An Assessment of Efficiency of Public Schools in Kuwait Using Data Envelopment Approach (DEA) and Tobit Regression

Mohammad Al-Enezi
Nadeem Burney
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Abstract

This paper examines the efficiency of public schools in Kuwait over each school level (kindergarten, primary, intermediate, and secondary) and six academic years (1979/80, 1984/85, 1989/90, 1994/95, 1999/2000 and 2004/05). The analysis is based on the entire public school population in the country and relies on a two-stage approach. In the first stage, estimates of technical, scale, allocative, and economic efficiencies are obtained on the basis of data envelopment analysis (DEA) technique. The second stage relates estimates of technical efficiency to school characteristics using the Tobit regression model. The explanatory variables included in the regression model are the schools' regional location, teachers' salary, proportion of teaching staff that are Kuwaitis, and whether a school is all-boys' or all-girls'. The estimates show that the public schools in Kuwait use more resources for the level of school output, operate below the optimum size (returns to scale are generally increasing), and use non-optimal input proportions. Teachers' salary is found to have positive effect on technical efficiency while the proportion of Kuwaiti teaching staff has a negative impact. All-girls schools are found to have higher efficiency than all-boys schools.

تقييم كفاءة المدارس الحكومية في دولة الكويت

محمد العنزي
نديم بيرني
جي جونس
مروه المسلم

ملخص

تقوم هذه الورقة بتقييم كفاءة المدارس الحكومية في دولة الكويت لجميع المراحل الدراسية (من رياض الأطفال، حتى مرحلة الثانوية) وذلك على مدى ست سنوات دراسية (1979/1980م، 1984/1985م، 1989/1990م، 1994/1995م، 1999/2000م، 2004/2005م). يستخدم التحليل المعلومات الخاصة بجميع المدارس في دولة الكويت، وذلك باتباع منهج من مرحلتين . يتم في المرحلة الأولى تقدير الكفاءة التقنية، وكفاءة الحجم، والكفاءة المالية والكفاءة الإقتصادية من خلال إستخدام تقنية (Data Envelopment Analysis). اما في المرحلة الثانية، فيتم تحديد العلاقة بين مواصفات المدرسة والكفاءة التقنية عن طريق نموذج إقتصادي قياسي (Tobit Regressin Model). وقد تم استخدام عدد من العوامل المؤثرة في هذا النموذج، مثل المحافظة التي تقع بها المدرسة، ورواتب المدرّسين، ونسبة المدرّسين الكويتيين، وجنس الطلبة (ذكور ام إناث). وقد بيّنت التقديرات الناتجة عن النموذج انّ المدارس الحكومية في دولة الكويت تستخدم موارد اكثر من الموارد اللازمة لمخرجاتها . كما انها تعمل بمستوى اقل من المستوى المثالي وتستخدم نسب مدخلات غير مثالية . كما وُجد انّ لرواتب المدرسين تاثير إيجابي على الكفاءة التقنية، بينما نسبة المدرّسين الكويتيين لها اثر سلبي على الكفاءة التقنية . واخيرا اتّضح انّ مدارس الإناث تتميز بكفاءة اعلى من مدارس الذكور.

* Economics Studies Department, Techno_Economic Division, Kuwait Institute for Scientific Research, POBox 24885, Safat 13109, Kuwait. Emails: Al-Enezi : msalenez@safat.kisr.edu.kw; Burney: nburney@safat.kisr. edu.kw; Al-Musallam: mmusalam@safat.kisr.edu.kw.

** Department of Economics, Lancaster University Management School, Lancaster, LA1 4YX, U.K. Email: j.johnes@lancaster.ac.uk.

Introduction

The public education system is the main provider of educational services in Kuwait.(1) Over the years, the system has grown in response to a growing population. To meet the capital and operational needs of the system, the government has invested substantial amount of resources during the last six decades. Between 1984/85 and 2006/07, government annual expenditure on education averaged around 6% of the country's gross domestic product. In the year 2006/07, it was KD 1.04 billion (or US $3.6 billion). The resources (money) have been injected into the system on the belief that providing more resources will improve outcomes. The available evidence, however, points to a situation that is far from satisfactory.

Burney *et al*. (1995, 2002) and the World Bank (2002) have shown that Kuwait's public education system suffers from production inefficiencies. The extent of inefficiencies, however, is not known. In addition, there is a general perception that the public education system is not responsive to the educational needs of the society and economy of the country (particularly the private sector).

To improve the performance of the system, the educational authorities have undertaken reforms that have increased the participation of the private sector. However, the management of the public schools remains under government control and the school administration has limited authority over school inputs and outputs. Despite all the reforms and changes, public expenditure per student on education in Kuwait is relatively high and has been increasing. With a rapidly growing population, the amount of resources required to meet the educational needs of the population could increase sharply. Unless necessary resources are allocated, this may impact the quality of education.

In this context, it becomes imperative on the authorities to pursue cost-effective measures, remove specific sources of inefficiencies, exploit economies of scale, and improve administrative, organizational and financial management of resources. This requires identifying and quantifying sources inefficiencies.

Improving education can have beneficial effects on an economy in terms of higher productivity, lower poverty, improved income inequality, better health and economic growth. Thus, getting more from the resources spent on education is vital for Kuwait.

This paper aims to provide an in-depth assessment of efficiency of public schools in Kuwait. The main reason for focusing on public schools is that the private schools in Kuwait follow different systems. The analysis is based on a two-stage approach. In the first stage, estimates of different measures of efficiency (e.g., technical, scale, allocative and economic) are obtained. In the second stage, possible determinants of school inefficiencies are investigated. As curricula, teaching techniques, assessment methods, teachers' qualification and experience, and other requirements vary across different school levels, the analysis is conducted separately for kindergarten, primary, intermediate and secondary schools. The investigation is carried out on data for six academic years, namely 1979/80, 1984/85, 1989/90, 1994/95, 1999/2000 and 2004/05. The data for the analysis were obtained from different published and unpublished records for the entire public school population held by the Ministry of Education (MOE, 2004/05).

Efficiency: Conceptual Framework

The overall economic efficiency (*EE*) of a decision-making unit (DMU) is a product of two different types of efficiencies: (a) Technical efficiency (*TE*), which is the capacity of the DMU to maximize output given a certain level of inputs; and (b) Allocative (or price) efficiency (*AE*), which is the ability of the DMU to allocate resources and select optimal input amounts in light of their relative prices. The technical efficiency is further distinguished into: pure technical efficiency (TE_{VRS}), which assumes that the DMU operates under variable return to scale (VRS); and overall technical efficiency (TE_{CRS}), which assumes that the DMU operates under constant return to scale (CRS). The latter measure of technical efficiency incorporates the inefficiency of the DMU from using wrong amount of inputs to produce the given amount of output, as well as inefficiency that arises from the DMU being of the wrong size (i.e., too big or too small). The ratio of overall technical efficiency and pure technical efficiency yields what is referred to as the scale efficiency ($SE = TE_{CRS}/TE_{VRS}$).

To measure efficiency, production frontiers need to be estimated. The literature offers two main approaches to estimating production frontiers: parametric and non-parametric models. Among the parametric models, stochastic frontier analysis (SFA) is the most commonly used method that requires assuming explicit functional form for technology (e.g., Cobb-Douglas, trans-logarithmic, etc.) as well as distribution of inefficiency (e.g., half normal, normal truncated at zero, and exponential).(2) As for the non-parametric models, the most commonly used method has been data envelopment analysis (DEA), which calculates the efficiency of a unit relative to the performance of other units producing the same good or service, and does not require making any assumption about functional form for technology and distribution of inefficiency.

Assume that the production frontier for school *k* is;

$$y_k = f\left(x_{1k},...x_{mk}\right)e^{v_k - u_k} \qquad \text{(Equation 1)}$$

where $v_k : N\left(0,\sigma_v^2\right)$, $u_k \geq 0$ (Aigner *et al*. 1977), and v_k and u_k are statistically independent.

The error terms are composed of two components. One is normal and is attributed to measurement error and random fluctuations (v_k), and the other is one-sided (typically exponential or half-normal) and is attributed to technical efficiency (u_k). The parameters of the function are typically estimated using maximum likelihood method, where (in case u_k is half-normal) the likelihood function is:

$$\ln L = -n\ln\sigma - \frac{n}{2}\ln\frac{2}{\pi} - \frac{1}{2}\sum_i \frac{\varepsilon_i^2}{\sigma^2} + \sum_i \ln\left[1 - \Phi\left(\frac{-\varepsilon_i\lambda}{\sigma}\right)\right] \qquad \text{(Equation 2)}$$

where $\lambda = \sigma_u/\sigma_v, \sigma^2 = \sigma_u^2 + \sigma_v^2$, and Φ is the distribution function of the standard normal distribution. If the coefficient λ is statistically different from zero, then there is evidence of inefficiency in the data.(3)

DEA analysis is based on finding the best virtual producer corresponding

to each real producer, where the virtual producer does not necessarily exist, but is computed from a linear combination of the inputs and outputs of one or more efficient producers. If the corresponding virtual producer does better than the real producers by producing more output with the same level of inputs or the same output with fewer inputs, then the real producer is inefficient. The technical efficiency of DMU *k* is defined as the ratio of the weighted sum of outputs to the weighted sum of inputs:(4)

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

where there are *s* outputs and *m* inputs; y_{rk} is the amount of output *r* produced by DMU *k*; x_{ik} is the amount of input *i* used by DMU *k*; u_r is the weight applied to output *r*; and v_i is the weight applied to input *i*. Input and output weights are derived by solving the following (input-oriented) linear programming (LP) equations (note that s_r and s_i represent output and input slacks respectively):

Minimize: $$\theta_k - \varepsilon \sum_{r=1}^{s} s_r - \varepsilon \sum_{i=1}^{m} s_i$$

Subject to:

$$y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0 \qquad r = 1,\ldots,s$$

$$\theta_k x_{ik} - \sum_{j=1}^{n} \lambda_j x_{ij} - s_j = 0 \qquad i = 1,\ldots,m$$

$$\lambda_j, s_r, s_i \geq 0 \qquad \forall j = 1,\ldots,n; r = 1,\ldots,s; i = 1,\ldots,m$$

The DMU k is efficient if the efficiency score $TE_k = \theta_k = 1$ and the slacks $s_r, s_i = 0, \forall r = 1,...,s$ and $i = 1,...,m$. It is to be noted that the DEA model may be

easily modified to incorporate VRS by the inclusion into the above equations of the additional constraint $\sum_{j=1}^{n} \lambda_j = 1$ and hence, measures of scale efficiency may be derived.

When input prices are known, a second set of linear programs may be solved in order to derive estimates of economic and allocative efficiency:

Minimize: $\sum_{i=1}^{m} w_{ik} x_{ik}^{*}$

Subject to:

$$y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 \qquad r = 1, \ldots, s$$

$$x_{ik}^{*} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0 \qquad i = 1, \ldots, m$$

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

where w_{ik} is the price of input i (i=1,…,m) for DMU k, x_{ik}^{*} is calculated from the LP problem and is the cost minimizing quantity of input i (i-1,…,m) for DMU k, given its output levels y_{rk} and input prices w_{ik}.

Thus, $EE_k = \sum_{i=1}^{m} w_{ik} x_{ik}^{*} \Big/ \sum_{i=1}^{m} w_{ik} x_{ik}$ and $AE_k = EE_k / TE_k$

While the SFA and the DEA techniques have their advantages and disadvantages, the DEA technique is relatively more popular because of the ease with which it can handle both multiple inputs and multiple outputs, and the fact that the technique makes no assumptions regarding the distribution of efficiencies and the function form of the production function. During the last more than two decades, a large number of studies have applied the concepts of efficiency to educational institutions. The studies differ in terms of their scope (i.e., type of educational institutions examined: primary schools, secondary schools, universities, etc.); method used (parametric *vs.* non-parametric);

approach adopted (input-oriented *vs.* output-oriented and production function *vs.* cost function); country of interest; and period or year of analysis.

Whereas a large number of the studies have relied on non-parametric methods, particularly DEA; other studies have used parametric methods, including SFA.[5] Some of the studies have gone beyond simply estimating the efficiency of educational establishments and have examined factors that might affect level of efficiency using appropriate techniques, usually Tobit regression. With the exception of Behrman *et al*. (1997), Dougherty (1990), Jimenez (1986), Jimenez and Paqueo (1996), Kantabutra and Tang (2006), Mizala *et al*. (2002), and Tyagi *et al*. (2008), the rest of the studies have examined efficiency of educational institutions in the developed countries.

Conceptual/Measurement Issues and Data

Descriptive Statistics

In order to estimate efficiencies the outputs and inputs of the education production function need to be specified. In general, schools use capital and labour to produce teaching outputs. It is vital that the teaching outputs be specified so as to capture the outcomes of education. Previous empirical studies have used standardized achievement or examination results, average attendance, number of graduates, number of enrolled students, retention rate and level of earnings after leaving school.

For Kuwait, standardized achievement and examination results are not available. Two possible and alternative output measures which are available are number of enrolled students (STUDENTS) and number of pupils satisfactorily completing school (GRADUATES). The latter is a more satisfactory measure of the output of the teaching process, but data are not available for all school levels and years. The former has the advantage in that data are available for all levels of schooling and all years. However, its disadvantage is that it is more a measure of input than output. There is, nevertheless, a high degree of correlation between student and graduate numbers in the context of schools, and hence student numbers (or variables relating to enrolment) have been used to represent teaching outputs by Lovell *et al.* (1994), Ouillette and Vierstraete (2006), and

Jones *et al.* (2008). On the other hand, Bonesrønning and Rattsø (1994) used graduates for output.

The list of possible input measures considered in empirical studies is large and can generally be grouped into three main categories: (a) School inputs; (b) Pupil-related inputs; and (c) Environmental inputs. Data on pupil-related and environmental inputs are not available for schools in Kuwait, and so this study relies exclusively on school inputs which include labour and capital. There are three possible input measures which may be derived from the data on schools in Kuwait: (a) Number of teachers (TEACHERS); (b) Number of administrative staff (STAFF); and (c) Number of class rooms (ROOMS). Ouellette and Vierstaete (2006) used teaching and non-teaching staff as inputs along with three indexes to reflect physical capital. Bonesrønning and Rattsø (1994) used teaching time as a single input.

For the purpose of this study, both STUDENTS and GRADUATES were considered as possible measures of output. However, data on GRADUATES were available for only primary and intermediate schools for years 1999/00 and 2004/05. Also, the data on STAFF were available for 1979/80, 1984/85 and 2004/05 only. Thus, in the final analysis, efficiency of public schools was estimated with STUDENTS as output measure, and TEACHERS and ROOMS as inputs.

Table 1 shows the number of public schools in Kuwait in each of the selected year (i.e., 1979/80, 1984/85, 1989/90, 1994/95, 1999/2000 and 2004/05). As is evident, between 1979/80 and 2004/05, the number of kindergarten schools almost tripled and that of secondary schools almost doubled. On the other hand, the increase in the number of primary and intermediate schools was only around 20%.

Table 1. Number of Public Schools in Kuwait

Level	Year					
	1979/80	1984/95	1989/90	1994/95	1999/2000	2004/05
Kindergarten	60	78	120	138	149	170
Primary	168	183	197	174	182	203
Intermediate	128	164	180	156	164	157
Secondary	66	102	136	108	118	114
Total	422	527	633	576	613	644

Data Source: CSO (2007)

Table 2 provides summary descriptive statistics of the variables by level of education for the year 2004/05. It shows that relatively speaking, in terms of enrolment, teachers, or room size of the primary schools is largest followed by intermediate, secondary and kindergarten schools.

Table 2. Descriptive Statistics: 2004/05

Level/Variable	Parameter			
	Minimum	Maximum	Mean	S.D.
Kindergarten				
Students	66	644	241	117
Teachers	9	41	23	7
Rooms	4	15	9	3
Primary				
Students	66	1163	651	206
Teachers	8	130	66	19
Rooms	5	44	25	7
Intermediate				
Students	58	1311	622	220
Teachers	13	109	63	18
Rooms	4	39	21	7
Secondary				
Students	17	1098	540	215
Teachers	25	184	80	26
Rooms	3	40	22	8

Source: Authors' estimates.

Estimates of Efficiency

The DEA estimates of school efficiencies (technical, scale, allocative and economic) obtained using an input-oriented approach are summarized in Table 3.[6,7] The number of schools included at each level of education differs over time. Thus, in examining the results, caution is necessary when making comparisons over time periods. Furthermore, because of the data constraints related to school outcomes/output and quality of inputs, as mentioned earlier, the results need to be interpreted with care.

As is evident, the mean pure technical efficiency varies for kindergarten schools from 0.700 in 2004/05 to 0.810 in 1994/95; for primary schools from 0.796 in 1994/95 to 0.852 in 2004/05; for intermediate schools from 0.431 in 1994/95 to 0.870 in 1979/80; and for secondary schools from 0.705 in 1994/95 to 0.834 in 1979/80. This implies that the public schools in Kuwait use more inputs than necessary for the students enrolled. Based on the evidence for 2004/05, the extent of over-use of inputs is 30% for kindergarten schools, 15% for primary schools, 16% for intermediate schools, and 22% for secondary schools (VRS result, Table 3). The evidence suggests that relatively, kindergarten schools are the most inefficient followed by secondary, intermediate and primary schools.

In addition to employing more resources, the public schools in Kuwait are not operating to their optimum scale size. This is reflected by scale efficiency of the schools. The mean scale efficiency varies for kindergarten schools from 0.713 in 1984/85 to 0.870 in 1999/00; for primary schools from 0.886 in 1989/90 to 0.964 in 1999/00; for intermediate schools from 0.680 in 1989/90 to 0.966 in 1979/80; and for secondary schools from 0.902 in 1999/00 to 0.976 in 1989/90. The evidence suggests that schools output (enrolled students) can be increased without increasing the inputs (teachers and class rooms). On the basis of estimates for the year 2004/05, the additional output that can be obtained from the available inputs is 29% for kindergarten schools, 7% for primary schools, 5% for intermediate schools, and 7% for secondary schools.

Table 3. DEA Estimates of Efficiency by Year and Level of School

Level	Technical Efficiency (TE)		Scale Efficiency (SE)	Allocative Efficiency (AE)	Economic Efficiency (EE)
	Overall (CRS)	Pure (VRS)			
1979/80					
Kindergarten	0.641	0.762	0.842	0.932	0.711
Primary	0.743	0.814	0.911	0.931	0.759
Intermediate	0.842	0.870	0.966	0.777	0.683
Secondary	0.755	0.834	0.909	0.944	0.790
1984/85					
Kindergarten	0.524	0.736	0.713	0.964	0.709
Primary	0.789	0.845	0.935	0.928	0.786
Intermediate	0.816	0.850	0.962	0.915	0.780
Secondary	0.777	0.833	0.929	0.905	0.759
1989/90					
Kindergarten	0.632	0.740	0.853	0.965	0.717
Primary	0.751	0.844	0.886	0.958	0.809
Intermediate	0.280	0.431	0.680	0.958	0.407
Secondary	0.850	0.871	0.976	0.879	0.768
1994/95					
Kindergarten	0.657	0.810	0.812	0.939	0.761
Primary	0.734	0.796	0.923	0.881	0.702
Intermediate	0.778	0.809	0.964	0.803	0.651
Secondary	0.641	0.705	0.907	0.886	0.625
1999/2000					
Kindergarten	0.621	0.712	0.870	0.949	0.675
Primary	0.801	0.831	0.964	0.844	0.703
Intermediate	0.577	0.695	0.845	0.924	0.647
Secondary	0.718	0.794	0.902	0.975	0.773
2004/05					
Kindergarten	0.499	0.700	0.714	0.917	0.643
Primary	0.794	0.852	0.934	0.860	0.733
Intermediate	0.794	0.840	0.946	0.838	0.704
Secondary	0.728	0.778	0.933	0.606	0.473

Source: Authors' estimates.

Finally, in addition to the technical and scale inefficiencies, public schools in Kuwait also suffer from inefficiencies due to employing inputs in non-optimal proportions, given the input prices. The mean allocative efficiency varies for kindergarten schools from 0.917 in 2004/05 to 0.965 in 1989/90; for primary schools from 0.844 in 1999/00 to 0.958 in 1989/90; for intermediate schools from 0.777 in 1979/80 to 0.958 in 1989/90; and for secondary schools from 0.606 in 2004/05 to 0.975 in 1999/00. This suggests that the cost of school output can be

lowered across all school levels in Kuwait. Based on estimates for 2004/05, the extent of potential cost savings is 8% for kindergarten schools, 14% for primary schools, 16% for intermediate schools, and 39% for secondary schools.(8)

Generally, allocative efficiency is highest for kindergarten schools, declines as school level increases, and is lowest for the secondary schools. This may be attributed to the proportion of foreign teachers in different schools levels and the compensation package that is offered to foreign teachers compared to their national counterparts. The proportion of Kuwaiti teachers in kindergarten, primary, intermediate, and secondary schools is 95%, 72%, 60% and 46%, respectively. Foreign teachers are hired on contract basis and draw much lower salaries compared to their Kuwaiti counterparts.(9)

The economic (or overall) efficiency varies for kindergarten schools from 0.643 in 2004/05 to 0.761 in 1994/95; for primary schools from 0.702 in 1994/95 to 0.809 in 1989/90; for intermediate schools from 0.407 in 1989/90 to 0.780 in 1984/85; and for secondary schools from 0.473 in 2004/05 to 0.790 in 1979/80. On the basis of estimates for 2004/05, this suggests that school output may be increased by 36% for kindergarten schools, 27% for primary schools, 30% by intermediate schools, and 53% for secondary schools by taking care of technical, scale and allocative inefficiencies.

Based on the school-specific estimates of efficiency and returns to scale, Table 4 shows that a large majority of schools operate under increasing returns to scale (IRS). IRS is observed at every level of education, but this is particularly strong for kindergarten, primary, and intermediate schools. For instance, in the year 2004/05, 99% of the kindergarten schools, 94% of the primary schools, 97% of the intermediate schools, and 46% of the secondary schools operated under IRS. This indicates that a vast majority of public schools are operating below the optimum scale size and do not take advantage of economies of scale.

Table 4. Number and Distribution (%) Public Schools in Kuwait by Returns to Scale

	Year					
Level	1979/80	1984/85	1989/90	1994/95	1999/2000	2004/05
Kindergarten						
CRS	2 (3.3)	2 (2.6)	1 (0.8)	2 (1.5)	2 (1.3)	1 (0.6)
DRS	0	2 (2.6)	5 (4.2)	3 (3.6)	1 (0.7)	0
IRS	58 (96.7)	74 (94.9)	114 (95.0)	130 (94.9)	146 (98.0)	169 (99.4)
Primary						
CRS	3 (1.8)	11 (6.1)	2 (1.1)	1 (0.5)	7 (3.9)	2 (1.0)
DRS	7 (4.3)	31 (17.2)	0	2 (1.2)	19 (10.4)	10 (4.9)
IRS	154 (93.9)	138 (76.7)	195 (98.9)	171 (98.3)	156 (85.7)	191 (94.1)
Intermediate						
CRS	4 (3.2)	9 (5.6)	1 (0.6)	3 (1.9)	1 (0.6)	4 (2.6)
DRS	13 (10.5)	26 (16.4)	0	44 (28.4)	61 (37.4)	0
IRS	107 (86.3)	124 (78.0)	179 (99.4)	108 (69.7)	101 (62.0)	152 (97.4)
Secondary						
CRS	2 (3.4)	2 (2.0)	6 (4.6)	2 (1.9)	3 (2.6)	5 (4.4)
DRS	19 (32.2)	60 (60.6)	84 (64.6)	1 (0.9)	4 (3.4)	57 (50.0)
IRS	38 (64.4)	37 (37.4)	40 (30.8)	104 (97.2)	110 (94.0)	52 (45.6)

Source: Authors' estimates.

N.B. Figures in parentheses are percentages.

To determine the likely impact of measure of output and number of inputs on school ranking on the basis of efficiency, sensitivity analysis was undertaken by conducting rank correlation coefficients test. The results are presented in Tables 5 and 6. It is evident that correlation coefficients are high, implying that the inclusion of STAFF as an additional input has no significant effect on school ranking based on efficiency score. Similarly, the definition of output (GRADUATES or STUDENTS) has no significant effect on school ranking based on efficiency score. This supports the researchers' choice of STUDENTS as measure of output and TEACHERS and ROOMS as inputs.

Table 5. Spearman's Rank Correlation Coefficients: Number of Inputs
(Two Inputs *vs.* Three Inputs)

	1979/80	1984/85	2004/05
Kindergarten			
TE			
CRS	0.999	0.978	0.937
VRS	0.825	0.652	0.774
SE	0.931	0.973	0.989
AE	0.755	0.528	0.723
EE	0.857	0.902	0.952
Observations	60	78	170
Primary			
TE			
CRS	0.992	0.998	0.942
VRS	0.988	0.979	0.979
SE	0.926	0.882	0.914
AE	0.465	0.767	0.993
EE	0.596	0.943	0.992
Observations	155	180	203
Intermediate			
TE			
CRS	0.993	0.964	0.966
VRS	0.921	0.970	0.966
SE	0.883	0.739	0.974
AE	0.913	0.914	0.981
EE	0.903	0.969	0.993
Observations	108	159	156
Secondary			
TE			
CRS	0.960	0.954	
VRS	0.796	0.929	
SE	0.778	0.714	
AE	0.787	0.929	
EE	0.886	0.955	
Observations	55	99	

Source: Authors' estimates.

Table 6. Spearman's Rank Correlation Coefficients: Output Measure
(STUDENTS *vs.* GRADUATES)

	2 Inputs		3 Inputs
	1999/2000	2004/05	2004/05
Primary			
TE			
CRS	0.930	0.884	0.912
VRS	0.933	0.899	0.913
SE	0.825	0.899	0.924
AE	0.984	0.979	0.975
EE	0.967	0.980	0.977
Observations	182	203	203
Intermediate			
TE			
CRS	0.573	0.897	0.899
VRS	0.684	0.916	0.910
SE	0.696	0.849	0.886
AE	0.954	0.993	0.984
EE	0.885	0.918	0.915
Observations	163	156	156

Source: Authors' estimates.

Determinants of School Efficiency

While DEA efficiencies provide an overview of the relative performance of schools, it may also be useful to examine whether there are any characteristics of the school which affect the efficiency with which the school converts its inputs into outputs. To determine the relationship between school characteristics and technical efficiency, the estimates of technical efficiency obtained using the VRS DEA method are regressed upon four possible factors:[10] (a) Geographical location of school;[11] (b) Proportion of teaching staff who are Kuwaiti nationals (KUWAIT); (c) Average salary level of the teaching staff (SALARY); and (d) Whether the school is an all boys school (BOYS).[12] The size of the school is not investigated as a possible determinant of efficiency since the dependent variables is the VRS efficiency; and therefore, size has already been taken into account in calculating the efficiency score.

The geographical location of a school might affect its efficiency for a number of reasons. Funding might vary by educational district and the geographical dummies would pick up such an effect. The regions themselves vary in terms of size, population and density of population. For example: Al-Aasimah, Hawally and Mubarak and Farwaniya are all small in area but have relatively large populations. Al-Ahmedi and Al-Jahra are much larger but more sparsely populated. Thus, the regional dummies may capture any rural-urban effect on efficiency. The quality of teaching staff would be expected to have a positive effect on efficiency. Average teacher salary is assumed to reflect quality of staff and should therefore have a positive effect on efficiency.

Evidence from previous empirical studies is mixe. Bradley *et al* (2001) find evidence of a significant positive effect of teacher salary on efficiency in English secondary schools while Ruggiero and Vitaliano (1999) find the opposite result in New York school districts. Rassoulli-Currier (2007) finds no significant relationship between teacher salary and efficiency in Oklahoma schools. The proportion of teachers with Kuwaiti nationality has also been included in the analysis because there has been a shift from foreign (experienced but relatively low-paid teachers) to Kuwaiti national (less experienced and more highly-paid) teachers. The variable SALARY therefore, may not be an ideal reflection of teacher experience and so KUWAIT is included as well. Finally, evidence from other countries suggests that all-boys' schools perform less well than all-girls' schools (Bradley *et al* 2001). Thus, the variable BOYS is included to explore this in the context of Kuwaiti education where segregated education is the norm.

Since the efficiency score is bounded by 0 and 1 (although the left hand boundary cannot be observed), the appropriate approach to modeling a censored dependent variable is to use a Tobit model.[13] The model assumes that there is a latent (i.e., unobservable) variable $z_j^* z_j^*$, which depends on a vector x_j (set of possible determinants of efficiency) through a parameter vector β.

The relationship between $z_j^* z_j^*$ and x_j is defined as follows:

$$z_j^* = x_j\beta + \varepsilon_j$$

where j represents the j^{th} school (j = 1,...,n) and $\varepsilon_j \sim N(0, \sigma^2) \varepsilon_j \sim N(0, \sigma^2)$. The observable efficiency of school j (i.e., $z_j z_j$) is related to unobservable efficiency (i.e., the latent variable $z_j^* z_j^*$) as follows:

$$z_j = L_{1j} \text{if } z_j^* \leq L_{1j}$$

$$z_j = z_j^* \text{ if } L_{1j} < z_j^* \leq L_{2j}$$

$$z_j = L_{2j} \text{if } z_j^* \geq L_{2j} z_j = L_{2j} \text{if } z_j^* \geq L_{2j}$$

where L_{1j} and L_{2j} are the lower and upper bounds of the data. In practice, no observations are at the lower bound. Consequently, a right censored random effects Tobit model is estimated.(14)

Tables 7 to 10 show the estimated models for the four educational levels (kindergarten, primary, intermediate, and secondary) for each of the six selected years.(15) The models are statistically significant in terms of the likelihood ratio test. In general, there is little evidence to claim that there are any systematic patterns in school efficiency across regions and school levels, and over time. There appears no consistency in the results both in terms of the sign of the coefficient of regional dummies and their significance level. Most of the regional dummies are either statistically insignificant, or their signs are not consistent across years. This is particularly true for kindergarten, intermediate, and secondary schools for most of the years. This implies that there is no systematic difference in the technical efficiency of kindergarten, intermediate, and secondary schools across different regional districts. In other words, the public schools across different educational districts are equally efficient or inefficient in converting school inputs into outputs. On the basis of information for 2004/05, however, it can be said that schools in Al-Aasimah region are more efficient compared to those in other regions.

With respect to teacher salary, the coefficient is positive for kindergarten and primary schools for all the years, and is statistically significant for five of the six years. In the case of intermediate schools, it is generally negative and

statistically insignificant. For the secondary schools, it is positive and statistically significant for 1994/95, 1999/2000 and 2004/05, and negative and statistically insignificant for 1979/80 and 1984/85. The evidence implies that higher teacher salary tends to improve the technical efficiency of kindergarten, primary and secondary schools, which is in line with the findings of Bradley *et al.* (2001) but contrary to those of Ruggiero and Vitaliano (1999). As salary is directly linked to qualification and experience, more qualified and experienced teachers are expected to improve school's efficiency.

Interestingly, the coefficient with respect to proportion of Kuwaiti teachers, is found to be negative for all school levels and statistically significant for most of the years. In other words, increases in the proportion of Kuwaiti teachers have adversely affected technical efficiency of schools. During the last many years, Kuwait has pursued a policy of replacing expatriate teachers with the nationals. It could be that in the process, more experienced and qualified expatriate teachers are being replaced by relatively young, inexperienced and less qualified national teachers.(16) This suggests that Kuwait should develop a policy of recruiting more qualified and experienced teachers to improve school efficiency.

Finally, with respect to dummy for gender, the coefficient is generally negative for most years for all three levels. It is negative and statistically significant for primary schools for 1989/90, 1994/95, 1999/2000, and 2004/05; negative and statistically significant for intermediate schools for 1994/95; and negative and statistically significant for secondary schools for 1994/95, 1999/2000 and 2004/05. This implies that the efficiency of all-girls' schools is higher compared to all-boys' schools. If the all-girls' schools are traditionally managed differently from the all-boys' schools, then the latter should amend their managerial practice to improve efficiency. It is more likely, however, that girls have characteristics which allow them to respond better to current teaching methods used in Kuwait, and consequently, their schools achieve greater efficiency. If this is the case, alternative methods of teaching which appeal more to the characteristics of boys need to be investigated to improve efficiency in all-boys' schools.

Table 7. Tobit Regression Results: Kindergarten Schools

	Year					
	1979/80	1984/85	1989/90	1994/95	1999/2000	2004/05
Al-Aasimah	-0.209** (4.03)	-0.019 (0.36)	-0.029 (0.87)	-0.032 (1.04)	-0.039 (1.62)	0.0119** (3.74)
Hawally	-0.158** (3.47)	-0.010 (0.23)	0.026 (0.87)	-0.007 (0.26)	-0.032 (1.45)	-0.043 (1.57)
Al-Farwaniya	-0.061 (1.25)		0.065** (2.06)	0.037 (1.23)	0.002 (0.08)	-0.063** (2.30)
Al-Ahmedi	0.010 (0.21)	-0.053 (1.05)	-0.006 (0.20)	0.014 (0.45)	0.055** (2.22)	0.016 (0.62)
Al-Jahra						-0.047 (1.55)
SALARY	0.444** (3.46)	0.124 (0.73)	0.261** (3.55)	0.291** (4.15)	0.472** (9.75)	0.217** (7.03)
KUWAIT	-0.072 (1.11)	-0.178** (2.14)		0.070 (0.28)	-1.018** (4.81)	-0.846** (4.53)
Intercept	0.752** (13.96)	0.799** (8,73)	0.539** (10.68)	0.434 (1.76)	1.119** (5.60)	1.241** (7.00)
Log-Likelihood	56.44	48.75	99.71	108.74	159.39	129.71
Chi-Square	41.73	5.61	22.94	23.97	110.47	71.92
Prob > Chi-Square	(0.000)	(0.346)	(0.000)	(0.001)	(0.000)	(0.000)
Number of Observation	60	78	120	137	149	170

Source: Authors estimates.
N.B. Figures in parentheses are t-statistics.

Table 8. Tobit Regression Results: Primary Schools

	Year					
	1979/80	1984/85	1989/90	1994/95	1999/2000	2004/05
Al-Aasimah	-0.126** (4.24)	-0.072** (2.28)	-0.149** (6.81)	-0.000 (0.02)	-0.013 (0.79)	0.086** (4.89)
Hawally	-0.024 (0.91)	-0.076** (2.95)	0.002 (0.10)	0.095** (5.19)	0.038** (2.34)	0.070** (4.09)
Al-Farwaniya	-0.003 (0.11)		0.001 (0.04)	0.143** (8.37)	0.038** (2.31)	0.032* (1.91)
Al-Ahmedi	-0.014 (0.61)	-0.059** (2.96)	0.003 (0.19)	0.083** (5.86)	0.047** (3.01)	0.035** (2.46)
Al-Jahra						0.048** (3.04)
SALARY	0.148 (1.40)	0.204** (2.29)	0.074* (1.76)	0.074** (3.73)	0.129** (5.13)	0.070** (2.69)
KUWAIT	-0.098** (2.50)	-0.126** (2.60)		-0.236** (5.98)	-0.313** (3.94)	-0.060 (1.44)
Gender	0.007 (0.46)	-0.003 (0.18)	-0.026** (2.45)	-0.040** (3.66)	-0.034** (3.10)	-0.021* (1.95)
Intercept	0.837** (23.99)	0.848** (20.74)	0.824** (28.81)	0.862** (23.77)	0.956** (11.96)	0.804** (22.59)
Log-Likelihood	169.42	154.01	209.55	256.77	235.73	258.66
Chi-square	77.61	44.87	77.94	163.38	72.95	35.90
Prob. > Chi-square	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of Observation	164	180	197	174	182	203

Source: Authors' estimates.
N.B. Figures in parentheses are t-statistics.

Table 9. Tobit Regression Results: Intermediate Schools

	Year					
	1979/80	1984/85	1989/90	1994/95	1999/2000	2004/05
Al-Aasimah	-0.068* (1.84)	-0.082** (3.01)	0.050 (1.31)	-0.002 (0.06)	-0.020 (0.60)	0.071** (2.74)
Hawally	-0.019 (0.58)	-0.000 (0.00)	-0.001 (0.03)	0.051** (2.16)	0.051 (1.49)	0.019 (0.58)
Al-Farwaniya	-0.028 (0.81)		0.040 (1.11)	0.091** (4.06)	-0.016 (0.46)	0.019 (0.76)
Al-Ahmedi	-0.030 (0.91)	-0.045** (2.09)	0.020 (0.61)	0.001 (0.06)	-0.051 (1.60)	-0.013 (0.57)
Al-Jahra						0.023 (0.92)
SALARY	-0.213 (1.40)	-0.146* (1.72)	-0.008 (0.08)	0.028 (1.34)	-0.036 (0.46)	0.102** (3.38)
KUWAIT	0.009 (0.12)	-0.052 (1.08)		-0.165** (3.18)	-0.246** (2.40)	-0.074 (1.38)
Gender	0.023 (1.17)	0.056** (3.23)	0.013 (0.60)	-0.060** (2.21)	-0.022 (0.36)	-0.004 (0.20)
Intercept	0.964** (18.96)	0.940** (23.51)	0.411** (7.29)	0.859** (24.93)	0.889** (9.08)	0.755** (20.80)
Log-Likelihood	103.83	150.45	88.63	164.27	95.49	151.53
Chi-square	11.60	62.03	3.83	39.23	49.51	22.03
Prob. > Chi-square	(0.115)	(0.000)	(0.700)	(0.000)	(0.000)	(0.005)
Number of Observation	124	159	180	155	163	156

Source: Authors' estimates.
N.B. Figures in parentheses are t-statistics.

Table 10. Tobit Regression Results: Secondary Schools

	Year					
	1979/80	1984/85	1989/90	1994/95	1999/2000	2004/05
Al-Aasimah	-0.194** (2.83)	-0.090* (1.97)	-0.016 (0.51)	-0.009 (0.19)	0.005 (0.13)	0.077 (1.54)
Hawally	-0.185** (2.88)	0.017 (0.46)	0.069** (2.63)	0.010 (0.23)	0.045 (1.31)	-0.012 (0.24)
Al-Farwaniya	-0.184** (2.51)		0.078** (2.71)	0.020 (0.46)	-0.031 (0.83)	0.019 (0.39)
Al-Ahmedi	-0.155** (2.22)	-0.064 (1.51)	-0.007 (0.28)	-0.042 (1.03)	-0.041 (1.18)	0.031 (0.69)
Al-Jahra						0.048 (0.90)
SALARY	-0.021 (0.06)	-0.060 (0.23)	-0.213** (2.22)	0.231** (4.46)	0.127** (2.01)	0.174** (3.46)
KUWAIT	-0.653** (2.76)	-0.107 (0.50)		-0.527** (4.02)	-0.484** (4.52)	-0.729** (5.18)
Gender	0.007 (0.16)	0.028 (0.71	-0.016 (1.09)	-0.116** (2.36)	-0.156** (3.10)	-0.236** (3.27)
Intercept	1.074** (9.86)	0.885** (9.25)	0.972** (19.24)	0.774** (12.64)	0.982** (13.17)	1.035** (9.18)
Log-Likelihood	38.71	59.25	120.04	72.99	80.28	50.21
Chi-square	31.62	18.17	30.32	31.51	31.97	38.10
Prob. > Chi-square	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)
Number of Observation	59	99	136	107	117	114

Source: Authors' estimates.
N.B. Figures in parentheses are t-statistics.

Conclusion

This paper investigates efficiency of public schools in Kuwait. In particular, different measures of efficiency (i.e., pure technical efficiency, overall technical efficiency, scale efficiency, allocative efficiency and economic efficiency) are estimated and examined. The analysis in the paper is based on a two stage approach. In the first stage, pure technical, overall technical, scale, allocative and economic efficiencies for public schools are estimated using the DEA technique. In the second stage, to determine relationship between school characteristics and technical efficiency, the estimates of pure technical efficiency are regressed upon a set of explanatory variables. As the dependent variable (i.e., technical efficiency) is bounded by 0 and 1, Tobit regression model is used to establish relationship between school characteristics and technical efficiency.

The set of explanatory variables included in the regression are dummy variables for geographical location of schools, dummy variable for whether the school is an all girls' or an all boys' school, the nationality of the teaching staff at schools (i.e., whether or not they are Kuwaiti nationals), and the average salary level of the teaching staff. As the curricula, teaching techniques, assessment method, teachers' qualification and experience, and other requirements vary across different school levels, the efficiency measures and regression models are estimated for kindergarten, primary, intermediate and secondary public schools separately.

The analysis was conducted for six selected years (i.e., 1979/80, 1984/85, 1989/90, 1994/95, 1999/00, 2004/05) on the entire public school population in the country. As discussed in the paper, because of the data constraints related to school outcomes/outputs and quality of inputs, the analysis is restricted to using narrow measures of school outputs, which is likely of have bearing on the results. Also, the differences in the quality of inputs could not be taken into account. Thus, the results need to be interpreted with some caution. To address the issues facing the education sector in Kuwait more comprehensively, the results, nevertheless, underscore the need for improving and maintaining better quality data by the educational authorities.

The evidence presented in the paper shows that the pure technical efficiency of public schools in Kuwait is low, implying that the schools use more inputs than necessary for the enrolled students. In addition, the schools are not operating to their optimum scale size. A large majority of the schools operate under IRS and are below the optimum scale size, which is particularly true for kindergarten, primary and intermediate schools. Furthermore, the estimates of allocative efficiency show that the schools suffer from inefficiencies due to employing inputs in non-optimal proportions. As a result of technical, scale and allocative inefficiencies, the economic efficiency of the schools is low. Evidence for 2004/05 shows that economic efficiency can be increased by 36% for kindergarten schools, 27% for primary schools, 30% for intermediate schools and 53% for secondary schools..

The analysis of the determinants of efficiency demonstrates that there is no evidence of any systematic differences in the technical efficiency of public schools across regions. In other words, schools across different educational districts are equally efficient or inefficient in converting school inputs into outputs. Higher teacher salary is found to improve the technical efficiency of kindergarten, primary and secondary schools ─ implying that more qualified and experienced teachers are expected to improve school efficiency. Interestingly, the proportion of Kuwaiti teachers is found to affect technical efficiency of schools adversely. This should be cause for concern as during the last many years, Kuwait authorities have pursued a policy of replacing expatriate teachers with the nationals. It could be that in the process, more experienced and qualified teachers are being replaced by relatively young, inexperienced and less qualified teachers. As a policy, Kuwait should recruit more qualified and experienced teacher to improve school efficiency.

Finally, the technical efficiency of all girls' schools is found to be superior compared to that of all boys' schools. Perhaps there is something in the way that the all girls' schools do that should be looked into and used to improve efficiency of all boys' schools. The findings of the study highlight the importance of undertaking follow-up research on input quality and school efficiency, and more detailed investigation into factors contributing to superior efficiency of all girls' schools.

Footnotes

(1) The public education system in the country consists of general education (two years of kindergarten, five years of primary, four years of intermediate, and three years of secondary education) and higher education (comprising college and university education). Education for the nationals is compulsory up to and including intermediate level. An important feature of Kuwait's public general education system is that beyond the kindergarten level, the schools are segregated. In the year 2006/07, the public education system (where education for the nationals is free of charge) accounts for approximately 66% of the total number of students enrolled in schools and 85% of the students enrolled in colleges and universities. Whereas the public education system mainly serves the needs of the nationals, private schools, colleges and universities cater to the needs of the foreign population. The private schools follow different systems and include Arabic, American, British, Indian, Pakistani, French and other schools.

(2) Since Christensen et al. (1973), the most widely used form of the production function has been the trans-logarithmic production function that does not impose a-priori restrictions on the values of the production parameters to be estimated.

(3) Battese and Cora (1977) define the inefficiency and variance parameters as $\lambda = {}^{\sigma_u}/_{\sigma} \in (0,1)$ $\lambda = {}^{\sigma_u}/_{\sigma} \in (0,1)$ and $\sigma = \sigma_v + \sigma_u \sigma = \sigma_v + \sigma_u$, respectively. If $\lambda = 0$ $\lambda = 0$, then all deviations from the frontier are noise. However, if $\lambda = 1$ $\lambda = 1$, then all deviations from the frontier are inefficiencies.

(4) The formulation of the problem differs from that of a DMU operating under CRS by the presence of $c_k c_k$ in the objective function and the constraint.

(5) For a review of studies on efficiency of educational institutions, see Burney *et al*. (2009) and Worthington (2001).

(6) The managers (or principals) of public schools in Kuwait have little control over the output or the inputs and ultimately, the central educational authorities control the level of inputs within the system. Hence, an input-oriented approach is used. It should be noted that the results vary little according to orientation (and CRS efficiency estimates are identical regardless of orientation).

(7) The DEAP program, which can be freely downloaded from http://www.uq.edu.au/economics/cepa/ software.htm, was used for estimating school efficiencies. To estimate economic (or cost) efficiency, average annual salary was used as price of teachers/staff. In the case of classrooms, because the cost would be the same for the authorities, the price was assumed to be the same across schools.

(8) The relatively high gains for secondary schools are an anomaly attributable to existence of outliers in terms of teacher salaries. The removal of two secondary schools with the lowest and highest salaries from the data raised the allocative efficiency to 0.775.

(9) The annual average salary of a teacher in kindergarten, primary, intermediate, and secondary school is KD 12,021; KD 8,293; KD 10,810 and KD 9,915, respectively. One would expect the average salary of a teacher in a secondary school to be higher than that in intermediate, primary and kindergarten levels, but quite obviously, not the case. The observed salary pattern in public schools in Kuwait points to foreign teachers getting lower salary compared to Kuwaiti teachers.

(10) Data limitations constrain the analysis by restricting the number of factors included in the investigation.

(11) The public general education system in Kuwait is administrated by the Ministry of Education and is divided into six educational districts namely: Al-Aasimah, Al-Ahmedi, Farwaniya, Hawally, Al-Jahra, and Mubarak Al-Kabir. The educational districts are not the same across the selected years. For instance, in the years 1979/80, 1984/85, 1989/90,, and 1999/2000, there was no Mubarak Al-Kabir district. Similarly, in the year 1984/85, there was no Al-Farwaniya district. To take account of the geographic location, dummy variables are defined such that they take the value 1 if the school is in a given region and 0 if otherwise.

(12) This last variable is only applicable to primary, intermediate and secondary education levels. Dummy variable is defined to account for the gender effect. The dummy variable takes the value 1 if the school is all boys' schools and 0 if the school is all girls' schools.

(13) The Tobit model is a special case of a censored regression model, which was proposed by Tobin (1958) to describe the relationship between a non-negative dependent variable and a vector of independent variables. For details, see Amemiya (1984; 1985) and Schnedler (2005).

(14) If the relationship parameter β is estimated by regressing the observed zj on xj, the resulting ordinary least square (OLS) estimator is inconsistent. Amemiya (1973) proved that the likelihood estimator suggested by Tobin for this model is consistent.

(15) In view of the number of educational districts across different years, the analysis for 2004/05 includes five regional dummies with Mubarak Al-Kabir as the base region. For all other years, the number of regional dummies is four (i.e., no dummy for Al-Jahra), with the exception of 1984/85 where there are only three dummies (i.e., Al-Farwaniya was dropped in addition to Al-Jahra), implying Al-Jahra is the base region.

(16) It may be noted that the expatriate teachers in public schools in Kuwait are hired on contract basis and draw much lower salaries compared to their Kuwaiti counterparts.

References

Aigner D.J., C.A. Lovell and P. Schmidt. 1977 . Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6**:** 21-37.

Amemiya, T. 1973. Regression analysis when the dependent variable is truncated normal. *Econometric* 41(6): 997-1016.

_____. 1984. Tobit models: A Survey. *Journal of Econometric* 24(1-2): 3-61.

_____. 1985. *Advanced Econometrics*. Oxford: Basil Blackwell.

Battese, G.E. and G.S. Cora. 1977. Estimation of a production frontier model: With application to the pastoral zone of Eastern Australia' *Australian Journal of Agricultural Economics* 21(x): 169-179.

Behrman, J.R.; S. Khan; D. Ross; and R. Sabot. 1997. School quality and cognitive achievement production: A case study for rural Pakistan. *Economics of Education Review* 16(2): 127-142.

Bonesrønning, H and J. Rattsø. 1994. Efficiency variation among the Norwegian high schools: consequences of equalization policy *Economics of Education Review* 13(4): 289-304.

Bradley, S., G. Johnes and J. Millington. 2001. The effect of competition on the efficiency of secondary schools in England. *European Journal of Operational Research* 135: 545-568.

Burney, N.A., M.A. Al-Ramadhan, B. Khalaf, A. Hoque and R. Dashti. 1995. Fiscal constraints, cost efficiency of social services, and determination and evaluation of fees on users. Kuwait Institute for Scientific Research, Report No. KISR4712, July, Kuwait.

_____, N. Al-Musallam, S. Al-Fulaij and W. Awadh. 2002. Public expenditure on education in Kuwait. Kuwait Institute for Scientific Research, Report No. KISR6738, December. Kuwait.

_____, A., J. Johnes, M. Al-Enezi, M, A. Al-Ramadhan, M. Al-Musallam, S. Hamada, N. Al-Musallam, G. Al-Essa, A. Al-Khayat, and F. Al-Husaini, F. 2009. An assessment of cost structure and efficiency of public schools in Kuwait. Kuwait Institute for Scientific Research, Report No. KISR9673, June, Kuwait.

Christensen, L.R., D.W. Jorgenson and L.V. Lau. 1973. Transcendental logarithmic production frontiers. *Review of Economics and Statistics* 55(1): 28-45.

CSO. 2007. *Annual Statistical Abstract*. Central Statistical Office, Kuwait.

Dougherty, C.R.S. 1990. Unit costs and economies of scale in vocational and teaching education: Evidence from the People's Republic of China. *Economics of Education Review* 9(4): 389-394.

Jimenez, E. 1986. The structure of educational costs: multi-product cost functions for primary and secondary education schools in Latin America. *Economics of Education Review* 5(1): 25-39.

_____ and V. Paqueo. 1996. Do local contributions affect the efficiency of public primary schools. *Economics of Education Review* 15(4): 377-386.

Jones, J.T., E.F. Toma and R.W. Zimmer. 2008. School attendance and district and school size. *Economics of Education Review* 27: 140-148

Kantabutra, S. and J.C.S. Tang. 2006. Urban-rural and size effects on school efficiency: The case of Northern Thailand. *Leadership and Policy in Schools* 5: 355-377.

Lovell, C.A.K., L.C. Walters and L.L. Wood. 1994. Stratified models of education production using modified data envelopment analysis and regression analysis. In *Data*

Envelopment Analysis: Theory, Methodology and Applications. Edited by A. Charnes, W.W. Cooper, A.Y. Lewin and L.M. Seiford. Dordrecht: Kluwer Academic.
MOE. 2004/05. Educational spending and student cost. Finance Division, Ministry of Education, Kuwait.

Mizala, A., P. Romaguera and D. Farren. 2002. The technical efficiency of schools in Chile. *Applied Economics* 34: 1533-1552.

Ouellette, P. and V. Vierstaete. 2006. Malmquist indexes with quasi-fixed inputs: An application to school districts in Québec. Department of Economics, Sherbrooke University, Québec, Canada.

Rassouli-Currier, S. 2007. Assessing the efficiency of Oklahoma public schools: A data envelopment analysis. *Southwestern Economic Review* 34(1):131-144.

Ruggiero, J. and D.F. Vitaliano. 1999. Assessing the efficiency of public schools using DEA and frontier regression. *Contemporary Economic Policy* 17(3): 321-331.

Schnedler, W. 2005. Likehood estimation for censored random vectors. *Econometric Review* 24(2): 195-217.

Tobin, J. 1958. Estimation for relationships with limited dependent variables. *Econometrica* 26(1): 24-36.

Tyagi, P., S.P. Yadav and S.P. Singh. 2008. Evaluation of elementary school performance: An application of data envelopment analysis. Department of Mathematics, IIT Roorkee-247667

World Bank. 2002. *Education Expenditure Analysis Study.* The World Bank, Washington, D.C.

Worthington, A.C. 2001. An empirical survey of frontier efficiency measurement techniques in education. *Education Economics* 9(3): 245-268.