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Determinants of School Efficiencies in Abu Dhabi Using DEA

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Abstract. This research measures and compares the efficiency of Abu Dhabi secondary public schools using data envelopment analysis (DEA). It seeks to identify an appropriate list of inputs and outputs for evaluating the efficiencies of schools in urban areas. Several scenarios were developed using different combinations of inputs and outputs. Sensitivity analysis was carried out to identify reductions (in inputs) or increase (in outputs) needed for inefficient schools. The inputs with greatest impact were cost per teacher, cost per students, and maximum class size. The outputs with greatest impact were three student tests. Analysis of variance showed that location and type of school had a significant impact on school efficiencies. Regression results show that both cost per students and cost per teacher are significant determinants of school efficiency. The paper makes a contribution to the understanding of schools' performance management, in order to inform schools, evaluators and policy decision makers.

Keywords: DEA, Abu Dhabi, Efficiency,

1. Introduction

1.1. Background

DEA offers clear advantages over other methods as a source of information in determining the efficiency of organizations that produce multiple outputs (Banker et al., 1989; Banker, et al., 1986; Bowlin, et al., 1985; Charnes, et al., 1989). The methodology measures the relative efficiency without prior assumption of input-output weights. The objective of this paper is to assess the schools' efficiency to some extent in the presence of multiple inputs and outputs by using DEA. Public education in Abu Dhabi is divided into three groups: Cycle 1 (Grades 1-5); Cycle 2 (Grades 6-9); and Cycle 3 (Grades 10-12). There are three main public school types in Abu Dhabi, public-private partnership (PPP) schools, model schools and government schools. However, the new school model (NSM) aims at unifying these school types in 2-5 years. Since 2009, all urban-secondary-public schools in Abu Dhabi are either PPP or model. All Abu Dhabi schools should be transformed to NSM in 5 years. The NSM is intended as a comprehensive foundation for learning that will enable desired student outcomes by developing major components of the educational experience: teaching quality, learning environment, school leadership, and parental involvement. Within this model, a new curriculum and new teaching methods will be introduced in order to develop the student as a creative independent thinker and problem-solver. All schools are government funded. ADEC is responsible for recruiting and hiring staff, principals and teachers.

1.2. School Efficiency Measurement: The DEA Approach

DEA was developed by Charnes et al. (1978) to evaluate public sector and not-for-profit organizations. DEA compares each decision-making unit (DMU) with all other DMUs in a set of DMUs, and calculates an aggregate performance measure based on a ratio of outputs and inputs. It can deal with multiple inputs and outputs for measuring the performance of each DMU.

Many studies report on using DEA to measure performance of schools (Coelho et al., 2007; Mayston, 2003; Dyson, 2000). In fact, DEA was used in many countries to measure the efficiency of schools. Most studies conclude that DEA is applicable to efficiency measurement of schools in the sense that it detects differences between schools and the results are fairly robust: USA (Bessent and Bessent, 1980; Bessent et al., 1982, 1983, 1984; Ludwin and Guthrie, 1989; Fare et al., 1989; Sengupta, 1987; Sengupta and Sfeir, 1986, 1988; Ray, 1991; Ganley and Cubbin, 1992; Ruggiero, 1996, 1999, 2004; Engert, 1996; Duncombe et al., 1997; Chalos and Cherian, 1995; Chalos, 1997; Grosskopf and Weber, 1999; Grosskopt et a., 2001; Rassouli-Currier, 2007; Christie et al., 2010); UK (Jesson et al., 1987; Mayston, 1996; Mancebon and Mar-Molinero, 2000; Bradley et al., 2001; Thanassoulis and Dunstan, 1994; Bates, 1997); Norway (Bonesrqnning and Rattsq, 1992, 1994); Finland (Kirjavainen and Loikkanen, 1998); Spain (Muniz, 2002); Sweden (Waldo, 2007); Portugal (Sarrico et al., 2010); Cyprus (Soteriou et al., 1998); China (Hu et al., 2009; Ng and Li, 2009); and Tunisia (Essid et al., 2010).

1.3. School Efficiency Inputs and Outputs

The operating expenses and the teaching staff are the most frequently selected inputs for educational processes (Ruggiero, 1998; Madaus et. Al. 1979; Mancebon & Bandres, 1999; Mancebon and Banders, 2001). Rutter and Maughan (2002) provide a more comprehensive list of inputs. Thanassoulis (1999) and Rutter and Maughan (2002) agree to the decisive importance of this category of inputs to student performance. 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. Charnes, Cooper and Rhodes (1981) and Bessent et al. (1982) the preferred specification of educational outcomes in most of the empirical literature has been student test scores. Senupta (1987) used average test scores in reading, mathematics, writing and spelling, McCarty and Yaisawarng (1993) specified passing students in mathematics, reading and writing proficiency, and Chalos and Cherian (1995) and Chalos (1997) employed verbal and math test scores. Studies by Ruggiero (1996) of New York State schools also specified social studies test scores, and Ray (1991) who added language and arts performance in an analysis of Connecticut high schools.

Following studies such as Bessent et al. (1980; 1982), Sengupta (1987), Diamond et al, (1990), and Beasely (1995), the current study has considered school related variables as inputs and test scores as outputs. To assess the intuitive picture of performance and to measure the dependency of efficiency on different variables we consider several models with different input-output combinations. The guiding principle in construction of models is to proceed from simple one (with less number of input-output variables) to more complicated ones (with greater number of variables).

2. Methods

2.1. Data, Study Sample, Inputs and Outputs

Data for the academic year 2009-2010 on Abu Dhabi public schools were collected. The study will focus on schools that are public, secondary level, located in urban areas, and have been in existence for at least 5 years. There are 22 schools that meet all four requirements. The outputs include the 12th grade average exit exam results (called Thanawiah); The Common Educational Proficiency Assessment (CEPA) average score; English, Math, Science and Arabic (EMSA) average scores. For ADEC secondary public schools, there are many cost related variables that are available. The list of inputs includes average student cost per school; average teacher cost per school; class capacity utilization; the teacher – student ratio in the school; and the teacher load. Golany and Roll (1989) note that the number of DMUs should be at least twice of the total number of input and output factors considered when applying the DEA model. In this study the number of DMUs was 22, while the total (available) inputs and outputs is 15, which means that we need to be extra careful in selecting the right combination of outputs and inputs for the DEA to yield high construct validity.

2.2. Analysis Method and Model

Correlation analysis will be used to reduce the number of inputs and outputs to the required numbers. DEA models (scenarios) will be developed with different combinations of inputs and outputs. Each model will attempt to incorporate variables that have low correlations. The issue of returns to scale concerns what happens to schools' outputs when they change the amount of inputs that they are using to produce their outputs. Both input minimization and output maximization options will be used. The objective is to answer two questions: “How well are the schools doing?" and "How much could they improve?". Such analysis will suggest performance targets for each inefficient school. It also identifies the units which are performing best and their operating practices can then be examined to establish a guide to "best practice" for other schools to emulate. The model designed here is a simple CCR model, which is probably the most widely used and best known DEA model. A constant returns to scale relationship is assumed between inputs and outputs.

3. Results

3.1. Variable Candidates and Scenarions

The number of schools (DMU’s) is 22 schools. Since there are a total of 15 input/output variables available, a correlation analysis is performed on the set of inputs and the set of outputs to reduce the number; and to find the best combination mix of inputs and outputs. Several scenarios could result. There is low correlation between cost per teacher, and the other 4 input variables. As a result, cost per teacher is a good candidate for a representative input variable. It could be a part of all scenarios. If average cost per student is an important input variable, it should be noted that it enjoys high correlation with teacher load and average student/teacher ratio. In addition, Class capacity is highly correlated with student/teacher ratio. As a result, class capacity could be a good representation of inputs. Other inputs listed here could be used, but some care should be practiced not to include them with their correlated counterparts. Both CEPA and G12 Thanawiyah have relatively low correlations with all other variables. CEPA and G12 Thanawiyah are correlated. Recommended that either one could be a candidate for inclusion in the analysis. EMSA variables are correlated with each other. As a result, only one of them could be included in the analysis. The one with the lowest correlation with CEPA or with G12 Thanawiyah is EMSA Grade 12 Math.

3.2. School Relative Efficiencies

School efficiencies are calculated under several scenarios. Given the conclusions reached with regard to correlation between the variables. Each scenario is associated with different combinations of inputs and outputs. This form of analysis could be thought of as a sensitivity of the model to different inputs and outputs. In other words, how would the efficiencies change given a change in the combination on inputs and outputs? For the both input minimization and output maximization analyses with constant returns to scale, efficiencies for selected scenarios analyzed are given in table 1. The last row in the table shows the average efficiency scores under each scenario. There are several obvious results that could be summarized here. For the 13 scenarios, only 4 schools reach the 100% efficiency score at least once. These schools are Qatr Al Nada, Al Ittihad, Al Mutanabbi, and Abu Dhabi Secondary school. For the 13 scenarios, 3 schools always in the lowest efficiency range (≤70%). These schools are Meriejeb, Al Manaseer, and Al Sarooj. For all 13 scenarios, 8 schools score a maximum of 80% (≤80%). One school, Al Mawahen Model school, constantly maintain a high efficiency score (≥90%), except once. This school never scored 100% efficiency. Three schools that scores 100% efficiency at least once, score poorly with regard to the first scenario (≤70%).

For the input minimization analysis, DEA provided actual and targets for each resource (the input variables). As a result, each school gets the potential improvement it could achieve to be efficient in comparison with its efficient peer (s). In addition, the output maximization analysis provided actual and targets for student outcomes to make the school efficient in comparison to its peers. Since such sensitivity analysis could be performed with each scenario, it was necessary to present and discuss results with the executive committee in ADEC. This was necessary to better concentrate and focus on few more appealing scenarios. For each scenario, DEA could provide sensitivity analysis. For example, the ninth scenario concentrates on CEPA score as the only output variable. The CEPA score is a major KPI in ADEC’s strategic plan. The scenario incorporates both average student cost and average teacher cost. Results show that four schools maintain 100% efficiency. As a result, no improvements are necessary. Results show that some schools require extensive improvements if they are to reach 100% efficiency. On average, cost per student could improve 16.41%, cost per teacher could improve 13.35%, unutilized class capacity could improve 24.07%, and the CEPA core could improve 15.8016%. The most inefficient schools require more improvements (i.e., Mereejeb, Al Manaseer, Al Maahad Al Islami, Al Sarooj, and Al Ain Secondary school).

The Abu Dhabi school reform has fundamentally changed the conditions under which public education is produced. The responsibility for providing education is gradually being decentralized from ADEC to schools. One of the aims with the reform was to increase efficiency in education. This paper estimated efficiency for the school year 2009-2010 using DEA. ADEC's policy makers could optimally utilize DEA in its schools to perform a number of tasks including resource allocation between schools; reallocating from the inefficient school to the efficient school; identification of "best practice" in school operations; identification of "poor practice" in school operations; target Setting for inefficient schools; monitoring school efficiency changes over time; and rewards for good performing schools.

Scenario Number	1	3	6	9	10	11	12	13
INPUTS	C/student	C/student C/teacher	C/student Class size	C/teacher C/student Class size	C/teacher C/student Class size	C/teacher C/student Class size	C/teacher C/student Class size	C/teacher C/student Class size
OUTPUTS	CEPA E12Math	G12	CEPA	CEPA	G12	E12Math	CEPA E12Math	G12 E12Math
Khalifah Bin Zayed	81.46	77.35	80.93	85.50	80.35	88.31	88.31	88.31
Mereijeb	54.82	70.76	60.14	79.00	78.12	75.15	79.00	78.12
Al Qadesyah	81.26	76.66	89.08	90.47	79.98	85.14	90.47	85.14
Qatr Al Nada	71.51	100.0	70.94	100.0	100.0	100.0	100.0	100.0
Khalifah Bin Zayed	72.79	68.71	77.45	83.84	73.38	82.14	83.84	82.14
Umm Ammar	70.02	80.81	76.98	91.88	87.99	87.13	91.88	87.99
Al Mawaheb Model	92.43	96.00	94.16	99.66	96.15	97.11	99.66	97.11
Al Manaseer	59.66	70.10	63.37	77.71	71.59	73.75	77.71	73.75
Zayed Al Awwal	74.54	86.36	69.90	84.56	86.36	90.35	90.35	90.35
Al Maahad Al Islami	60.31	74.24	57.31	79.66	77.51	84.88	84.87	84.87
Al Ittihad Model	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Al Sarooj	57,66	72.05	61.31	77.61	76.82	75.07	77.61	76.82
Mohammad Bin Khalid	65.12	74.39	68.34	85.43	80.35	84.34	85.43	84.34
Al Mutanabbi	73.44	82.74	100.0	100.0	100.0	100.0	100.0	100.0
Darwish Bin Karam	83.07	77.07	84.13	90.56	78.65	90.73	90.73	90.73
Al Montaha	75.69	80.96	83.04	94.56	86.68	89.67	94.56	89.67
Palestine school	62.89	81.89	67.02	86.85	84.87	82.52	86.85	84.87
Al Ain Secondary	40.13	75.42	36.48	76.26	75.42	79.13	97.13	79.13
Abu Dhab Secondary	96.28	95.06	100.0	100.0	100.0	100.0	100.0	100.0
Khaled Bin Al Waleed	76.82	82.60	77.84	91.18	88.64	93.37	93.37	93.37
Hanen Secondary	67.82	83.73	73.67	93.41	86.37	86.95	93.41	86.95
Aishah Bint Abi Baker	60.87	87.77	61.44	92.29	87.77	86.44	92.29	87.77
Average efficiency	69.13318	81.57591	75.16045	89.11045	85.31818	87.82636	90.79409	88.24682

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