Data Envelopment Analysis (DEA):
Efficiency as an Indicator of Schools' Performance

by

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ABSTRACT

This paper reports the findings of a project that examined the determinants contributing to school efficiency based on the 'High Standard Quality Education' framework (PKSBSTKP) compiled by the Malaysian School Inspectorate and evaluated the relative efficiencies of all the secondary schools in the Sri Aman/Betong Division for the year 2002. The research reveals that the PKSBSTKP performances of all the participating schools were average. The frontier analysis shows that 9 schools were efficient and 7 schools were inefficient. There were obvious differences in evaluating performances of schools by DEA and the methodology of PKSBSTKP. However, there was no significant difference in the efficiencies between schools in the urban and rural area of the Sri Aman/Betong Division. Based on slack analysis, the output maximization BCC model shows that all the three principal inputs, student quality, managerial quality and school facilities were of equal importance. For the output variables, school uniqueness topped the list, followed by students' academic performance, and change of academic performance and achievement in co-curriculum.

INTRODUCTION

It is an important but difficult to accomplish mission in assessing the performance of an educational system. Educational process possesses all the distinctive characteristics of any other production unit in the business sector – perishable, heterogeneous and simultaneous. However, a deeper analysis reveals special features peculiar to educational process. These features, namely multi-nature of the outputs, time dependence, cumulative, dual role (input and output) played by students, effect of non-discretionary inputs and heterogeneity nature of the process conducted on students, complicate the evaluation procedure of an educational system (Mancebon & Bandres, 1999). This evaluation procedure is further complicated by the limited knowledge about what factors affect educational outputs, the difficulties faced to measure educational outputs such as cognitive skills, communicating skills, affective traits and societal values, and the simultaneous relationship between educational inputs and outputs (Darling-Hammond, 1991, Orme and Smith, 1996).

Despite the difficulties encountered, school performance assessment or school efficiency evaluation are being carried out to set performance targets, to make resource allocation decisions and to improve overall performance. There are at least two key challenges in this evaluation procedure. Can the evaluation procedure be repeated in any school? Will the results hold up using any evaluation methodology? The methodology challenge has highlighted the need for a fairer way to compare the performance of schools, taking into consideration all the peculiar features of educational process.

A study entitled "Evaluating school efficiency using Data Envelopment Analysis" was carried out in 2003 to identify the possible determinants of school efficiency and the strengths of DEA as a methodology to evaluate school efficiency.

OBJECTIVES OF THE STUDY

The objectives of this study were:

- To identify the determinants contributing to school efficiency based on the 'High Standard Quality Education' framework compiled by the Malaysian School Inspectorate.
- To evaluate the relative efficiency of schools.

LITERATURE REVIEW

For decades, many applied fields share a common concern over design and action on how to improve actual performance of an organization. The concept of a "best practice" emerges to vet these deliberate actions. There are three important characteristics associated with a "best practice": a comparative process, an action and a linkage between an action and some outcome or goal. From the 1980s onwards, researchers started to direct their effort towards extending "best practice" to education. This led to school improvement initiatives and studies on the characteristics of school environment conducive to learning (Rutter & Maughan, 2002). Researchers like E. Rhodes, W. W. Cooper and E. Thanassoulis started seeking appropriate measurement methodologies for school efficiency.

Efficiency

In economics, where a process has a single input and a single output, efficiency is defined as: Efficiency = $\frac{\text{output}}{\text{input}}$. The theory of production from economics can be considered as a formal model to link inputs and outputs. This theory has several strengths. First, some formal relationship between inputs and outputs exist and a "best practice" can be identified by comparing different units transforming inputs to outputs based on this relationship. Secondly, there exists an optimal situation for transforming inputs to outputs where all units are assessed relative to that optimum.

The production process that occurs in schools seems to have the same characteristics of the above economic model in the business sector – utilization of physical and human resources as inputs to produce outputs as shown in Figure 1.

Educational Inputs

The literature on educational inputs is plentiful. These inputs are divided into two categories. These are endogenous inputs that can be controlled by schools and exogenous inputs that cannot be controlled by schools. It seems that human resources and school resources are the two main endogenous determinants affecting school efficiency emerging from studies on school efficiency. The operating expenses and the teaching staff are the most frequently selected inputs for educational processes (Madaus et. Al. 1979, Mancebon & Bandres, 1999). However, Rutter and Maughan (2002) provide a more comprehensive list of inputs. First is the school management that includes good leadership that provides strategic vision, staff participation with a shared vision and goal, and appropriate rewards. Secondly, ethos qualities include an orderly atmosphere, attractive working environment, shared high expectations and good teacher-pupil relationships. Third is effective monitoring that means regular measurement of pupil performance, assessment of teacher efficiency and evaluation of overall school performance. Fourth is good classroom management that is efficient lessons, clarity of purposes and contents in these lessons. Finally, the pedagogic qualities include effective teaching, active participation from pupils, maximization of learning time and the like.

There are many studies confirming that exogenous or non-discretionary inputs, the determinants of the education process that fall outside the control of the schools such as the socio-economic level of the family and the previous education received by the pupil affect school efficiency (Madaus et. Al. 1979, Mancebon & Bandres, 1999, Ruggiero, 1998). Thanassoulis (1999) and Rutter and Maughan (2002) term these non-discretionary inputs as the contextual factors. The findings of such studies all agree to the decisive importance of this category of inputs to student performance. Sammons et al (1996) find that these factors such as student prior attainment, gender, ethnicity and free school meals are statistically significant, contributing about 44.5% of the variation in student academic achievement. Mancebon and Badres (1999) suggest the inclusion of 'socio-economic component', 'human capital component' and 'aspiration component' for the estimation of school efficiency, which account for 74% of the variance in student academic achievement. However, Rutter and Maughan (2002) report that school influences can be stronger than those of student characteristics and home background in their academic performance.

Educational Outputs

The special characteristics of the education process reviewed earlier indicate the difficulty in establishing a theoretical specification for this process that is valid for all schools. Hence, one of the obstacles encountered by studies on school efficiency are the conceptualization and measurement of outputs. However, most studies established the importance of academic performance in this efficiency evaluation (Madaus et. Al. 1979, Mancebon & Bandres, 1999). Mancebon and Bandres (1999) suggest that the variables selected for academic performance must reflect both the quantity and quality of the academic standards achieved by schools. For quantity, one of the suggestions is the proportion of students passing an examination. The marks obtained by students in the subjects that form the curriculum is the variable most supported in the literature for quality. Other studies suggest that school beautification activities, sports and other co-curriculum activities are also desirable outputs (Thanassoulis & Dunstan, 1994, Lovell et al, 1993).

Efficiency Model

In recent literature, three approaches to measure educational efficiency have been developed: data envelopment analysis (DEA), regression analysis and ratio approach. The technical and conceptual limitations of ratio analysis and regression techniques with respect to the measurement of efficiency or the determination of the educational production function have been cited. The most frequent documented difficulty is their inability to deal with multiple outputs. Regression techniques require parametric specifications of a production function but the production function identified then may be problematic. Another weakness of regression technique is that the predicted values provide the average level and not the maximum achievable output given certain inputs. DEA offers clear advantages over other methods as a source of information. It is preferable to either ratio analysis or regression analysis in determining the efficiency of organizations that produce multiple outputs (Banker, Charnes, Cooper, Swarts, & Thomas, 1989; Banker, Conrad, & Strauss, 1986; Bowlin, Charnes, Cooper & Sherman, 1985; Charnes, Cooper, Divine, Ruefli, & Thomas, 1989; Seiford & Thrall, 1990; Sexton, 1986; Sherman, 1986). Hirshberger, Osmonbekov and Donthu (2001) conclude that DEA is better for evaluating management performance, because of the inflexibility of the regression analysis model. On top of these, DEA can also identify specific DMUs that serve as a benchmark to the inefficient DMU. Thus, DEA seems more favorable to measure efficiency, compared to regression analysis.

METHODOLOGY

This research consisted of two stages in attempting to answer the two objectives. In the first stage, a reclassification of the original variables in PKSBSTKP yielded a few principal components that were linear combinations of the original variables (inputs or outputs) without a substantial loss of information. In the second stage, the corresponding scores of these principal components were then calculated for all the participating schools and these scores were used to evaluate their efficiencies.

Subjects

All the secondary schools from the Sri Aman/Betong Division were included in this study. Schools in the Sri Aman/Betong Division were chosen based on the assumption that DEA's homogeneity of schools could be maintained in this division.

Instrumentation

A set of forms was designed by the researchers and used to obtain additional inputs and outputs data to capture the effect of non-discretionary variables on school efficiency. More specifically, it solicited information on the parents' social-economic background, the parents' educational level, the number of external tutoring subjects for the students, and the performance of schools in public examinations such as PMR and SPM. This instrument was administered to the school principals and form teachers.

Data Collection

This study collected the secondary data through the Sarawak Education Department on the schools' working manuals of 'High Standard Quality Education' for the year 2002. On top of these, the forms prepared by the researchers were given to the principals and form teachers for obtaining additional inputs and outputs to capture the effects of non-discretionary variables on school efficiency.

Data Analysis – Efficiency Model: Data Envelopment Analysis

In this research, data envelopment analysis (DEA) was used in an attempt to deal with the issue of measuring the relative efficiency of the participating schools. DEA was used in the analyses because it is empirically based and capable of finding a summary measure of efficiency with multiple inputs and outputs. In educational services, the emphasized efficiency is the pure technical efficiency which deals with the usage of labor, capital, and machinery as inputs to produce outputs relative to best practice in a given sample. By applying DEA, the efficiency of each school is evaluated by comparing the school with a group of other schools that have the same sets of inputs and outputs. DEA segregates schools into efficient and inefficient schools. The output orientation model of DEA – BCC (Banker, Charnes and Cooper, 1984) was chosen to measure relative technical efficiency for this research. The interpretation of the BCC model that estimates the relative efficiency score, ϕ_O of DMU_o is given by

Maximize ϕ_O

Subject to:

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi_O y_{ro} \qquad r = 1, 2, \ldots, s \qquad (3.1)$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \qquad i = 1, 2, \ldots, m \qquad (3.2)$$

$$\sum_{j=1}^{n} \lambda_j = 1, \ \lambda_j \geq 0, \qquad j = 1, 2, \ldots, n$$

where

x_{ij} = amount of i^{th} input of DMU j, $i = 1, 2, \ldots, m$ where m = the number of inputs

y_{rj} = amount of r^{th} output of DMU j, $r = 1, 2, \ldots, s$ where s = the number of outputs

n = the total number of DMUs.

The use of this model implies that the efficiency score, ϕ_o will take a value equal to or less than 1. A score equal to 1 indicates that the DMU is radial efficient. A score less than 1 is an indicator of technical inefficiency and the DMU could increase its production by the proportion ϕ_o-1 without altering its current level of resources, under the same external conditions.

FINDINGS

The findings will be presented in four parts according to the research questions of the two objectives of this study. The research questions of the first objective were:

(1) What were the determinants that contributed to the technical efficiencies of the participating schools for the year 2002 based on the PKSBSTKP?
(2) Did the additional inputs and outputs from the forms change the technical efficiencies of these schools?

The research questions of the second objective were:

(1) What were the performances of the 16 secondary schools in the Sri Aman/Betong Division for the year 2002 according to the PKSBSTKP?
(2) What were the technical efficiencies of these schools for the year 2002 based on the PKSBSTKP?

What were the determinants that contributed to the technical efficiencies of the participating schools for the year 2002 based on the PKSBSTKP?

When the number of units is not substantially greater than the number of the inputs and outputs taken into account in the evaluation process, a high proportion of these units become efficient and the DEA approach fails to discriminate between them. In this study, the number of decision units was only 16 while the total number of inputs and outputs was 12. As such, principal component analysis was adopted to reduce these variables so that the discriminating power of DEA on these units would be enhanced. The discriminating analysis indicated that the first three principal components I_1, I_2 and I_3 accounted for 83.5% of the total variance in the data from the original inputs. The analysis also suggested that the three principal components of the outputs extracted, O_1, O_2 and O_3, account for 73.6% of the total variance for the six output variables from the PKSBSTKP. Table 1 and Table 2 give the simple structures on the loadings of each principal component.

The meaning of the principal components is inferred from the variables significantly loaded on their component. A rule of thumb frequently used is considering loadings that are greater than 0.30 in absolute values to be significant. The summary of the reduced inputs and outputs is shown in figure 2.

Did the additional inputs and outputs from the forms change the technical efficiencies of these schools?

The additional input and output variables used in this study were collected from schools directly using a set of forms and the reports on public examination results released by the Malaysian Ministry of Education. From the 11 schools returning the data collection forms, 10 schools had duly completed the forms. To investigate the effect of these additional input and output variables on the relative efficiency of schools, a series of DEA runs were performed ranging from an analysis involving all the data from PKSBSTKP in DEA run 1 to that involving PKSBSTKP and the additional inputs and outputs in run 3. Inclusion and exclusion of additional input and output variables were done to evaluate the relative efficiency of a school. In our experiment, this led to four different DEA runs. Table 3 summarizes the variables included in the four DEA runs, each with a different set of input and output variables.

The summary of the result as indicated in Table 3 and figure 3 shows that run 1 was identical to run 4. This implies that the presence of public examination results were not likely to have a significant impact on school efficiency and therefore it may not be necessary to include public examination results as an output variable in evaluating school efficiency. The p-value of 0.173 from Wilcoxon Signed Ranks test supports that the fact that there was no significant difference between the efficient score in run 1 and run 4. There is a marked change both in the number of schools evaluated inefficient and the average efficiency scores within pairs of DEA run 1 and run 2. In DEA run 1, without non-discretionary inputs, 60% of the schools are evaluated as inefficient, whereas with the non-discretionary and discretionary inputs in run 2, 80% of the schools are evaluated as inefficient. So, when the number of inefficient schools increased from 60% to 80%, the average efficiency score decreased from 87.08 to 77.06. 7 schools changed their efficiency scores in run 2. This noticeable change as shown in figure 3 provided the reasonable discriminating capability of the non-discretionary input variables in evaluating school efficiency. Wilcoxon Signed Ranks test with the p-value of 0.018 indicates that the difference was significant between the two run.

What were the performances of the 16 secondary schools in the Sri Aman/Betong Division for the year 2002 according to the PKSBSTKP?

Generally, the PKSBSTKP performances of all the 16 participating schools were average. SM06 scored the highest marks of 69.03 and SM02 was at the bottom of the list with 44.27 marks (see Table 5).

What were the technical efficiencies of these schools for the year 2002 based on the PKSBSTKP?

Relative Technical Efficiency

Considering the inputs and outputs from PKSBSTKP data described in the earlier section, the BCC model was employed to determine the relative technical efficiencies for all the 16 participating schools. The efficiency score analysis in table 6 shows that nine schools were relatively efficient with their efficiency scores equal to 100 (see Table 6). This shows that the resource utilizations of these schools were handled efficiently. The other 7 inefficient schools all had their efficiency scores less than 100.

The figures also show that inefficient schools could improve their efficiency by decreasing input resources and increasing output resources. For example, the relative efficiency score of SM13 was 92.65 %. This shows that it could only reach 92.65 % of the output level of efficient school with the same level of inputs. Despite having inefficient score, SM13, SM14, SM12, SM09, and SM05 were very close to the efficient frontier. Unfortunately this was not so for SM10 and SM02.

Benchmarking

Discrimination among the nine efficient schools was undertaken by using the frequency in the reference set to interpret the contents of efficiency. The frequency with which a school showed up in the reference set of other schools represented the feasibility of the school to be benchmarked by the peer compared with other efficient school. The higher the frequency, the more similar the efficient school's internal environment compared to the inefficient schools. The 9 efficient schools could be categorized into three groups: Group 1 − SM15 could be placed in the high frequency benchmark group, Group 2 − SM08, SM16, SM11, and SM03 were in the middle frequency benchmark group, and Group 3 − SM06 and SM01 were classified in the low frequency benchmark group. It must be noted that SM07 and SM04 could be categorized further into a fourth group that was, rare frequency benchmark group as there was no reference being made to them. This implies that SM07 and SM04 were not very similar to the other seven efficient schools and might have their own peculiarities. The BCC model can identify a set of efficient peer schools for each inefficient school. Table 7 contains the sets of efficient schools identified by the BBC model of DEA to be benchmarked by the inefficient schools for improvement.

Potential Improvement

Estimation on the possible decrease in inputs or increase in outputs for inefficient schools in order for them to move to the efficiency frontier was carried out. This was done through an analysis of the potential improvement for all the inputs and outputs for the 7 inefficient schools as shown in Figure 5.

The breakdown in terms of the specific outputs and inputs shows that the average potential increase in the students' academic performance (O_1) was 18.31%. The average potential increment of improvement in academic performance and achievement in co-curriculum (O_2) was 54.84%. Finally, the average potential increase for other aspects and school uniqueness (O_3) was 23.16%. The average potential reduction in the input variables for quality of students (I_1), managerial quality (I_2), and school facilities (I_3) were 1.5% 0.7%, and 1.49% respectively. However, not all the recommendations of this model are feasible in the public educational system. Reduction in the inputs of quality of students, managerial quality and school facilities are unfavourable. Furthermore, reducing the managerial quality and the facilities of school cannot be feasibly managed by a school alone. Possible strategies must be examined on a school basic in collaboration with the ministry of education. Thus, the areas that need feasible recommendations for improvement would be those that are tied to the educational outputs of schools.

CONCLUSION

'High Standard Quality Education' framework for the year 2002 was a very comprehensive document to assess school efficiency. It utilized all the educational inputs and outputs peculiar to educational processes reviewed in the literature for the evaluating process. However, the computation of the final score for a school in PKSBSTKP does not provide the maximum achievable outputs of a school operating under certain given inputs and hence is inadequate for comparison purposes. On top of this, the process of determining the score for each variable by a school was very subjective. In the end, the final score was an absolute measure of a school's efficiency from its management. A fairer methodology which can overcome the above inadequacy needs to be employed. Data envelopment analysis stands out in this type of estimations. It offers clear advantages for efficiency evaluation as compared to other methodologies. However, the discriminating power of DEA will be lost if the number of DMUs is not substantially greater than the number of inputs and outputs taken into consideration for the evaluating process. In this research, there were 16 schools and 12 variables. A principal component analysis was essential to reduce these 12 variables to 3 principal component input variables and 3 principal component output variables. Even though this reduction resulted in a loss of 16.5% and 26.4% of the variances in the original input and output data respectively, the 6 principal components met the suggestions made by Madaus et al, 1979, Mancebon and Bandres, 1999 and Rutter and Maughan, 2002 as the important determinants of school efficiency.

In this research, additional inputs and outputs were gathered through a set of forms designed by the researchers. These were students' household incomes, the parents' educational levels, and quality of student intakes indicated by the students' UPSR and PMR results, and the number of tutoring subjects taken. The analysis shows that these non-discretionary input variables had a profound impact on efficiency evaluation of schools. This is consistent with the findings reported by Sammons et al, 1996, Mancebon and Badres, 1999 and Rutter and Maughan, 2002.

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APPENDICES

Figure 1: Education production process

Figure 2: Dimension reduction of the inputs and outputs

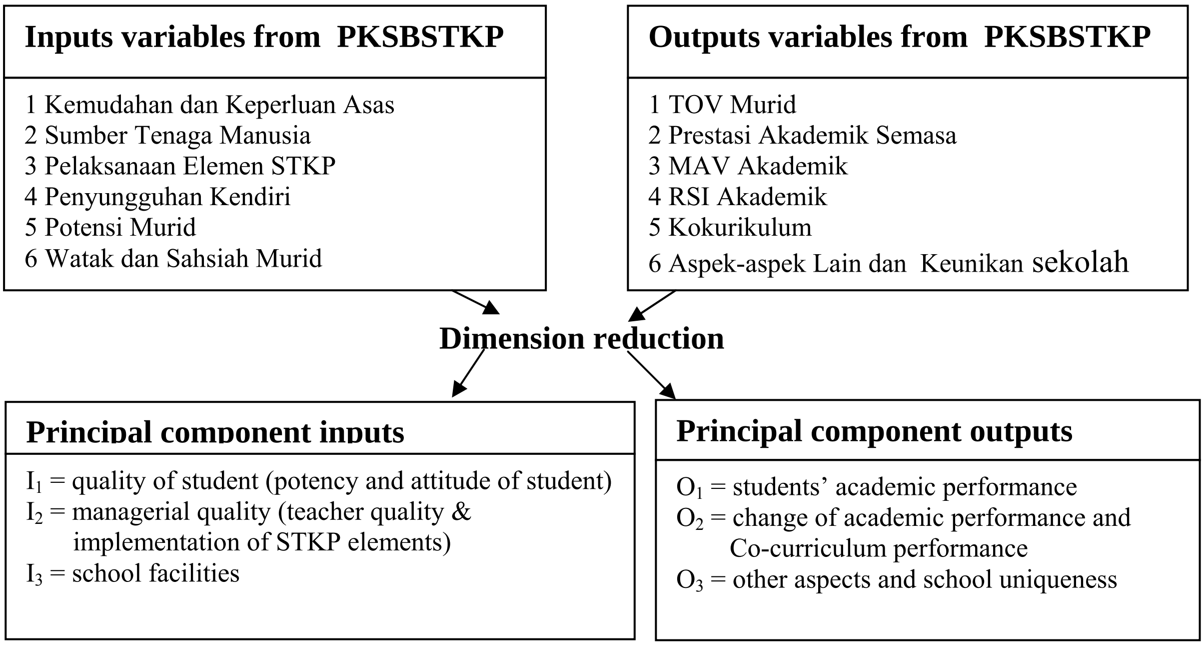

Figure 3: Relative Efficiency for DEA Run 1 and Run 4

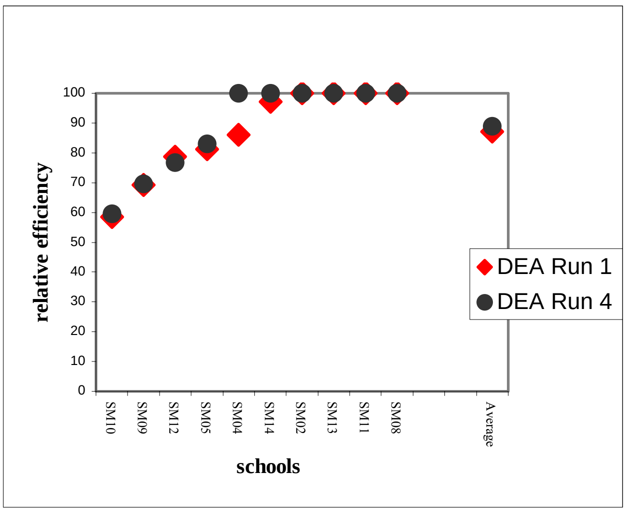

Figure 4: Relative Efficiency for DEA Run 1 and Run 2

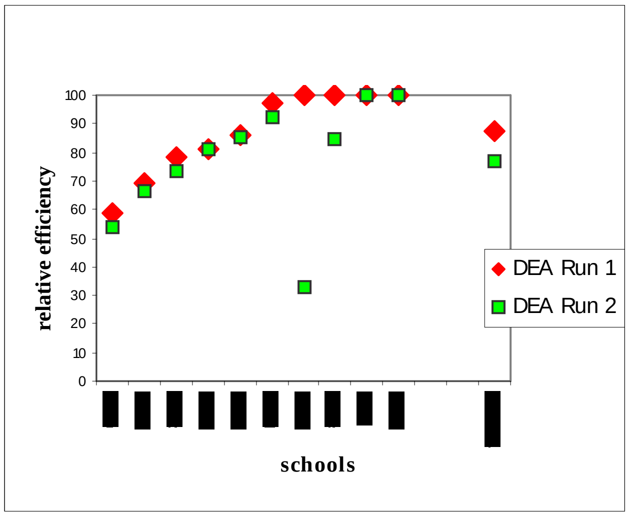

Figure 5: The average potential improvement for all the inputs and outputs

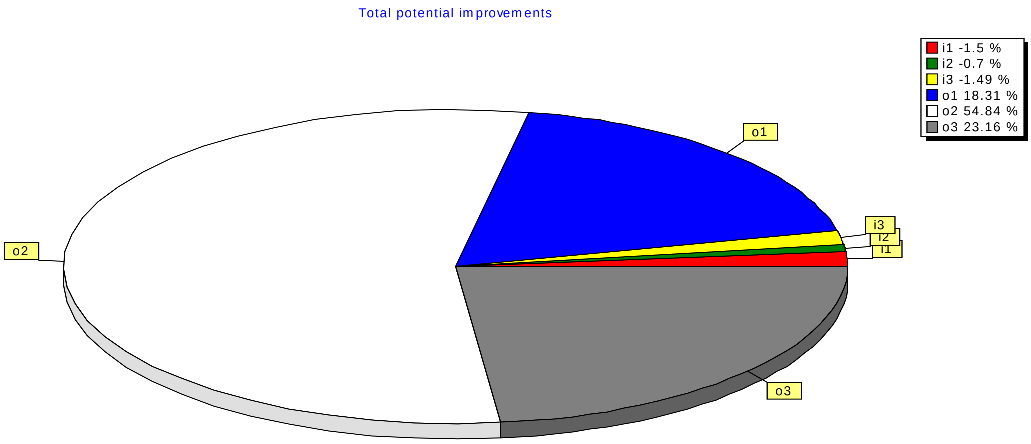

Table 1: Loadings of the three principal components of the inputs

Input Variables	Raw Component			Rescaled Component		
	1	2	3	1	2	3
Kemudahan dan keperluan asas	2.435	-1.145	13.404	0.178	-0.084	0.980
Kualiti sumber tenaga manusia	1.026	5.178	-0.286	0.168	0.847	-0.047
Pelaksanaan elemen STKP	-0.966	7.833	-0.405	-0.116	0.942	-0.049
Penyungguhan kendiri murid	3.388	1.731	1.331	0.649	0.332	0.255
Potensi murid	5.941	-0.445	1.681	0.911	-0.068	0.258
Kemajuan watak dan sahsiah murid	6.807	-0.260	-0.377	0.927	-0.035	-0.051

Table 2: Loadings of the three principal components of the outputs

Ouput Variables	Raw Component			Rescaled Component		
	1	2	3	1	2	3
TOV murid berdasarkan gred semua matapelajaran	2.653	-1.166	-0.148	0.495	-0.217	-0.028
Prestasi semasa akademik	15.64	1.921	-5.934	0.824	0.101	-0.313
MAV3 akademik	22.98	0.284	4.479	0.947	0.012	0.185
RS13 akademik	5.449	32.02	3.709	0.165	0.972	0.113
Pencapaian kokurikulum	4.174	-10.17	1.843	0.248	-0.604	0.109
Aspek-aspek lain dan keunikan sekolah	-1.39	-0.029	24.777	-0.055	-0.001	0.989

Table 3: Variables considered in different DEA runs

		DEA run 1	DEA run 2	DEA run 3	DEA run 4
Input variables form PKSBSTKP	**Output variables form PKSBSTKP**				
Kemudahan dan keperluan asas	TOV murid berdasarkan gred semua mata pelajaran	./	./	./	./
kualiti sumber tenaga manusia	Prestasi semasa akademik	./	./	./	./
pelaksanaan elemen STKP	MAV3 akademik	./	./	./	./
Penyungguhan kendiri murid	RSI3 akademik	./	./	./	./
Potensi murid	Pencapaian kokurikulum	./	./	./	./
kemajuan watak dan sahsiah murid	aspek-aspek lain dan keunikan sekolah	./	./	./	./
non-discretionary input variables					
Pendapatan keluarga			./	./	

pendidikan ibubapa	./	./	
Tuisyen di luar sekolah	./	./	
input UPSR	./	./	
input PMR	./	./	
Output variables from the public examinations			
Output PMR		./	./
Output SPM		./	./

Table 4: Relative efficiency for four DEA runs

	DEA run 1	**DEA run 2**	**DEA run 3**	**DEA run 4**
Unit	**Score**	**Score**	**Score**	**Score**
SM12	78.63	73.7	76.74	76.74
SM14	97.17	92.6	100	100
SM02	100	32.69	100	100
SM04	86.06	85.2	100	100
SM13	100	84.89	100	100
SM11	100	100	100	100
SM10	58.56	53.99	59.63	59.63
SM08	100	100	100	100
SM09	69.28	66.34	69.66	69.66
SM05	81.14	81.14	83.01	83.01
Average	87.084	77.055	88.904	88.904

Table 5: PKSBSTKP performances of the schools

sekolah	kemudahan dan keperluan asas	kualiti sumber tenaga manusia	pelaksanaan elemen STKP	penyungguhan kendiri murid	TOV murid Berdasarkan gred semua mata pelajaran	potensi murid	kemajuan watak dan sahsiah murid	prestasi semasa akademik	MAV3 akademik	RSI3 akademik	pencapaian kokurikulum	aspek-aspek lain dan keunikan sekolah	purata markah pencapaian
SM11	92.16	62.88	57.43	56.86	40.29	68.14	63.8	2.98	6.07	68.94	57.14	38.14	51.24
SM07	54.3	83.8	85.3	57.8	58.3	55.3	55.8	0.7	2.2	0.1	92.9	71.4	51.49
SM16	46.1	65.03	73.14	56.17	52.13	68.31	67	11.18	11.32	85.36	53.5	64.28	54.46
SM08	50.5	69.3	72.4	54.6	51.9	65.6	58.6	50.9	44.2	100	71.4	32.1	60.13
SM06	74.9	85.3	81.2	75.1	52.9	79.5	71.4	41.3	65.2	44.8	80.7	76.1	69.03
SM01	85.6	67.7	63.6	61	47.6	74.8	67.2	12.5	1.36	100	31.4	20	52.73
SM03	65.23	68.24	76	58.14	44.1	68.85	70	0.43	1.8	81.95	50	85.71	55.87
SM04	58.68	74.09	76.28	54.39	47.18	66.49	66.37	22.49	69.76	52.86	42.86	57.14	57.38
SM15	59.4	70	70.6	54.2	54.2	54.2	46.1	16.6	60	100	80	42.9	59.02
SM13	68.3	70.3	66.5	63.7	53.8	70.1	66.6	53.8	31.3	21	66.5	1.3	52.77
SM14	62.2	77.15	72.1	56.73	51.81	71.19	68.93	44.36	30.35	85.1	64	44.07	60.67
SM12	85	74.3	90	57.6	44.3	70.3	70	3.5	26.7	49.7	85.7	67	60.34
SM09	75.2	70.7	84.3	55.7	38.6	59.1	55.7	3.3	4.9	46.1	57.1	60.7	50.95
SM05	52.5	70.5	75.7	55.7	45.3	64.7	66.1	17.4	14.2	82.6	75	35.7	54.62
SM10	65.53	66.96	71.42	53.71	47.86	65.69	66.28	4.41	4.16	41.25	57.1	42.9	48.94
SM02	54	70.78	69.71	58.57	46.48	64.63	75.79	2.1	3.5	4.3	81.4	0	44.27

Table 6: Relative efficiency scores for all the participating schools

DMU	Score	Scale
SM11	100	Constant
SM07	100	Constant
SM16	100	Constant
SM08	100	Constant
SM06	100	Constant
SM01	100	Constant
SM03	100	Constant
SM04	100	Constant
SM15	100	Constant
SM13	92.65	Decreasing
SM14	90.25	Increasing
SM12	89.12	Increasing
SM09	86.56	Decreasing
SM05	84.81	Increasing
SM10	69.26	Decreasing
SM02	28.3	Decreasing

Table 7: Sets of efficient schools to be benchmarked by the inefficient schools for improvement

Inefficient school	Efficient schools to be benchmarked
SM13	SM11
SM14	SM15, SM01, SM08
SM12	SM15, SM06, SM03
SM09	SM15, SM03
SM05	SM15, SM08, SM16
SM10	SM15, SM11, SM16, SM03
SM02	SM15, SM11, SM08, SM16