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In memory of Lawrence Michelo (1976 - 2013)

Contents

TECHNICAL EFFICIENCY OF UGANDA'S PRIMARY SCHOOLS

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This article measures the technical efficiency of Uganda's primary schools over the 1995-2009 period. Technical efficiency measures the extent to which a given school or group of schools turn the inputs at their disposal into desirable educational outputs. Ideally, we would measure desirable educational outcomes in terms of factors such as self-confidence, earning potential, and occupational mobility, but these tend to be long-term. Therefore, this study focused on more immediate educational outputs. The study demonstrates that Uganda's primary schools are technically inefficient, as none has attained an efficiency score of 100%. Nevertheless, the observed inefficiency should be interpreted cautiously, bearing in mind existing institutional and resource gaps in terms of physical and human infrastructure (e.g. classrooms, funding, toilets, and teachers). Additionally, pupil attributes should be incorporated in an efficiency analysis.

1. Introduction[1]

The introduction of the Universal Primary Education (UPE) programme increased access to education in Uganda. There was a 4% increase in the number of pupils enrolled between 2008 and 2009 and a 7% increase in the number of primary schools between 2008 and 2009. The total number of classrooms also increased by 6% over the same period. However, the provision of adequate infrastructure for the children enrolled in primary schools remains a key challenge. At the national level, about one in every three pupils does not have adequate sitting and writing space (Uganda Bureau of Statistics, 2010). Although substantial resources have been directed to primary education in Uganda, there is a knowledge gap with regard to the extent to which the resources have been converted into desirable educational outputs. To bridge this gap, this article sought to measure the extent to which primary schools in Uganda were technically efficient.

The article measures the technical efficiency of Uganda's primary schools over the 1995-2009 period. Ajibefun (2008) notes that the measurement of technical efficiency is important for the following reasons: Firstly, it is an indicator of performance by which production units are evaluated. Secondly, measurement of the causes of inefficiency makes it possible to explore the sources of efficiency differentials and to eliminate the causes of inefficiency. Finally, the identification of the sources of inefficiency is essential to the institution of policies to improve performance.

The article is organised into eight sections. The next section presents previous selected studies on primary education. Section 3 describes the methodology employed. The unit of analysis, data type, sources, and sample size are presented in section 4. Empirical results are presented in section 5; whilst section 6 positions the article's findings within the body of existing knowledge. The article's conclusions are the subject matter of section 7, while the policy implications of the article are presented in section 8.

2. Previous Studies on Primary Education in Uganda

The economics of education has been analysed through three approaches: child development, production function, and school 'market' structure. The early childhood approach looks at the student's environment to explain the development of cognitive skills. Family background and the social environment in which a child develops, often without regard to school inputs, are the main determinants of cognitive achievement. The production function approach stresses the linkage between school inputs and cognitive achievements, whilst the education market approach focuses upon how competition in the provision of education affects the cognitive skills of students. However, elements of all three approaches affect cognitive achievement. Todd and Wolpin (2003) point out that focusing on a particular aspect to the exclusion of others requires very restrictive assumptions.

Previous studies have been undertaken with respect to Uganda's primary education. These relate to factors such as a shortage of teachers and accountability and transparency. A shortage of teachers has been cited in various studies (Ministry of Education and Sports, 2000). While student enrolment has steadily grown since the inception of UPE, the number of primary teachers has not grown at a commensurate rate to ensure the acceptable teacher-pupil ratio of 40:1.

Transparency International (2010) presented a regional overview of accountability and transparency in primary education management in seven African countries (including Uganda). The World Bank (2010) introduced the term ‘quiet corruption’ to indicate various types of malpractice by frontline providers (teachers, doctors, inspectors, and other government representatives) that do not involve monetary exchange. The cited behaviours include potentially observable deviations, such as absenteeism, and hard-to-observe deviations from expected conduct, such as a lower level of effort than expected or the deliberate bending of rules for personal advantage. The report notes that primary school teachers in a number of African countries (including Uganda) are not in school 15-25% of the time (absenteeism), but, additionally, a considerable fraction of those present are not found teaching (low-effort).

Nishimura et al (2009) make a comparative analysis of universal primary education in four countries, namely, Ghana, Kenya, Malawi, and Uganda, to identify common and unique themes and to examine how these seemingly similar policies are responding to the capacity and needs of each country. The results show that effective policy implementation requires considerable consultation with key stakeholders and a baseline survey that would enable systematic implementation and consideration of equity.

The leakage of resources is a key constraint to primary education in Uganda. Between 1995 and 2001, leakage of capitation grants to schools in Uganda fell from 80% to 20%. While some of this improvement may have occurred without the Public Expenditure Tracking Studies (PETS), it seems the decrease of leakage was mainly a result of the PETS and the policy changes that it triggered (UNESCO, 2004). The above demonstrates that primary education has various institutional (policy and infrastructural) challenges.

3. Measuring Technical Efficiency Using Data Envelopment Analysis

Farrell (1957, cited in Coelli, 1996) proposed that the efficiency of a firm consists of two components: technical efficiency, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative (price) efficiency, which reflects the ability of a firm to use inputs in optimal proportions, given their respective prices and the production technology. Technical efficiency was measured by means of a non-parametric Data Envelopment Analysis (DEA). A combination of technical and allocative efficiency yields a measure of total economic (overall) efficiency. In the context of education, this implies academic achievement for a given level of expenditure.

The three measures of efficiency (technical, allocative, and economic) are bounded by zero and unity. They are measured along a ray from the origin to the observed production point. They hold the relative proportions of inputs (or outputs) constant. One merit of these radial efficiency measures is that they are unit invariant. This means that changing the units of measurement does not change the value of the efficiency measure (Coelli, 1996). The final dimension of efficiency is scale efficiency. A production unit is 'scale efficient' when its size of operation is optimal. At the optimal scale, when the size of operation is either reduced or increased, its efficiency will drop. A scale efficient unit is one that operates at optimal returns to scale.

Charnes et al (1978) proposed a DEA model, which had an input-orientation and assumed Constant Returns to Scale (CRS). They specified a fractional linear programme that computes the relative efficiency of each Decision Making Unit (DMU) by comparing it to all the other observations in the sample. Their exposition proceeds as follows.

Suppose that there is data on K inputs and M outputs on each of N firms, or DMUs as they are referred to in the DEA literature. For the i^{th} DMU these are represented by the vectors x_i and y_i, respectively. The KxN input matrix, X, and the MxN output matrix, Y, represent the data of all the DMUs. DEA constructs a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier.

DEA is best introduced by means of ratio form. For each DMU (specifically a primary school in the case of this article) one seeks to obtain a measure of the ratio of all outputs over all inputs, which takes the following form, $\frac{u'y_i}{v'x_i}$, where u is an Mx1 vector of output weights and v is a Kx1 vector of input weights. In order to select optimal weights, the following mathematical programming problem is specified:

$$
\begin{aligned}
& Max_{u,v}\left[\frac{u'y_i}{v'x_i}\right] \\
& subject \quad to \\
& \frac{u'y_j}{v'x_j} \leq 1, \quad j = 1,2,....,N \\
& u,v \geq 0
\end{aligned}
\tag{1}
$$

The mathematical programming problem entails finding values for *u* and *v*, such that the efficiency measure of the i^{th} primary school is maximised subject to the constraint that the overall efficiency measures must be equal to or less than unity (one). However the ratio formulation has a disadvantage of having an infinite number of solutions. For instance, if (u^*, v^*) is a solution, then $(\alpha u^*, \alpha v^*)$ is another possible solution, amongst others. To address this problem one can impose the constraint $v'x_i = 1$, which yields equation (2):

$$
\begin{aligned}
& Max_{\mu,v}\left[\mu' y_i\right] \\
& subject \quad to \\
& v'x_i = 1, \\
& \mu' y_j - v'x_j \leq 0, \quad j = 1,2,...,N, \\
& \mu, v \geq 0,
\end{aligned}
\tag{2}
$$

where the notation change from u and v to μ and ν reflects the transformation. This form is known as the *multiplier* form of the linear programming problem.

By means of duality in linear programming, one can derive an equivalent envelopment form of this problem (Coelli, 1996):

$$
\begin{aligned}
& Min_{\theta,\lambda}\theta \\
& subject \quad to \\
& -y_i + Y\lambda \geq 0, \\
& \theta x_i - X\lambda \geq 0, \\
& \lambda \geq 0
\end{aligned}
\qquad (3)
$$

where θ is a scalar and λ is an Nx1 vector of constants. This envelopment form entails fewer constraints than the multiplier form (K+M □ N+1) and therefore is the generally preferable form to solve. The value of θ obtained is the efficiency score for the i^{th} school. It has to satisfy $0 \leq \theta \leq 1$, with a value of 1 showing a point on the production frontier. It is therefore a technically efficient school according to Farrell's (1957) definition. It is worth noting that the linear programming problem must be solved N times, once for each school in the sample to yield a value of θ.

The CRS assumption is only appropriate when all schools operate at an optimal scale. Constraints in the operating environment may cause a school to operate at non-optimal scale. Banker et al (1984) suggest an extension of the CRS DEA model to provide for Variable Returns to Scale (VRS) situations. The use of the CRS specification when not all schools are operating at the optimal scale results in a measure of technical efficiency that is confounded by scale efficiency. The use of the VRS DEA specification permits the calculation of scale inefficiency.

The CRS linear programming problem can be modified to account for VRS by adding the convexity constraint $N1'\lambda = 1$ to equation (3), where N1 is an Nx1 vector of ones (Coelli, 1996). This approach forms a convex hull of intersecting planes, which envelop the data points more tightly than the CRS canonical hull and thus provide technical efficiency scores which are equal to or greater than those obtainable by the CRS model.

4. Unit of Analysis, Data Type, Sources, and Sample Size

This study investigated the technical efficiency and total factor productivity growth of Uganda's primary schools. The study's unit of analysis is a primary school. A stratified random sample of 500 primary schools (200 public, 150 private, and 150 community-owned) in Uganda over the 1995-2009 period was selected. Input data to various primary schools were obtained from the planning department of the Ministry of Education and Sports. Educational output data relating to the academic achievement by students were obtained from the Uganda National Examinations Board.

Education is a transforming process in which policies, practices, and environmental qualities, operating at the student, classroom, school, and district levels, impact teaching and learning. Resources or inputs, such as school buildings, teachers, books, and technology, help develop each student's potential. At the same time, students bring inputs of their own, including abilities, attitudes, and the influences and resources of families and communities. In what follows, we discuss how we constructed input and output variables.

Output Variables

True educational output is very difficult to measure empirically due to its inherent intangibility. Education does not only consist of the ability to repeat information and answer questions, but it also involves the skills to interpret information and learn how to behave in society. In spite of the multi-product nature of education, most studies have used the results obtained in cognitive tests since they are difficult to manipulate and respond to administration demands. Hoxby (2000) notes that the most important reason for using these results could be that both policymakers and parents use this criterion to choose schools for their children.

The study's output measures focus on the process type or production volume style estimates of educational output. The study examined four measures of primary schools' output in the Primary Leaving Examinations (PLE): division 1, division 2, division 3, and division 4. Student academic achievement, as measured by examinations and other test scores, has been the most extensively studied educational benefit both in the developed and developing worlds (Simmons & Alexander, 1978). A school embraces various resources in a series of processes that ultimately aim to improve upon the educational achievement of students and contribute to literate communities. Below are the details with regard to the educational output variables constructed.

- Division 1 comprises the number of pupils who passed PLE with division 1. Qualifying for division 1 entails getting between 4 and 12 aggregates.

- Division 2 comprises the number of pupils who passed PLE with division 2. Qualifying for division 2 entails getting between 13 and 23 aggregates.

- Division 3 comprises the number of pupils who passed PLE with division 3. Qualifying for division 3 entails getting between 24 and 29 aggregates.

- Division 4 comprises the number of pupils who passed PLE with division 4. Qualifying for division 4 entails getting between 30 and 34 aggregates.

Input Variables

Sutherland et al (2009) note that two sets of inputs determine educational outcomes, namely discretionary and nondiscretionary. Discretionary inputs include factors under the control of the education system and can be defined in physical inputs, such as number of teachers, teacher-student ratios, class sizes, instruction time, teacher quality, and, to a lesser extent, other resources in schools. The non-discretionary inputs cover environmental inputs, which are not amenable to direct control. Student achievement is considered to be dependent upon, amongst other factors, family and peer-group effects and innate ability. While difficult to measure, these factors are often proxied by measures of socio-economic status.

Five inputs are constructed, namely teachers, pupils, classrooms, toilets, and average class size. The input of teachers includes the total number of teachers in each primary school irrespective of level of education. The numbers of toilet cubicles are lumped together and are not decomposed by sex. Jaiyeoba and Atanda (2011) note that toilets (conveniences) represent one of the strong school-based quality factors that contributes to students' academic achievement. Average class size is constructed by dividing the total student population by the number of classrooms in a primary school. This variable is usually considered a school input in efficiency analysis, according to the results of some studies in which a direct relationship is found between reduced class size and higher academic performance (Card & Krueger, 1992; Hoxby, 2000; Krueger, 2003; Mora et al, 2010). Other studies conclude that this variable is not significant (Hanushek, 2003; Pritchett & Filmer, 1999).

Table 1 Definition and Measurement of Input and Output Variables

Variables	*Definition*
Outputs	
Division 1	Number of pupils who passed Primary Leaving Examinations with division one (i.e. 4-12 aggregates).
Division 2	Number of pupils who passed Primary Leaving Examinations with division two (i.e. 13-23 aggregates).
Division 3	Number of pupils who passed Primary Leaving Examinations with division three (i.e. 24-29 aggregates).
Division 4	Number of pupils who passed Primary Leaving Examinations with division four (i.e. 30-34 aggregates).
Inputs	
Teachers	Total number of teachers in a given primary school.
Pupils	The total number of pupils in a primary school.
Classrooms	Total number of classrooms in a primary school.
Toilets	Total number of toilets in the school.
Average class size	Total student population divided by the number of classrooms.

Table 1 presents the article's definition and measurement of the input and output variables. In nonparametric data envelopment analysis when we deal with multi-inputs and multi-outputs, we do not have straightforward hypotheses. All we can hypothesise is that decision-making units with an efficiency score of 1 or 100% are deemed technically efficient, while those whose scores are less than 1 or 100% are inefficient. It is the case that when super-efficiency is analysed, efficiency scores can exceed 100%.

5. Empirical Results

The empirical results are discussed under the following headings: descriptive statistical analysis, correlation analysis, and technical efficiency.

Descriptive Statistical Analysis

The descriptive statistics of the educational inputs and outputs for 500 schools over the 1995-2009 period are presented in Table 2. The table indicates that the mean number of teachers in the sampled primary schools stood at about 12 teachers with a standard deviation of 6 teachers. Considering that a primary school has seven classes with several streams, the average number of teachers in Uganda's primary schools is far below the number necessary to adequately attend to the learners to produce satisfactory academic achievement. Turning to the number of pupils in the sampled schools, it emerges that the average number of pupils in the sampled schools stood at 711 with a standard deviation of 344. The average number of classrooms in the sampled schools stood at 17 with a standard deviation of about 10. This in turn, translates into an average class size of 70 pupils (this is higher than the recommended class size of 40) with a standard deviation of 160. It is clear that classes in Uganda's primary schools are overcrowded. USAID (2007) notes that overcrowded or large classrooms are those where the pupil-teacher ratios exceed 40:1. Primary teachers in Uganda face many obstacles when attempting to teach in overcrowded classes.

Turning to the average educational outputs, the average number of pupils who attained division 1 stood at 2 with a standard deviation of 10. The mean number of pupils who attained division 2 stood at 14 with a standard deviation of approximately 15. The mean number of pupils who attained division 3 stood at 12 with a standard deviation of about 9 pupils; while the mean number of students who attained division 4 stood at about 8 with a standard deviation of about 6 pupils.

Table 2 Mean and Standard Deviation of Input and Output Variables, Pooled Dataset 1995-2009

Variable	Mean	Standard Deviation	Sample Variance	Kurtosis	Skewness	Range
Division 1	2.16	10.19	103.93	290.87	15.85	199.00
Division 2	14.22	14.77	218.23	24.35	3.72	143.00
Division 3	12.47	8.57	73.37	13.71	2.18	91.00
Division 4	7.97	5.58	31.18	1.80	1.21	33.00
Teachers	11.70	5.75	33.09	1.36	0.98	31.00
Pupils	711.51	344.38	118597.48	1.49	0.96	2253.00
Toilets	13.18	9.97	99.39	4.94	1.65	70.00
Classrooms	17.52	9.81	96.29	1.79	0.84	66.00
Average Class Size	70.37	160.71	25826.56	79.70	8.26	2026.68

Correlation Analysis

Table 3 presents the Pearson correlation matrix of input and output variables for the pooled dataset (1995-2009) with a total of 7,500 observations. Some correlation coefficients are significant while others are not. We report both the significant and insignificant correlation coefficients, especially those with implications on the resources at the disposal of the sampled schools.

It is clear from Table 3 that divisions 3 and 4 are highly and positively correlated. This implies that a primary school, which had many of its pupils in either division, had a high likelihood of having more pupils in the other. The number of teachers was highly and positively correlated with the number of pupils. The number of classrooms and toilets was positively and highly correlated. Average class size was negatively correlated with divisions 2, 3, and 4. This therefore implies that overcrowded classes are likely to work against the academic performance of students.

The principal technical efficiency results reported in this section were derived by allowing for variable returns to scale. Variable returns to scale results are presented because they are more plausible in the real-world, where decision-making units operate in less than optimal conditions. The mean technical efficiency scores differed by location and ownership. Table 4 presents the mean constant returns to scale, variable returns to scale, and scale efficiency scores by region, as well as ownership and rural-urban divides.

Table 3 Pearson Correlation Matrix of Input and Output Variables, Pooled Dataset 1995-2009

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Division 1	1.00								
(2) Division 2	0.29	1.00							
(3) Division 3	0.02	0.38	1.00						
(4) Division 4	-0.09	0.08	0.61	1.00					
(5) Total-teachers	-0.01	-0.02	0.01	0.02	1.00				
(6) Total Pupils	0.02	-0.04	-0.01	0.02	0.76	1.00			
(7) Toilets	0.02	0.02	0.02	0.03	0.51	0.47	1.00		
(8) Classrooms	0.01	-0.01	0.04	0.06	0.64	0.55	0.56	1.00	
(9) Average Class Size	0.01	-0.01	-0.03	-0.02	0.07	0.08	-0.14	-0.38	1.00

Table 4 Mean Technical Efficiency Scores (Constant Returns to Scale, Variable Returns to Scale, and Scale Efficiency), 1995-2009

	Constant Returns to Scale Technical Efficiency (CRS TE)	Variable Returns to Scale Technical Efficiency (VRS TE)	Scale Efficiency $= \frac{CRS\ TE}{VRS\ TE}$
National	0.856	0.944	0.905
Urban	0.844	0.943	0.895
Rural	0.719	0.779	0.923
Regions			
Central	0.975	0.985	0.989
Eastern	0.791	0.864	0.916
Northern	0.765	0.897	0.853
Western	0.911	0.912	0.998
Ownership			
Public	0.805	0.859	0.938
Private	0.949	0.973	0.975
Community	0.535	0.943	0.567

At the national level, the constant returns to scale technical efficiency score stands at 0.856, while the variable returns to scale technical efficiency score stands at 0.944, which yields a scale efficiency score of 0.905. Along the rural-urban divide, urban primary schools are more technically efficient (with a VRS technical efficiency score of 0.943) compared to rural schools (0.779). At the regional level, the Central Region is technically more efficient, with a VRS technical efficiency score of 0.985, followed by the Western (0.912), Northern (0.897), and Eastern (0.864) Regions. By ownership, privately owned schools are more technically efficient (0.973), followed by community-owned schools/faith-based schools (0.943) and public schools (0.859). Technical efficiency scores only refer to the relative performance within the sample. Primary schools with an efficiency score of one are efficient relative to all other schools in the sample, but may not be efficient by some absolute standard. Inefficiency is inherently unobservable – all we can do is benchmark primary schools against each other, not against some absolute standard.

In what follows, the technical efficiency results are linked to discretionary variables. To accomplish this, schools were arbitrarily categorised into three cohorts: low performers (with a mean VRS technical efficiency score in the 53 – 70% bracket); moderate performers (with a mean VRS technical efficiency score in the 71 – 85% range); and high performers (with a mean VRS technical efficiency score in the 86 – 100% range). Table 5 presents the means of the discretionary variables for the three categories.

Table 5 Means of Discretionary Variables by Category of Performance, 1995-2009

Discretionary Variable	Low Performers (VRS TE: 53-70%)	Moderate Performers (VRS TE: 71-85%)	High Performers (VRS TE: 85-100%)
Teachers	8.8	23.4	52.7
Pupils	1067.3	925.0	853.8
Classrooms	9.9	26.4	39.5
Toilets	13.1	35.0	52.6
Average Class Size	140.7	105.6	52.8

As indicated in Table 5, there is a direct relationship between the numbers of teachers, classrooms, and toilets and a school's technical efficiency score. Conversely, there is an inverse relationship between technical efficiency and the number of pupils and average class size. This implies that big classes adversely affect academic achievement.

This study also attempted to link the technical efficiency scores of the various cohorts of schools to the following non-discretionary variables: regional poverty levels, regional parental literacy, teacher effort, and teacher remuneration. There are marked differences between rural and urban poverty levels in Uganda, with poverty remaining higher in rural areas than in urban areas. Rural areas account for 85% of the population but 94.4% of the poor, while urban areas account for 15% of the population but only 5.6% of the poor. As of the fiscal year 2009/10, the proportion of the total population that is poor by region was as follows: 2.7% in Central Region; 6.9% in Eastern Region; 8.9% in Northern Region; and 5% in Western Region (Republic of Uganda, 2011).

There is a correlation between regional poverty levels and a given region's mean technical efficiency score of its primary schools. The Central Region, with the lowest proportion of poor people (2.7%), has the highest technical efficiency score (0.975), followed by the Western Region (0.911). There is an inverse relationship between educational achievement and poverty levels across regions. Similar results have been found by other researchers. For instance, Lacour and Tissington (2011) investigated the effects of poverty on academic achievement in the United States. They found that low achievement is closely correlated with lack of resources.

Parental involvement is associated with higher student achievement outcomes. However, parental involvement is also determined by the literacy of parents. In Uganda, according to the 2009/10 household survey results, the percentage of households that had never attended school stood at 13.9% in Northern Region; 8% in Central Region; 11.4% in Western Region; and 7.9% in Eastern Region (Republic of Uganda, 2011). By approximately linking a region's literacy level to its academic achievement, it emerges that the Central Region, with 8% of people who have never attended school (or a literary rate of 92%), has the highest technical efficiency of primary schools (97.5%). On the other hand, the Northern Region, with the lowest literacy rate of 86%, has the lowest level of technical efficiency (76.5%).

Teacher effort is an important input into learning. The most crucial forms of quiet corruption in education are teacher absence and low effort while in school. Evidence on the extent of teacher absence has improved greatly over the last decade. Early evidence comes from head-teacher or teacher self-reports of the duration of absence during a given time period (usually 1 – 4 weeks). According to a World Bank study, more than half the teachers in Tanzania and Uganda were absent at least one day in the previous week, and about a quarter of teachers were absent for two or more days. In Uganda, head teachers were twice as likely to be absent as regular teachers. Nearly one-third of teachers were not in the classroom during learning periods (World Bank, 2010).

Schools combine instructional materials and teacher and pupil interaction to produce cognitive skills. The World Bank (2010) documents the leakage of two key inputs, namely instructional materials and school inspection. A teacher with few or no instructional materials will find it harder to impart the necessary skills to his or her charges. Additionally, school inspection ensures that the right pedagogical strategies are being implemented and instructional materials are well deployed. The clearest example of the extent of leakage of instructional resources comes from two PETS surveys in Uganda in the 1990s. The first study revealed that an average of only 13% of the resources intended for schools were reaching them. In addition, more than 70% of students were in schools that had not been inspected in the previous year.

Teacher motivation and incentives in order to increase student performance is an increasingly popular education policy around the world. Fryer (2011) describes a school-based randomised trial in over 200 New York City public schools designed to better understand the impact of teacher incentives on student achievement. No evidence is found that teacher incentives increase student performance, attendance, or graduation, nor is there any evidence that the incentives change student or teacher behaviour. It should be noted that, currently, a primary school teacher in Uganda earns Sh.260,000 (approximately US$100) per month, while secondary schools teachers receive about Sh.450,000 (Mubiru, 2010). These figures are out of touch with the rising costs of living. The poor academic achievement can to some extent be blamed on poor teacher remuneration and unfavourable working conditions.

6. Discussion and Further Research

The technical efficiency of some primary schools in the sample is less than 100%. This should be of some concern to policy makers and planners interested in good value for money. Given the existing levels of both technical and scale inefficiency, the attainment of the national education objectives, as well as education-related global and regional targets such as the Dakar Framework for Action and the Millennium Development Goals, will be compromised. The efficient use of existing resources should be the centrepiece of the country's education policy.

Nevertheless, the degree of inefficiency is high, and the policy response should be contingent upon the primary school's operating environment. Appropriate action ought to be taken only after a thorough investigation. DEA is an important indicator that may serve as the point of departure for decisions on funding or resource distribution. Naturally, these kinds of decisions must also consider the specific circumstances (beyond the control of the schools) that individual schools have to face in terms of socio-economic differences, where, for example, operating in a 'disadvantaged area' would mean that a specific school needs more resources.

Technical and scale inefficiency are present in varying degrees in a majority of schools in both developing and developed countries. For instance, Mizala et al (2002) assessed the technical efficiency of Chilean schools. According to their DEA results, a typical school has an efficiency of 95%, while the range is from 53% to 100%. Hu et al (2009) report that half of the schools sampled from Beijing primary schools reach technical and scale efficiency, with an average technical value of 0.90, which is an optimistic result, although some of the schools were low in technical efficiency. Academic performance has also been found to be dictated by the functionality of facilities. For example, USAID (2009) notes that higher performing schools in Ghana are more likely to have electricity and functional toilets. High performing schools also tended to be located in urban areas.

This article estimated the technical efficiency and total factor productivity growth of Uganda's primary schools. As a follow-up to this study, there are myriad areas that merit further investigation. There is a dearth of knowledge with regard to the extent to which Uganda's primary schools are provided with discretionary and non-discretionary resources in fulfilling their mandates. Academic achievement is also affected by student characteristics (parental and community involvement) and other environmental factors. It would be intuitive to find out how student attributes interact with the school characteristics as well as the community variables to impact upon academic achievement. Parent involvement has been shown to be an important variable that positively influences children's education. More schools have observed its importance and are encouraging families to become more involved. Because of this trend, it is essential to understand what is meant by parental involvement and in what ways it influences children's education.

Given that this article has demonstrated that private schools are relatively more technically efficient than public and community schools, there is need to find out what accounts for this state of affairs. We do not know the internal efficiency of primary education in Uganda and the drivers of regional differences in technical efficiency. There is need to find out the lessons that public and community schools can draw from private schools to enhance their performance in the spirit of public-private partnerships for education.

7. Conclusion

The following conclusions emerge from this study. The mean technical efficiency scores differ by location and ownership. The technical efficiency results are affected by discretionary and non-discretionary variables. There is a direct relationship between the numbers of teachers, classrooms, and toilets and a school's technical efficiency score. Conversely, there is an inverse relationship between technical efficiency and the number of pupils, as well as the average class size. This implies that big classes adversely affect academic achievement. There is a correlation between regional poverty levels and a given region's mean technical efficiency score of its primary schools. There is an inverse relationship between educational achievement and poverty levels across regions.

Parental involvement is associated with higher student achievement outcomes. However, parental involvement is also determined by the literacy of parents. If schools operate under low efficiency, the resources will not be properly utilised and the sustainability of education will not be ensured. One of the most important challenges to Uganda's primary education sub-sector is low technical efficiency.

Educational quality is the key object of schools. The indicators of teachers' salaries, student-teacher ratios, and the time students spend in school have an obvious effect on schools' technical efficiency. Considering the status-quo of Uganda's primary schools, we suggest that teachers' salaries be increased. Additionally, there is need to reduce student-teacher ratios, provide better toilet facilities, and address teacher absenteeism, which impacts on the quality of time that students spend at school. These initiatives will help schools scale-up their technical efficiency.

8. Policy Implications

The article has various policy implications. The technical efficiency results were linked to discretionary and non-discretionary variables. There is a direct relationship between the numbers of teachers, classrooms, and toilets and a school's technical efficiency score. Conversely, there is an inverse relationship between technical efficiency and the number of pupils as well as average class size. This result implies that big classes adversely affect academic achievement. The study also attempted to link the technical efficiency scores of the various cohorts of schools to some non-discretionary variables. There is a correlation between regional poverty levels and a given region's mean technical efficiency score of its primary schools. The Central Region, with the lowest proportion of poor people (2.7%), has the highest technical efficiency score (0.975), followed by the Western Region (0.911). There is an inverse relationship between educational achievement and poverty levels across regions.

Parental involvement is associated with higher student achievement outcomes. However, parental involvement is also determined by the literacy of parents. Linking a region's literacy level to its academic achievement shows that the Central Region, with the highest literary rate of 92%, has the highest technical efficiency of primary schools (97.5%). On the other hand, the Northern Region, with the lowest literacy rate of 86%, has the lowest level of technical efficiency (76.5%).

This study demonstrated that Uganda's primary schools are technically inefficient. Given that there is clearly a resource gap in terms of physical and human infrastructure (classrooms, toilets, and teachers), one can be tempted to conjecture that they are doing their best within the limitations posed by the available resources. There are schools in both rural and urban areas that are under-resourced, with ratios of over 100 pupils per teacher.

It has been found that higher pupil-teacher ratios adversely affect academic achievement and thereby the technical efficiency of schools. The pupil-classroom ratios (average class size) are far higher than the corresponding pupil-teacher ratios. This suggests that there are many classes that take place in non-classroom environments, which inconveniences pupils and teachers due to class-transfers, especially when the weather conditions change. There is an urgent need to increase the number of classrooms, number of teachers, and toilet facilities.

Notes

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