5. Technical efficiency in Uganda’s primary education system: Panel data evidence

Joseph Muvawala¹ and Eria Hisali²

Abstract
This paper estimates the technical efficiency and its determinants for Uganda’s primary education system using parametric models based on a panel data set on performance index and educational inputs of various categories of primary schools for the 2001-to-2008 period. Generally, all primary schools in Uganda are technically inefficient, but private and urban schools are relatively more so than government-aided and rural schools. Hence, it is feasible to improve learning outcomes without increasing spending on primary education for private schools, where a 56% improvement might be expected. For government-aided and rural schools, efficiency gains on the basis of current funding will result in a mere 1% improvement in learning outcomes. Improvements in learning outcomes for government-aided schools will require increased resources.

Key words: panel data, parametric, primary schools, stochastic frontier, technical efficiency

Efficacité technique du système éducatif primaire en Ouganda : indications des données de panel

Résumé
L’article évalue l’efficacité technique du système éducatif primaire ougandais et des facteurs déterminants de cette efficacité à l’aide de modèles paramétriques sur la base d’un ensemble de données de panel relatives à l’indice de la performance et aux intrants éducatifs dans diverses catégories d’établissements d’enseignement primaire, de 2001 à 2008. Si, de manière générale, tous les établissements d’enseignement primaire en Ouganda sont inefficaces du point de vue technique, les établissements privés et urbains le sont relativement plus que ceux qui bénéficient d’un financement public ou sont situés en zone rurale. Il est donc possible d’améliorer les résultats d’apprentissage sans pour autant augmenter les dépenses de l’enseignement primaire privé, qui pourrait enregistrer une amélioration de 56%. En ce qui concerne les établissements ruraux et bénéficiant de fonds publics, les gains en matière d’efficacité entraîneront une amélioration de 1% seulement des résultats d’apprentissage, si l’on s’en tient à l’enveloppe actuelle. L’amélioration des résultats d’apprentissage dans les établissements publics nécessitera des ressources accrues.

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1.0 INTRODUCTION

The last decade has witnessed increased resource allocation to the education sector in Uganda. From 1996 to 2007, the allocation averaged 20% of total government spending, placing Uganda’s education expenditures 6 percentage-points above the sub-Sahara African average. About 60% of the country’s total education expenditures have been devoted to the primary school level. Primary education requirements are projected to grow fourfold over the current Education Sector Strategic Plan (ESSP) period (GoU 2006). However, the primary education budget is projected to fall by about 50% between 2009 and 2015 (GoU 2006), as a result of competing demands from the secondary school and other levels of education. Moreover, resource constraints are likely to worsen because of high population growth. These trends justify an examination of the efficiency with which allocated resources are transformed into outcomes in Uganda’s primary education subsector.

Generally, an efficient production system yields higher output for a given set of inputs, or conversely, uses fewer inputs to yield a given output (Kumbhaker and Lovell 2000). A number of researchers have studied the relationship between resource allocation and the degree to which they contribute to optimal outcomes (Kirjavainen and Loikkanen 1998; Grosskopf and Valdmanis 1987; Evans et al 2000; Ruggiero 1998). These studies reveal considerable inefficiency in the provision of education. Grosskopf et al (1997), for instance, suggest that education spending in most countries could be reduced by up to 30%, yet still achieve the same outcomes, if the schools were operated efficiently.

This study analyzes the relationship between resource allocation and the observed outcomes in Uganda’s primary education subsector. This is especially important because of the heavy public sector involvement in the provision of primary education, which may create incentives for schools to operate as semi-monopolies.

This paper is organized as follows: Section 2 provides an anecdotal analysis of inefficiencies in primary education provision in Uganda; Section 3 explains the methods used in estimating technical efficiency of primary schools; Section 4 presents the results; and Section 5 discusses the empirical results and concludes the paper.
2.0 PRIMARY EDUCATION DELIVERY AND INTERNAL INEFFICIENCY IN UGANDA: AN ANECDOTAL ANALYSIS

In January 1997, the Ugandan government formalized its commitment to primary education with implementation of Universal Primary Education as part of a wider framework for education development under the Education Strategic Investment Plan (ESIP) 1998-2003. The main priorities of the ESIP included expanding access and equity in education, improving quality delivery of education services, and capacity development (Hallak et al 2000). Under the UPE program government and other stakeholders seek to provide the minimum facilities and resources needed for completion of primary school education.

Since the introduction of the UPE program, progress in education has been remarkable. For example, the net enrolment ratio has risen to more than 90%. But despite this progress, only a few children complete the primary cycle of schooling and even fewer attain the minimum competencies needed to become literate and numerate. This situation raises questions about efficiency.

Six probable sources of inefficiency affect primary education in Uganda: 1) leakage of resources between the central government and the school, through ghost teachers, misuse of UPE and grants to district governments; 2) leakage of resources within the school, mainly attributable to high rates of pupil, teacher, and head teacher absenteeism; 3) deployment of teachers both across and within districts; 4) allocation of resources within government schools, where class sizes are largest in the early grades and smallest in the later grades; 5) use of education policy as a means of accessing donor financing, and the speed at which the UPE policy was introduced; and 6) inherent inefficiencies in the decentralization of primary education.

With regard to leakage within the system, based on expenditure and personnel audits and evaluations, the estimated leakages of recurrent expenditures between the Ministry of Finance, Planning and Economic Development and the schools is UGX 16 billion, or 6% of total budgeted recurrent primary education expenditures (Annual Budget Performance Report, 2005/06). The single largest source of government-to-school leakage is the UPE grant, estimated at 16% of total UPE grants, or UGX 5 billion (Winkler 2007).

In addition to leakage, a two-month delay separated the release of UPE grants by the central government and their arrival at schools. The cost of this delay is not always included in surveys undertaken by MoES. Although questionable expenditures have not been quantified at the district level, a
number of problems adversely affect the use of resources and constitute “questionable expenditures.” These include delays and uncertainty in funding, which make it difficult to plan and spend efficiently; inadequate supervision of construction projects; delays in receiving and damage to textbooks; and teachers’ and students’ failure to use textbooks in the classroom.

The implications of these losses are important. Given the very low ratio of books to students (about 1:3), loss of and failure to use textbooks may have considerable consequences, such as grade repetition and dropout. This affects the cost to government of enrolling primary students. For instance, the unit cost of an enrolled student in Uganda is UGX 50,534. A student who successfully completes primary school without repeating any grades would cost UGX 353,738 (Winkler 2007). However, the average cost of a primary school graduate, including repetition and dropout, is UGX 923,833, or 2.6 times what it would be if there was no grade repetition or dropout.

In addition, an examination of the data reveals low completion rates. This is mainly the result of high drop-out rates in P 1 and from P 5 to P 7. Grade repetition rates range from 12% to 15%, with the highest in P7. Drop-out rates in lower grades are generally below repetition rates, suggesting that non-compliance with automatic promotion at this level has little impact on the completion rate. However, from P5, drop-out rates rise substantially above repetition rates, indicating that some pupils who repeat grades may subsequently drop out. Rising repetition rates have a number of implications. One implication has been overcrowding, which has raised costs. Therefore, grade repetition is key to improving overall efficiency and attaining equity.

The target of actions taken through the UPE program was a 54% primary completion rate. However, results from UNEB show a completion rate of 49.4% in 2007, once again raising the question of education efficiency. The persistently high drop-out rates and low completion rates are evidence that the resources committed to primary education are not resulting in the expected outcomes.

Another concern is the percentage of the national wage bill devoted to primary education. The current national mean wage bill is UGX 39,259 per student, but this varies across districts and schools. For example, the mean wage bill is UGX 50,526 per student for the top-spending quintile of schools, almost double the mean of UGX 26,585 for the bottom-spending quintile (Winkler 2007). The question is whether these variations are a result of explicit MoES policy or of policies and practices that have nothing to do with effective delivery of education.
The inefficiencies can also be attributed to the rapid implementation of the UPE program, which, in the short run, meant larger class sizes, a higher percentage of unqualified teachers, and fewer resources for the delivery of education services. In other words, the UPE program itself may be a cause of the inefficiencies the primary education system, mainly as a result of large numbers and inadequate financing.

Another issue for Ugandan education policy is the trend toward liberalization and decentralization. In a case study of Uganda’s ESIP, Teskey and Hooper (1999) observed that the 1995 Constitution provides for political devolution and administrative decentralization of most public services, including primary education. Hence, decentralization is important to the ESIP, which must take into account a fundamental shift of power and responsibility from central to local government. The central government is now responsible for the “policy formulation and planning, inspection and management” of national programs, but districts have final authority over “personnel matter, district plans, budgets and tendering” (Hallack et al 2000). Thus, restructuring of the primary education system has had major implications for policy formulation and for efficient and effective use of resources.

In addition to local and central governments, international agencies have committed large amounts of aid to Ugandan education. Such aid does not come without the donors influencing policy formulation. For instance, according to a press release from the IMF on February 8, 2000, “enhanced HIPC assistance would be provided as soon as Uganda finalized a poverty reduction strategy paper—in a participatory process with civil society—with broad endorsement by the Boards of the World Bank and IMF.”

Furthermore, it is probable that Ugandan decision-makers formulate policy with the intention of attracting aid, but without being cognizant of the socio-economic characteristics of Ugandans. These characteristics, however, have been among the principal causes of inefficiency in the system. Havelock and Huberman (2007) concluded that inadequate planning and failure to make provision for the systems into which the innovation is being introduced contributed to internal inefficiencies in the education sector.

In consideration of these shortcomings, the national government and other stakeholders have taken steps to improve the UPE program. Efforts have been made to monitor administration, and additional funding has been provided to deal with limitations associated with the lack of resources.
3.0 METHODS

The parametric technique of the Stochastic Frontier Analysis (SFA) introduced by Aigner Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) is employed to measure technical efficiency of primary schools in Uganda.

A parametric approach was chosen for three reasons. First, the production process, especially in education, is characterized by stochastic elements (Millimet et al 2004; Pascoe and Herrero 2001). Second, data envelopment methodology requires that the number of decision-making units evaluated must be less than the total number of inputs and outputs (Thomas 2000). However, the sample for the present study (primary schools in various districts in Uganda) is larger than what can be appropriately handled by the DEA, as the DMUs (primary schools) exceed the total number of inputs and outputs in the primary school production function specified. Third, the stochastic approach makes a marginal effect analysis possible (Bravo-Ureta and Pinheiro 1993; Coelli 1995).

3.1 Analytical framework and model specification

The education production function is used to explain how institutions generate outcomes from a flow of inputs (Clive 2000). The specification relates education outcomes (students’ achievement measured by the pass rate) to education inputs plus a composite error term for both public and private schools. The composite error term consists of a term to capture a random element and another to capture technical inefficiency. Each school is considered to be a decision-making unit that operates under the assumption of variable returns to scale. Therefore, a primary school stochastic frontier model is formulated within the generalized production framework of Zellner and Revankar (1969) and Zellner and Ryu (1998). This framework is convenient for parsimonious modeling of a production function with variable returns to scale (William et al 2005). An alternative is made to introduce the stochastic inefficiency term and the stochastic error in the primary school production relationship. This is because the initial production function is linear in form, and thus, need not be solved for the log of output before the stochastic terms are added.

As adopted by Pascoe et al. (2003), a general stochastic primary school production frontier model can be given by:

\[ Y_j = f(\ln X_j) + v_j - u_j \]
where \( Y \), is the output produced by school \( j \) measured by the pass rate of school \( j \). \( X \) is a vector of factor inputs; \( v \) is the stochastic error term; and is the estimate of the technical inefficiency of school \( j \). Both \( v \) and \( u \) are assumed to be independently and identically distributed (iid), with variance \( \delta_v^2 \) and \( \delta_u^2 \), respectively. The empirical primary school production frontier is specified and identified in the form of a typical Battese and Coelli (1992) model as follows:

\[
Y_{it} = X'_{it} \beta' + z \tag{2}
\]

Where \( z = v_j - u_j \);

\[
\beta' = (\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9);
\]

\[
X' = (XTR, NTRB, NCR, TH, SR, SR, E, HE) \] such that:

- \( XTR \) is the number of teachers.
- \( NTRB \) is the number of textbooks.
- \( NCR \) is the number of classrooms.
- \( TH \) is the number of teachers’ houses per school.
- \( SF \) is supervisor frequency.
- \( HE \) is head teacher experience.
- \( Y \) is the performance index of candidates from a given primary school who sit the Primary Leaving Examination (PLE).

The dependent variable (performance index of candidates at primary level P7) is preferred because education is a value-added product (that is, theoretically, every year of school increases the knowledge level of pupils). Education outcomes can be measured using the knowledge test and the competency test. The knowledge test gauges knowledge, whereas the competency test determines mastery of certain competencies such as numeracy and literacy. Competency tests have been administered by the Uganda National Examinations Board (UNEB), but these have been diagnostic rather than continuous in that different respondents are tested each time. The only continuous dataset available is the knowledge test at P7, compiled annually by the UNEB. This study used a school-level panel on the performance of government and private primary schools for the 2001-to-2008 period.

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3 To calculate PLE Performance Index, candidates in each grade are weighted such that passing with the best grade carries high weight, and failure is given zero weight. The weights are summed and expressed as a ratio of the expected maximum weight, which is estimated by multiplying the highest weight by the number of candidates who sat exams.
The SFA technique was used to obtain maximum-likelihood estimates of the parameters of the stochastic frontiers of education production functions of a sample of rural, urban, private, government-aided and district schools to measure their technical efficiency.

In estimating the frontiers, the study used pooled panel data. The inefficiency term was specified as partially normal, while the symmetric idiosyncratic term was specified as absolutely normal. Pooled panel data were used because preliminary analyses revealed that using unpooled panel observations on private schools and urban schools yielded infinite iterations and failed to achieve convergence.

The SFA model was specified in linear-log form. Hence, the data of all independent variables were in log terms, while the dependent variable is an index. The estimate of the inefficiency term is taken as a measure of the percentage by which the particular observation (the school and/or the district) fails to achieve the frontier, that is, the ideal performance index (Green 2008).

4.0 RESULTS

4.1 Summary statistics of the performance index

A statistical summary of the performance index data for government-aided and private school is presented in Appendix Table 1. The low overall mean performance index (44%) is strongly influenced by government-aided schools, which constitute the overwhelming majority (97.3%) of schools. The mean performance index of the small number of private schools is 53%. However, the coefficient of kurtosis of the distribution of the performance index for private schools is comparable to that of government-aided schools, and it exhibits a low peak in the distribution.

4.2 Ownership: Government-aided versus private schools

The models for government-aided and private schools indicate non-zero values of the estimated percentage standard deviations of the inefficiency error. This suggests that neither type of school operates along their respective frontiers. That is, they do not achieve their expected ideal performance rates, and thus, exhibit technical inefficiency. As well, the percentage standard deviation (56%) by which a given private school fails to achieve the frontier is much greater than the percentage standard deviation (0.32%) by which a given government-aided school fails to achieve the frontier.
These results imply that government-aided schools make use of inputs with more technical efficiency than do private schools. Thus, private schools seem to be more technically inefficient than government-aided schools.

As well, unlike private schools, all the estimated partial elasticities for government-aided schools were significant at the 5% test level. This could indicate that the determinants of technical efficiency included in the frontier specification for government-aided schools are different from the determinants of technical efficiency for private schools (Appendix Table 2).

### 4.3 Location: Rural versus urban

Frontier estimates for rural and urban schools are similar to those of government-aided and private schools, respectively, reflecting the fact that most government-aided schools are in rural areas, and most private schools are in urban areas. The results indicate that the standard percentage of deviation by which a given urban school fails to attain the frontier is 52%, compared with 0.25% for a given rural school. The implication is that both rural and urban schools are inefficient (Appendix Table 3).

The frontier output showed that all the estimated partial elasticities for rural and urban schools were significant and insignificant, respectively, at 5%. This may indicate that the determinants of technical efficiency included in the frontier specification for rural schools could be much different from the determinants of technical efficiency for urban schools.

### 4.4 Administrative unit controls: Districts

Measurement of technical efficiency for districts was deemed crucial to avoid over-generalization and to account for the fact that the delivery of primary education in Uganda is a function of district authorities. The frontier esti-

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4 The Likelihood Ratio (LR) test rejects the hypothesis that there is no technical inefficiency component in the model for private schools and fails to reject (with maximum probability) the hypothesis that there is no technical inefficiency component in the model for government-aided schools.

5 The Likelihood Ratio (LR) test rejects the hypothesis that there is no technical inefficiency component in the model for urban schools and fails to reject (with maximum probability) the hypothesis that there is no technical inefficiency component in the model for rural schools.

6 The estimated total errors are smaller for rural (22.7%) than urban schools (27.1%). The frontier estimates also show that the estimated percentage ratio of the standard deviation of the inefficiency component to the standard deviation of the idiosyncratic component (λ) is far greater for urban than rural schools.
mate for 52 districts' countrywide indicates that all districts are technically inefficient, with the level of inefficiency ranging from 21.8% off the frontier (Hoima district) to 0.1% (Iganga) (Appendix Table 4).

The results show that, generally, all schools and districts are inefficient, and that private schools are relatively more inefficient than government-aided schools. These findings are consistent with recent surveys indicating that the cost of producing a primary graduate, without considering learning achievement, is Shs. 492 per student. This is more than twice the Shs. 189 that would be needed to produce a primary graduate if Uganda's education system was perfectly efficient. Furthermore, the annual unit cost of a graduate achieving a specific minimum knowledge is Shs. 2,424, almost thirteen times the efficient standard for Uganda.

4.5 Determinants of technical efficiency

A further analysis examined determinants of technical efficiency, using ownership and location as controls. The residualisation methodology was used to determine which independent variables significantly enter into the residual model. Variables with coefficients that were statistically significant in the residual model were deemed irrelevant in the determination of technical efficiency of a particular school category. Appendix Table 5 indicates the results of the residualisation process for government-aided and private schools.

Textbooks, teachers and desks are significant at 5% test level in the residual model for government-aided schools, and therefore, do not enter into the inefficiency error term. Thus, textbooks, teachers and desks are not associated with technical inefficiency or efficiency for government-aided schools. On the other hand, teacher houses, classroom space and inspection are statistically insignificant, and therefore, enter into the inefficiency error term.

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7 The variables used for each district are the same, and the same specification of the stochastic frontier as was used under urban and rural schools and government and private schools was considered. The same distribution assumptions of the two error terms were considered and pooled panel data were used.

8 Procedure: Technical efficiency models were run for different school categories. Technical efficiency parameters were estimated and used to generate the residuals. The residuals were regressed on the independent variables to determine which independent variables significantly enter into the residual model.

9 The F-statistic reported indicates that on the whole, the included factors are insignificant in residual model for Government aided schools and this further confirms they enter into the inefficiency error term.
implying that they are associated with technical efficiency or inefficiency (Appendix Table 5).

Teacher’s houses, classrooms, textbooks, inspection, teachers and desks are significant at 5% test level in the residual model for private schools, and therefore, do not enter the inefficiency error term. This implies that none of the factors included in the frontier are associated with inefficiency in private schools. This result is further supported by the F-statistic, which indicates that, on the whole, the factors included are significant in the residual model for private schools, confirming that they do not determine efficiency.

These results clearly demonstrate that the determinants of technical efficiency differ for private and government-aided schools. Based on this finding, government authorities cannot adopt one-size-fits-all policy interventions to reduce inefficiencies in education. Individual factors like teachers’ houses, classrooms, inspection and desks are associated with technical efficiency for government-aided schools, but not for private schools.

5.0 DISCUSSION AND CONCLUSIONS

The results of this study validate the hypothesis that technical inefficiency in education delivery exists for all categories of primary schools in Uganda. Urban and private schools are more technically inefficient than are rural and government-aided schools. Hence, it is possible to improve learning outcomes without increasing spending on primary education in private schools whose percentage deviation from their production frontier is 56%. The results for private school are consistent with Grosskopf et al (1997), who suggest that if schools were operated efficiently, education spending in most countries could be reduced by up to 30% and still achieve the same outcomes.

For government-aided and rural schools, it is not possible to significantly increase learning outcomes with the same resource allocation, because their percentage deviation from their production frontier is only 1%.

Hence, efficiency interventions introduced in the context of current resource allocations to primary education would result in a mere 1% improvement in learning outcomes. The message is that without resource increases, efficiency interventions alone will not improve learning outcomes in Uganda.

This analysis provides evidence that governments cannot increase learning outcome through mass access reforms without substantially increasing
funding to education. Moreover, at current levels of funding, even those efficiency interventions that are implemented are insufficient to achieve the learning outcomes agenda. In many mass access reform programs like UPE in Uganda and Tanzania, governments have not been able to provide funding commensurate with the increased enrolment stemming from high population growth and from the policy itself. In Uganda, for example, government spending amounts to less than $0.10 per child per day to support teaching and learning at the school level. This is clearly inadequate and will continue to impede effective teaching and improved learning outcomes.

But while the evidence shows an association between technical efficiency and learning outcomes, the association is not causal. It is not surprising that studies which apply simple ratio analysis to measure efficiency have concluded that urban and private schools are efficient because their average pass rate at the P7 level exceeds 50%. This conclusion is valid if the cost of achieving the over-50% pass rate is not taken into account. However, recent studies in Uganda have established that the average annual amount invested per student in urban/private schools is Shs. 426,789, which is 17 times that of rural/government-aided schools Shs. 24,936.

The findings raise questions about the sequencing of government interventions. For example, should governments make efficiency a top priority or should they focus on achieving learning outcomes and make efficiency a second-tier priority? In other words, does the cost of achieving a certain level of learning outcomes matter in the initial stages of mass access reforms like UPE? A number of studies on what determines learning outcomes have concluded that a passing culture has a positive and significant influence. Based on this, in the initial stages of a mass education program, the government should make improving learning outcomes the first priority, and efficiency, the second.

This study demonstrates that determinants of efficiency depend on the location and ownership of schools. This finding sends an important message to education policy-makers: expenditures on inputs influence the efficiency level of rural, but not urban schools. Policy-makers should, therefore, avoid one-size-fits-all interventions. While policy for government-aided and rural schools should emphasize expenditure inspection, classroom construction, textbooks and teachers’ houses, policy for private schools should target the households of pupils. This is beyond the mandate of the education sector and calls for integrated planning by the government as a whole.
REFERENCES


APPENDIX: MODEL RESULTS

Table 1. Performance index descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>All schools</th>
<th>Government-aided schools</th>
<th>Private schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>37,516</td>
<td>36,502</td>
<td>1,014</td>
</tr>
<tr>
<td>Mean</td>
<td>0.4471658</td>
<td>0.444587</td>
<td>0.5399952</td>
</tr>
<tr>
<td>Maximum</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
<td>0.0044643</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.191532</td>
<td>0.1890551</td>
<td>0.4951767</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.0762815</td>
<td>0.0571257</td>
<td>-0.1375758</td>
</tr>
</tbody>
</table>

Source: author computations

Table 2. Technical efficiency estimates of government-aided and private Schools

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Government aided Schools</th>
<th>Private Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>δu</td>
<td>Estimate: 0.0032386, Standard Error: 0.0962995</td>
<td>Estimate: 0.5608038, Standard Error: 0.0172087</td>
</tr>
<tr>
<td>δv</td>
<td>Estimate: 0.4736384, Standard Error: 0.0022036</td>
<td>Estimate: 4.66e-09, Standard Error: 4.92e-07</td>
</tr>
<tr>
<td>δ2</td>
<td>Estimate: 0.2243439, Standard Error: 0.0021127</td>
<td>Estimate: 0.314501, Standard Error: 0.0193014</td>
</tr>
<tr>
<td>Λ</td>
<td>Estimate: 0.0068377, Standard Error: 0.0965635</td>
<td>Estimate: 1.20e+08, Standard Error: 0.0172087</td>
</tr>
<tr>
<td>LR test of δu=0: Pr&gt;chibar2=1.000</td>
<td>LR test of δu=0: Pr&gt;chibar2=0.000</td>
<td></td>
</tr>
<tr>
<td>Convergence achieved after 20 iterations</td>
<td>Convergence achieved after 34 iterations</td>
<td></td>
</tr>
</tbody>
</table>

Source: author computations
Table 3. Technical efficiency estimates for rural and urban schools

| Parameter | Rural schools | | | Urban schools | |
|-----------|---------------|------------------|------------------|------------------|
|           | Estimate | Standard error | Estimate | Standard error |
| $\delta_u$ | 0.0025782 | 0.0621834 | 0.5205847 | 0.0068881 |
| $\delta_v$ | 0.4762601 | 0.0023243 | 1.41e-09 | 1.19e-07 |
| $\delta_2$ | 0.2268303 | 0.0022203 | .2710084 | 0.0071716 |
| $\Lambda$ | 0.0054135 | 0.0623489 | 3.70e+08 | 0.0068881 |

LR test of $\delta_u=0$: Pr>chibar2=1.000
LR test of $\delta_u=0$: Pr>chibar2=0.000

Convergence achieved after 21 iterations
Convergence achieved after 36 iterations

Source: author computations

Table 4. Technical efficiency estimates for district primary schools, by reverse order of inefficiency

<table>
<thead>
<tr>
<th>S/n</th>
<th>District</th>
<th>Estimate</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hoima</td>
<td>0.2184035</td>
<td>0.0237951</td>
</tr>
<tr>
<td>2</td>
<td>Bugiri</td>
<td>0.2026792</td>
<td>0.0335642</td>
</tr>
<tr>
<td>3</td>
<td>Kabalore</td>
<td>0.1932331</td>
<td>0.0293291</td>
</tr>
<tr>
<td>4</td>
<td>Wakiso</td>
<td>0.1859553</td>
<td>0.0227506</td>
</tr>
<tr>
<td>5</td>
<td>Katakwi</td>
<td>0.1790658</td>
<td>0.017204</td>
</tr>
<tr>
<td>6</td>
<td>Moroto</td>
<td>0.169529</td>
<td>0.0211958</td>
</tr>
<tr>
<td>7</td>
<td>Kumi</td>
<td>0.1658609</td>
<td>0.0115826</td>
</tr>
<tr>
<td>8</td>
<td>Kampala</td>
<td>0.1638588</td>
<td>0.0147741</td>
</tr>
<tr>
<td>9</td>
<td>Kasese</td>
<td>0.1627969</td>
<td>0.0143555</td>
</tr>
<tr>
<td>10</td>
<td>Pader</td>
<td>0.1526437</td>
<td>0.0471574</td>
</tr>
<tr>
<td>11</td>
<td>Bundibugyo</td>
<td>0.1523177</td>
<td>0.0341951</td>
</tr>
<tr>
<td>12</td>
<td>Ntungamo</td>
<td>0.1519698</td>
<td>0.0215283</td>
</tr>
<tr>
<td>13</td>
<td>Busia</td>
<td>0.1491074</td>
<td>0.0234781</td>
</tr>
<tr>
<td>14</td>
<td>Masindi</td>
<td>0.144346</td>
<td>0.0144527</td>
</tr>
</tbody>
</table>

10 The number of iterations to reach convergence for urban schools was almost twice the number needed to reach convergence for rural schools.