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Sustainability through Efficiency of Alternative Educational Institutions: An Empirical Study using DEA Approach

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ABSTRACT

Sustainability and scalability of business require appropriate strategy and system through accurate allocation and utilization of available resources. Efficiency considers maximization of the output with a given level of input or minimization of the input for a given level of output. This study has been conducted considering the micro level variables, isolated from persuade of macro level factors. A comparative analysis in efficiency among government and private and charitable educational institutions has been conducted with the help of primary data, collected in West Burdwan District, West Bengal. Tim Coelli's DEAP software has been used to test the efficiency through Data Envelopment Analysis with multiple inputs and outputs. An output oriented DEA model has been validated for this study; in government institutions the inputs are limited and thus the possibility to minimize the same is not applicable, hence the output oriented DEA has been postulated. It has been found that there is a considerable inequality in efficiency distribution of educational institutions as measured through data envelopment analysis; it is also found that, the charitable educational institutions are highly efficient, followed by the private and government educational institutions. The different level of efficiency among these three types of institutions has been proven significant with Mann-Whitney U test. The recommended approach in this study confers decision making assistance for institutional policy implication, strategy evaluation and resource allocation.

Introduction

Adam Smith, the father of Economics, talked about 'wealth of nation' in his study. The neo-classical economists move further and talked about "welfare of nation". Education is always an indispensable part of welfare of the state and it is the basic for any mixed economic country, like India. In the era of globalization, when consumers are having choices among alternatives, organizations should assess themselves for long run success. Today, in the world of competition the most significant issue for any organization is to maintain its sustainability. Organizations need to have appropriate strategy for the same. Efficiency in operation can be the key in this connection in order to attain competitive advantage and long run sustainability. In this study, we have considered three distinct categories of organizations, namely, State Government Schools (SGS), Private Schools (PRS) and Charitable not-for-profit Schools (CHS); the efficiency of these three types of schools have been measured and examined whether those variations are statistically significant or not.

The outline of this study as follows. Objectives of the study have been considered in the next section. Section III deals with hypothesis of the study. The data source and methodological

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framework to estimate school-specific efficiency score has been considered in Section IV. Section V deals with empirical results and discussion; data envelopment analysis has been used to compare the efficiency scores of alternative school categories and the same has been statistically tested to examine the intensity among difference of efficiency scores of different category of schools. The concluding comments have been placed in Section VI.

Objectives of the Study

The main objective of the study is to find an impression on the education in the district of West Burdwan. More specifically, it inquiries about the following concerns:

1. To compare the relative efficiency of the alternative education service providers (viz. State Government Schools, Private Schools and Charitable not-for-profit Schools) in the district of West Burdwan.
2. To examine the statistical intensity among the variations of efficiency across State Government Schools, Private Schools and Charitable not-for-profit Schools

Hypotheses of the Study

H_0: Regarding efficiency of alternative categories of schools, it is hypothesized that no difference exist in the performance level across State Government Schools, Private Schools and Charitable not-for-profit Schools

Methodology of the Study

Data Source

The micro-empirical study is carried out in the District of West Burdwan with the help of school specific information, which are collected through organizational level primary survey. The availability of good number of schools under three categories (State Government Schools, Private Schools and Charitable not-for-profit Schools) of schools directed us to consider the West Burdwan District under the state of West Bengal, India as the area of study. A total of ninety numbers of schools, where 9^{th} and 10^{th} standard classes are available, are considered, where thirty numbers of State Government Schools, thirty numbers of Private Schools and thirty numbers of charitable not-for-profit Schools are there in the sample size. Firstly, fifteen numbers of schools under each category have been considered for every sub-division through quota sampling. Then judgment sampling has been used to find out the final schools under sample. During sampling procedure, much concentration has been given to consider sampling units as the true representative of the population; and the sample units can evenly spread across the geographical area of study.

Structured questionnaire has been constructed to collect data from the schools. The questionnaire comprises of variety of issues and their information, which include, available facilities, available personnel, infrastructural set up and others. The information has been collected from the highest authority of the organization i.e., Principal or Headmaster or their deputy. The clerical staffs also provided data from their depository. A participatory conduct has been maintained during the course of our field survey to have reliable and authentic data from the source.

School Efficiency Estimation

A multi-input multi-output Data Envelopment Analysis (DEA) has been carried out to determine the technical and scale efficiency level of all three types of schools i.e., State Government Schools, Private Schools and Charitable not-for-profit Schools. A firm's ability to achieve maximum output from a standard set of inputs can be revealed through Technical Efficiency (TE). The concept of "constant return to scale" (CRS) is accurately considered when all DMUs (Decision Making Units in DEA Estimation) are functioning at an optimal scale. Constraint on Finance, Imperfect competition etc. may cause a DMU to be not functioned at optimal scale (Coelli et al, 1998). Thus an extension of CRS DEA model has been recommended by Banker et al (1984) to explain the variable return to scale (VRS) circumstances.

The exercise of the CRS measurement when not all DMU's are functioning at the optimal scale will result in assesses of TE which are confounded by scale efficiencies (SE). Apply of the VRS specification will authorize the calculation of TE free from the SE effects. SE= TE_{CRS} / TE_{VRS}. If differences exist among the two TE scores (TE_{CRS} and TE_{VRS}) for the concerned DMU, then this specify that the DMU has scale inefficiency and that can be determined from the variations between the two scores (Coelli, 2002). To acquire individual measures of technical efficiency and scale efficiency, input-oriented technical efficiency measurement to the data is applied. This measurement assures two different kinds of scale behavior: constant returns to scale (CRS) and variable returns to scale (VRS).

The presence of optimal, sub-optimal and supra-optimal scale has been identified in the calculation of scale efficiency. If the school is scale-efficient, then it means that the school is operating at its optimum size, and hence that the productivity of inputs cannot be improved by increasing or decreasing the size of the school. If the school is considered to be not operating at its optimum size, then two possible cases arises: the scale inefficiency results from increasing returns to scale (i.e. increasing the size of the school helps to improve its productivity and thereby reduces unit costs) and the scale inefficiency is due to decreasing returns to scale (i.e. the school can raise its productivity and lessen unit costs by choosing a smaller size) (Nguyen et al 2004). When the returns to scales are constant, increasing and decreasing then it is alternatively known as optimal, sub-optimal and supra-optimal scale respectively. In the analysis part, optimal, sub-optimal and supra-optimal scales are identified and the relative percentages of school in each category are also estimated. Sub-optimal firms are operating below their optimal scale; this means that these firms could increase their technical efficiency by continuing to increase their size. Supra-optimal firms are operating above

their optimal scale and hence could increase their technical efficiency by decreasing their size. (Bielik et al 2004).

Let Y be an (M × N) matrix of outputs of schools in the sample, where the element y_{ij} represents the i^{th} output of the j^{th} school. Let X be a (P × N) matrix of inputs, in which the element x_{kj} represents the k^{th} input of the j^{th} school and z an N-vector of weights to be defined. Elements of these vectors are $z_1,\ldots, z_N$. The vector y_j (M × 1) is the vector of outputs and x_j is the (P × 1) vector of inputs of the j^{th} school. The CRS input-oriented measurement of technical efficiency for the j^{th} school is calculated as the solution to the following mathematical programming problem.

$\lambda^j_c = \min_{\square\square z}\square\square$,

subject to:

$y_{1i} \square y_{11}z_1 \square y_{12}z_2 \square \ldots \square y_{1N}z_N$

$y_{2i} \square y_{21}z_1 \square y_{22}z_2 \square \ldots \square y_{2N}z_N$

$y_{Mi} \square y_{11}z_1 \square y_{12}z_2 \square \ldots \square y_{MN}z_N$

$x_{11}z_1 \square x_{12}z_2 \square \ldots \square x_{1N}z_N \square \square x_{1i}$

$x_{21}z_1 \square x_{22}z_2 \square \ldots \square x_{2N}z_N \square \square x_{2i}$

$x_{P1}z_1 \square x_{P2}z_2 \square \ldots \square x_{PN}z_N \square \square x_{Pi}$

$z_j \square 0$ for all j.

The scale value $\square$ represents a proportional reduction in all inputs such that $0\square\square\square 1$, and λ^j_c is the minimum value of λ, so that $\lambda^j_c x^j$ represents the vector of technically efficient inputs for the j^{th} school. Maximum technical efficiency is achieved when λ^j_c equals unity. In other words, if the DEA gives the outcome $\lambda^j_c = 1$, the school is operating at the best-practice and it is not able to improve its performance any further, given the existing set of observations. If $\lambda^j_c < 1$, we can conclude that the school is operating below the best-practice frontier.

The VRS technical efficiency for the j^{th} school is computed as:

$\square^j_v \square \min_{\square,z}\square$,

subject to:

$y_{1i} \square y_{11}z_1 \square y_{12}z_2 \square \ldots\ldots \square y_{1N}z_N$

$y_{2i} \square y_{21}z_1 \square y_{22}z_2 \square \ldots\ldots \square y_{2N}z_N$

$y_{Mi} \square y_{11}z_1 \square y_{12}z_2 \square \ldots\ldots \square y_{MN}z_N$

$x_{11}z_1 \square x_{12}z_2 \square \ldots\ldots \square x_{1N}z_N \square \square x_{1i}$

$x_{21}z_1 \square x_{22}z_2 \square \ldots\ldots \square x_{2N}z_N \square \square x_{2i}$

$x_{P1}z_1 \square x_{P2}z_2 \square \ldots\ldots \square x_{PN}z_N \square \square x_{Pi}$

$l_1z_1 \square l_2z_2 \square \ldots\ldots \square l_Nz_N \square\square 1$

$z \square 0$.

Given these two estimates of technical efficiency, the input-oriented scale efficiency measure for the j^{th} school is calculated as the ratio of CRS technical efficiency to VRS technical efficiency, i.e. $S^j = \lambda^j_c / \lambda^j_v$. If the value of this ratio is equal to unity (i.e., $S^j = 1$), the school is scale-efficient, meaning that the school is operating at its optimum size, and hence that the productivity of inputs cannot be improved by increasing or decreasing the size of the school. If the value of this ratio is less than unity (i.e., $S^j < 1$), the school is considered to be not operating at its optimum size. In the first of two possible cases, (i), if $S^j < 1$ and, $\lambda^j_c = \lambda^j_n$ the scale inefficiency results from increasing returns to scale. In other words, increasing the size of the school helps to improve its productivity and thereby reduces unit costs. In the second possible case, (ii), if $S^j < 1$ and $\lambda^j_c < \lambda^j_n$, the scale inefficiency is due to decreasing returns to scale, indicating that the school can raise its productivity and lessen unit costs by choosing a smaller size.(Nguyen et al 2004)

For the estimation of efficiency, used input and output variables are listed in the Table 1.

Table-1: Input and Output Variables

Variable	Category	Code
Output	Students successfully moved to next course[1]	SNC
Output	Number of students[2]	NOS
Input	Academic Staff[3]	ACS
Input	Operating Expenses[4]	OPE
Input	Physical Area	PHA
Input	Infrastructural Facilities	INF

Results and Discussion

In this article different of input-output combinations is used in the framework of DEA. Different combinations of input and output variables provide different results. Though the different combinations show the tendency of the result of the study, but to find the final conclusion all the estimates are taken together at the final analysis. A single time period has been considered to perform the study. In private schools, it might be possible to increase the input resource to provide the service to a given maximum level. But the same is not possible in case of government schools. Sometimes a few departments of a

[1] The same output variable has been identified by Cheo (2009), Oliveira and Santos (2005), Cordero *et al.* (2008), Barbosa and Wilhelm (2009)

[2] The same output variable has been identified by Kao and Hung (2008), Martin (2006), Ouellette and Vierstraete (2010), Tyagi *et al.,*(2009)

[3] The same input variable has been identified by Kim *et al.* (2006), Kantabutra and Tang (2006), Spircu *et al.*(2007), Gimenez *et al.*(2007), Conroy and Arguea (2008), Cheo (2009), Addonizio (2009) Chen and Chen (2011)

[4] The same input variable has been identified by Kim *et al.* (2006), Kao and Hung (2008), Tyagi *et al.*(2009), Addonizio (2009)

government school may have adequate or even more resources, but most of the other departments suffer from lack of assets. Thus, by "input orientation", where the concept is to minimize the inputs to achieve a given level of output, is not considered. So, in this article, efficiency analysis has been carried out by considering the "output orientation" only.

Table-2: Estimates of Efficiency Scores and Returns to Scale

Type of School	Average Efficiency Score		Return to Scale		
	TE_{VRS}	Scale Efficiency	Increasing (IRS)	Decreasing (DRS)	Constant (CRS)
SGS	0.4935	0.6725	18(60.00)	01(03.33)	11(36.67)
PRS	0.6350	0.6375	21(70.00)	04(13.33)	05(16.67)
CHS	0.7677	0.8580	18(60.00)	07(23.33)	05(16.67)

Source: Field Survey 2013-14

Note: The statistical analysis has been carried out by using *DEAP* statistical package

Note: Figures within the parenthesis represent respective percentage with reference to number of schools in a specific school category

SGS: State Government Schools; PRS: Private Schools; CHS: Charitable not-for-profit Schools; TE_{VRS}: Technical Efficiency at Variable Return to Scale; IRS: Increasing Return to Scale; DRS: Decreasing Return to Scale; CRS: Constant Return to Scale

The result reveals that the Charitable not-for-profit Schools have the highest technical efficiency score, followed by Private Schools and State Government Schools. But the scenario is different in calculation of scale efficiency, where State Government Schools is having the second best score followed by Private Schools. In return to scale estimation, Sixty percent of State Government Schools, Seventy percent of Private Schools and sixty percent of Charitable not-for-profit Schools are having increasing return to scale, which shows all the schools under these category can increase their technical efficiency by increasing their inputs. 3.33 percent of State Government Schools, 13.33 percent of Private Schools and 23.33 percent of Charitable not-for-profit Schools are having decreasing return to scale, which means all the schools under this category can increase their technical efficiency by decreasing their inputs. 36.67 percent of State Government Schools, 16.67 percent of Private Schools and 16.67 percent of Charitable not-for-profit Schools are operating at optimal scale.

The different level of efficiency among these three types of institutions has been proven significant with Mann-Whitney U test. The result is as follows:

Table-3: Result of Mann Whitney U Test

		SGS and PRS			SGS and CHS			PRS and CHS		
School		SGS	PRS	Total	SGS	CHS	Total	PRS	CHS	Total
N		30	30	60	30	30	60	30	30	60
Mean Rank		15.5	14.70	15.10	15.5	14.33	14.97	14.70	14.33	14.57
Sum of Ranks		465	441	906	465	433	898	441	433	874
Test Statistic[b]	Mann-Whitney U	2.00			.000			2.00		
	Wilcoxon W	38.000			10.000			12.000		
	z	-3.383			-2.841			-2.378		
	Asymp. Sig. (2-tailed)	.001			.004			.017		
	Exact Sig. [2*(1-tailed sig.)]	.000[a]			.002[a]			.016[a]		
Remarks		TE of SGS and PRS are Significantly Different			TE of SGS and CHS are Significantly Different			TE of PRS and CHS are Significantly Different		

[a] Not corrected for ties.

[b] Grouping Variable: School

Source: Field Survey

Note: The statistical analysis has been made using *SPSS* statistical package for Mann Whitney U Test (Rank Sum Rest).

In the first combinations of schools the calculated *z* value of Mann Whitney U Test is higher than the tabulated value of *z*; so, the hypothesis for these two categories of schools is rejected. So, the result reveals that these two categories of schools operate differently. Similarly, both in the second and third combinations of schools the calculated *z* value of Mann Whitney U Test is higher than the tabulated value of *z*; so, the hypothesis of operating both categories of schools in a similar way is rejected.

Conclusions

Efficiency in education services is important in outreaching the same to the major sections of the population. At the same time it is also important to maintain the sustainability of the institution, both for profitability at micro level and welfare at macro level. The policy makers should focus on the appropriate resource allocation in order to achieve highest level of

efficiency. More the efficiency, more the sustainability. Strategy for sustainability is thus focus in this juncture.

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