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Evaluating The Efficiency Of Indonesia's Secondary School Education

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Abstract

This study employs a Data Envelopment Analysis (DEA) to investigate secondary school efficiency and Stochastic Frontier Analysis (SFA) to examine determinants that affect average secondary school student score in Indonesia. Using the DEA, this study measures the efficiency of the region with regards to the average student score using various input indicators including teacher-to-student ratio, number of teacher holding the first-degree qualification, average secondary school expense, average duration to school and average distance to school, while output variable is the average student score for 33 regions in Indonesia. The findings suggest the average technical efficiency of secondary school in the region is 89 percent with the most efficient regions are Sumatera Utara, Kepulauan Bangka Belitung, DKI Jakarta, Jawa Timur, Bali, Sulawesi Barat, Maluku, Maluku Utara and Papua Barat. With the SFA, this study identifies factors that significantly affect average student score in the region. The results suggest that a higher ratio of teacher-to-student and higher numbers of the teacher with the first-degree qualification significantly affect average student score in the region. However, there is no evidence that average secondary school expense and school proximity (average duration and distance to school) significantly affect secondary school efficiency.

Keywords: *School Efficiency, Stochastic Frontier, Data Envelopment*

1. Introduction

Formal education in Indonesia consists of pre-primary (two years), primary (six years), lower secondary (three years), upper secondary (three years) and tertiary education. The completion upper secondary schools allow students to enter tertiary education, leading to higher education degree such as diploma, bachelor, master, specialized postgraduate and doctorate. The Government of Indonesia has expanded basic education from six to nine years, primary and lower secondary level, through the issuance of the Education Law No. 2 Year 1989. This law states that every Indonesian aged 7 to 15 has the right to obtain the basic education and it is made both compulsory and free through a nine-year basic education program in 1994. The Government of Indonesia also committed to abolishing school fee including tuition and monthly fee at the primary and lower secondary level in response to relieve education costs for poor students and to keep them in school. Participation in this initiative is voluntary for schools. If schools waive fees for students, the schools will receive an additional grant from the government as extra-budgetary support.

Even though Indonesia has a nine-year basic education program and free tuition policy for primary and lower secondary level, it is widely known that one of the biggest problems in Indonesia education is the low level of student attainments in most all school levels compared to other countries. The OECD/PISA International Student Assessment 2012 report shows that Indonesian student achievement is much lagged behind from other countries. In general, Indonesia ranked at the bottom two with Peru. This survey measured 15-year-old secondary school student performance in mathematics, reading, science and problem-solving. There were 34 OECD member countries and 31 partner countries involved in the survey which representing of more than 80 percent of the world economy.

This low-level secondary school student performance in Indonesia could be attributed to several factors. A low student-to-teacher ratio could be the main reason. (Organisation for Economic Co-operation and Development (OECD) & The Asian Development Bank (ADB), 2015) show that secondary school in Indonesia has a low student-to-teacher ratio of 16:1. A substandard qualification and educational background of teacher could be another factor that might contribute to the low educational achievement. In Indonesia, number of teacher holding higher educational background (i,e master or doctorate level) are very few than those with lower level qualifications. The quality of school infrastructure and availability of affordable textbooks could be other important points that might affect education achievement in Indonesia. (UNESCO, 2005) suggests multiple strategies to improve the quality of education in Indonesia including revising curriculum to provide students with minimum essential skills, improving teachers' qualifications, and setting standards for the quality of school facilities and the provision of affordable textbooks.

There is a great importance to measure relative efficiency of school in order to search solutions to improve educational efficiency and attainment. For example, Hu et. al (2009) suggest that increasing investment in the education sector improve the efficiency of the primary school in Beijing, China. (Stergiou, 2013) suggests that school innovations could have a significant contribution to the increase of student achievement, while Scippacercola and (Scippacercola & D'Ambra, 2014) find that number of teacher, number student per class and teacher qualification have a significant impact on the student achievement.

To the best knowledge of the author, there are no previous studies on the evaluation of secondary school efficiency at the regional level in Indonesia; thus this study attempts to fill this gap. This study consists of two stage of analysis. In the 1st stage of analysis, this study employs a DEA framework to examine the relationship between inputs variables and secondary school efficiency in Indonesia. The school efficiency is defined as the production of a certain amount of desirable output (student average score) given a minimum set of economic inputs (i.e teacher-to-student ratio, teacher qualification or school proximity). There are five inputs used in the study: teacher-to-student ratio, number of teacher holding the first-degree qualification, average secondary school expense, average duration to school and average distance to school. In the 2nd stage, this study applies SFA framework to examine factors that may significantly affect secondary school inefficiency in Indonesia.

The contributions of the study are two folds. First, this study measures the efficiency of secondary school in Indonesia at the regional level. It is proposed that measure efficiency is not at the country level, but decompose it into the regional level. Second, this study investigates what input factors that may significantly affect secondary school efficiency in Indonesia. The remainder of this paper is organized as follows: Section 2 provides the literature review. Section 3 is data. Section 4 describes the method of DEA and SFA. Section 5 presents result and discussion. Section 6 is the conclusion.

There are numerous empirical studies on the measurement of primary or secondary school efficiency both developed and developing countries, but research on Indonesia is relatively rare. For examples, Italy (Agasisti, 2003) and, (Scippacercola & D'Ambra, 2014), Greece (2013), (Hu, Zhang, & Liang, 2009), Uganda (Muvawala, J., & Hisali, 2012). United Arab Emirates (Badri, M., Mohaidat, J., El Mourad, 2014). India (Dutta, 2012) and Indonesia (Haryadi, 2011). (Haryadi, 2011) adopts the DEA method to measure technical efficiency in Indonesia's education sector and the results suggest that the average of technical efficiency is about 99 percent with average cost efficiency is about 22.4 percent at all school levels.

Data Envelopment Analysis (DEA) models have been used to assess school performance and efficiency in many countries. Hu et al. (2009) used DEA to evaluate a sample of 58 primary schools in six districts in Beijing, China and search solutions on how to improve the efficiency of the primary school in Beijing as a result of under-investment. The authors found that teacher salaries, student-teacher-ratios and time student in school have an obvious effect on school's technical efficiency. (Stergiou, 2013) measures the efficiency level of primary school education in Greece using DEA and ordinary least square method. The results suggest that students' family socioeconomic status, school area, and school innovations are positively related to efficiency. (Agasisti, 2003) uses DEA and Tobit regression to compute efficiency scores for a sample of Italian schools, by employing the OECD-PISA 2006 data aggregated at school-level and to examine factors that might affect schools' efficiency. (Badri, M., Mohaidat, J., El Mourad, 2014) measure and compare the efficiency of selected Abu Dhabi secondary public schools using DEA and the results showed that input with the greatest impact was cost per teacher and cost per student, while (Dutta, 2012) uses the DEA to compare efficiency of elementary school across Indian state schools and found that investment in education sector needs to be improved to increase school efficiency.

There are also growing studies examining the use of the SFA to assess school efficiency. For example, (Scippacercola & D’Ambra, 2014) adopt the SFA method to estimate secondary school efficiency in the Campania region, Italy and found that number of teacher, number student per class and teacher qualification have the significant impact on the student achievement. (Muvawala, J., & Hisali, 2012) use the SFA to estimate technical efficiency and its determinants for Uganda’s primary education system. The results suggest that all primary schools in Uganda are technically inefficient, and some factors that have a significant impact on the school performance are location and ownership of schools.

A number of studies have investigated the relationship between education attainment and inputs such as teacher-to-student ratio, school facilities, teacher qualification, and average school expense or school proximity. The relationship between education performance and the teacher-to-student ratio has been highlighted in (Badri, M., Mohaidat, J., El Mourad, 2014), (Dutta, 2012), (Muvawala, J., & Hisali, 2012), (Scippacercola & D’Ambra, 2014) and (Stergiou, 2013). In education literature, there is a growing consensus that higher teacher-to-student ratio is more preferred, as it tends to improve student performance and educational attainment. School infrastructure and facilities such as computer rooms, buildings, teacher aids, and materials are also considered to have a significant contribution to the student performance (Dutta, 2012) and (Stergiou, 2013). The school with better facilities and infrastructures would generally have higher school efficiency. There is also sufficient evidence that school with teachers holding higher education backgrounds and experience would have a greater efficiency and higher student performance (Hu et al., 2009) and (Muvawala, J., & Hisali, 2012). The importance to include average school expenditure as education factor input has been incorporated in several studies, for example, (Badri, M., Mohaidat, J., El Mourad, 2014) and (Hu et al., 2009). The school proximity may also have a significant contribution to the increase of student attainment. It is expected less proximity and less duration to school are much favorable for students.

2. Method

a. Data Envelopment Analysis

The DEA framework has been used extensively to perform efficiency study (Charnes et al., 1978) and (Charnes, Cooper, Lewin, & Seiford, 1994) The DEA is a methodology that allows the evaluation of the relative efficiency of a set of comparable entities by some specific mathematical programming models. These entities are often called decision-making units (DMUs). The DMU is regarded as the entity responsible for converting inputs into outputs and whose performances are to be evaluated. This procedure is a linear programming based mathematical method which does not require the functional form, relating the inputs to the outputs. The DEA optimizes each observation with the aim of building the efficiency frontier, which consists of a discrete curve formed solely by efficient DMUs.

The first stage of analysis applies a non-parametric of DEA to rank relative efficiency of the region with respects to average student score for 33 regions in Indonesia. To measure relative efficiency, a benchmark DMU (i.e region) is used to

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evaluate with other region performances. The DEA allows each region to fall on or below the frontier. The region that lies on the frontier is regarded as the efficient region and thus this study assigns that efficient region as the benchmark. This study then compares the relative performance of other regions through measuring the distance between efficient regions and inefficient regions. The level of inefficiency can be measured in two ways: output or input-oriented. As this study will maximize the output of average student score, the output-oriented model is used in the study. The output-oriented measurements indicate that the amount by which the output (average student score) must be proportionally increased in order to achieve the frontier while keeping inputs constant.

A DEA model can be formulated as a fractional or linear programming. Each DMU will be treated as the focal DMU while separate optimizations are performed. The objective of the optimizations is to select the weights used when calculating the DMUs relative efficiency. A DMU's efficiency is defined as the sum of weighted outputs divided by the sum of weighted inputs. Each optimization selects the set of weights that result in the highest possible efficiency for the focal DMU associated with that optimization. These separate optimizations share a common set of constraints: when the set of weights are applied to any DMU, it must not result in an efficiency rating greater than one. A fractional formulation for the case of s outputs, m inputs, and n DMUs where the y terms represent output levels, the x terms represent input levels, and u and v terms represent the weights associated with outputs and inputs respectively.

Suppose there are n DMUs: DMU1, DMU2, and DMUn. Some common inputs and outputs items for each of this j=1 …n, DMUs are selected as follows: 1) Numerical data are available for each input and output, with data assumed to be positive for all DMUs. 2) The smaller inputs amounts are generally more preferable, and larger output amount is also preferable so the efficiency score should reflect this principle. 3) The measurement units of the different inputs and outputs need not be congruent. For example, some of the inputs are average duration to school (in term of minutes), average duration to school (in term of kilometers), number of teacher holding the first-degree qualification (in term of number) or average secondary school expense (in term of Rupiah); while the output is average student score (in term of score, ranging from 0 to 100)

Suppose m input items and s output items are selected. Let the input and output data for DMUj be $(x_{ij}, x_{2j}, \dots, x_{mj})$and $(y_{ij}, y_{2j}, \dots, y_{sj})$ respectively. The input data matrix X and the output data matrix Y can be arranged as follows:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{pmatrix} \quad (1)$$

$$Y = \begin{pmatrix} y_{11} & \cdots & y_{1n} \\ \vdots & \ddots & \vdots \\ y_{s1} & \cdots & x_{sn} \end{pmatrix} \quad (2)$$

Where X is an (m x n) matrix and Y an (s x n) matrix.

As this study measures the efficiency of each DMU once and hence need n optimizations, one for each DMUj is to be evaluated. This study solves the following fractional programming problem to obtain values for the input weights (v_i) $(i = 1,2, \dots, m)$ and the output weight(u_r) $(r = 1,2, \dots, s)$.

$$\text{Maximize } \frac{\sum_{r=1}^{s} u_r y_{r1}}{\sum_{r=1}^{m} v_i x_{i1}} \quad (3)$$

Subject to:

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$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{r=1}^{m} v_i x_{ij}} \leq 1 \text{ for } j = 1, \dots, n \quad (4)$$

$$v_1, v_2, \dots, v_m \geq 0 \quad (5)$$

$$u_1, u_2, \dots, u_s \geq 0 \quad (6)$$

The constraints indicate that the ratio of output and input should not exceed 1 for every DMU. The objective is to obtain weights (v_i) and (u_r) that maximize the ratio of the DMU being evaluated. Due to the virtue of the constraints, the optimal value $\theta^*$is at most 1. As the objective and cost functions from FP above are not linear, thus it cannot be solved by linear optimization method. (Charnes et al., 1994) transform this non-linear problem into linearity with some algebraic manipulations. The modification allows the DEA to be solved using a linear method. Th linear function of the above formulation is as follows:

$$\text{Maximize} \quad \sum_{r=1}^{s} u_r y_{r1} - \sum_{r=1}^{m} v_i x_{i1} \quad (7)$$

Subject to:

$$-\sum_{r=1}^{m} v_i x_{ij} \leq -1 \quad (8)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{r=1}^{m} v_i x_{ij} \leq 0 \text{ for } j = 1, \dots, n \quad (9)$$

$$v_1, v_2, \dots, v_m \geq 0 \quad (10)$$

$$u_1, u_2, \dots, u_s \geq 0 \quad (11)$$

The DEA approach has several advantages. The DEA is specifically designed to assess efficiency using multiple inputs and multiple outputs; the DEA does not require any prior assumptions on the underlying functional relationships between inputs and outputs. The endogeneity is not an issue in DEA because the shape of the frontier depends only on individual observations, not on any assumed functional form. The DEA may also provide suggestions on how to improve less inefficient DMUs towards efficient DMUs through slack adjustments. Further, the DEA is a useful tool for benchmarking and can suggest a remedy to improve implementation program of inefficient units (Bill, 1997).

Apart from those advantages, the DEA has also several limitations. The DEA is based on a number of simplifying assumptions that need to be acknowledged when interpreting the results. The DEA results are particularly sensitive to the measurement errors. An understated input or overstated output may produce outlier results and distort the frontier, thus reducing the efficiency score of nearby units. The DEA scores are also sensitive to input and output specification and the size of the samples. For example, increasing the sample sizes or DMUs tend to reduce the average efficiency score, while reducing them may artificially inflate the efficiency scores. Another limitation of the DEA as it only measures the efficiency score relative to the best practice or efficient unit. Thus, it may not meaningful to compare the efficiency scores between two different studies because the difference in the best practice between the samples is unknown.

b. Stochastic Frontier Analysis

The SFA can be used to explain what factors that might influence secondary school efficiency in the regions with regards to the average student score. The model specification could include education outcome, i.e. average student score to various education inputs plus error terms. The error terms will capture random elements as well as other components of technical inefficiency. Each region will be considered to be a decision-making unit (DMU) that operates under the assumption of the variable return to scale. This study adopts (Pascoe, Andersen, & De Wilde, 2001), a general stochastic secondary school production frontier model, as follows:

$$Y = f(\ln X) + v_j + u_j \quad (12)$$

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Where Y is the average student score at j region; X is a vector of inputs; v_j is the stochastic error term and is the estimate of the technical inefficiency of region j. Both v_j and u_j are assumed to be independently and identically distributed, with variance δ_v^2 and δ_u^2 respectively. The empirical secondary school production is following the model specification of (Battese & Coelli, 1992), as follows:

$$y_{it} = \beta' X'_{it} + v_j - u_j \quad (13)$$

Where:
$\beta' = \beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$
$X' = X_1, X_2, X_3, X_4, X_5$
X1 is the teacher-to-student ratio;
X2 is the number of teacher with the first-degree qualification;
X3 is the average secondary school expense (in term of Rupiah);
X4 is the average duration to school (in term of minutes);
X5 is the average distance to school (in term of kilometers);
y is the regional average student score (ranging from 0 to 100).

The dependent variable of average student score is preferred as it represents educational attainments. The education outcome at the regional level is measured by the standardized test and the tests are similar across regions. The standardized test for secondary school in Indonesia has been administered by the Ministry of Education. Given availability of data, this study uses a school panel on the performance of average student score at the regional level for the year 2012. The SFA model is specified in the linear-log form and thus all independent variables are converted into the log-form, while the output variable is the average student score calculated at the regional level. The estimate of inefficiency is taken as a measure of the percentage of the variable of interest (i.e average student score or region) has failed to reach the efficient frontier.

The selections of input and output variables are largely based from previous empirical studies (Agasisti, 2003), (Badri, M., Mohaidat, J., El Mourad, 2014), (Dutta, 2012); (Hu et al., 2009), (Muvawala, J., & Hisali, 2012), (Scippacercola & D'Ambra, 2014) and ((Stergiou, 2013). The data for this study is collected from the 2012 Education Statistics of Indonesia's Central Bureau of Statistics. The input variables are teacher-to-student ratio (x1), number of teacher holding the first-degree qualification (x2), average secondary school expense (in term of Rupiah) (x3), average duration to school (in term of minutes) (x4) and average distance to school (in term of kilometers) (x5), while output variable (y) is the average student score (ranging from 0 to 100), which is used to assess the regional efficiency with respects to the education.

3. Result and Discussion

In the 1st stage analysis, this study aims to measure the efficiency of the region with regards to the average student score using non-parametric of the DEA. In this study, there are five inputs: teacher-to-student ratio, number of teacher holding the first-degree qualification, average secondary school expense (in term of Rupiah), average duration to school (in term of minutes and average distance to school (in term of kilometers); while the output is the average student score which reflects regional educational attainment.

Table 1 shows the relative regional efficiency with respects to the average student score. The output maximization model provides information on how much the average student score could be improved given its inputs. The efficient regions are regarded when they succeed to achieve higher average student score given the low level of inputs. In the third column (variable return to scale) shows that following regions: Sumatera Utara, Kepulauan Bangka Belitung, DKI Jakarta, Jawa Timur, Bali,

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Sulawesi Barat, Maluku, Maluku Utara and Papua Barat are the benchmark regions as they have 100 percent of efficiency level. In other words, these regions have achieved the maximum average of student score given the constant level of inputs. The most inefficient regions are Sulawesi Tengah and Nusa Tenggara Timur with the efficiency level of only 68 and 70 percent respectively.

Table 1. The School Technical Efficiency across Regions

Region	CRSTE	VRSTE	NIRSTE	SCALE	RTS
Aceh	0.79	0.79	0.80	1	1
Sumut	1	1	1	1	0
Sumbar	0.81	0.81	0.82	1	1
Riau	0.95	0.96	0.99	1	1
Kep. Riau	0.88	0.92	1	0.96	1
Jambi	0.85	0.85	0.87	1	1
Sumsel	0.98	0.98	1	1	1
Kep.Babel	0.94	1	1	0.94	1
Bengkulu	0.70	0.71	0.72	0.98	1
Lampung	0.87	0.87	1	1	1
DKI Jakarta	0.94	1	1	0.94	-1
Jawa Barat	0.79	0.79	0.80	1	1
Banten	0.82	0.82	0.84	1	-1
Jawa Tengah	0.94	0.94	0.97	1	1
DI Yogyakarta	0.83	0.83	1	1	0
Jawa Timur	1	1	1	1	1
Bali	1	1	1	1	0
NTB	0.92	0.92	0.94	1	1
NTT	0.70	0.70	0.71	1	0
Kalbar	0.88	0.88	0.97	1	1
Kalteng	0.91	0.91	1	1	0
Kalsel	0.83	0.83	0.88	1	1
Kaltim	0.81	0.81	0.83	1	1
Sulawesi Utara	0.95	0.95	0.96	1	1
Gorontalo	0.75	0.77	0.78	0.97	1
Sultengah	0.68	0.68	0.70	1	0
Sulsel	0.89	0.89	0.90	1	1
Sulbar	0.96	1	1	0.96	1
Sulteng	0.84	0.84	0.88	1	0
Maluku	1	1	1	1	0
Maluku Utara	1	1	1	1	0
Papua	0.85	0.85	1	1.00	1
Papua Barat	1	1	1	1.00	0

Source: author's own calculation

Notes:
CRSTE : constant return to scale (technical efficiency)
VRSTE : variable return to scale (technical efficiency)
NIRSTE : non-increasing return to scale (technical efficiency)
RTS : return to scale
-1 = decreasing return to scale
0 = constant return to scale
1 = increasing return scale

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The 2nd stage of analysis identifies factors that might significantly affect average student score in the region either positive or negative. This study applies one-stage stochastic frontier function (SFA), since this method has less biased and produces more efficient results (Kumbhakar, Ghosh, & McGuckin, 1991) In this analysis, the dependent variable is the average student score, while the independent variables are teacher-to-student ratio, number of teacher holding the first-degree qualification, average secondary school expense (in term of Rupiah), average duration to school (in term of minutes) and average distance to school (in term of kilometers)

The SFA estimations suggest following results: (a) the higher ratio of teacher-to-student (x1) significantly affects average student score in the region. (b) The higher number of teachers holding first-degree qualification (x2) has a statistically significant impact on the educational attainment. (c) The average secondary school expense (x3) does not have a significant impact on the average student score. (d) The duration to school (x4) has an insignificant impact on the educational attainment. (e) The average distance to school (x5) has not a statistically significant impact on the average student score.

Table 2. The SFA Estimation Results

y	Coefficient	Standard Error	z	P>|z|
x1	-29.44	14.92	-2	0.05
x2	7.76	2.17	3.57	0
x3	-0.72	11.96	-0.1	0.95
x4	-10.86	17.57	-0.6	0.53
x5	10.78	5.79	1.86	0.06
constant	26.47	68.57	0.39	0.69
/lnsig2v	3.23	0.25	13	0
/lnsig2u	-5.31	511.16	-0	0.99
sigma_v	5.02	0.62		
sigma_u	0.07	18		
sigma2	25.23	6.42		
lambda	0.01	18.11		

Source: author’s own calculation

4. Conclusion

This study employs a data envelopment analysis (DEA) to investigate secondary school efficiency and stochastic frontier analysis (SFA) to examine determinants that affect average secondary school student score in Indonesia. Using the DEA, this study measures the efficiency of the region with regards to the average student score using various input indicators including teacher-to-student ratio, number of teacher holding the first-degree qualification, average secondary school expense, average duration to school and average distance to school, while output variable is the average student score for 33 regions in Indonesia. The findings suggest the average technical efficiency of secondary school in the region is 89 percent with the most efficient regions are Sumatera Utara, Kepulauan Bangka Belitung, DKI Jakarta, Jawa Timur, Bali, Sulawesi Barat, Maluku, Maluku Utara and Papua Barat. With the SFA, this study identifies factors that significantly affect average student score in the region. The results suggest that a higher ratio of teacher-to-student and higher numbers of the teacher holding the first-degree qualification significantly affect average student score in the region. However, there is no evidence that average secondary school expense and school proximity (average duration and distance to school) significantly affect secondary school efficiency.

To increase the average score of the secondary school student, the government needs to pursue policy options in particular by increasing teacher-to-student ratio and improving teacher qualification. The government should also understand that the other measures such as average school expense and geographical distance are not significant determinants of school attainment in the region.

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