.795). In fact, this model also provides as many as 15 provinces (44.12%) perform under the average of efficiency scores. Then, according to the description of discrimination phase introduced by Thanassoulis, Tyson and Foster (1987) it can be said that province of Central Kalimantan should be able to support its activity by using only 94.1% of the existing resources whereas provinces of Bengkulu and Aceh Special Region should be able to endorse their activity levels by employing the existing resources as many as 94.5% and 95.3%, respectively. Overall, VRS model provides better results than CRS model in measuring elementary schools efficiency in Indonesia in the period 2014/2015.Figure 1 shows the comparison of CRS model and VRS model of the efficiency scores for all 34 provinces in Indonesia.

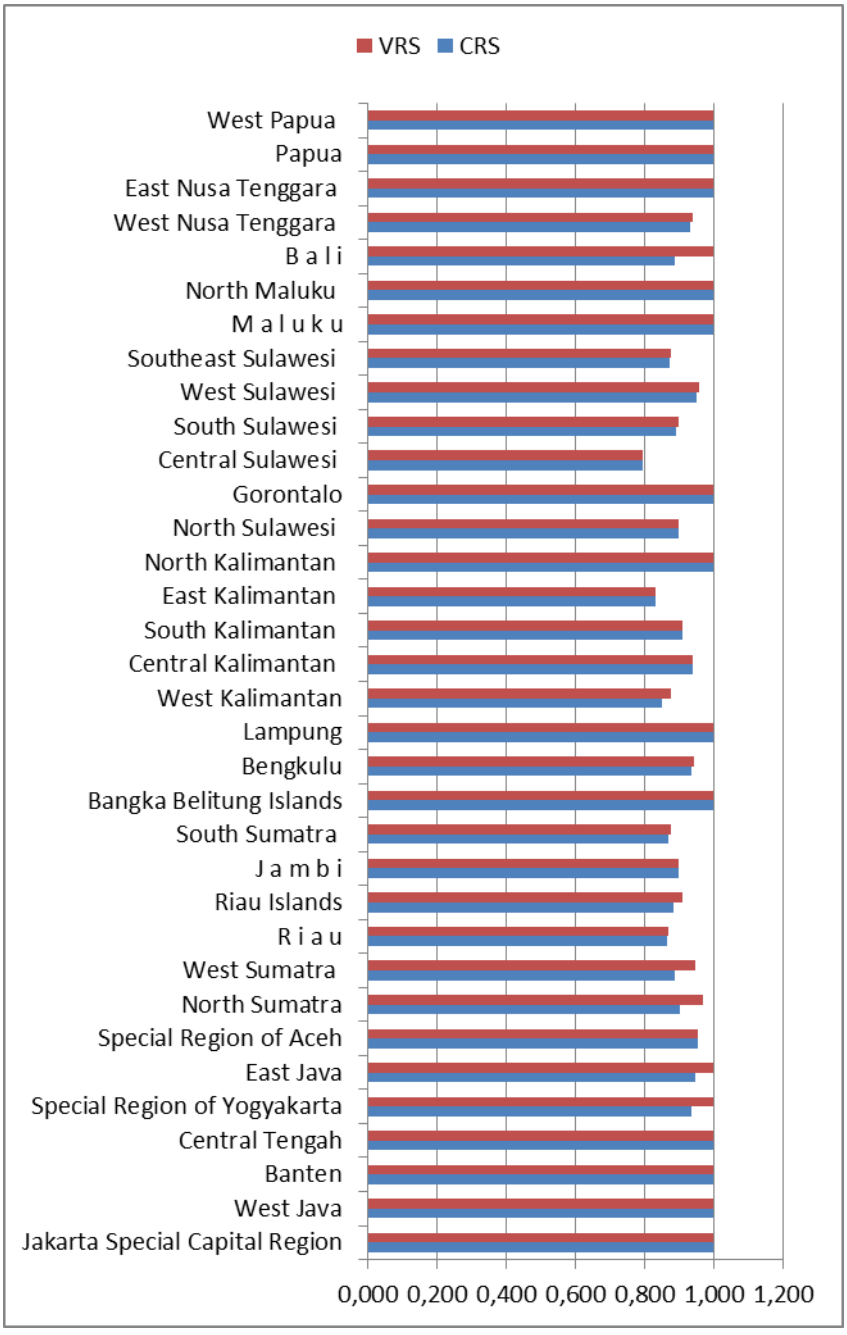

Figure 1 Efficiency Score of CRS and VRS Models

Table 3 shows the general description of slacks, which is the space of improvement by arranging the input variables by reducing input variables proportionally without changing the outputs quantity in order to go in the efficiency point of each inefficient DMU. Slacks not only can recognize the problem faced by schools of their performances but also able to provide an

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appropriate direction for improvement to achieve fully efficient performances. Therefore, slacks exist only on DMUs that perform inefficiently because they represent the remaining portion of inefficiency. When a DMU is not able to reach frontier efficiency then slack is required to push the DMU into efficiency performance. Slack values on both of input and output variables have zero value when the efficiency score equal to one on CRS model or VRS model or both of them.

Table 3. Descriptive Statistics of Slacks

Variables	Minimum	Maximum	Mean	Std. Dev
Output				
y_1	0.000	635.234	50.933	115.123
y_2	0.000	0.000	0.000	0.000
y_3	0.000	2.714	0.361	0.685
Input				
x_1	0.000	1,957.642	212.534	397.213
x_2	0.000	19,605.471	1,560.739	3,640.661
x_3	0.000	9,189.735	1,328.871	2,483.408
x_4	0.000	22,369.457	657.925	3,836.330
x_5	0.000	19,290.992	2,221.040	4,264.176
x_6	0.000	1,230.624	149.606	309.345

The results reveal that Central Kalimantan province is able to improve its efficiency by reducing input variable as many as 5.9% on VRS model. Referring to slack values are produced from DEAP program then this province needs to reduce the facilities and infrastructures; the number of schools about 517 units, the number of classes about 2.664 units and the number of libraries about 205 units. Further, Central Kalimantan province has to reduce the teachers and education personnel; the number of permanent teachers as many as 5.508. Moreover, Aceh Special Region province can improve its efficiency by reducing input variables of 4.7%; the number of schools as many as 571 units, the number of classes as many as 5.625 units and the number of libraries as many as 782 units. Other than that, the teachers and education personnel are needed to be reduced in order to get efficient performance; the number of permanent teachers as many as 6.486 teachers and the number of teachers with more than bachelor degree as many as 9,190 teachers.

Analyzing the Relationship between Environmental Variables and Efficiency

This study uses MM-Estimator of robust regression to investigate the environmental variables that probably affect the efficiency score in the first stage. The approach is able to provide a good estimation although the data are

used in the analysis is contained outliers. The environmental variables are used in this study that may affect the efficiency score are the repetition rate of elementary students (x_1), the dropouts rate (x_2), the ratio of public schools and private schools (x_3), the national exam average of Indonesian Language (x_4), the national exam average of Mathematics (x_5), the national exam average of science (x_6), the number of part-time teachers (x_7), the completion rate (x_8) and the qualified teachers rate (x_9). Table 4 shows the descriptive statistics of the environmental variables are used in this study while table 5 describes the comparison of the coefficient estimates of OLS regression and robust regression.

Table 4. Descriptive Statistics of Environmental Variables

Variables	Minimum	Maximum	Mean	Std Deviation
Repetition Rate (x_1)	0.54	3.90	1.816	0.817
Drop Outs Rate (x_2)	0.29	1.79	0.812	0.304
Public/private schools (x_3)	1.53	60.30	16.364	14.474
Average of Indonesian Language (x_4)	5.00	8.22	6.474	0.859
Average of Mathematics (x_5)	5.00	7.68	6.026	0.728
Average of Science (x_6)	5.00	7.46	6.342	0.621
Part-timer Teacher (x_7)	1,553.00	80,617.00	17,367.059	19,441.266
Completion Rate (x_8)	98.59	99.98	99.568	0.272
Qualified Teacher Rate (x_9)	44.89	89.11	73.864	12.167

Table 5. Coefficient Estimates

Variables	OLS Regression				Robust Regression			
	Estimate	Std. Error	*t*-value	Pr(>|t|)	Estimate	Std. Error	*t*-value	Pr(>|t|)
(Intercept)	514.5000	556.9000	0.924	0.365	-160.1000	376.1000	-0.426	0.6741
x_1	0.4109	1.6140	0.255	0.801	2.2600	0.9849	2.295	0.0308
x_2	-1.0830	5.4500	-0.199	0.844	1.1880	6.1770	0.192	0.8491
x_3	-0.0081	0.0850	-0.095	0.925	-0.0852	0.0487	-1.75	0.0929
x_4	2.0810	2.1520	0.967	0.343	-1.7500	1.4110	-1.241	0.2267
x_5	0.3406	2.5570	0.133	0.895	3.2270	1.6550	1.95	0.0629
x_6	0.1210	3.0700	0.039	0.969	5.1260	1.6390	3.127	0.0046

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x_7	0.0001	0.0001	0.746	0.463	-0.0002	0.0001	-3.03	0.0058
x_8	-4.2540	5.6260	-0.756	0.457	2.4150	3.6180	0.667	0.5109
x_9	-0.1934	0.1568	-1.234	0.229	-0.3951	0.0569	-6.942	0.0000

Table 5 indicates that there is quite differences of the results of OLS regression and robust regression due to the presence of outliers in the data, which highly influence the results of estimation. As mentioned above, when there is an existence of outliers then robust regression is better used in the analysis because it provides a greater degree of accuracy of estimate parameters. According to table 5, robust regression produces better results for predicting the factors influence the elementary school performances in Indonesia. Standard error values in the robust regression for all variables, except variable x_2, are smaller than these values in OLS regression. Moreover, the results show that there is no independent variable that statistically significant in OLS regression, but there are three independent variables significantly influence the dependent variable (elementary school efficiency); the repetition rate (x_1), the average of science of national exam (x_6) and the qualified teachers' rate (x_9).

Turning to the unstandardized coefficients of these variables, the repetition rate has positive coefficient which indicates that the greater of the repetition rate, the greater the efficiency score of its elementary school. The parameter estimate of the repetition rate is 0.4109, which indicates that for every point increase in the repetition rate variable then the efficiency of elementary school is predicted to be higher by 0.4109 points. Further, the average of science national exam also has a positive impact on school efficiency by 0.1210. Hence, for every unit increase in the average of science national exam, it is expected to increase an approximately 0.1210 points in elementary school efficiency. The coefficient for the qualified teacher rate variable is -0.1934, which indicate the negative influence of this variable on the efficiency of the elementary school. In other words, for every unit increase in the qualified teacher rate, it is expected to decrease the school efficiency.

The remaining variables; drop outs rate (x_2), the ratio of public schools and private schools (x_3), the national exam average of Indonesian Language (x_4), the national exam average of Mathematics (x_5), the number of part-time teachers (x_7), the completion rate (x_8); are not statistically significant. However, the independent variables which are not significant are not significantly different from 0 so that they should be considered when interpreting the coefficients. Moreover, the coefficient of dropouts rate (x_2) is 1.1880 which means that for a one-unit increase in this variable, it is expected to increase as many as 1.1880 points in the school efficiency while the coefficient of the ratio of public schools and private schools (x_3) indicates that for every unit increase in this variable, it is expected to decrease as many as 0.0852 points in elementary school efficiency. Further, for every unit increase in the national exam average of Indonesian Language (x_4) variable, it is predicted to decrease the efficiency of elementary school as many as 1.7500 points whereas the national exam average of Mathematics (x_5) variable is expected to increase the efficiency of elementary school by 3.2270 points. The number of part-time teachers (x_7) and the completion rate (x_8) variables have different impact on the efficiency. The first

variable is expected to decrease the school efficiency by 0.0002 points for every increasing unit while the second variable is predicted to increase the efficiency by 2.4150 points for every increasing unit.

Conclusions

This study investigates the efficiency measurement of elementary schools in Indonesia by using two-stage DEA approach wherein the first stage is calculated the efficiency score for 34 provinces in Indonesia with six inputs and three outputs by applying DEA method. It is the most popular method to measure the efficiency of DMUs, which is based on non-parametric linear programming. However, two models of this method; CRS and VRS models are compared. The empirical results reveal that overall; VRS model of DEA provides better efficiency score than CRS model for measuring elementary school performances in Indonesia. Moreover, CRS model produces 35.29% provinces with efficient performances of their elementary schools while VRS model produces about 47.06% provinces with the elementary schools perform efficiently.

The relationship between the efficiency of the schools and the environmental variables is analyzed in the second step. Due to the existence of outliers in the data, this study uses MM-Estimator of robust regression to provide the empirical results, which describe the impact of the environmental variables on the efficiency of elementary school in all provinces in Indonesia. The results show that there are three factors significantly influence the school efficiency; the repetition rate, the average of science of national exam and the qualified teachers' rate.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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