Technical Efficiency and Productivity of Primary Schools in Uganda

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Abstract

There is increasing interest in measuring the productive performance of educational institutions, given their rising operational costs. This paper presents the findings of an evaluation of the technical efficiency and total factor productivity growth for a stratified random sample of 500 primary schools (200 public, 150 private and 150 community owned) in Uganda over the 1995–2009 period. A non-parametric data envelopment analysis (DEA) and DEA-based Malmquist Total Factor Productivity (TFP) Index with an output orientation are employed. At the national level, the constant returns to scale technical efficiency score stands at 0.856 while the variable returns to scale (VRS) 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 a 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). The results have been linked to background discretionary variables. Given an output-oriented Malmquist TFP Index, the mean TFP change of 0.931 indicates that, on average over the sample period, there was a 6.9 per cent regress in productivity. Looking at the mean technical efficiency change (0.993) and the mean technical or technological change (0.951), the productivity losses were largely the result of technical inefficiency.

Acknowledgements

1. Introduction

The introduction of the Universal Primary Education (UPE) programme increased access to education in Uganda, with the rural population as main beneficiary. There was a 4% increase in the number of pupils enrolled, 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 children enrolled in primary school remains a key challenge to the education sector. At a national level, about one in every three pupils enrolled in primary education does not have adequate sitting and writing space (Uganda Bureau of Statistics, 2010).

Considerable resources have been allocated to Uganda's primary education sub-sector. For example, in the fiscal year 2008/09, the Government of Uganda's recurrent budget allocation to the education sector was USh716.74 billion out of the total discretionary recurrent budget of USh2516.890 billion, translating into a share of 28%. The total Education and Sports Sector budget allocation (recurrent and development) was USh786.41bn (net of direct donor project aid), of which the primary education sub-sector was allocated USh443.255 billion translating into a budget share of 56% (Republic of Uganda, 2010c). Although a rising proportion of Uganda's resources has been directed at the primary education sub-sector, it is not clear to which extent they translate into desirable educational outputs.

The main purpose of this study is to measure the technical efficiency and total factor productivity growth of Uganda's primary schools. Specifically, the study seeks to evaluate the technical and scale efficiency as well as assess total factor productivity changes of primary schools in Uganda over the 1995–2009 period.

Efficiency is an important area of economic analysis that has been attracting the attention of economists, especially in the last three decades. Ajibefun (2008) notes that the measurement of technical efficiency is important for the following reasons: Firstly, it is a success indicator or performance measure by which production units are evaluated. Secondly, the measurement of causes of inefficiency makes it possible to explore the sources of efficiency differentials and the elimination of the causes of inefficiency. Finally, the identification of sources of inefficiency is essential to drafting public and private policies designed to improve performance.

The study was guided by the following research questions: Are Uganda's primary schools technically efficient? Whether and to what extent have Uganda's primary schools

experienced progress or regress in total factor productivity? What are the real sources of productivity change? Does catching up with the efficiency benchmark due to changes in pure technical efficiency or scale efficiency primarily drive improvements in the overall productivity? Or is the productivity growth of primary schools mainly determined by a frontier shift stemming from technological improvements in education provision? A nonparametric data envelopment analysis (DEA) and DEA-Malmquist Total Factor Productivity (TFP) Index have been used. These nonparametric methods were employed due to, amongst other reasons, the unique nature of educational production involving multiple inputs and outputs.

The rest of the paper is organized as follows: Section 2 presents an overview of the policy context of Uganda's primary education while Section 3 presents previous studies on primary education in Uganda. Section 4 describes the methodology employed in reaching the study's objectives. Empirical results are presented in Section 5, whilst Section 6 presents a discussion which relates the study's findings to those of other studies. The policy implications of the study are presented in Section 7, and the conclusion is in Section 8.

2. Policy Context of Uganda's Primary Education

Over the period 1996–2010, the Education Sector Strategic Plan (ESSP) has evolved as follows: In 1998, the Ministry of Education and Sports developed and launched the Education Sector Investment Plan (ESIP) as the sectoral development framework for the period (1998–2003). The broad objectives of the ESIP were: (a) Achieving equitable access to education at all levels; (b) improving the quality of education, particularly at the primary level; (c) enhancing the management of education service delivery at all levels; and (d) developing the capacity of the Ministry of Education and Sports to plan, programme and manage an investment portfolio that will effectively develop the education sector.

The policy objectives of the Education Sector Strategic Plan (2004/05–2014/15) presented to the Ministry of Education and Sports (2004) were:

1. An education system relevant to Uganda's national development goals. This objective, which addresses access problems and solutions, is sub-divided into three sub-objectives that are aligned with the following three sub-systems: primary, post-primary, and tertiary, which forms part of: (i) universal participation in a flexible basic education system; (ii) increased and equitable participation in a coherent and flexible post-primary system; and (iii) expanded and equitable participation in a coordinated, flexible, and diversified tertiary system.

2. Students achieving education goals. The sub-objectives of this objective are also stated in terms of the three sub-systems and their functions in educating children, youth, and young adults. They include: (i) Primary-level pupils mastering basic literacy (reading and writing), numeracy, and basic life skills; (ii) post-primary students prepared to enter the workforce and higher education; and (iii) tertiary graduates prepared to be innovative, creative, and entrepreneurial in the private and public sectors.

3. An effective and efficient education sector. The sub-objectives focus on improving management and administration, decentralization, quality assurance, and Public-Private Partnerships (PPPs). They include: (i) Decentralized authority, financing, and management of education services; (ii) strengthened capacity of the ministry – its agencies and institutions – to provide leadership and management; (iii) quality assurance and accountability throughout the sector;

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and (iv) partnerships between the ministry and other agencies in service delivery and capacity building.

Although the attainment of an effective and efficient education sector in accordance with the Education Sector Strategic Plan (2004/05–2014/15) was reliant on PPPs, there was no institutional framework at its launch, nor currently. It should be noted that currently there is no legal provision for PPPs in Uganda. It is noted that "Government approved the PPP Policy and Principles to be enshrined in the PPP Bill for presentation to Parliament in the coming financial year. The proposed PPP Bill will provide the framework for the implementation of selected public infrastructure by harnessing private sector financial and human resource skills, while sharing the construction and operational risks between public and private sectors. This will ensure improved efficiency and value for money in the delivery of public infrastructure services, including speedy implementation of public-private sector investments." (Republic of Uganda, 2010b). The inclusion of PPPs in the Education Sector Strategic Plan (2004/05–2014/15) was, and still is, a policy discrepancy/deficiency.

In 2008, before the expiry of the timeframe for the ESSP (2004/05–2014/15), a new Education Sector Strategic Plan (2007–2015) was launched. The policy objectives of the revised ESSP 2007–2015 are: (a) Increase and improve equitable access to quality education; (b) improve the quality and relevancy of primary education; and (c) improve effectiveness and efficiency in the delivery of primary education.

Although it is claimed that the ESSP (2004/05–2014/15) succeeded the Education Sector Investment Plan, a critical examination of the objectives of each of these plans demonstrates that there are clear gaps. For instance, the objectives of the Education Sector Investment Plan were (a) Achieving equitable access to education at all levels; (b) improving the quality of education, particularly at the primary level; (c) enhancing the management of education service delivery at all levels; and (d) developing the capacity of the Ministry of Education and Sports to plan, programme and manage an investment portfolio that will effectively develop the education sector. The objectives of the ESIP are at variance with those of the ESSP (2004/05–2014/15), which were: (a) An education system relevant to Uganda's national development goals; (b) students achieving education goals; and (c) an effective and efficient education sector. This, therefore, shows a lack of continuity in the objectives of the different plans. Similarly, although it is claimed that the Education Sector Strategic Plan (2007–2015) succeeded ESSP (2004/05–2014/15), its policy objectives are: (a) Increase and improve equitable access to quality education; (b) improve the quality and relevancy of primary education; and (c) improve effectiveness and efficiency in the delivery of primary education, do not clearly derive from ESSP (2004/05–2014/15).

Although it is claimed that there is a policy guiding UPE, there are hardly any policy documents upon which changes in Uganda's primary education sub-sector are based. Currently, UPE is the cornerstone of Uganda's primary education sub-sector. However, there is no document detailing what UPE is and how it was supposed to be implemented. The UPE policy is not to be found in writing. It is a policy that was motivated by the current government's manifesto ahead of the 1996 presidential and parliamentary elections. There are no proper guidelines on how the figure of four (4) children per family was arrived at. It is clear that UPE was a politics-based policy and not an evidence-based

policy. In Republic of Uganda (1999), it is noted that: "Governments have the power and authority to make vital decisions in education. Very often lip service is paid to mass education. Government not only made a pledge in May 1997 about UPE but also took action to implement the pledge by December 1997 despite some resistance from bureaucrats and technocrats in education. There was strong Presidential and Ministerial (Education) leadership and backing of UPE." What follows is some documentary evidence to attest to the absence of policy documentation.

The Primary Education and Teacher Development Project (PETDP) was approved in 1993, to support the government's long-term objectives of access, quality, and relevance in the education sector by monitoring resource mobilization and allocation in the sector, and by financing specific investments. Midway through the implementation of the PETDP, President Yoweri Museveni fulfilled an election promise to eliminate primary school fees, in a "big bang" approach to achieving UPE. The result was an almost doubling of enrolments in early 1997, which overwhelmed schools and threatened a collapse of the system unless additional resources could be made available (World Bank, 2004).

Similarly, there are other policies that are being implemented for which there is no documentation, save for guidelines in a few cases. Policies for which there is a lack of proper documentation include, but are not limited to: (a) Automatic Promotion Policy; (b) Text Book Policy; (c) Instruction in Local Language Policy (Lower Primary); (d) Early Childhood Development Policy; and (e) Customized Performance Targets Policy.

There are certain aspects that can be considered as "missing middles" in the UPE programme. The "missing middles" are the preconditions that ought to be in place for the smooth implementation of the universal primary education programme. Government's overemphasis on the physical inputs while paying little or no attention to other crucial inputs greatly undermines the performance of the programme. For instance, whereas prior to the inception of UPE parents were participating in the running of schools by way of Parent Teachers Associations (PTAs), upon the commencement of UPE the government paralyzed the initiative to participate. This has taken various forms. For instance, threats to arrest headmasters who charge parents a fee for the provision of food for the learners. Besides, the threat to punish head teachers due to the poor performance of their schools has resulted in head teachers forcing pupils to repeat Primary Six in order to escape being punished for poor grades (Ministry of Education and Sports, 2008a). It is worth noting that repetition rates are highest in Primary Six because of the threat to punish head teachers whose schools perform poorly. Teachers' salaries and other living conditions is one missing link which was not given due weight in the implementation of the programme. It is self-defeating to expect a poorly remunerated teacher to teach well. Additionally, there are factors that dictate attendance of especially female pupils, for instance sanitation facilities. Some schools lack proper classroom structures which forces them to conduct classes under trees. In turn, this means that changes in the weather impact on attendance and teaching.

Primary education also suffers from inadequate and/or poor sanitation and hygiene facilities. The Ministry of Education and Sports (2006) notes that sanitation and hygiene facilities are inadequate in most primary schools. Various dimensions corroborate the pathetic state of sanitation and hygiene. For instance, the average pupil-to-stance ratio declined from 61:1 in 2004 to 69:1 in 2006. The pupil-to-stance ratio denotes the

number of pupils in the school divided by the total number of latrine stances in the school. Additionally, some schools do not provide separate facilities for boys and girls, which runs counter to the privacy of the two genders. In other cases, there is a mix of toilet facilities for teachers and students. This goes against the basic Requirements and Minimum Standards Indicators for Educational Institutions (Republic of Uganda, 2001). It should be noted that the available toilets do not cater for pupils with disabilities. The inadequate and/or poor sanitation and hygienic facilities is corroborated by Transparency International (2010).

Inadequate funding is another factor constraining Uganda's primary education. UPE should have been informed by a baseline survey, which in part would have identified the school-going children who were out of school and provided information on the unit cost of supporting a child through primary education. A document from the Ministry of Education and Sports (2000a) in part notes that the UPE capitation grant is inadequate. This is exacerbated by, among other things, the use of outdated enrolment figures; exclusion of vital items as not being eligible for UPE expenditure support; price escalation given that the formula was fixed in 1997; delays in flows of UPE funds; remoteness of some schools; as well as parents abdicating their obligation to educate their children to government. Inadequate funding for UPE is a concern also observed by other studies, for instance the South African Institute of International Affairs (2004).

UPE is not universal enough as it does not provide for all those in need of education (which is a right enshrined in the Uganda Constitution, 1995). Juuko and Kabonesa (2007) note that although Uganda is a signatory to most international and regional instruments related to education (e.g. The Dakar Framework for Action and the Millennium Development Goals), implementation and respect of the frameworks are still problematic. They note that although the law imposes an obligation on both parents to provide their children with education, in most cases single mothers are unable to pay. Further, the authors note that the government has tried to provide primary education, leading to increased enrolment. Nevertheless, it has not met all the obligations laid out in the international instruments and has not ensured availability of, accessibility to, acceptability of and adaptability to education. The government has not provided compulsory education, scholastic materials, structures or an environment that promotes quality education. This demonstrates the existence of policy discrepancies in the UPE policy versus international and regional frameworks to which Uganda is a signatory.

Nonfunctional school management committees constrain the performance of Uganda's primary education. A School Management Committee (SMC) is a government structure used in the management of Uganda's UPE (Ministry of Education and Sports, 2009). Each school is mandated to have an SMC, which is tasked with, among other things: (i) providing overall direction to the running of the school; (ii) ensuring that the school has a development plan for ensuring quality education; (iii) approving the school's annual budget; and (iv) monitoring the finances to ensure that they are properly utilized. The oversight role of SMCs is compromised because, in most cases, head teachers have people who will not challenge their views. Requiring head teachers to constitute a body to bring them to account is a policy discrepancy. Moreover, Transparency International (2010) found that in Uganda 47% of SMC members had not received the requisite financial management training.

The foregoing policy context of Uganda's primary education shows that there are a myriad policy challenges to the proper implementation of the UPE programme, which is the cornerstone of the country's primary education.

3. Previous Studies on Primary Education in Uganda

The economics of education literature is voluminous and still growing rapidly. Three approaches, namely child development, production function, and school "market" structure, have been used to analyze the economics of education in the literature. The early childhood approach looks at the student's environment to explain the development of cognitive skills. In this approach, family background and the social environment in which a child is raised, often without regard to school inputs, are deemed to be 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 on how competition in the provision of education affects the cognitive skills of students. Note that elements of all three approaches will affect the cognitive achievements of students. Todd and Wolpin (2003) point out that focusing on only one particular aspect to the exclusion of others, require very restrictive assumptions.

Previous empirical studies have been undertaken with respect to Uganda's primary education. These relate to, amongst other factors, policies enacted since the inception of UPE (e.g., automatic promotion policy; customized performance targets policy; teacher absenteeism); working conditions for teachers in Uganda; shortage of teachers; and accountability and transparency in primary education management.

A document by the Republic of Uganda (2010c) erroneously cites the automatic promotion policy as an efficiency measure to reduce repetition and dropout rates in primary schools. It should be noted that this runs counter to ensuring educational accountability and conventional logical reasoning. There is a knowledge gap with regard to the impact of the automatic promotion policy on academic progression at post-primary levels. A critical examination by the Ministry of Education and Sports (2008a) shows that the automatic promotion policy potentially conflicts with the customized performance targets of head teachers and deputy head teachers.

The Ministry of Education and Sports launched the Customized Performance Targets policy (Ministry of Education and Sports, 2008a). Although there was resistance to this new policy, by mid-December 2009, 85% of head teachers in 12 sampled districts had signed up to this new policy (Republic of Uganda, 2010b). The indicators of head teachers' performance include variables which are beyond their control, for instance, effective teaching, learning achievements, general management and leadership, financial

management and control, sanitation, effective utilization of and innovativeness in instrumental materials, human resource management, records management, mitigation of HIV/Aids in the school, and asset management. How this impacts their performance is unknown. Additionally, it is not known whether the requisite institutional and physical infrastructure is in place for this policy to deliver its envisaged objectives.

Although teacher absenteeism has been cited as a form silent corruption (World Bank, 2010), it is not fully known why teachers are absent. In her budget speech for the financial year 2010/11, the Minister of Finance, Planning and Economic Development, announced a salary increase of 30% for teachers in remote and hard-to-reach areas (Republic of Uganda, 2010a). What is unknown is who is included in this enhancement. Trying to solve the problem of poor teacher remuneration in a piece-meal way and in selected areas of the country might cause more harm than good as teachers in other areas are serving under equally difficult circumstances. We do not know what informed the 30% increment and who will benefit from it. Whereas the Republic of Uganda (2010b) provides a 30% increase to enhance the salaries of primary school teachers, The State of the Nation Address (Republic of Uganda, 2010b) refers to the payment of hard-to-reach-areas allowances to 2,398 teachers stationed in Kalangala, Mukono (Buvuma and Koome Islands), Karamoja region (Moroto, Kotido, Nakapiripirit, Moroto and Kotido districts), and Kasese district. The allowance comprises 30% of the basic salary. There is a need to reconcile the differing positions of the two policy documents. It should be noted that salary enhancement is only part of the solution to teachers' problems. Studies, for instance those by the Ministry of Education and Sports (2009), cite other conditions which characterize poor working conditions for teachers in Uganda. These include, among other things, poor housing and lack of in-service training. There is therefore an urgent need for a teacher satisfaction study regarding their working conditions to obtain their views on what factors constrain their work and suggestions to improve their operating environment. The Quality Enhancement Initiative recognizes four pillars to quality education, namely teacher, student, management and community (Ministry of Education and Sports, 2009). The four pillars represent critical performance indicators needed to enhance the quality of primary education in the 12 poorly performing districts.

A shortage of teachers in Uganda has been cited in various studies (Ministry of Education and Sports, 2000b). While student enrolment has steadily grown since the inception of UPE, the number of primary education teachers has not grown at a commensurate rate to ensure the acceptable teacher-pupil ratio of 40:1.

Transparency International (2010) presents a regional overview of accountability and transparency in primary education management in seven African countries (including Uganda). In the same vein, the World Bank (2010) introduces 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 both potentially observable deviations, such as absenteeism, but also 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. World Bank (2010) notes that primary school teachers in a number of African countries (including Uganda) are not in school 15 to 25% of the time (absenteeism) but, in addition, a considerable fraction of those in school are found not to be teaching (low effort).

Nishimura et al. (2009) conducted a comparative analysis of UPE 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 would require considerable consultation with key stakeholders and a baseline survey that will enable the systematic implementation and consideration of equity. Mutual accountability and responsibility between the government and parents/communities is also key to the sustainability of the UPE policy.

The leakage of resources is one of many constraints 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 more likely that the decrease in leakage was mainly a result of PETS and the policy changes that it triggered (UNESCO, 2004).

It is clear from the policy context of Uganda's primary education and from the previous studies that primary education has a number of institutional (policy and infrastructural) challenges.

4. Methodology

4.1 Performance framework for schools

Systems theory can be employed in the analysis of education production. A school can be viewed as a system from various perspectives. It is a physical system of buildings; it is a system of many interacting staff; it comprises complex logistics; it is a system for educating students; and it is an information system (Aldred et al., 1971). In approaching any given school, any one of these systems perspectives might be appropriate. However, this study chooses to emphasize the school as a system for educating students. A school is a system for imparting knowledge, which consists of a number of sub-systems to achieve that, including, but not limited to: the library system; teaching system; feeding system; and accounts system.

Systems theory has had a significant effect on management science and the understanding of organizations. A system is a collection of parts unified to accomplish an overall goal and can be seen as having inputs, processes, outputs, outcomes, as well as impact. Systems share feedback among each of these aspects. The components of a simple system, as well as the relationship between them, is shown in Figure 1.

Figure 1. Performance framework for schools
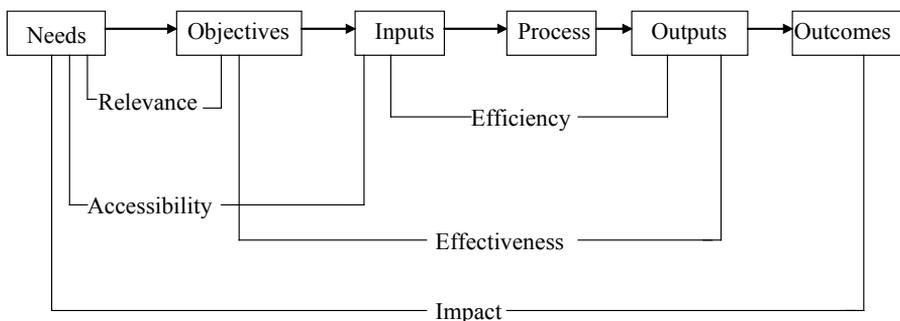
By means of the schematic flow in Figure 1, this study investigates technical efficiency by examining the relationship between inputs and outputs for a primary school. Inputs would include resources such as raw materials, money, technology and people.

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These inputs go through a process where they are planned, organized, motivated and controlled to ultimately meet the organization's goals of improving upon the educational attainment status of its students.

As educational resources are extremely constrained in Uganda, it is of particular importance that these scarce resources be used as effectively and efficiently as possible. In this section, the tools that were employed to measure technical efficiency and total factor productivity growth are discussed. The effectiveness of educational spending is difficult to assess accurately. A number of studies, however, have dealt with the efficiency of resource use in educational production. Worthington (2001) provides an empirical survey of frontier efficiency measurement techniques in education. Earlier studies have employed either the parametric Stochastic Frontier Approach (SFA) and the nonparametric DEA, or the Free Disposal Hull (FDH).

Askin and Standbridge (1993) define effectiveness as doing the right task, efficiency as doing a task right, and performance as accomplishing the right task efficiently. Sink and Tuttle (1989) maintain that system performance is a function of the complex interaction among seven criteria: efficiency, effectiveness, quality, productivity, quality of work life, innovation, and

Askin and Standbridge (1993) define effectiveness as doing the right task, efficiency as doing a task right, and performance as accomplishing the right task efficiently. Sink and Tuttle (1989) maintain that system performance is a function of the complex interaction among seven criteria: efficiency, effectiveness, quality, productivity, quality of work life, innovation, and profitability. Efficiency is concerned with measuring how inputs are converted into valued outputs. Productivity is the ratio of outputs that an organization produces to inputs that are used in the production process. Thus productivity may include the notion of efficiency but is not confined to it. The research presented here focuses on technical efficiency (the amount by which inputs can be reduced without a reduction in outputs) and total factor productivity growth (measuring changes in the levels of output produced and inputs used between periods) for two reasons. First, efficiency and productivity are prerequisites for organizational performance. Second, they are potentially more objectively quantifiable than other dimensions of performance and, finally, they are a significant policy priority.

4.2 Examining efficiency using data envelopment analysis

Farrell (1957) drew upon the work of Debreu (1951) and Koopmans (1951) (cited in Charnes et al., 1978) to define a simple measure of firm efficiency that could account multiple inputs (cited in Coelli, 1996). Farrell (1957) 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 non-parametric 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 spectrum from the origin to the observed production point. Hence they the relative proportions of inputs (or outputs) are held constant. One advantage of these radial efficiency measures is that they are unit invariant. This means that changing the units of measurement (for instance, measuring the quantity of labour either in person hours or against person years) 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.

The Constant Returns to Scale DEA model

Charnes et al. (1978) propose a DEA model that has an input orientation and assumed constant returns to scale (CRS). They specify 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 is explained below.

Suppose that there are data on K inputs and M outputs on each of N firms or DMUs, as the latter are referred to in the DEA literature. For the ith 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 study) one seeks to obtain a measure of the ratio of all outputs over all inputs, which takes the following form: $\dfrac{u'y_i}{v'x_i}$ 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:

$$Max_{u,v}\left[\frac{u'y_i}{v'x_i}\right]$$

$$subject \quad to$$

$$\frac{u'y_j}{v'x_j} \le 1, \quad j = 1,2,....,N$$

$$u,v \ge 0$$

(1)

The mathematical programming problem entails finding values for u and v, such that the efficiency measure of the ith primary school is maximized subject to the constraint that the overall efficiency measures must be equal to or less than unity (one). However, the ratio formulation has the 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:

$$Max_{\mu,v}\left[\mu'y_i\right]$$
$$subject \quad to$$
$$v'x_i = 1,$$
$$\mu'y_j - v'x_j \le 0, \quad j = 1,2,...,N,$$
$$\mu, v \ge 0, \tag{2}$$

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):

$$Min_{\theta,\lambda}\theta$$
$$subject \quad to$$
$$-y_i + Y\lambda \ge 0,$$
$$\theta x_i - X\lambda \ge 0,$$
$$\lambda \ge 0 \tag{3}$$

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 ith school. It has to satisfy $0 \le \theta \le 1$, with a value of 1 showing a point on the production frontier and, 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 variable returns to scale DEA Model and scale efficiencies

The CRS assumption is only appropriate when all schools operate at an optimal scale. Constraints in the operating environment, for instance imperfect competition, financial and human resource constraints, may cause a school to operate at a non-optimal scale. Banker et al. (1984) suggest an extension of the CRS DEA model to provide for 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 which 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 that envelope

the data points more tightly than the CRS canonical hull and thus provides technical efficiency scores which are equal to or greater than those obtainable by the CRS model.

4.3 Examining productivity under the Malmquist Total Factor Productivity Index

In the case of a process with a single input and a single output, productivity is the ratio of the unit's outputs to its inputs. Productivity is a function of production technology, the efficiency of the production process and the production environment. The Malmquist TFP Index is used in the measurement of productivity. This is because the method has additional benefits (over the Tornqvist/Fisher methods) in that price data are not required, and that the TFP indices obtained can be decomposed into two components, one part technical efficiency change (firms getting closer to the frontier) and another part technical change (shifts in the frontier). One principal drawback of these methods is that panel data are required, while Tornqvist/Fisher methods may be calculated with only a single observation in each time period (Coelli et al., 1998). Färe et al. (1994) employ the Malmquist Index of TFP growth defined in Caves et al. (1982), and illustrate how the component distance functions can be estimated using DEA-like methods. They also show how the resulting TFP indices can be decomposed into technical efficiency change and technical change components.

The panel data set permits the use of DEA-like linear programmes and a (input- or output-oriented) Malmquist TFP Index to measure productivity change and to decompose this productivity change into technical change and technical efficiency change.

Following Färe et al. (1994), an output-oriented Malmquist Productivity Change Index is specified as follows:

$$M_o^{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)} \left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_o^t(y_t, x_t)}{d_o^{t+1}(y_t, x_t)} \right]^{\frac{1}{2}}.$$

$$(4)$$

where the subscript o indicates an output orientation, M is the productivity of the most recent production point (x_{t+1}, y_{t+1}) (using $t+1$ technology) relative to the earlier production point (x_t, y_t) (using t technology), d is output distance, and all other variables are as previously defined.

The term "M" represents the productivity of the production point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t). A score of greater than unity indicates productivity progress in the sense that the school delivers a unit of output in period $t+1$ using fewer inputs. In other words, the school in period $t+1$ is more efficient relative to itself in period t. Similarly, a score less than unity implies productivity regress and a unit score indicates constant productivity (Färe et al., 1994).

4.4 Unit of analysis, data type, sources and sample size

The study sought to investigate the technical efficiency and total factor productivity growth of Uganda's primary schools. As such, 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 has been selected. Input data of 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 in the various schools were obtained from the Uganda National Examinations Board.

The choice of the sample size, number of inputs as well as the number of outputs have been guided by the rule of thumb proposed by Banker and Morey (1989). The rule is such that $n \geq 3(m + s)$, where: n is the number of primary schools included in the sample; m is the number of inputs; and s is the number of outputs included in the analysis. The rule captures two issues: sample size and number of factors $[m + s]$.

A longitudinal or panel data set was assembled and a common set of input and output indicators constructed to support the estimation of DEA and Malmquist models. Input as well as output data were gathered for the 500 primary schools over the 1995–2009 time period. The potential gains from using panel data to measure technical efficiency appear to be quite large. A panel obviously contains more information about a particular DMU than a cross-section of the data.

Output and input variables constructed

Education is a transforming process in which policies, practices, and environmental qualities, operating at the student, classroom, school, and district levels, impact on 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. Inputs controlled by the school, such as expenditures and teachers hired, are measured regularly, as are key outcomes throughout a student's education, such as test scores, retention, and graduation. In contrast, data on other inputs, such as family and community influences, are not easy to collect (Seiler et al., 2006). Typically, input variables are available or can be constructed from raw data. Afonso and Aubyn (2005) note that educational output variables include, amongst other things, graduation rates, as well as student mathematical, reading and scientific literacy indicators. They further note that input variables may include expenditure per student and physical indicators such as average class size; the ratio of students to teaching staff; number of instruction hours; and the use and availability of computers. In what follows, we discuss how input and output variables were constructed.

Output variables: True educational output is very difficult to measure empirically due to its inherent intangibility, so education does not only consist of the ability to repeat information and answer questions, but also involves the skills to interpret the information and learning 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 they respond to administration demands. But, according to Hoxby (2000) perhaps the most important reason could be that both policy makers and parents use this criterion to evaluate the educational output and its subsequent information to choose the school for their children and even their place of residence.

The study's output measures focus on the process type or production volume style estimates of educational output. The study examines four measures of a primary school's output in the Primary Leaving Examinations (PLE). These include division 1; division 2; division 3; and division 4. Student academic achievement, as measured by examination and other test scores, has been the most extensively studied educational benefit both in the developed and developing world (Simmons and Alexander, 1978). A typical education system like a school embraces a variety of resources (human, material and knowledge, amongst other things), which are used 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 education output variables constructed:

(a) Division 1. 'Division 1' comprises the number of pupils who passed Primary Leaving Examinations with division 1. Qualifying for division 1 entails obtaining between 4 and 12 aggregates.

(b) Division 2. 'Division 2' comprises the number of pupils who passed Primary Leaving Examinations with division 2. Qualifying for division 2 entails obtaining between 13 and 23 aggregates.

(c) Division 3. 'Division 3' comprises the number of pupils who passed Primary Leaving Examinations with division 3. Qualifying for division 3 entails obtaining between 24 and 29 aggregates.

(d) Division 4. 'Division 4' comprises the number of pupils who passed Primary Leaving Examinations with division 4. Qualifying for division 4 entails obtaining between 30 and 34 aggregates.

Input variables: Sutherland et al. (2009) note that two main 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 teacher numbers, 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 that are not amenable to direct control. Typically, student achievement is considered to be dependent upon factors such as family and peer-group effects, and innate ability. While difficult to measure, these factors are often proxied by measures of socioeconomic status.

A typical educational institution like a primary school embraces a variety of resources (human, financial, physical and material, amongst other things) used in a series of processes that ultimately aim to improve upon the educational achievement of learners.

Five inputs were constructed, namely teachers; pupils; classrooms; toilets; and average class size:

(a) Teachers. 'Teachers' includes the total number of teachers in each primary school, irrespective of level of education.

(b) Pupils. 'Pupils' relates to the total number of pupils in a primary school.

(c) Classrooms. 'Classrooms' relates to the total number of classrooms in a primary school.

(d) Toilets. 'Toilets' comprises the total number of toilet cubicles in a primary school. The number of toilet cubicles is lumped together and is not decomposed by sex. Jaiyeoba and Atanda (2011) have noted that toilets (conveniences) represent one of the strong school-based quality factors that contribute to students' academic achievement.

(e) Average class size. '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 groups and higher academic performance (Card and Krueger, 1992; Hoxby, 2000; Krueger, 2003; Mora et al., 2010). However, other studies conclude that this variable is not significant (Hanushek, 2003; Pritchett and 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	Total number of pupils in a primary school
Classrooms	Total number of classrooms in a primary school
Toilets	Total number of toilets in a primary school
Average class size	Total student population divided by the number of classrooms

Orientation

Data envelopment models can be estimated by assuming either input- or output-orientation. The input-oriented measures address the following question: "By how much can input quantities be proportionally reduced without changing the output quantities produced?" Alternatively, one can pose the following question: "By how much can output quantities be proportionally expanded without altering the input quantities used?" The input- and output-oriented measures provide equivalent measures of technical efficiency when constant returns to scale exist, but will be unequal when increasing or decreasing returns to scale are present (Coelli, 1996). The study has adopted the output orientation, following Giambona et al. (2010), because it is more suitable than an input orientation. Output orientation implies the goal of achieving greater output, i.e., higher student proficiency for given inputs under the assumption that primary schools exercise sufficient control over inputs and outputs, so the inputs are not conceived as environmental factors but de facto as explanatory variables. Therefore, a school has a higher efficiency score of the educational system (or performance score) if, for the given inputs (educational resources available at home and family background), its students have a higher value of performance for the national Primary Leaving Examinations.

5. Empirical Results

The empirical results are categorized under the following headers: descriptive statistical analysis; correlation analysis; technical efficiency and total factor productivity growth. What we see are relative efficiency measures which should not be taken to be efficient by some absolute standard.

5.1 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 11.698, with a standard deviation of 5.752. 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 it would take 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 9.8. 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 (PTR) exceed 40:1. Primary teachers in Uganda face many obstacles when attempting to teach in overcrowded classes.

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

continued next page

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Table 2 continued

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

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 8.6 while the mean number of students who attained division 4 stood at 7.9, with a standard deviation of 5.6.

5.2 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 for the resources at the disposal of the sampled schools.

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) Class rooms	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

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 is highly and positively correlated with the number of pupils. The number of classrooms and toilets are positively and highly correlated. Average class size is negatively correlated with divisions 2, 3 and 4. This therefore implies that the overcrowded classes are likely to work against the good academic performance of students.

5.3 Technical efficiency

The principal technical efficiency results reported in this section were derived by allowing for variable returns to scale, while constant returns to scale were assumed in the computation of total factor productivity growth. Variable returns to scale results are presented because they are more plausible in the real world where DMUs operate in less than optimal conditions. The mean technical efficiency scores differ by location and ownership. Table 4 presents the mean constant returns to scale, variable returns to scale and scale efficiency scores by region, ownership, and rural-urban divides.

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 $= \dfrac{CRS\ E}{VRS\ E}$
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 a 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 necessarily be efficient by some absolute standard. This is important – inefficiency is inherently unobservable – all we can do is benchmark primary schools against each other, not against an absolute standard.

In what follows, the technical efficiency results are linked to discretionary variables. To accomplish this, schools were arbitrarily categorized into three cohorts, namely 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 number of teachers, classrooms, 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 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 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 the central region; 6.9% in the eastern region; 8.9% in the northern region; and 5% in the 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 education 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 the United States. They found that low achievement is closely correlated with lack of resources, and numerous studies have documented the correlation between low socioeconomic status and low achievement. Several strategies exist to assist teachers in closing the poverty achievement gap for students.

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 the northern region; 8% in the central region; 11.4% in the western region; and 7.9% in the 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 in 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 form of quiet corruption in education is the low levels of teacher effort that arise from 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 to 4 weeks). More than half the teachers in Tanzania and Uganda were absent at least one day in the preceding 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 than 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 their charges. Additionally, school inspections ensure 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 Public Expenditure Tracking Study 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 randomized trial in over two hundred 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, at the time of writing, a primary school teacher in Uganda earns USh260,000 (approximately US$100) per month, while secondary schools teachers receive about USh450,000 (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.

5.4 Total factor productivity growth

Total factor productivity measures the efficiency with which all factor inputs, including labour, ICT capital and conventional capital (non-ICT equipment and structures), are utilized. The Malmquist Productivity Change Index allows decomposing TFP into its two components: technical efficiency change (which reveals whether a school is moving close to the frontier), and technological change (which reveals whether the production function is moving outward). The efficiency change is a ratio of two distance functions, which measures the change in the output-oriented measure of the technical efficiency between period t and t + 1. A value of the efficiency term greater than, equal to, or less than one indicates whether the DMU (a primary school for this study) is moving closer to, is unchanging, or is diverging from the production frontier, respectively.

We analyze overall TFP growth and its two components, efficiency change and technological progress. The change in TFP can be decomposed into two mutually exclusive components, the change of productive efficiency (catching up or imitation) and shifts in technology over time (innovation). Having specified an output-oriented Malmquist Productivity Change Index, the estimated indices are interpreted as follows: A score of less than unity indicates productivity regress in the sense that the primary school delivers a unit of output in period $t + 1$ using more inputs. That is, the primary school in period $t + 1$ is less efficient relative to itself in period t. Similarly, a score greater than unity implies productivity progress and a unit score indicates constant productivity. Table 6 reports the Malmquist TFP Index summary of annual means. It shows the annual means of technical efficiency change, technical change, pure efficiency change, scale efficiency change and total factor productivity change over the study period (1995–2009).

Table 6: Malmquist TFP Index summary of annual means, 1995–2009

Year*	Technical efficiency change (i)=(iii)(iv)	Technical change (ii)	Pure efficiency change (iii)	Scale efficiency change (iv)	Total factor productivity change (v)=(i)(ii)
1996	1.032	1.390	1.111	0.929	1.435
1997	1.051	0.451	0.932	1.128	0.474
1998	1.187	0.321	1.061	1.119	0.381
1999	0.865	1.064	1.010	0.856	0.920
2000	1.027	0.680	1.026	1.001	0.698
2001	0.990	1.034	0.999	0.991	1.024
2002	0.916	1.104	0.849	1.079	1.011
2003	1.017	0.983	1.072	0.949	1.000
2004	0.937	1.106	0.965	0.971	1.036
2005	1.064	0.947	1.039	1.024	1.008
2006	1.001	1.066	1.008	0.993	1.067
2007	0.958	1.016	0.984	0.974	0.974
2008	0.961	1.098	0.856	1.123	1.055
2009	0.899	1.051	0.899	1.000	0.945
Mean	0.993	0.951	0.987	1.010	0.931

Note that 1996 refers to the change between 1995 and 1996, and so on.

Given an output-oriented Malmquist TFP Index, the mean TFP change of 0.931 indicates that, on average, over the sample period there was a 6.9% productivity decline. Looking at the mean technical efficiency change (0.993) and the mean technical or technological change (0.951), the productivity losses were largely the result of technical inefficiency. This is because the mean technical efficiency change (0.993) is greater than the mean technical or technological change of (0.951). Additionally, since the overall technical efficiency change is the product of pure technical efficiency and scale efficiency, the pure efficiency change was 0.987 (98.7%) whereas scale efficiency change stood at 1.010 (101%), which implies that the major source of technical inefficiency was scale inefficiency. Figure 2 presents the evolution of the total factor productivity change.

Figure 2: Malmquist Total Factor Productivity Index versus efficiency change and technical efficiency change, 1996–2009
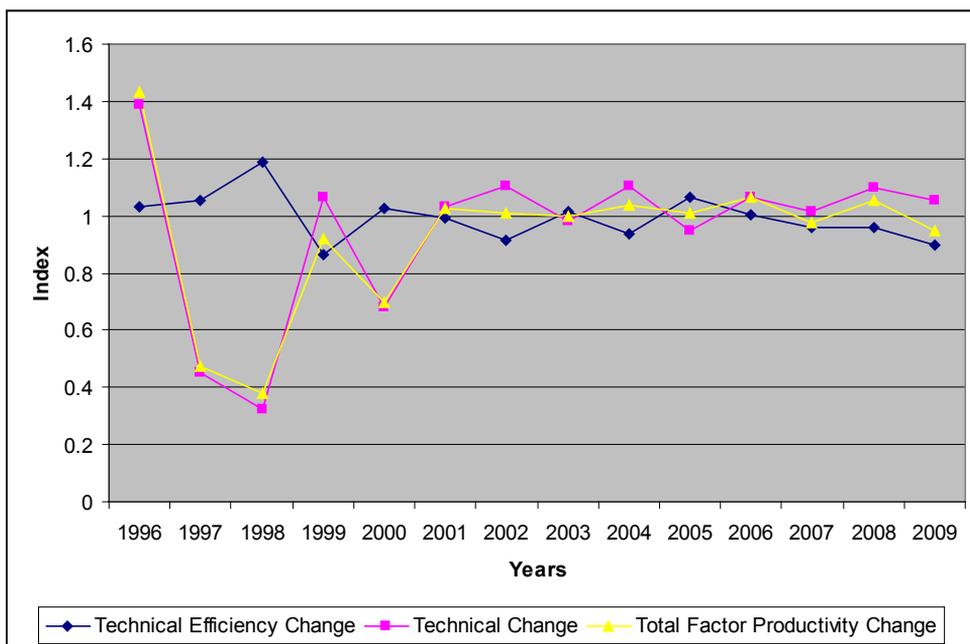
No single factor can explain the uneven TFP growth over the study period. This is because there are several policy changes that have taken place, as observed earlier, in the policy context of primary education in Uganda. However, the striking results for 1997, 1998 and 2000 can be partly attributed to the sharp rise in enrolment figures due to the UPE programme.

6. Discussion and Further Research

The technical efficiency of some primary schools in the sample is less than 100% and this should be of some concern to the Ministry of Education and Sports, 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. Therefore, the efficient use of existing resources should be at the centre of national education policy.

Nevertheless, the degree of inefficiency and policy response should be contingent upon the primary school's operating environment and appropriate action ought to be taken only after a thorough investigation. DEA is an important indicator that may serve as a 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 socioeconomic differences, where, e.g., operating in a "disadvantaged area" per se would mean that a specific school needs more resources. Technical as well as scale inefficiency are present in varying degrees in a majority of schools in both developing and developed countries. For instance, Mizala et al. (2002) assess 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 Beijing primary schools sampled 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 were more likely to have electricity and functional toilets than low performing schools. High performing schools also tend to be located in urban communities.

There is a mixed picture with regard to total factor productivity change in education institutions around the world. Whereas it has been found to rise in some studies (Kanina, 2012; Salleh, 2012) it has been found to decline in others (Leigh and Ryan, 2009). In addition, the causes of either the decline or the rise are mixed. In most cases where total factor productivity had declined, technical regress offered more of an insight into the decline than technical inefficiency. The present study found that total factor productivity declines mainly due to technical inefficiency rather than technical regress.

This study attempted to estimate the technical efficiency and total factor productivity growth of Uganda's primary schools. As a follow up to this study, there are many areas that merit further investigation. There is a dearth of knowledge about 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. There is a clear need 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 the importance of this and are encouraging families to become more involved. Because of this recent trend, it is essential to understand what is meant by parent involvement and in what ways it influences children's education. There is also a need to investigate the impact of the effectiveness of school management committees on academic achievement.

There is an urgent need to regularly monitor school quality indicators, given that quality poses a challenge to the UPE programme. Lessons from the implementation of the UPE programme are crucial for the success of the recently introduced universal secondary education programme.

Despite high enrolment, many pupils do not complete the full course of primary education. As such, there is a need to investigate the factors responsible for low learning outcomes, low primary completion rates, and low pupil transition from primary to secondary education.

There is a knowledge gap with respect to whether primary schools are adequately funded and whether they have the requisite resources to deliver on their mandates. This question can partly be answered via unit costing of the UPE programme. Unit cost means the cost of a school place occupied by a single student for one year. Survey data are needed to permit an examination of the effects of the elimination of school fees on the resources available at the school level in Uganda. This would provide a comprehensive picture of the costs and benefits of school fee elimination in Uganda.

Beyond the number of teachers, there is a need to regularly monitor the number of hours that teachers actually spend with learners. There is also a need to know how teachers' experience impacts on the academic performance of their students. Research on teacher motivation and incentives is urgently needed. This would partly answer the question why teacher absenteeism is increasing, especially among public primary schools.

The following related research questions might be worthy of investigation. What are the drivers of petty corruption in schools? What are the determinants of teacher absenteeism? Why are there problems with toilets, sanitation and hygiene in general? Why is there poor building construction? Why are school inspections unsystematic and infrequent? Why has the supply of teachers not kept pace with the demand for teachers? What is the performance of school feeding programmes? Why do teachers not integrate HIV/Aids education into the mainstream curriculum? What is the impact of HIV/Aids on the supply of teachers, teacher performance and student attendance? What is the impact of HIV/Aids on the academic achievement of learners living with the virus?

Given that this study has demonstrated that private schools are relatively more technically efficient than public and community schools, there is a 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 a 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. The study has estimated the total factor productivity growth, which is part of the bigger picture. There is a further need to investigate the determinants of the overall TFP growth as well as the determinants of efficiency change and technological change.

7. Policy Implications

This study has various policy implications. 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 9.8, which translates into an average class size of 70 pupils implying that classes in Uganda's primary schools are overcrowded. The mean technical efficiency scores differ by location and ownership. At the national level, 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 94.3%) than rural schools (77.9%). At a regional level, the central region is technically more efficient, with a VRS technical efficiency score of 98.5%, followed by the western (91.2%); northern (89.7%) and eastern (86.4%) regions. By ownership, privately-owned schools are more technically efficient with a score of 97.3%, followed by community-owned schools/faith-based schools (94.3%) and public schools (85.9%).

The technical efficiency results were linked to discretionary and non-discretionary variables. There is a direct relationship between the number of teachers, classrooms, 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 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 education 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 8% of people who have never attended school (or a literary rate of 92%), has the highest technical efficiency in their 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 motivation and incentives in order to increase student performance

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are increasingly popular education policies around the world. At the time of writing, a primary school teacher in Uganda earns USh260,000 (approximately US$100) per month, while secondary schools teachers receive about USh450,000 (Mubiru, 2010).

The study also measured the total factor productivity growth of Uganda's primary schools. There was a 6.9% productivity regress, which was largely the result of technical inefficiency. No single factor can explain the uneven TFP growth over the study period because several policy changes had been effected over time.

This work demonstrates in part 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, amongst other things) it is tempting to conjecture that they are doing their best within the limitations posed by the available resources. There are schools both in 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, therefore, suggests that there are many lessons that take place in non-classroom environments. For example, cases of classrooms being held under trees (see Appendix 1) have been reported. This inconveniences both the pupils and their teachers when it is time for 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, among other things.

8. Conclusion

This study assessed the technical efficiency and total factor productivity growth of primary schools in Uganda. To this end a stratified random sample of 500 primary schools were analyzed, classified by type (private, public and community) over the period 1995–2009. Technical efficiency scores were estimated via a nonparametric DEA method, while total factor productivity growth was analyzed using the DEA-Malmquist Index with an output orientation. A typical primary school in Uganda has an efficiency of 94%, with a range from 53% to 100%. The larger range for efficiency scores can be explained by the fact that there is an important variance in academic achievement among schools with similar characteristics in Uganda. When technical efficiency was estimated for primary schools as a whole and then analyzed for the three types of school, it was concluded that private schools are the most efficient, followed by community and public schools. The mean total factor productivity change of 0.931 indicates that, on average over the sample period, there was a 6.9 per cent productivity regress. Looking at the mean technical efficiency change (0.993) and the mean technical or technological change (0.951), it was concluded that the productivity losses were largely the result of technical inefficiency.

Some conclusions emerged 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 number of teachers; classrooms; 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 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 education 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. The study also measured the total factor productivity growth of Uganda's primary schools. There was productivity regress, which was largely the result of technical inefficiency. No single factor can explain the uneven TFP growth over the study period because several policy changes had been effected over time.

If schools run with low efficiency, the education resources will not be well used and the sustainability of education will not be assured. One of the most important challenges to Uganda's primary education sub-sector is low technical efficiency. This study has unearthed some rules which could be useful for the secondary and tertiary education sub-sectors.

These rules are as follows: First, with enough input and the present modes of administration, half of Uganda's primary schools reach technical and scale efficiency, the average technical value is 94%, which is an optimistic result, although some of the schools are low in technical efficiency. If there is no special reason, the schools' administrators should check the internal management mechanism and compare this with other schools with good efficiency to see where they can make efforts to improve the school's efficiency. It means that adequate investment will help schools attain satisfactory efficiency.

Second, educational quality is the key objective of schools. Judging from the data of sample schools, excellent rates in mathematics and English are the key variables which affect results. The quality of primary education depends on amongst other things how the government, teachers, students, management and the community (including parents) support education. Thus, there is much diversity in the quality of education among schools.

Third, the indicators of teachers' salaries, student-teacher ratios and time that students are in school have an obvious effect on schools' technical efficiency. Considering the status quo of Uganda's primary schools, it is suggested that teachers' salaries be enhanced. Additionally, there is a 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 will help schools scale up their technical efficiency.

The research findings also show that schools in rural districts have lower education product efficiency. It is advisable that education policy makers should take this phenomenon into serious consideration. Motivating teachers, slightly reducing the students' time in schools as well as making the resources used more efficient, will be helpful in enhancing education efficiency.

Because of the research purpose and the limited data, the impact that pupil attributes such as families' socioeconomic status, parents' education achievement; area poverty status, social cultural influence, and other things, have on education achievement of pupils are not discussed in detail. Considering the many other factors which may affect school efficiency will help to find the best solution with regard to scaling up education technical efficiency. This merits a follow-up study.

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Appendix 1: Pupils in Pader District Receive Instruction in an Open Space

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