ANALYSIS OF TECHNICAL EFFICIENCY OF SECONDARY SCHOOLS IN ZAMBIA

By

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DECLARATION

I, MUTINTA CHAAMPITA, declare that this dissertation:

a) Represents my own work;

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APPROVAL

This dissertation of MUTINTA CHAAMPITA is approved as partially fulfilling the requirements for the award of the Masters of Art degree in Economics by the University of Zambia.

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ABSTRACT

The importance of quality and efficient education sector has attracted a lot of attention both in terms of academic work and political commitment in developed countries. In contrast, there has been little work done concerning efficiency of the education sector carried out in African countries. Zambia today is no exception; there is an increasing demand for more secondary school education to match the needs of a growing population in Zambia. A lack of adequate resources presents a binding constraint. The efficiency with which available resources are being utilized is another challenge that cannot be overlooked. The high school education sub-sector (Grades 10-12) has not expanded since the 1970s (FNDP 2005). There is an added problem of poor performance among schools. Pass rates at Grade 12 level is consistently below 70% since 2000. Weaknesses in the operations of schools undermine their service coverage potential even in situations where funding is not the main constraining problem resulting in a poor service delivery system.

The study used stochastic frontier analysis and data envelopment analyses which are parametric and non parametric methods respectively to calculate efficiency score for each school. The parametric specification estimated technical efficiency assuming exponential distribution. The non parametric specification used constant and variable returns to scale in calculating efficiency. School level data from Examination Council of Zambia and Ministry of Education respectively was used. We used School enrolment and number of pupils who obtain Grade 12 School Certificate as outputs. Recurrent expenditure, number of classrooms in a school, Pupil teacher ratio and book- to- pupil ratio were used as inputs.

The average technical efficiency measured by the stochastic production frontier method is 82% for enrolment. The DEA mean efficiency score is 77% and 65% for pass rate and enrolment respectively. We did not obtain technical efficiency scores for pass rate using SFA because it failed to display the asymmetric error term required to model inefficiency. Also one hundred and thirty observations out of two hundred and one observations have consistent rankings between SFA and DEA. The rank order correlation coefficient of efficiency is 0.66 between the two methods.

This study has demonstrated that inefficiency of resource use in schools is significant. The unsuitable scale of operation of secondary schools can be used as a productivity control tool. Policy attention is drawn to the rank order correlation coefficient which suggests that using either DEA or SFA is sufficient to identify efficient schools.

DEDICATION

To my parents Mr. Ellison Chaampita and Mrs. Rosemary kwale Chaampita.

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LIST OF ABBREVIATIONS AND ACRONYMS

BCC	Banker, Charnes and Cooper Model
CCR	Charnes, Cooper and Rhodes Model
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Units
DRS	Decreasing Returns to Scale
ECZ	Education Automated Statistical Information Toolkit
EDASSIST	Examination council of Zambia
FNDP	Fifth National Development Plan
GCSE	General Certificate of Secondary Education
GNP	Gross National Product
IRS	Increasing Returns to Scale
LP	Linear Programming
MOE	Ministry of Education
NFT	Non Follow through
NIRS	Non Increasing Returns To Scale
OLS	Ordinary Least Squares
PFT	Project Follow through
PISA	Programme for International Student Assessment
RESET	Regression Specification Error Test
Sch	School
SE	Scale Economies
Sec	Secondary
SFA	Stochastic Frontier Analysis
SK test	Skewness Kurtosis Test
TE	Technical Efficiency
TFP	Total Factor Productivity
UCZ	United Church of Zambia
VATT	Valtion Taloudellinen Tutkimuskeskus
VIF	Variance Inflation Factor
VRS	Variable Returns to Scale
ZMK	Zambian Kwacha

CHAPTER 1

INTRODUCTION

1.0 Background to the study

In most developed countries, the importance of a quality and efficient education sector has attracted a lot of attention both in terms of academic work and political commitment. Issues concerning the production and efficiency differences among schools and providers of education have been the subject of a number of studies in the years past (Hanushek, 1979; Smith et al, 2006; Muriel, 2008). In contrast, there has not been much work done concerning efficiency of the education sector carried out in African countries. Zambia is no exception, as it has witnessed stagnation and reversal in the initial gains it attained to improve education in earlier post independence days. Today, there is an increasing demand for more secondary school education to match the needs of a growing population in Zambia. The high school education sub-sector (Grades 10-12) has not expanded since the 1970s (FNDP, 2005).

There is an added problem of poor student performance among schools with pass rates at Grade 12 level of consistently being under 70% since 2000. Not only do schools appear to be less effective today than in the past, but many also consider them to be inferior. Inefficiency and other operational weaknesses could be a source of this poor performance. Apart from increasing resources or investment in education, there is a concern for improving productive activity and student performance in public schools in order to obtain maximum output from available funding. At the heart of the debate is the question of how efficiently and effectively secondary schools utilize resources at their disposal. This study contributes to the debate about school efficiency by employing two of the most modern and powerful tools available, stochastic frontier analysis and data envelopment analysis.

Zambia, Tanzania and Egypt expanded their primary schools at the expense of growth of secondary schools (Blaug, 1979). In Zambia primary schools enjoyed free education and enrolments shot up while secondary school expansion remained relatively unchanged. Consequently, significant numbers of pupils get pushed-out of the educational system after grade 7 and 9 examinations (Kelly, (1999). 25.9% of pupils progressed from basic to high schools (Ministry of Education, 2003). There is a need to expand the secondary school education sector in order to minimize on the number of pupils who are pushed out of the education system. This will require investing significant sums of money in education to build infrastructure and train more staff. Inadequate or misallocated financial resources are seen as the root cause of the problem. Despite concepts on what constitutes adequate funding being popular, it's purely political and economic issues that drive the demands of the economy. They are likely to be changed by the requirements of the economy and political views on what constitutes appropriate levels of government support of programs (Hanushek, 1997).

Funding to secondary schools has been declining, especially between 1990 and 2001 during recession and economic restructuring. The schools over the years have found themselves in a dilemma of being vulnerable to funding reductions (Kelly, 1999). Donor bilateral and multilateral budgetary support had been on an increase. Also comparatively to other countries Zambia ranks lowly in education sector's share of GNP. In 1992, 2.7% of GNP was devoted to education compared to countries in the region around Zambia who devoted at least 6% (World Bank, 1996). Overall, sub Saharan Africa devoted 3.9% of GNP to education in that year.

The country has been implementing far reaching reforms in the education sector. Education boards have been established and they are in charge of schools. Each high school is required to have a board and the running of the school is managed by high schools management team. Boards raise school finances through; grants from government, PTA funds and production unit. Teachers are employed by the teaching service commission while the school boards are responsible for personnel it employs. Workers employed by the government for the board is the responsibility of government (Ministry of Education, 2005).

Aided schools are managed by church organizations and they are responsible for organizing their boards. They receive funding, teaching staff and learning materials from government. The head teacher reports to the board.

The principal behind school boards was to make schools more efficient, effective and responsive to their communities. This was to be realized by breaking the highly centralized and bureaucratic administrative structures. Thus, efficiency in service production and delivery would imply increased accountability. This strengthens governance in the management and deployment of resources. It also hands decision-making authority to school boards, who include community stakeholders. It also enhances communication in decision making which would eventually lead to improved performance by learners.

The success of the reform may have a relation with empirical evidence provided on the measurement of efficiency in implementation, monitoring and evaluation stages of the program.

1.1 Statement of the problem

Performance of public schools is characterized by significant inefficiency (Ministry of Education, 2007). There is no empirical basis for understanding the scale and nature of inefficiency in Zambian school context. The levels of funding have not had adequate impact in raising poor sector performance in terms of access and quality of service. Poor conditions existing in schools i.e. poor infrastructure, lack of adequate learning materials, laboratories and libraries etc have been attributed as factors that worsen performance of public schools. Also the inefficiencies are driven by population growth which is generating a high demand for school places while growth in school infrastructure has lagged behind.

Little is known about how efficiency differs across schools in different localities i.e. between rural and urban areas. The extent of the problem of long distance to school, inequity in teacher deployment, is more prevalent in rural than urban schools (Ministry of Education, 2007). Also schools in rural areas generally have schooling places available but suffer from a shortage of teachers, with some rural areas having pupil-teacher ratio double that of the urban areas. There exists regressive public expenditure with urban schools having better budgetary allocations than those in rural areas.

In 2000 the government introduced educational reforms aimed at making education sector efficient and effective. Educational boards were introduced to strengthen school management. However it is not clear whether performance has improved.

1.2 Justification of study

The government has launched reforms in the public sector whose purpose is to improve on efficiency. If equipped with detailed information on efficiency in the education system, the government and policy makers will have information that identifies potential for increased efficiency in the performance of secondary schools (Ruggiero et al, 1995).

A significant proportion of the national budget is met with the support of donor bilateral support (The World Bank, 2005). A sizeable share is allocated to educational sector. Policy makers would benefit from evidence about the sources of public inefficiency, particularly when many sources of finance, such as tax revenues, are under acute pressure. This could be an important determinant of subsequent opportunities for higher education and employment opportunities for school leavers. Weaknesses in the operations of schools undermine their service coverage potential even in situations where funding is not the main constraining problem resulting in a poor delivery system. Knowledge on efficiency would help reduce waste in the utilization resources if the schools that absorb a large portion of the budget are technically efficient. Information on the efficiency of each secondary school would help policy makers and government design effective school expansion programmes. The value of wasted resources cannot be compared to the human and economic costs of inferior education. Programmes designed to influence population's education, when applied can reduce poverty because education other than its contribution to growth, education just like health is also consumption good whose acquisition directly impacts on people's well being (Grossman, 1972). This study is concerned with using theory (production theory) to assist in the evaluation of secondary school performance. In addition, the study is concerned with using theory to uncover opportunities for resource conservation or output improvements that would otherwise remain hidden from our view. This will give policy makers the option of comparing alternative policies

From the literature search procedure conducted, we could not find any study on Zambia's educational institutions that addresses the problem of technical efficiency. This paper will attempt to contribute to the existing models of literature from developing countries on efficiency.

1.3.0 Research objectives

1.3.1 General objectives

The principle objective of this study is to analyse the technical efficiency of secondary schools in Zambia. The specific objectives are;

1.3.2 Specific objectives

(i) To estimate the amount of technical efficiency of secondary schools.

(ii) To compare efficiency rankings of schools between DEA and SFA methods.

(iii) To find out if the schools that are efficient with enrolment are necessarily efficient at producing students with a formal qualification.

1.4 Hypothesis

(i) There is no technical inefficiency in Zambian schools. [SFA Model returns to OLS]

(ii) There spread of efficiency between the DEA and SFA observations between its ranks is likely to be similar.

(iii) There is no significant difference between the efficiency scores of rural and urban schools.

CHAPTER 2

LITERATURE REVIEW

Whereas there a number of published studies on efficiency in education using Data envelopment Analysis, there are a limited number of studies addressing the efficiency of education system using stochastic frontier analysis that has been published. They have mainly been conducted in developed countries. In African countries, there may be few studies or none at all that have been published on efficiency in education system, and we did not find any study on Zambia. Literature for this research paper was obtained from the internet using Google scholar and Jstor.

Most empirical studies analyzing technical efficiency focus on relationships between inputs and outputs. They use various measures to capture inputs and outputs but they have typically included financial indicators such as expenditure per student and physical indicators such as average class size, ratio of students to teaching staff, and outcomes such as student test scores.

Charnes et al (1981) used Data Envelopment Analysis to evaluate between Management Efficiency and Program Efficiency in order to enable compare between two different programs project follow through (PFT) and non follow through program (NFT). Charnes et al (1981) assumed constant returns to scale, output augmenting orientation. The outputs for their study, they considered; Total Reading Score as measured by the Metropolitan Achievement Test, Total Mathematics Score as measured by the Metropolitan Achievement Test, Coopersmith Self-Esteem Inventory intended as a measure of self-esteem. For the inputs, they considered; Education level of mother as measured in terms of percentage of high school graduates among female Parents, Highest occupation of a family member according to a pre-arranged rating scale, Parental visit index representing the number of visits to the school site, Parent counseling index calculated from data on time spent with child on school-related topics such as reading together, etc, and Number of teachers at a given site. Charnes et al (1981) found a mean efficiency Score of 94% for program follow through. The Minimum score was 83% and the maximum was 100%. For non follow through, the mean efficiency score found was 96%. The minimum score was 87% while the maximum was 100%. Charnes et al (1981) found no significant difference between the two programs- project follow through (PFT) and non follow through program (NFT).

Mancebon et al (2000) used output oriented DEA to evaluate the performance of Southampton, and Portsmouth primary schools. Variable returns to scale were adopted and also tests were carried out to check if constant returns to scale were supported by the data. The DEA procedure was estimated twice one with all the variables included and the other when a specific variable is dropped one at a time, with a view to check if the variable exerts a discernible influence on the efficiency. Mathematics results were found not to significantly contribute to the explanation of efficiency. Other variables introduced, and discarded, were the proportion of girls, the proportion of pupils who do not have special educational needs, the expenditure per pupil. However science was found to have a strong impact on efficiency. Religious orientation, parental influence and level of exclusions were all found to have impacted on the ability of a school to deliver the best possible results in standard assessment tests. Constant returns to scale were found not to be appropriate for the data, because all the variables were in percentages and were bounded between 0 and 100%. Further the CRS model was found to allow for extrapolation beyond the observed range of values; therefore VRS was adopted because it allows only for interpolation within observed data. Eight of the 176 schools were found to be efficient, the average efficiency of 78.50%. The minimum efficiency score found was 41.7%.

Jones (2003) used output oriented VRS data envelopment analysis to measure teaching efficiency of 2568 graduates with economics as a major or joint major subject from UK's universities. Jones (2003) followed the Thanassoulis & Portela (2002) methodology that assumes efficiency to be composed of two components, one which reflects students own effort and the other, the efficiency in teaching of the university attended by the student. The purpose was to test whether DEA ran at individual level would produce different efficiency scores from those produced using a higher level DEA i.e. comprising institution and individual components in one DEA score. Individual level inputs included - total A level score reflected academic ability on arrival at university, dummies' for gender, marital status, nationality, part time, not living in parents home, etc while Outputs included degree mark and degree value. Department level Outputs comprised mean value of degree value, mean value of degree mark, total number of graduates, total number of graduates with 1st or upper second, percentage of graduates with 1st or upper second. Inputs comprised "A score" mean value of "A score", number of graduates on a part-time course, number of graduates who are married, number of graduates who are females, number of graduates who are from the UK, number of graduates who lived in the parental Home, number of graduates who did not attend an independent school, percentage of graduates not on a part-time course, percentage of graduates who are married, percentage of graduates who are female,

Several DEA runs were made which had several definitions of inputs and outputs. Jones (2003) found mean efficiency score which ranged from 80.6% to 98.3% for efficiency measures across all students. The individual level efficiencies by department were also examined. And university-within-all-universities efficiency mean was found to vary from 85% to 100%. Aggregated DEA analyses which include both institution and individual components were found to produce misleading results. Results suggested that DEA runs at an aggregate rather than individual level only reflected the efforts and characteristics of the students rather than the departments, to which they belong, making unit analysis important.

Robert et al (2004) employed a two stage analysis using DEA in first stage to extract efficiency scores and OLS regression in the second stage to account for the inefficiencies for New Zealand secondary schools. Various measures of School expenditures were considered i.e. administration expenses, expenditure on learning resources, depreciation expenses, expenditure for raising local funds and property management expenses. Also considered under inputs included teachers measured by the number of Full Time Teacher Equivalents, number of teacher aides, number of pupils at each of the year levels 11, 12 and 13 and all other school years combined. The outputs included School Certificate results for year 11, Sixth Form Certificate for year 12, number of students gaining four Cs or better sitting the University Bursaries Examination in year 13.

CRS input oriented model was adopted and weights were used to overcome the problem of handling multiple outputs and inputs in the DEA specification in the first stage. The average mean score found was 85.97%. The efficiencies of individual schools range from 31.70% to 100%. In the second stage OLS was run with efficiency score as the dependent variable against several variables including social economic background, school size, teacher-experience and teacher qualifications. Social economic status of the community from which the school draws its pupils, school size and teacher experience; although not teacher qualifications were found to be significant.

Borge et al (2006) used input oriented data envelopment analysis to determine the efficiency potential by comparing performance and resource use among Norwegian schools in the lower-secondary-school sector. Assessment grades in English, Norwegian and mathematics were used as outputs; the inputs used were the total number of teacher hours by certified and noncertified teachers, respectively. In the benchmark model, assessment grades in the core subjects were used as indicators of educational output. Borge et al (2006) also formulated a model where the average grades in other subjects are included as an additional output, in order to avoid underestimating the degree of efficiency in municipalities where schools devote large amounts of effort and resources to other subjects.

a third model was Formulated where the results of the written national exam are included as an extra output in order to avoid the pitfall of variation in grading practices which was a potential problem. Inputs included comprised number of individual dummy variables on the student's gender, quarter of birth i.e. given that they graduated in the year they turned 16, graduation earlier or later than expected, and whether they are immigrants or adopted.

Family background were captured by parents' education and income and dummy variables reflecting whether the parents were married to each other, cohabitants, separated, divorced, or none of these. A fraction of students at each school that receive adapted teaching i.e. special needs was also included in the list of regressors.

To control for the effect of social economic variables, regressions with individual grades as dependent variable were estimated and variables capturing family background were used as explanatory variables to be used in DEA.

In the first model, the mean efficiency score found was 78% when all municipalities are given equal weight. The weighted average of efficiency score (with the number of students as weights) was used to reflect the national efficiency potential; and found a weighted average of 86%, which yielded an efficiency potential of 14%. The second model yielded an efficiency potential of 13.6% and the third model yielded similar results with the first model.

Portela et al (2007) used an output oriented CRS DEA model that allowed factor weights to vary freely for various schools to assess student achievement. Free weights methodology was used for the purpose of identifying worst performing schools. The model imposing a common weighting scheme was also ran in order to benchmark schools that maintain an efficiency status of 100% or best performing schools. Free weights model was run from the perspectives of society and of educational authorities.

From society's perspective inputs included Average scores on entry, Average number of years in school for the parents, percentage of secondary students not subsidized by the state. Outputs comprised of Average scores on exit on national exams, percentage of students entering public higher education, percentage of students that completed secondary education in 3 years and percentage of students that did not abandon secondary education

From education's authorities' perspectives, all inputs used on society' perspectives were used, and teacher salaries per pupil was added. Also the same outputs as in the society's perspectives used.

Results for free weighting showed an average of 97.7% with minimum efficiency score of 89% and many schools achieved a maximum score of 100% for the authorities' perspectives. From society's perspective, average efficiency found was 96.9% with minimum of 80% and a maximum 100% which also represented a considerable number in sample. The extremely high efficiency scores were thought of being attributable to the small sample size which generally involved schools which were concerned with quality and efficiency issues. Results for a single weighting showed an average efficiency score of 94.5% and minimum efficiency stood at 77.3%. Four schools were found to have maintained their efficiency status of 100% and were considered benchmarks. Three schools were found to have failed to maintain a 100% score under single weighting and therefore failed benchmarking test.

Meunier (2008) applied data envelopment analysis to measure the efficiency of Swiss secondary schools. The study adopted the methodologies of Charnes et al (1978) and Banker et al (1984) which entail constant and variable returns to scale. The latter methodology was adopted mainly for the reason that schools may not be operating in optimal size which is implied in the former methodology. Input orientation was assumed for both models.

Reading score and the inverse standard deviation of the reading score were used as outputs. The inverse standard deviation of the reading score was used in order to measure the homogeneity of pupil performances within schools.

Inputs were number of teachers per pupil, number of hours of supervision per year, number of teachers per pupil with a teaching diploma and number of computers per pupil. The variable returns to scale results showed that on average schools were operating with 83.48% level of efficiency. Constant returns to scale results showed that the schools were 80.43% efficient. Also the average sizes of the efficient schools were found to be larger than that of the inefficient schools i.e. average efficiency of schools with less than 213 pupils was 75.60% whilst the average efficiency of schools with more than 516.5 pupils was 86.55%.

Ergulen et al (2009) examined technical efficiency across high schools in Nigde province of Turkey using DEA for the period 2004-2005. Input orientation was applied and both constant and variable returns to scale models were assumed in the methodology.
Output variables they considered were students' university exam scores on science, social science, and weighted average of Turkish and mathematics. Inputs were number of science teachers per student, number of social science teachers per student, number of classrooms per student and number of laboratories per student.

Jackknifing method was employed to control for the problem of outliers affecting efficiency scores. Average efficiency scores of 61.7% and 68.6% for the constant and variable returns methodology respectively were found. Their range of the efficiency scores were 16.5% to 100% and 16.7% to 100% for constant and variable returns respectively, which showed considerable differences in efficiency levels. Also the removal of efficient schools vis-a-vie jackknifing methodology was found to have no effect on the efficiency ranking of schools. The schools that were found to be efficient using CRS were also found to be efficient using VRS and appeared frequently as reference set for inefficient schools. The authors contended that such findings showed the importance of scale economies in education, since inefficiencies consistently decreased when IRS technology was used, as it was found, in earlier empirical studies.

Coelho (2007) used the Battese and Coelli (1995) stochastic frontier analysis to test the effect of decentralization/managerial autonomy on efficiency in education for OECD countries. The model was estimated for an unbalanced panel of 18 OECD countries in 2000 and 2003. Student achievement in mathematical, reading and scientific ability of 15 year old students were considered outputs. Inputs included cumulative expenditure per student, index of economic, social and cultural status to capture students´ socio-economic background. The share of public providers in the system and the degree of decentralization/managerial autonomy of public providers were used to express organizational structure. Six specifications for the inefficiency equation were tested and were labeled models "a" "b" up to "f". Models "a" "b" and "c" tested the isolated effect of social and cultural status, the share of public providers in the system and the degree of decentralization/managerial autonomy of public providers respectively. Model "d" treated the effects of the share of public providers in the system and the degree of decentralization/managerial autonomy of public providers on the general efficiency of education systems as being autonomous and independent from each other.

Model "e" considered that the effect of decentralization on efficiency was mediated by the share of public providers in the education system. Model "f" tested the effect on efficiency of an overall index of decentralization that assumed private schools corresponded to a level of decentralization of one and that public schools are in this respect comparable to private schools, i.e. the type of ownership is irrelevant

They found consistent results between the different models. Apart from the expected positive effect of students' socio-economic background on efficiency not reflecting in the estimate of the technical inefficiency coefficient, they found that the share of public providers exerted a negative effect on efficiency whereas decentralization was positively associated with efficiency.

The average efficiency for the OECD countries was 96%; minimum efficiency was 79.2% while the maximum was 99.7%. The author observed that the most efficient countries had better economic and cultural status, higher levels of decentralization of decision making in the public sector, and lower shares of public providers in comparison with the most inefficient countries.

Pereira et al (2007) used stochastic frontier analysis methodology to investigate the determinants and the degree of efficiency in the utilization of resources in Portugal. For cross sectional data, the error term with two components as in the aigner et al and meeusen et al (1977) models was specified. It was operationalised using the Cobb-Douglas functional form with truncated normal distribution of the asymmetric error. The stochastic frontier model was also extended to consider panel data as in the battese et al (1993) model.

Output measure used was average score in the 12th grade national examinations. Inputs included the average number of teachers per 100 students as an input quantity measure, teacher-class ratio, teacher average age as a proxy for seniority, school size, and dummy variable to differentiate private institutions. Average household electricity consumption and illiteracy rate as environmental regressors. Teacher seniority, school size and private management were found to have a positive impact on output. The area where the school is located was also found to play significant role i.e. environmental regressors were significant. Further, All variables were significant in the cross section formulation that is with and without environment incorporated, while in panel formulation teacher-student ratio was insignificant. Teacher class ratio was only insignificant in the case without environment. However it was found to affect outcomes negatively. The rest of the variables were significant. The cross sectional estimates i.e. the estimates obtained when environmental variables incorporated and without the environment incorporated in the estimations produced a mean efficiency score of 94% for both cases. For panel data estimates, a mean score of 83% without environmental variables and 84% with environmental variables were found.

Kirjavainen (2007) applied SFA to school level panel data from the years 2000-2004 to evaluate the efficiency of Finnish upper secondary schools. He estimated five different stochastic frontier models with the assumption of half normal distribution for the inefficiency term namely; pooled stochastic frontier model, random effects model, fixed effects model, true random effects model and true fixed effects model. He ran the above models using results obtained in matriculation examinations against several variables including teaching expenditure per student (model A) and student teacher ratio (model B). Input variables he considered included students social economic status measured by; educational level of parents, share of white collar workers, share of single parents. School resources were measured by; teaching expenditures per student and other current expenditures per student. Length of studies was also added.

Kirjavainen (2007) tested the truncated normal distribution for the pooled panel data model and random effect model; the test results were statistically insignificant. Estimations done under the exponential distributions did not converge. Most of the explanatory variables had the expected signs; parent's education level, share of white collar jobs increased achievement where as share of single parent's decreased achievement. Both types of expenditures had significant coefficient, however the sign of the coefficient was negative.

Average length of studies was found to affect achievement negatively in all models. Student teacher ratio was significant in all the models except the fixed effects model; it affects achievement positively in all the models. The average inefficiency for model (B) varied between 3-17%, for model (A) it varied between 3-15%. The problem of choosing the appropriate model was not fully resolved in the paper.

Chakraborty (2009) used SFA in applying the battese and coelli model to school districts in Kansas to measure the efficiency of public education. In the first model, following the battese and Coelli (1992) model, a generalized frontier production function with a special interest of testing if inefficiency effects were present in the model was run. In second model, the Battese and Coelli (1995) model was used and specified the socio-economic and environmental variables to explore the sources of the technical inefficiency effects. Outputs considered were standardized test scores in math and reading. Inputs included operating expenditure per-pupil (full-time equivalent, FTE), student-teacher ratio, student-administrative staff ratio, average contract salary for teachers and administrative staff, and district enrolment.

Variables measuring teachers' quality were percent of teachers with MA and/or PhD degrees and the percent of teachers with ten or above years of teaching experience. The variables for controlling the socioeconomic conditions of the students were: percent of students belonging to minority, percent of students enrolled in a special-education program, and percent of students qualified for free and subsidized lunches. The findings rejected hypothesis of no inefficiency effects in the first model. Mean efficiencies were found to decrease marginally for school year 2003, 2004, and 2005. The means were 99.8%, 99.3%, and 97.4 %. The overall mean efficiency found for Model-1 was 98.8 %. Only six of the thirteen variables were statistically significant i.e. Enrolment, Operating expenditure per student, coefficient on the time variable, Students belongs to minority, social economic variable and the intercept.

Results of second model showed that exogenous variables in the inefficiency function were able to explain a substantial part of the unconditional variance of the one-sided error term. also, the overall mean efficiency was 95.9%, and the mean efficiency for Kansas schools were found to increases marginally for study periods 2003, 2004, and 2005 the mean efficiencies were 95.3%, 96.0%, and 96.1% respectively.

Some papers have used mixed methodological approach incorporating both non-parametric techniques and regression analysis to evaluate the efficiency of educational production in different schools. We include a few papers in our review;

Ruggiero et al (1999) used both data envelopment analysis and stochastic frontier regression to assess the efficiency of 520 public schools in New York school districts. The 1990-91 fiscal year data was used for analysis. The dependent variables used were operating expenditures per pupil, scores on standardized tests, salary, dropout rates, and graduation rates were the five outcome measures. Explanatory variables used were Regents diplomas of candidates in percent, and Poverty rate in percentage, Households with school-age children percentage, single female parent households, and student enrolment. A two-stage DEA approach was employed to control for fixed factors. In the first stage, only discretionary inputs were used. In the second stage, the efficiency index obtained from the first stage was regressed upon the exogenous factors to disentangle inefficiency from environmental effects. The error variance from this second regression was used to provide a measure of TE. Without the environment incorporated mean efficiency score found was 71%, and the authors were of the view the results were inaccurate. A second-step Tobit regression model estimated with unadjusted DEA efficiency scores as the dependent variable was ran. The explanatory variables included input prices and environmental factors. The average school district efficiency found was 87.5%.

The inclusion of environmental variables substantially increased the estimated efficiency of the school districts. Other results found; higher teacher salaries were strongly associated with less efficient operation of school district, higher percentage of households with school age children raised DEA efficiency, higher incidence of poverty was related to more efficient operation, the coefficient of single-parent households was negative, indicating greater inefficiency and school district size was found to have no effect on efficiency. The stochastic frontier regression considered followed the Aigner et al (1977) error model. Alternate functional forms tested included translog and the log quadratic. The Cobb-Douglas model was found to best fit the data in terms of statistical significance. The distributional assumptions of the error tested included the truncated normal which was rejected, half-normal, and the exponential. The exponential distribution consistently estimated less inefficiency than the half normal, and was the model adopted in the study. a mean inefficiency of 14% was found. Also none of the grade school test scores had a statistically significant coefficient. The rest of the variables had statistically significant coefficients; the high school dropout rate, the coefficient on the Regents diploma variable were found to have a negative effect on production, the coefficient of teachers salary was found to have a positive effect. The coefficients on the three family environmental variables are significant and consistent with the DEA-tobit model in that they had opposite signs.

Aaltonen et al (2006) used both DEA and SFA to measure differences in efficiency and changes in productivity among Finnish municipalities who provide comprehensive school education. The two-stage DEA results showed that average cost efficiency in comprehensive school education was 81% with VRS specification and 77% for CRS accounting for the years 1998-2004. Strong evidence of increasing returns to scale was found.

The cross sectional stochastic frontier analysis (SFA) showed average cost inefficiency of 8% for the half normal specification and 5% for the truncated and exponential distributions. The panel data estimations showed that the overall inefficiency using true fixed effects estimates is between 11.9% and 13.3% for truncated normal and half normal respectively. For the pooled panel data inefficiency scores found were 11.2% for truncated normal and 8.3% for half normal distribution. Stochastic frontier analysis was also used to extract test score efficiency using OECD PISA test results (2000-2003) for Finnish schools. Average efficiency scores of 97% and higher were found for the different test results used as outputs. For the years 2000 and 2003 there was no inefficiency found.

Mizala et al (2002) used both SFA and DEA to assess the technical efficiency of Chilean schools. Academic achievement was used as an output, measured by school's average score in standardized Spanish and Mathematics tests. Among the list of inputs considered, included pupil teacher ratio and number of students representing school size, average experience of teachers, and a measure pupil characteristics i.e. social economic level. These together with other variables were meant to capture school characteristics. Social economic data was also used to represent student characteristic.

Following the Aigner et al (1977) model to determine whether inefficiency exists in the data, the method of maximum likelihood was used and tests to determine the presence of inefficiency in the educational production of Chilean schools were carried out. The inefficiency term was assumed to follow the half normal distribution. Sufficient statistical evidence for the presence of inefficiencies was found in the data. Average efficiency found was 93.18%. The most efficient school had an efficiency of 98.19% while the least efficient had 73.04%. Students from lower socioeconomic levels were found to perform more poorly, on average, than students from families with higher income and education levels. School size was statistically insignificant in explaining educational achievement. A negative and significant Pupil teacher ratio was found. Teacher experience was insignificant.

The DEA method applied followed the Banker et al (1984) method which allows inefficiencies to be sorted according to scale and technical measures mainly because school size as measured by the number of students was a significant variable. The authors did not differentiate between inefficiencies of scale and technical inefficiencies in the BCC model, citing the reason that the purpose of them estimating DEA was for comparison with SFA efficiency results.

The same inputs from the stochastic production frontier model and the same output measurement were used. The DEA results showed that a typical school is 95.39% efficient in Chile. Also 58% of the schools were fully efficient with a 100% efficiency score. Minimum efficiency was 53%.

Smith et al (2005) were solicited to apply the techniques of DEA and SFA to analyze the relative performance of secondary schools in England. The modeling strategy for the SFA included, testing whether to model separately schools with and without sixth forms, and whether to use ordinary least squares or stochastic frontier methods. The Ramsey RESET test suggested that different models should be used for schools with sixth forms and those without. The use of SFA was found not be appropriate because none of the models examined exhibited the requisite asymmetric error term required to model inefficiency in SFA, therefore, OLS was used.

They used GCSE uncapped value added score for output. Inputs included number of learning support staff, number of administrative and clerical staff and expenditure on learning resources.

The environmental variables included pupils not eligible for free school meals and pupils with English as additional language. For the allocative efficiency model, total expected expenditure on inputs was included.

The OLS results showed that the number of staff, of whatever category, per pupil does not explain variation in GCSE results among schools. Higher expenditure on learning resources was significantly related to higher GCSE results. Higher GCSE results were associated with a higher proportion of pupils who do not receive free school meals, who speak English as an additional language, and who do not have special education needs. Schools with 6th forms achieve lower GCSE results than those without.

The DEA was modelled to follow the Banker (et al 1984) modifications. Three DEA models were run which all included the single output GCSE uncapped value added score but differed according to how inputs were specified. The first two models were estimated using both input and output orientation, while the third assumed output orientation. The first model included a vector of physical inputs which included staffing and resources such as teaching materials and equipment and a vector of hypothesised constraints which included pupils not eligible for free school meals and pupils with English as additional language. The idea was to identify technical efficiency, without reference to whether the optimal mix of inputs is being deployed by the schools. The second model used total expected expenditure as well as a vector of hypothesised constraints. The purpose was to identify the overall efficiency of the school, given the inputs it consumes. The third model used only a vector of hypothesised constraints. It was meant to capture the extent to which schools secure the best possible results given the school's external environments. The DEA results showed that for model one school with 6th form operated with 88.4% and 90.7% level of efficiency for input and output orientation respectively. The schools without 6th form 89.9% and 91.1% respectively. For model two, the schools with 6th form operated with 83.2% and 87.6% respectively. The schools without 6th

form 85.5% and 87.9% respectively. Model three had 85.5% for schools with 6th form and 86.1% for those without.

Also estimated was the average level of allocative efficiency among the same schools and found 94.1% for schools with 6th form and 95.2% for the schools without 6th form.

Caroline et al (2007) used both DEA and SFA in evaluating the efficiency performance of Philippine private higher educational institutions for the years 1999-2003. The SFA was specified to follow the Battese and Coelli model for panel data. The maximum-likelihood method was used in SFA model for the estimation of the parameters and for the prediction of technical efficiency of schools. The inefficiency effects in the inputs used were measured using one aggregate output variable total revenues and three input variables faculty members, property plant and equipment, and total operating expenses.

School-specific variables were used namely age, ownership, and autonomous status to test the inefficiency effects in the model. An average revenue technical efficiency of 71.2% was found. The estimated coefficients of the three inputs showed a positive sign for the estimated total faculty members and property, plant, and equipment, the former was found to be significantly associated with efficiency while the latter was not. The estimated coefficient for operating expenses was negative and insignificant. The inefficiency effects showed that age and ownership had positive effect on technical inefficiency and were statistically significant at a 5% level of significance while autonomous status had a negative sign and was statistically insignificant

In the DEA model, Input variables used were number of faculty members, property, plant and equipment, and operating expenses.

The educational institutions' outputs were student enrolment, graduates per year, and total revenues. The type of scale returns assumed in the study was not given. the DEA was specified to be output oriented Malmquist productivity index to measure the total factor productivity (TFP) change. The results showed that on average, deterioration in TE (97.6%) was due to scale inefficiency effects (98.9%) and pure inefficiency (98.7%). Decomposition of the total factor productivity (TFP) index showed that 0.6% productivity growth was brought about by 3% growth in technological progress.

CHAPTER 3

METHODOLOGY

3.0 Theoretical framework

The concept of efficiency in a broad sense is used to characterise the utilization of resources. Koopmans (1951) provided a formal definition of technical efficiency: a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output. Technical efficiencies will be estimated using Data envelopment analysis and Stochastic Frontier Analysis.

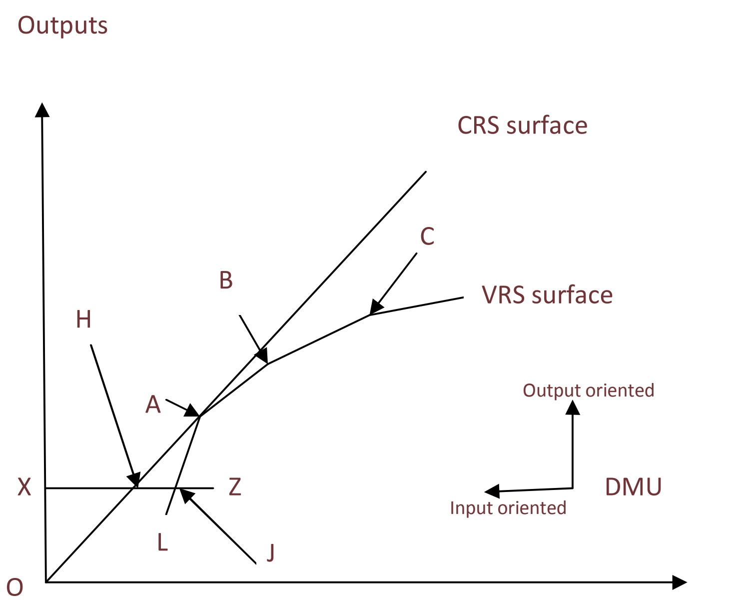
Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) employ quite distinct methodologies for frontier estimation and efficiency measurement.

DEA is a linear programming model which was stimulated by the pioneering work of Farrell (1957). It was generalized by Charnes et al (1978) to measure efficiency under the assumption of constant returns to scale. It was later extended by Banker et al (1984) to allow variable returns to scale. DEA is a programming technique that envelops the observed data to determine a best-practice frontier. Its main strength may be its lack of parameterization; it requires no assumptions about the form of the technology, does not require input price data and it can handle multiple inputs and outputs without difficulty.

Lovell, et al (1994) argued that efficiency estimates are generally higher with a BCC specification than CCR because the BCC envelopes data much more tightly than the CCR. This is because BCC exhibits variable returns to scale, because only convex combinations of efficient producers form the best practice frontier. Also in both models other than estimating efficiency estimates, they are able to identify efficient role models and provide information on the nature of scale economies. In figure 1, the CRS frontier is represented by a straight line that starts at the origin and passes through school *A*. Under CRS only school *A* would be rated efficient while school *Z*, *L*, *B* and *C* inefficient. The models with CRS envelopment surface assume that an increase in inputs will result in a proportional increase in outputs

The VRS model allows an increase in input values to result in a non-proportional increase of output levels. The VRS frontier is represented by the piecewise linear curve passing through observation *L*, *A*, *B*, and *C*. only school *A* is technically efficient as well as scale efficient i.e. operating at optimal size, the rest of the schools (*L, B*, and *C*) are technically efficient but scale inefficient, that is the are not operating at the optimal size. School *Z* is neither technically nor scale efficient. It's possible for school *Z* to reduce input usage up to point *J* and still produce the same output if it were technically efficient. The distance between school *Z* and the two frontiers will help determine the scale efficiency. The ratio $^{XH}/_{XJ}$ is the scale efficiency of school *Z* if it operating at point *J*. The VRS surface envelops the population by connecting the outermost DMUs, including the one approached by the CRS surface. Hence the BCC model envelops more data and efficiency scores are bigger than or equal to scores of CCR.

Figure 1: DEA envelopment surface



Source: Borge et al 2006

Disposability properties in DEA are assumed to be specified as either strong or weak or free. Strong disposability states that if any input is increased, output does not decrease.' This assumption is weakened here to weak disposability of inputs, which states that if all inputs are increased proportionally, output does not decrease. Free disposability of outputs means that outputs can be disposed of at no cost.

The distinction between weak and strong disposability is important. Strong disposability excludes congestion; this decomposition should be chosen for technologies where congestion does not occur. If, on the other hand, congestion is relevant, weak disposability is the appropriate disposability and hence scale efficiency should be measured under the weak disposability model. Fare et al (1983) showed that the structure of technical efficiency of a firm can be technically inefficient if it operates on the interior of its production set, if it operates in a congested region of its technology, or if it operates too large or too small scale.

Property of free disposal emphasizes that if it is possible to dispose of inputs/outputs costlessly, then it doesn't hurt to have extra input/output in production, therefore free disposability implies that inputs/outputs can be disposed of at no cost. In the context of secondary school production it is reasonable to assume that both inputs and outputs will be freely disposable.

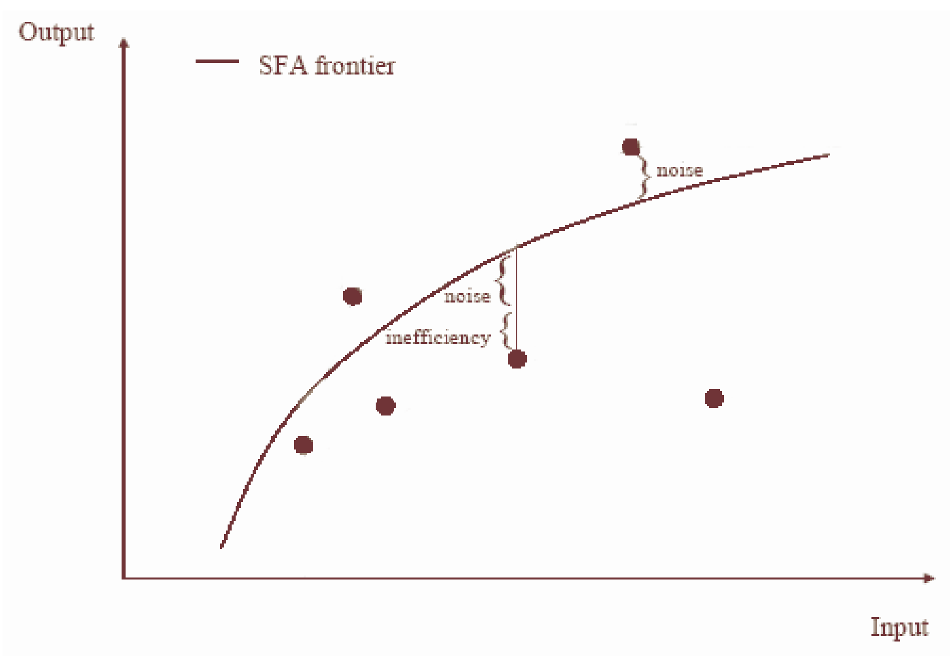
There are two perspectives on technical efficiency in terms of either inputs or outputs. The first is an input oriented measure which estimates how much inputs could be scaled back without reducing the level of outputs. The second the output orientation, considers how much outputs could be boosted given current levels of inputs. Differences between the two occur because of the shape of the efficiency frontier, which may be subject to diminishing returns to scale after resource inputs reach certain levels. We will use output orientation, since schools usually have fixed inputs and they have to maximize their output. They have little control over their inputs, but can greatly influence their outputs; therefore output orientation is more appropriate.

Stochastic frontier Analysis's (SFA) roots is traced back to the work of Aigner and Chu (1968) who used Parametric non stochastic linear programming model to estimate the coefficients of the production frontier based on a deterministic model using a Cobb Douglas functional form. The model did not allow for the influence of measurement errors or statistical noise on the frontier. All deviations from the frontier were assumed to be the result of technical inefficiency.

The concept of a stochastic production frontier was developed and extended by Aigner, Lovell, and Schmidt (1977). Adequate characterization in the utilization of the disturbance term for frontier models was developed specifying the error term as being made up of two components, one normal and the other a one-sided distribution.

The specification acknowledged that some deviations from the maximum observed output may occur due to factors unrelated to inefficiency (Coelho, 2007).This is illustrated by figure 2 below which shows points deviating away from the frontier. The point above the frontier labeled "noise" shows deviations from the maximum observed output due to randomness. The point below the frontier whose label has a component of noise shows deviations from the maximum being a combination of randomness and inefficiency i.e. inaccuracy in the measurement of output; exogenous shocks outside the control of the production system.

Figure 2: SFA Efficiency Frontier



Source: Coelho (2007), PhD thesis, University of Birmingham.

Jondrow et al (1982) in the paper "on the estimation of technical inefficiency in the stochastic frontier production function model" showed a way to derive firm-specific measures of technical inefficiency via the expected value of efficiency conditional on the observed error. Jondrow et al (1982) made distributional assumptions about the error as well as the inefficiency that considered the half normal and the exponential distributions as the arbitrary choice due to lack of a priori justification for selecting a particular distributional form for the technical inefficiency effects. Aigner et al (1977) were particularly concerned with the case in which the inefficiency is derived from a distribution of inefficiency assumed to be independently and identically distributed with a truncation above at zero with a constant variance of inefficiency.

Educational production has been estimated in a variety of forms, although most frequently variants of linear or logarithmic models**.** The production technology needs to be specified *a priori* through a particular functional form; we will consider the Aigner et al (1977) model.

3.1 Model specification

3.1.1 DEA specification of technical efficiency

We will use the (CCR) model prepared by Charnes, cooper and Rhodes (with constant returns to scale) which is a development of the DEA model to measure the technical efficiency of secondary schools in Zambia. We will also use the (BCC) model to overcome the problem of technical efficiency scores being confounded by scale inefficiency that is if scale of operation is an important factor in secondary school production in Zambia.

If we assume that there are n schools using m different inputs, and producing s different outputs. y and x are output and inputs respectively with u and v as output and input weights respectively. Specifically, DMU $_j$ consumes x_{ij} of input i and produces y_{jr} of output r. We further assume that $x_{ij} > 0$ and $y_{jr} > 0$, and also that that each DMU has at least one input and one output.

Charnes, cooper and Rhodes (CCR) (1978) proposed a linear programming problem that is capable of getting the efficient virtual producer corresponding to each real Producer for each school and the efficiency index. It takes the form:

$$\max h_0(u,v)= \sum_{r=1}^{s} u_r\, y_{ro} \tag{1}$$

s.t

$$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0, j = 1, \dots \dots, n \tag{2}$$

$$\sum_{i=1}^{m} v_i\, x_{io} = 1 \quad \text{where;} \tag{3}$$

$$u_r, v_i \geq o, r = 1, \dots \dots, s \quad i = 1, \dots \dots, m$$

The above example of the (CCR) uses constant return to scale, whose assumption is that the firm is operating at its optimal size. In practice this may not be the case, imperfect competition, constraints on finance, etc may all make the DMU not operating in an optimal situation. Banker et al. (1984) proposed a variable returns to scale (VRS) specification, as an extension of the constant return to scale (CRS) DEA model, known as the BCC model.

3.1.2 The Banker, Charnes and Cooper (1984) Model

When the CRS model is operating when not all the DMUs are working at the optimal scale, the measures of technical efficiency become confounded by scale efficiencies. Banker, Charnes and cooper (1984) offer a modification that allows inefficiencies to be divided in to scale and technical inefficiency measure. The linear programming is expressed as:

Max $h_o(u,v) = \sum_{r=1}^{s} u_r\, y_{ro} - u_o$ (4)

s.t

$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{r=1}^{m} v_i\, x_{ij} - u_o \leq 0, j = 1, \dots \dots, n$ (5)

$\sum_{r=1}^{m} v_i\, x_{io} = 1$ where; (6)

$u_r, v_i \geq 0, r = 1, \dots \dots, s \quad i = 1, \dots \dots, m$

u_o free or unconstrained in sign.

3.1.3Scale efficiency

We will use the ratio of CRS efficiencies to VRS efficiencies to establish if there are any discernible scale inefficiencies. To obtain scale efficiency for DMU $_{j,}$ Coelli (1996) showed that it can be obtained by

$$SE_j = \frac{TE_{j\,CRS}}{TE_{j\,VRS}} \quad (7)$$

A school's score will be one if it is scale-efficient or less than one if it's not.

3.1.4 Stochastic Frontier Analysis (SFA) Model

The stochastic frontier model will beestimated by using maximum likelihood estimation advanced by Aigner, Lovell and Schmidt (1976). It is specified in terms of a general production function for the I th production as

$Y_i = f(x_i, \beta) + v_i - u_i$ (8)

Where Y_i is output, X_i is the relevant set of independent variables, β represents the coefficients to be estimated, U_i are non-negative random variables assumed to account for technical inefficiency in production, V_i is a white noise error

In this approach it is assumed that the noise component is independently and identically distributed as vi ~ $N(0,\sigma_v^2)$. The ui ≥ 0 is the non-negative technical inefficiency component of the error term. u_i is assumed to follow either a half-normal , exponential or truncated distribution

3.1.5 Empirical application

The log linear stochastic frontier is formulated to account for the variation in enrolment among the schools. It is a function of recurrent expenditure, number of classrooms, pupil teacher ratio, and book to student ratio and will be estimated by;

$$lnY_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 ln\ x_{2i} + \beta_3 \ln x_{3i} + \beta_4 \ln x_{4i} + V_i - U_i \qquad (9)$$

Where Y_i = enrolment rate and grade 12 pass rate respectively.

x_{1i} = Is recurrent expenditure

x_{2i} =Number of classrooms in a school

x_{3i} =Pupil teacher ratio

x_{41} = Book pupil ratio

3.2 Data

The Analysis in this paper will be based on the Ed assist Zambia data and examinations council of Zambia annual report (2002). They were made available with the courtesy of the ministry of education and examinations council of Zambia respectively. A survey of Ed assist Zambia for the year 2002 showed that there were a total number of 253 secondary schools (Grade 8-12 level) throughout Zambia. Examinations council of Zambia annual report (2002) obtained data numbers of grade 12's who get school certificates per school. There were 236 schools in their data set.

In the copperbelt, there were a total number of 58 schools, of which 38 were government schools, 16 grant aided schools and 4 private. In Lusaka province, there were a total number of 27 schools, of which 9 were government schools, 17 private schools and 1 grant aided. Southern province had a total of 35 schools, of which 11 were government schools, 17 grant aided schools and 7 private schools. Western province had a total of 14 schools, of which 10 were government schools, and 4 grant-aided. Luapula had a total of 18 schools, of which 14 were government schools, and 4 grant-aided. Eastern province had a total of 36 schools of which 27 were government schools, 8 grant-aided and 1 private school. North-western had a total of 18 schools, of which 16 were government schools, and 2 were grant-aided. Northern Province had a total of 22 schools, of which 17 were government schools, 4 grant-aided, and 1 private school. Central province had a total of 25 schools, of which 17 were government schools, 2 were grant aided, and 6 were private schools.

Once we eliminated the schools for which the required data was missing or inconsistent in some way, the sample size for MOE data was reduced to 201. Listing the ECZ data to match the “sorted” MOE data resulted in dropping 73 observations from ECZ data. We remained with 163 observations which were consistent between the two data sets. We do not expect the changes to bias the study because the remaining data set is relatively representative i.e. statistically large.

We will use the data on Zambian schools obtained from the ministry of education (EDASSIST) and examinations council of Zambia annual reports for the year 2002. The choice of period was mainly driven by the availability of data on the variables of interest. The data set runs from 2001 to 2008, however we settled on the year 2002 mainly for the fact that we could not get consistent observations across different years on variables of interest. Also economic theory suggests that production in the short run is relatively constant, and as such we expect no major changes in efficiencies in for the data set of 2001 to 2008.

3.3.0 Variable description

Measurement of school outcomes is problematic due to complex nature of schools production. School production process is akin to black box syndrome. Adequate information about the prices of inputs and outputs is usually missing; no clear consensus is available on what the inputs and outputs are and what constitutes appropriate measurement techniques;

(Hanushek, 1979). In theory, it can be argued that the ultimate goal of education is to develop the individual both in terms of skills and knowledge to make them more productive and to influence their characters in to what is socially acceptable. Efficiency analysis and other forms of school assessment inevitably focus on what can be quantified. The selection of the input and output variables is carried out in line with existing empirical literature.

For our outputs we consider enrolment and pass rate. Percentage of pupils who obtain grade 12 school certificates is used to measure pass rate. Since schools sit for the same examination, it becomes a basis for comparing the performance of school in the country. Enrolment is considered as an output because it is a resource user in schools. Admittedly, measurement of educational output poses important questions, but the variables employed here have been widely used in other studies (Caroline et al, 2007; Chen 2006; Meunier, 2008)

The input side of efficiency analysis is usually considered less problematic than the output side (Smith and Street, 2006). The four input variables considered for our study include;
Pupil –teacher- ratio is used as a proxy of the labor input i.e. it is as an indicator for the degree of "intensity" in the utilization of teaching staff. The lower the pupil-teacher- ratio, the more time teachers can potentially allocate to each student, hence improve performance, all things equal. This ratio alone provides an imperfect measure of the teaching effort put into the educational production process. Total number of hours worked could not be considered mainly because government staff in developing countries can spend time away from duty without being accounted for.

Number of classrooms is used as a proxy of capital, since it captures the availability of basic facilities, as this can be a binding constraint in developing countries. Only classes in permanent structure condition were considered in our analysis. Those in Temporary structure condition were excluded.
Recurrent expenditure includes expenditures on professional staff, auxiliary staff, department, grants, and capital.

Book –to- student ratio measures the availability of learning materials. A large book to student ratio signals students having better access to text books. Lockheed & Hanushek (1987) reviewed literature and found that text books were efficient at improving student performance, students who frequently used text books performed significantly higher than classes in which students did not frequently use textbooks.

To control for environment in which the schools operate, we introduce a dummy variable for location to measure the effect of being in either in rural or urban locality on both enrolment and pass rate. A summary of all the variables considered in this study is listed in table 1 below.

Table 1: Summary of the variables considered in the study

Variable	**Definition**	**Unit of measurement**
X1	Pupil- teacher- ratio	Number of pupils per one teacher
X2	Classrooms	Number of classes
X3	expenditure	Recurrent exp on learning resources (in ZMK)
X4	Book- to- student ratio	Number of books per pupil
X5	Dummy for location	If urban=1,Rural=0

Output variables to be used are:

Variable	**Definition**	**Unit of measurement**
Y1	Pass rate	Percentage of students getting grade 12 school certificate
Y2	Enrolment	Number of student enrolment

Source: owner's own computations

3.3.1Preliminary statistical analysis

Correlation coefficients between variables were calculated and examined, correlations tended to be low. This is an indication that our study is not plagued by problems of high co-linearity between the predictor variables. Appendix A1 contains VIF and pair wise correlations between the predictor variables. The highest correlations were to be found between the book -to–student ratio and pupil- teacher- ratio, the negative relation suggests that bigger classes intensely rely on teacher experience in teaching pupils than text book resources, or simply bigger classes have fewer books to use. Recurrent expenditure is negatively correlated with teacher–pupil- ratio, confirming that higher expenditure (on infrastructure) tends to decongest class room. Number of classrooms is positively correlated to pupil- teacher- ratio suggesting that teachers in bigger schools have more work to do. Book- to- student ratio is positively correlated to number of class rooms suggesting bigger schools use more of text books to teach. Recurrent expenditure has a positive correlation with book- to- pupil ratio. This tells us that pupils from schools with bigger budgets have more books to read. Recurrent expenditure is positively correlated with number of classrooms suggests that schools with more money are more likely to get bigger. Table 2 below provides variable statistics.

Table 2: Variable statistics

Description of Variables	Mean	Std dev	min	max
Outputs				
Enrolment	592.67	396.08	42	2237
Pass rate	.72	.19	.09	1
Inputs				
Pupil teacher ratio	18.35	6.74	1.91	44.5
Classrooms	14.84	12.49	1	152
Book student ratio	3.33	3.67	.04	23.92
Recurrent expenditure(Zmk)	2.13e+08	3.44e+08	1300000	2.21e+09

Source: owner's own computations

3.4 Estimation methods

To analyze the efficiency of secondary schools Zambia, we used school level cross sectional data for the year 2002 from Ministry of education and Examination council of Zambia.

We used stochastic frontier analysis and Data envelopment analysis to estimate technical efficiency of each school because of their known theoretical properties and popularity, which allows for comparisons with other studies.

However the use of SFA is dependent on the availability of evidence of differential efficiency among schools. This means that the specification must produce a skewed residual justifying the use of SFA. We used OLS to test for the presence of the skewed residual. The skewed residual is the necessary condition required to model inefficiency in SFA (Aigner et al, 1997).

We considered three principal distributions of the u inefficiency residual to model SFA. The truncated normal was easily rejected (iterations could not converge in stata 10). We had to make choice on which model is appropriate between the half normal and the exponential distributions based on the magnitude of the error variance.

We ran two models; model 1 with enrolment as the dependent variable and model 2 having pass rate on the dependent variable. The explanatory variables used were the same for the two models. The models were formulated to account for the variation in (enrolment or pass rate) among the schools as a function of recurrent expenditure, number of classrooms, pupil - teacher ratio, and book to student ratio.

Model 1: $\ln Y_i = \beta_0 + \sum \beta \ln X_i + V_i - U_i$ (10)

Model 2: $Z_i = \beta_0 + \sum \beta \ln X_i + V_i - U_i$ (11)

X_i= vector of the above listed variables. Y_i=enrolment Z_i=pass rate

Ramsey's omitted variable regression specification error test (RESET) was implemented in Stata 10 to test for misspecification in our models.

The DEA model was run using DEA excel solver developed by Joe zhu. We used jackknifing method to test for the stability and consistency of DEA results. We made use of the Mann Whitney U test to test if the DEA efficiency scores of schools in urban areas are significantly different from those obtaining in rural schools. Spearman rank correlation coefficient was used to test if the ranks provided by SFA are significantly different from those provided by DEA.

3.5 Diagnostic Tests

The RESET Test

The RESET test (Regression Specification Error Test) is designed to detect omitted variables and incorrect functional form. Omitted variables are variables that significantly influence the dependent variable and must be in the model, but are excluded. Rejection of the null hypothesis implies the original model is inadequate and can be improved. A failure to reject the null hypothesis tells us that the test has not been able to detect any misspecification. The test artificially includes powers of the predictions of the model, and then tests whether the model significantly improves (Johnston & Dinardo, 1997). If it improves then it implies the original model must have been inadequate.

Mann Whitney (Wilcoxon rank-sum) U-Test

The Mann Whitney is used to test the hypothesis that two independent samples are drawn from populations with the same distribution i.e. the two groups are stochastically equal; (Mann & Whitney, 1947). It converts the scores on the continuous variable to ranks, across the two groups. It then evaluates whether the ranks for the two groups differ significantly.

Jackknife- standard error of the sample mean.

The Jackknife tests the sensitivity of efficiency scores to sampling variation of the frontier. Specifically it estimates bias and variance of a statistic of interest, and tests the null hypothesis that the distribution of a statistic is centered at some pre-specified point (Efron, 1980). It runs simulations carrying out re-sampling of observations without re-estimating efficiency scores. It measures efficiency scores by leaving the associated observation out of the calculations one at time and then testing efficiency rankings of observations and average efficiency values. It then generates confidence intervals around the original DEA mean estimate. If the original DEA mean falls outside the confidence interval, then there is bias and we conclude that there exists outlier observations in sample.

The Skewness Kurtosis Test

This is a test based on a combination of the third and fourth sample moments which are ($\sqrt{b_1}$) and (b_2) respectively of a random variable and detects if they are non-normally distributed; (D'Agostino et al, 1990). The moments measure skewness and kurtosis and then combine the two tests into an overall test statistic. For the normal distribution the skewness and kurtosis are equal to 0 and 3 respectively and non normality is portrayed by the values of the central moments differing from the normal values.

Spearman Rank correlation test

The Spearman test uses ranks to test for association between pairs of variables. The underlying relationship must be monotonic. A correlation coefficient of 1 (a perfect positive relationship) implies that the rankings are exactly the same. A value of zero indicates the absence of correlation between the rankings and reverse ranking is implied by a value of -1 (a perfect negative relationship).

CHAPTER 4

RESULTS AND INTERPRETATION

4.0 Efficiency Results from Stochastic Frontier Analysis

Model 1

The full OLS results obtained from estimating Model 1 are in Appendix A3. The model passes the Ramsey RESET test suggesting that there is no misspecification in the model. It also displays skewed residual as can be seen from the results of the skewnes kurtosis test and regression residual specification plots in Appendix A3 and Appendix A2 respectively at the appendix. This fulfills the condition required to model inefficiency in SFA. We estimated model 1 using SFA considering the half normal and exponential distributions[1] . The results are reported in Table 3 below

Table 3: SFA results

# of Observations =229	Half Normal Distribution		Exponential distribution	
Variable	coefficient	SE	Coefficient	SE
Recurrent Expenditure	.1343355	.0189475**[2]	.1168066	.0179407**
Number of Classrooms	.5713202	.0419336**	.6322612	.0426264**
Pupil teacher ratio	.7621297	.0664599**	.7027836	.064648**
Book to student ratio	-.079737	.0288902**	-.0751974	.0265248**
Dummy (rural=1;urban=0)	.0314683	.0482268	.02331	.0450414
Constant	.4699426	.4039819	.7166676	.3759982*
/lnsig2v	-2.632772	.1931087	-2.642045	.1474776
/lnsig2u	-1.696462	.2403877	-2.843781	.2616011
sigma-v	.2681025	.0258865	.2668623	.0196781
sigma-u	.4281716	.0514636	.2412575	.0315566
Lambda	1.597045	.0702352	.9040523	.0432605
	Mean efficiency	**std. Dev**	**Min**	**max**
half normal	.7391309	.1151105	.2337231	.9551052
exponential	.8090914	.116632	.1552401	.9661936
Likelihood-ratio test of sigma_u=0: chibar2(01) = 11.85 Prob>=chibar2 = 0.000 for half normal model				
Likelihood-ratio test of sigma_u=0: chibar2(01) = 29.64 Prob>=chibar2 = 0.000 for exponential model				

[1] The Truncated distribution did not converge in stata 10

[2] Note** statistically significant at 1%, * statistically significant at 5%

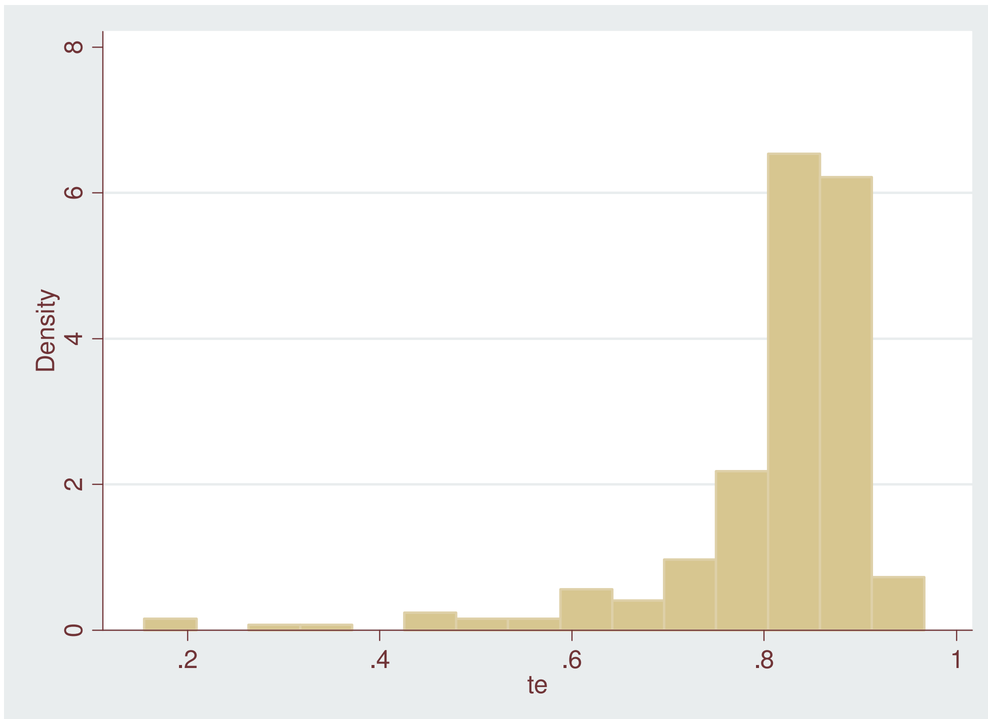
Given that the nature of production function in education is largely unknown; our interpretation of parameter estimates is done with much caution. The primary purpose in this study is providing estimates of efficiency rather than the parameter estimates. That alone made exploration of trans-logarithmic functional form which provides second-order approximation to the unknown, but true, functional form of production function redundant.

The maximum likelihood estimates for the parameters of the two models together with their standard errors are given in table 3 above. Almost all variables estimated were highly significant at 1 per cent level of significance. The number of classrooms, pupil- teacher ratio and the recurrent expenditure are positively and significantly related to enrolments (as expected) at both one and five percent level of significance. Therefore, a school that has an abundance of these resources is more likely to increase its enrolments. As the results show, all the coefficients with the exception of the dummy for location and the constant term are significant in the half normal model.

In the exponential model the constant term is also insignificant but the dummy for location is significant at the 5 percent level of significance. Book–to- student ratio is negative and significantly different from zero at five percent level of significance. An increase in book to student ratio leads to a decrease in enrolment for both half normal and exponential distributions. This may suggest the existence of a tradeoff between expending resources on procuring teaching aids (books) and expending the resources on boosting enrolments.
The dummy variable is insignificant in both the half normal and exponential distributions. This implies that enrolment is not affected by whether the school is located in rural or urban area.

In both models the likelihood ratio test suggests that the value of the variance component is different from zero[$\lambda = {}^{\sigma_u}/_{\sigma_v} \neq 0$]. This also attests to the rejection of the null hypothesis of no inefficiency in the Zambian data. However, the value of lambda under exponential model suggests that it fits the data well and therefore is more appropriate than in the half normal model. In this study, we therefore adopt the exponential model for analysis. Under this model, ninety percent of the variation in inefficiency is explained by the model and ten percent is due to statistical noise. The average school has a mean efficiency score is 81%. The most efficient school has an efficiency level of 96% while the least efficient 15%. No school achieves an efficiency level of 1, due to the fact that expected inefficiency is always non-zero. Further, by examining histogram in figure 3 below, we are able to discern a pattern of inefficiency.

Figure 3: Histogram of school efficiency with regard to enrolment



Source: owner's own computation

We notice that the interval with the highest density falls in classes that are between 82.5% and 92.5% level of efficiency. This tells us that the majority of schools are operating with an efficiency level of between 82.5% and 92.5% in our sample. Between 75.5% and 82.4% level of efficiency, we observe generally a moderate frequency density which tells us that a fair number of school are falling in this interval. Moving from efficiency levels of 74.4% towards 14.5%, we generally observe successively fewer schools in the underlying efficiencies as shown by the respective frequency density frequencies. Above 92.6% we observe a low frequency density signifying that few schools are operating in the implied underlying efficiency level.

Model 2

The full OLS results for Model2 are contained in Appendix A4 at the appendices. The model passes the Ramsey RESET test suggesting that there is no misspecification in the model. We observe that;

Book to student ratio does not explain variation in pass rate. This may be due to limited variation among schools in book to student ratio (standard deviation reported in table 2 is relatively small). Number of classrooms also does not explain variation in pass rate. Higher recurrent expenditure is significantly associated with higher pass rate. Pupil-teacher ratio is negative and significant. This means that larger classes are associated with poor performance.

The results of the skewness kurtosis test in Appendix A3 points to a failure to reject the null hypothesis of no significant difference between the cumulative distributions of the residuals against that of the theoretical normal distribution both at one and five percent level of significance. It means that variations in pass rate are attributable to random statistical noise as opposed to the presence of inefficiency in the data. We conclude that the residuals are normally distributed and the use of SFA is inappropriate and therefore not justified.

4.1 Efficiency Results from Data Envelopment Analysis

A reference set of efficient schools is determined by finding the schools which produce the highest output for a given set of inputs. In this instance there are thirty three "efficient" schools with an efficiency score of 100% for pass rate out of hundred and sixty three schools using VRS. The remaining hundred and thirty schools had a technical efficiency score of less than 100%. This means that 80% of secondary schools in Zambia operate below the efficient frontier. We find that these inefficient schools collectively have a mean efficiency score of 71%. This means that on average, these schools could increase their output by 29% using the same level of inputs in order for them to operate on the efficiency frontier. The technical efficiency scores among these inefficient schools range from 99.5% for (Mpika boys) to 9.7% (Madzimoyo day sec school). This wide variability in efficiency provides evidence of inefficiency in Zambian schools operations. The findings suggest that Mpika and Madzimoyo secondary schools could increase their pass rates by 0.5% and 90.3% with their current inputs. The average efficiency score of all secondary schools in regard of pass rate as an output is 76.87%. This result indicates that, collectively, schools could increase their output (pass rate) levels by 23.13% with the same level of resource inputs.

The constant returns to scale (CRS) DEA model estimates in regard of pass rate as an output indicate average technical efficiency scores range from 9.5% to 100%. Seventeen out of one hundred and sixty three secondary schools where found to be efficient with an efficiency score of 100%. One hundred and forty six schools (90%) operate below the efficient frontier. Madzimoyo secondary consistently has come up at the lower end of efficiency frontier again. Theory suggests that estimates of technical efficiency provided by CRS (DEA) are confounded with scale of operations when scale efficiency effects are important (Charnes et al 1984). We find this theory to be consistent with the Zambian secondary school efficiency results. Therefore we adopted VRS (DEA) results for our analysis since they are much more reliable.

The VRS (DEA) estimates of efficiency in regard of enrolment as an output have twenty seven out of two hundred and three schools fully efficient. This represents 13% of secondary schools operating on the efficiency frontier. The inefficient schools collectively have a mean efficiency score of 57.50%. They have to nearly double their output i.e. to increase it by 42.50% if they have to operate on the efficiency frontier.

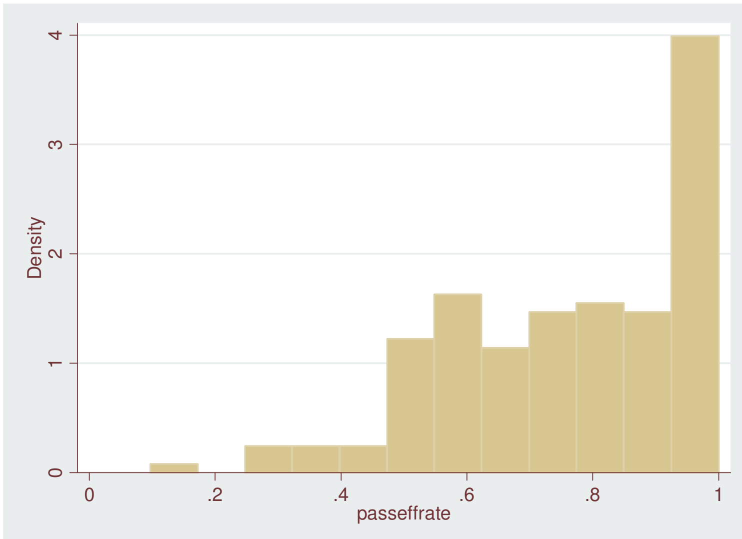
The average efficiency score of all secondary schools in regard of enrolment as an output is 63.15%. It means that secondary schools in Zambia on average can increase their output by 39.88% with the same level of inputs at their disposal. Anoya zulu and Chifundo junior and high school appear on top and bottom of the efficiency list with 100% and 11% respectively. This means that chifundo junior and high school can only achieve 11% of what other schools with similar amount of inputs get.

When constant returns to scale are used, 11 schools are found to be fully efficient with an efficiency score of 100%. One hundred and ninety two (95%) of schools are inefficient. Constant returns to scale assume that all schools are operating at scale efficient levels which are less likely to be the case in this set up. Chifundo junior and secondary school also appear as the least efficient school in CRS case as well.

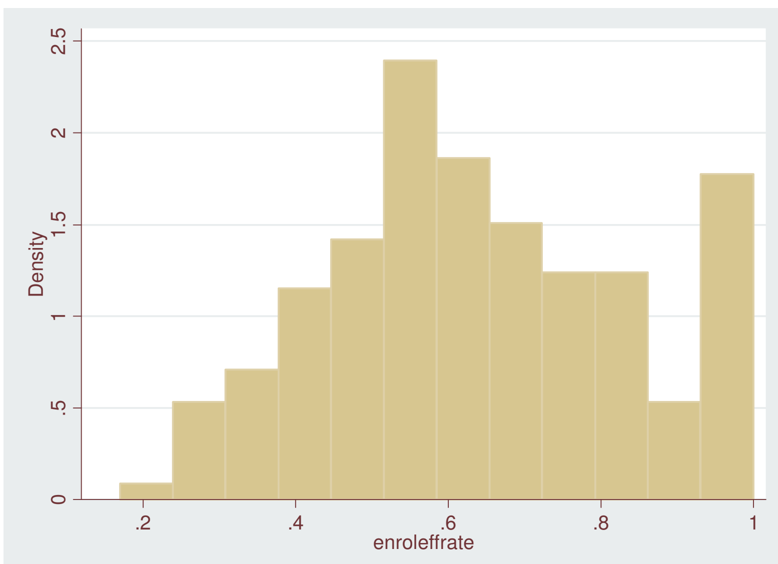
We have constructed histograms for two efficiencies of pass rate and enrolment respectively. We have listed the results in Figure 4 below.

Figure 4: Histograms of pass rate and enrolment efficiency from DEA

Histogram of School DEA efficiency with regard to pass rate



Histogram of school DEA efficiency with regard to Enrolment



Source: owners own computation

There are a number of notable features about the histograms in figure 4 above;

The enrolment efficiency class below 15% has no observations. Between 17.5% and 49.4% level of efficiency, we observe generally a low but rising frequency density. This tells us that relative to the whole population few but steadily increasing schools fall in this class. The interval with the highest density falls in classes that are between 49.5% and 69.5% level of efficiency. It tells us in relative terms the majority of schools in terms of efficiency are operating at efficiency levels that are not too far above or below the fifties range. Between 70.5% and 84.4% levels of efficiency the number in this interval seems to be reducing steadily. As efficiency approaches efficiency levels that are between 84.5% and 95.5%, we notice a low frequency density which tells to us that there are very few schools in this class. Finally we notice that schools tend to increase in the class that is operating with an efficiency level of between 99.5% and 100.5%.

For pass rate we observe that for the class below 25.5% there is a very low frequency density signifying near none observations. It is only madzimoyo secondary school that is found in this category. Between efficiency levels of 25.6% and 48.5%, we observe low but constant frequency density, which tells us that there are few schools of about equal numbers evenly spread across the classes with an efficiency level of between 25.6% and 48.5%. For classes exhibiting efficiency levels of between 48.9% and 95.5%, we observe that there is a generally increased frequency density signifying that most schools are clustered in this range. We find the class with the highest frequency density (modal class) to be among schools with the efficiency level that is between 95.6% and 100.5%.

4.1.1 Comparison of efficiency scores of Pass rate and enrolment

Appendix A9 shows how each particular school is fairing it terms of both enrolment and pass rate efficiency. We observe that there are 13 schools that are fully efficient at enrolment and pass rate at the same time as can be seen from observation 1-13. From observation 14 -18, we observe schools that are fully efficient at enrolment but have a varying efficiency for pass rate. From observation 19 -163 we notice that efficiency is of decreasing order for enrolment, but we notice 18 pockets of fully efficient schools for pass rate, otherwise the rest of the other schools exhibit varying inefficiency. Overall efficiency of schools is relatively better for pass rates (76.87%) than enrolments (64.53%) but these results suggests that substantial wastefulness could be avoided if all schools were to operate efficiently.

The Appendix A5 provides evidence of the stability of DEA efficiency results provided by jackknifing method. It tests the consistency of DEA results just in case a school with outlier observation was included in the analysis. The results show that the means for both enrolment and pass rate are stable; they are not significantly affected by outlier observations.

We used non-parametric Wilcoxon rank-sum (Mann-Whitney) to test our hypothesis of no significant difference in the efficiency scores between rural and urban schools. We do not reject the null hypothesis at five percent level of significance for both enrolment and pass rate and conclude that there is no significant difference in the DEA efficiency scores between urban and rural schools. Appendix A6 also shows the mean efficiency scores for schools in rural and urban locations for pass rate and enrolment respectfully.

4.2 Scale efficiency analysis [pass rate]

The average scale efficiency score of all the schools is 74%. Eighteen of the one hundred sixty three schools are operating at optimal size with a scale efficiency score of 100%. It means that their size is such that they employ all their factors at full capacity in production for the particular input-output mix. Six schools are operating on increasing returns to scale and are very close to their optimal size. The average scale efficiency of schools with increasing returns to scale is 98.5%. On average they can increase their size by 1.5% to become fully efficient. One hundred thirty nine schools were operating on decreasing returns to scale. The average scale efficiency of schools with decreasing returns to scale is 68.9%. On average, these schools can reduce their size by 31.1% without affecting their current output levels. Transferring excesses from the schools that are experiencing decreasing returns to scale to those experiencing increasing return will result in some efficiency gains. In the context of Zambian secondary schools, the efficiency gains would be minimal considering that many schools are on decreasing returns while only few schools are on increasing returns to scale. The VRS model technical for pass rate, location and scale efficiency scores for individual schools are contained in Appendix A7.

4.2.1 Comparison of SFA and DEA Efficiency Rankings

Appendix A8 is divided into two groups representing the ranks of results obtained by SFA and DEA methods. The groups have been arranged in to three groups in order of most efficient to least efficient represent the upper-quartile range, inter-quartile, and the lower-quartile range. The first 63 observations under both SFA and DEA represent the upper-quartile. These observations only includes schools with efficiency level of 81.03% and above for SFA and 74.20% and above for DEA. Forty one out of sixty three schools are confirmed both by the SFA and DEA ranks to belong to the upper-quartile range. That is they are found in upper quartile range in both methods. These are the most efficient and effective schools in the two models, as they obtain more output with less input (efficient), and the output obtained is higher than average (effective). The spread of efficiency in this category is 15.59% and 25.8% for the SFA and DEA respectively. Among the schools is Samfya secondary which is among the highest in both methods and Mwense and Mbala high school which are lowest for SFA and DEA methods respectively. However the twenty two schools are highly ranked by the SFA model but appear in the inter-quartile range in the DEA method. Among these schools is Fatima girls, Mpika boys, Canicius secondary schools. The reverse is true for the DEA-SFA ranks. Twelve schools which appear in the upper-quartile range in DEA, the highly ranked appear in the Inter-quartile range, in the SFA. Among the schools is dagama, Livingstone day Mumbwa high school, Monze secondary and Namwala etc. Ten school schools appear in the lower quartile-range in SFA despite being in the upper quartile in the DEA. Examples include Banani international, Kitwe boys, Nakonde and Maiteneke etc.

In the lower quartile range forty four schools are confirmed to belong to this group by both SFA and DEA methodologies. It is represented by schools from observation 139 to 201. These are lowly ranked in terms of efficiency with respect to enrolment, and they include Liberty high school, Olympia, Chipembi girls, Lusaka high school, Makeni Islamic and Livingstone high secondary school. However ten schools which are lowly ranked in the SFA are highly ranked by the DEA, also nine schools appear in the inter-quartile range in the DEA despite being lowly ranked by the SFA. For the DEA-SFA ranks, nineteen schools which are lowly ranked by DEA appear in the inter-quartile range. They include Caritas Convent, Roma girls, Mazabuka girls' high school etc. The spread is 59.12% and 40.5% between the SFA and DEA respectively.

Forty five schools are confirmed to belong to the inter-quartile range by both the SFA and DEA methodologies. From observation number sixty four to one hundred thirty eight represent the inter-quartile range. These are "mid-table" schools in terms of efficiency rankings. The spread between the highest ranked and lowest ranked school in this category is 6.25% and 21.20% for SFA and DEA respectively. They include Matero boys, st.edmonds, Chibombo high school, and Mpelembe secondary schools.

Overall, 130 out of 201 schools have consistent rankings for both SFA and DEA. 71 schools have a differentiated ranking between the two methods. Also SFA method consistently has a smaller spread of efficiency between its observations across the different categories of quartile ranges except in the lower quartile range where DEA spread is much smaller.

The rank order correlation coefficient provided by the spearman rank between the SFA and DEA efficiency scores is 0.66 [$p<0.01$]; it suggests that there are some considerable close correspondence between school-specific ranks and ratings under the two alternative model specifications.

CHAPTER 5

DISCUSSION

The findings of this study are in line with other efficiency studies conducted elsewhere, which indicate the wide prevalence of technical inefficiency in education. Ergulen et al (2009) employed DEA to examine technical efficiency across high schools in Nigde province of Turkey. Average efficiency scores found were 61.7% and 68.6% for the constant and variable returns methodology respectively. Mancebon et al (2000) using DEA found an average efficiency of 78.50% for Southampton, and Portsmouth primary schools.

Ruggiero et al (1999) employed both DEA and SFA to assess the efficiency of 520 public schools in New York school districts. In the DEA specification, the average school district efficiency found was 87.5%. The SFA specification followed the Aigner et al error model; the exponential model used got a mean inefficiency of 14%. Mizala et al (2002) applied both DEA and SFA to Chilean secondary schools. The Average efficiency found for SFA was 93.18% and for DEA result showed that a typical school operated with 95.39% level of efficiency.

Outside of education, Masiye (2007) analyzed the performance of thirty hospitals in Zambia using DEA. Mean efficiency score found was 67%. Average scale efficiency score was 80%for all hospitals. The inefficiency levels observed suggest a substantial amount of resource savings if inefficient schools became efficient, which could go a long way in injecting additional resources to the educational system to address the shortage of secondary school places. The country is under pressure to increase the number of secondary schools to meet the rising demand for secondary schooling places.

The study has also revealed that there is prevalent scale inefficiency in Zambian secondary schools with regards to pass rate as an output. Decreasing returns to scale is the dominant scale, implying that contraction of scale of inputs could reduce unit costs. This implies that in the short run some schools may need to scale down for reasons of efficiency. The long run solution requires investing in new schools which would expected to absorb these excess inputs.

The result of model2 in the OLS revealed the effect of school variables on pass rate. The influence of schooling variables on pass rate is found to be important in this study. Number of classrooms was found to be insignificant; it bore a negative sign which implies that a larger school can be associated with poor performance. The significant Pupil teacher ratio bears a negative sign which reiterates the message that larger classes are associated with poor performance.

Book-to-student ratio also did not explain variation in pass rate. This may be due to limited variation among schools in book to student ratio (standard deviation reported in table 2 is relatively small) or it could be suggestive that there may be less dependence/use on text books in secondary schools. Directing policy decision to actively influence schooling variables could greatly improve performance. We take note of the fact that some of the school policy variables may be easier to change than others. These include, for example, allocation of resources with regard to student-teacher ratio, school size, and number of text books per pupil. Other policy variables, such as those concerning the amount of money to dispense, may be more difficult to control given that budget is donor driven. They may be subject to policy control in the future-for example, by increasing budgetary allocation to education derived from own resources.

The choice of distribution between exponential and half normal distribution was guided by econometric diagnostics. SFA results show that exponential distribution fit better the data than the half normal. We chose the distribution that fits best, e.g., has the least error variance (Schmidt and Lovell, 1979). Exponential distribution fulfilled the condition and therefore was adopted as model of analysis. We also notice that the exponential distribution consistently estimates less inefficiency for each school compared to the half normal distribution.

In DEA when pass rate is used as an output we observe that the constant returns to scale mean efficiency is [55.67%] and out of [163] secondary schools, [17] were found to be efficient. When variable returns are used the corresponding values are [71%] [163] [33]. The results indicate that the number of efficient schools increase when variable returns are used without significantly affecting the scores of highly inefficient schools. A similar pattern is observed for efficiency scores of enrolment. This finding is consistent with the finding of (Ergulen. A, 2009). This tells us that scale economies are important in education and the use of VRS in education is appropriate.

In Zambia the comparison of technical efficiency across secondary schools is subject to certain limitations. In particular, some secondary schools, unlike their counterparts, do have the discretion to select students for admission and eliminate low achievers by setting a higher entrance pass mark for grade 10. This implies that these secondary schools accept mainly students who achieve better results (those with more ability), a characteristic not controlled for in the available variables.

The comparison of SFA-DEA revealed that a number of schools had similar order of ranking between the two methods. The Spearman rank order correlation of 0.66, is suggestive that one can fruitfully employ either DEA or frontier regression to identify efficient schools in Zambia.

CONCLUSION

The existence of inefficiency is almost certain in the production of secondary education in Zambia. The results obtained allow the conclusion that schools in Zambia display an average technical efficiency of 82%, as measured by the stochastic production frontier method, ranging from 17% to 96% for enrolment. We could not obtain technical efficiency scores for pass rate using SFA because it failed to display the asymmetric error term required to model inefficiency in SFA. The DEA (VRS) results show that, a typical school has an efficiency of 77%, while the range is from 10% to 100% for pass rate, and a mean score of 65% with range from 17% to 100% for enrolment. The larger range for efficiency scores obtained using the DEA methodology shows that in Zambia there is an important variance in academic achievement and enrolment among schools with similar characteristics.

It should be noted that DEA and SFA are primarily diagnostic tools and they do not prescribe any strategies to make inefficient units efficient. Such improvement strategies must be studied and implemented by understanding the operations of the efficient units. Therefore, the results should be evaluated in the light of the knowledge on educational systems, types of school operations, teaching methods and quality/quantity of learning offered to the pupil etc. The 33 schools that were ranked fully efficient by DEA (VRS) for pass rate could be studied in how they conduct their operations with a view to help the inefficient schools. A similar study can be carried out on the 41 schools that were confirmed to belong to the most efficient rank for enrolment by both DEA and SFA. These results are more indicative than definitive measures of efficiency. They point to directions which could be a starting point for further investigation. Inspections could be conducted by teams of educators and other professionals to determine if these ratings reflect real differences in efficiency. There after determine if inefficient schools can replicate some of the “good” that is seen in efficient schools. Schools whose ratings show poor performance may not readily admit to their inadequacy, and may claim that poor results reflect measurement problems. It is much easier to dispute the results than to make the necessary changes required to improve efficiency.

If inefficiency is eliminated or minimized, the extra resources saved could be re-invested in expanding the secondary education sector in Zambia. It was possible to disentangle the effects of scale on technical efficiency of schools. Planners should actively seek to use scale efficiency as a productivity control tool. Planners should determine sizes where schools perform more productively (scale efficient schools), schools greater than this size (Schools exhibiting DRS) should be divided into smaller schools. This should be done in phases so as to maximize educational productivity. Schools that are smaller than this size (schools exhibiting IRS) should be considered for expansion in order to take advantage of increasing returns to scale. The use of knowledge of returns to scale in this way to scale schools to optimal sizes is more of a long run than short run phenomenon which means careful planning is absolutely essential.

5.1Policy Implications

There a number of options available to deal with the inefficiency observed in some schools. Due to the social nature of schools and political considerations, closure of inefficient schools is not a feasible option. Strategies to encourage schools to pay more attention to efficiency considerations should therefore be pursued. Currently, the performance of schools is assessed only in terms of outputs such as pass rate and progression rate. Little attention is paid to the input side such as funding, level of staffing and other resources. There is need to consider both the outputs and inputs in assessing schools performance. For instance, a ranking mechanism of school efficiency levels may be implemented and results published in form of a “league table” depicting schools with highest points to those with lowest points in descending order. Thus, schools found to be inefficient may be relegated, while those found to operate efficiently may be upgraded on the “league table”.

In this respect, ranking of schools maybe be done by setting targets on the basis of available resources. Schools may be provided with self evaluation techniques using benchmarking criteria to assess their performance, i.e. using an excel based software or any other convenient programme. This can be followed up by an external evaluation which may be used as a basis for comparison among different schools on the league table as discussed above. To simplify this process, online facilities may be employed for both internal and external evaluation. The final rating of schools outcomes could be published in form of a "league table", and then financing, being a core variable and remuneration of teaching staff could be tied to how well schools perform. Ultimately, this information could help people in making an informed choice in selecting the "best schools". A possible side effect of rankings is the promotion of efforts to prepare pupils for exams more than anything else.

On the basis of the league table, schools that may perform poorly may be downgraded with a view to correcting the unsuitable scale of operation or size and hence reduce costs to improve overall efficiency. This would entail downsizing both the services provided and staff composition as some schools may be using more of a given resource only because they have been historically over-funded or over-staffed relative to their outputs. The schools ranking may be used as a basis for the conversion process. The details of efficiency improvement measures may be derived from a critical analysis of the determinants of inefficiency.

5.2 Study Limitations and recommendation for future studies

Based on results found which shows significant inefficiency in the Zambian secondary educational sector, researchers should focus on household variables, to shed more light on the effect of the environment on efficiency and sources of inefficiency. We could not find data disaggregated at district level on house hold data which are outside the control of school but significantly affects in part the performance of schools such as number of siblings of pupil, educational level of parents, family income, whether meals are taken during lunch or not etc, and therefore we did not delve in to finding out the sources of inefficiency.

Future research should focus on the source of school inefficiency so that it can be possible to design effective policies which will help schools to operate efficiently. Second stage Tobit regression in DEA can be used to account for the effect of the environment on efficiency while the Battese and Coelli in SFA model can be used to account for the sources of inefficiencies. Until there is a better understanding on why schools exhibit different inefficiency, it may not be prudent to adopt the various structural reforms in the education sector on grounds of greater efficiency.

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Appendices

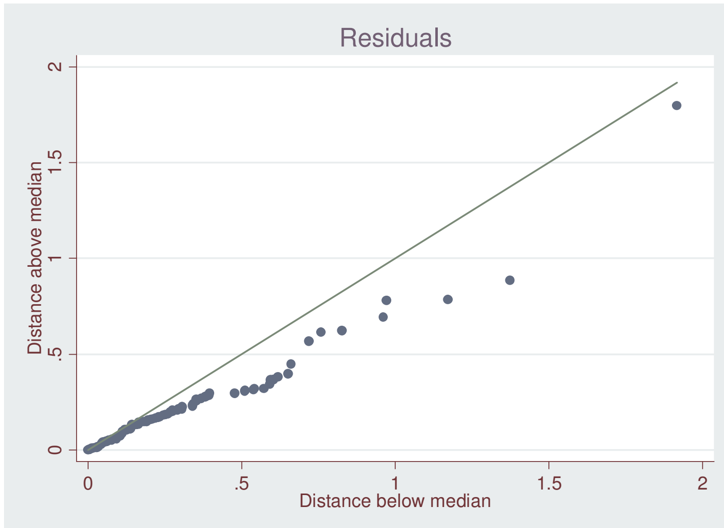
Appendix A1: VIF, and correlation between predictor variables

Variable	VIF	1/VIF
Pupil teacher ratio	1.32	0.755222
Book to student ratio	1.26	0.791947
Number of classrooms	1.23	0.811065
Recurrent expenditure	1.22	0.822823
Mean VIF	1.26	

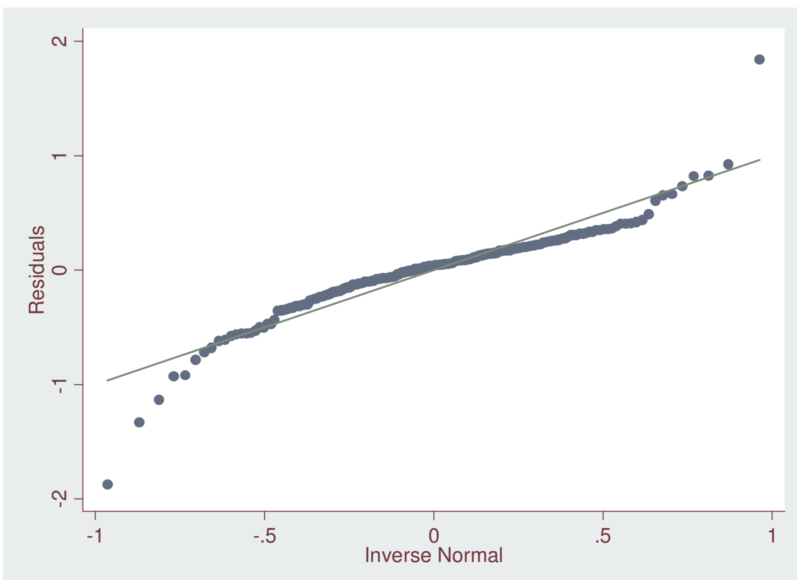
	Recurrent expenditure	**Number of classrooms**	**Pupil teacher ratio**	**Book student ratio**
Recurrent expenditure	1.0000			
Number of classrooms	0.1175	1.0000		
Pupil teacher ratio	-0.1301	0.0660	1.0000	
Book student ratio	0.1038	0.0091	-0.3902	1.0000

Appendix A2

Symmetry plot



Quantile normal-plot



Appendix A3: Regression results with enrolment as output and SK-test results

enrolment	Coefficient	Standard error
Recurrent expenditure	.1500208	.0202476**
Number of classrooms	.5741638	.0424572**
Pupil teacher ratio	.8001784	.0683912**
Book student ratio	-.0750313	.0304393**
Dummy (rural=0;urban=1)	.0407845	.0509078
Constant term	-.2755132	.4167779
Obs 229		
R^2 0.7394		
P Reset 0.5212		

Skewness/Kurtosis tests for Normality

			----- joint -----	
Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
resid	0.000	0.000	40.28	0.0000

Appendix A4: Regression results with pass rate as an output and SK-test results

Pass rate	Coefficient	Standard error
Recurrent expenditure	.029731	.0112714 **
Number of classrooms	-.0330403	.0241892
Pupil teacher ratio	-.0821064	.0396242*
Book student ratio	.0179906	.0163034
Dummy(rural=0;urban=1)	-.0714147	.0286517*
Constant term	.5113756	.2364307*
Obs 163		
R^2 0.1545		
P Reset 0.0691		

Skewness/Kurtosis tests for Normality

			----- joint -----	
Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
resid	0.079	0.359	3.98	0.1364

Appendix A5

Jackknife on pass rate efficiency scores

```
.
.  jackknife r(mean): summarize bccscore
(running summarize on estimation sample)

Jackknife replications ( 163)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
.............

Jackknife results                               Number of obs      =        163
                                                Replications       =        163

      command:  summarize bccscore
        _jk_1:  r(mean)
          n():  r(N)
```

	Coef.	Jackknife Std. Err.	t	P>|t|	[95% Conf. Interval]	
_jk_1	.7687117	.0156707	49.05	0.000	.7377664	.7996569

Jackknife on enrolment efficiency scores

```
. jackknife r(mean): summarize  bccscore4enrol
(running summarize on estimation sample)

Jackknife replications ( 163)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
.............

Jackknife results                               Number of obs      =        163
                                                Replications       =        163

      command:  summarize bccscore4enrol
        _jk_1:  r(mean)
          n():  r(N)
```

	Coef.	Jackknife Std. Err.	t	P>|t|	[95% Conf. Interval]	
_jk_1	.6452761	.0158541	40.70	0.000	.6139687	.6765834

Appendix A6: Mann-Whitney results

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

       dummy |      obs    rank sum    expected
-------------+---------------------------------
           0 |       86        7456        7052
           1 |       77        5910        6314
-------------+---------------------------------
    combined |      163       13366       13366

unadjusted variance    90500.67
adjustment for ties     -161.63
                     ----------
adjusted variance      90339.04

Ho: bccsco~l(dummy==0) = bccsco~l(dummy==1)
             z =   1.344
    Prob > |z| =   0.1789
```

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

      dummy1 |      obs    rank sum    expected
-------------+---------------------------------
           0 |       86      6692.5        7052
           1 |       77      6673.5        6314
-------------+---------------------------------
    combined |      163       13366       13366

unadjusted variance    90500.67
adjustment for ties     -773.77
                     ----------
adjusted variance      89726.90

Ho: bccscore(dummy1==0) = bccscore(dummy1==1)
             z =  -1.200
    Prob > |z| =   0.2301
```

	Mean Enrolment score	Mean Pass rate score
Schools in Urban Area	.6223377	.7935065
Schools in Rural Area	.665814	.7465116

Appendix A7; Location, efficiency score, Scale efficiency score and returns-to-scale characteristics of pass rate for each school

Unit name	**BCC Score**	**location**	**scale efficiency score**	**Type of scale inefficiency**
Anoya Zulu Day	1.00	urban	1.00	No scale inefficiency
Arakan	0.88	urban	0.71	DRS
Butondo High Sch	0.55	urban	0.43	DRS
Bwacha High Sch	0.54	urban	0.49	DRS
Canisius Sec Sch	0.91	rural	0.51	DRS
Caritas Convent Sec	0.98	urban	0.66	DRS
chadiza high sch	0.48	urban	0.50	DRS
chama high	0.51	rural	0.70	DRS
Chambishi Sec	0.62	urban	0.87	DRS
Chamboli sec	0.76	urban	0.54	DRS
Chankawa Sec	0.76	urban	0.66	DRS
chassa sec	0.92	rural	0.47	DRS
Chati High Sch	0.36	rural	0.68	DRS
Chavuma Day Sec	0.90	urban	0.99	DRS
Chavuma Junior Sec	0.53	urban	0.88	DRS
Chibombo High Sch	0.72	rural	0.64	DRS
Chifubu High Sch	0.61	urban	0.52	DRS
Chikankata Sec Sch	0.83	rural	0.60	DRS
Chikola Sec	0.56	urban	0.40	DRS
Chikuni Girls Sec	1.00	rural	1.00	No scale inefficiency
Chililabombwe Sec	0.85	urban	0.48	DRS
Chindwin High Sch	1.00	urban	0.85	constant
Chingola High Sch	0.57	urban	0.45	DRS
Chinsali Girls	0.93	urban	0.64	DRS
Chipembi Girls High	0.90	rural	0.60	DRS

Chipempe	1.00	rural	1.00	No scale inefficiency
Chipepo Sec	0.52	rural	0.87	DRS
chisale day	0.30	rural	0.83	DRS
Chitulika High Sch	0.98	urban	0.73	DRS
Chiwala Sec	0.63	rural	0.86	DRS
Choma Sec	0.75	urban	0.78	DRS
Chongwe Sec	0.95	rural	0.77	DRS
Dagama Sch	1.00	urban	1.00	No scale inefficiency
emusa day sch	0.62	rural	0.88	DRS
Fatima Girls	0.99	rural	0.44	DRS
feni sec sch	0.85	rural	0.99	IRS
Francis Davidson	0.91	urban	0.98	IRS
gondar day sec sch	0.81	rural	0.96	IRS
Helen Kaunda Sec	0.80	urban	0.69	DRS
Highland Sec	0.83	urban	0.91	DRS
Highridge	0.61	urban	0.75	DRS
hillside girls high	0.54	urban	0.75	DRS
hofmeyer day sec	1.00	rural	1.00	No scale inefficiency
Holycross sec	0.95	urban	0.88	DRS
Ibenga Girls Sec	0.92	rural	0.95	DRS
Ibex Hill Sch	1.00	urban	1.00	No scale inefficiency
Isoka High Sch	0.58	urban	0.74	DRS
Kabanga Christian	0.72	urban	0.95	DRS
Kabompo Sec sch	0.54	urban	0.66	DRS
Kabunda Girls High S	0.71	rural	0.70	DRS
kabundi High Sch	0.56	urban	0.67	DRS
Kafue Day Sch	0.81	urban	0.74	DRS
Kafue Sec Sch	0.96	rural	0.56	DRS

Kafushi High Sch	0.68	rural	0.41	DRS
Kalabo sec	0.37	rural	0.42	DRS
kalene Day Sec	1.00	rural	0.68	constant
Kalonga High Sch	0.58	urban	0.46	DRS
Kalulushi Sec	0.45	urban	0.57	DRS
kansenshi Sec	0.68	urban	0.73	DRS
kantanshi Sec	0.78	urban	0.57	DRS
Kasama Boys High	0.42	rural	0.54	DRS
Kasempa Boys sec	0.63	rural	0.65	DRS
Kasempa Day Sec	0.49	rural	0.99	IRS
Kasisi Girls	1.00	rural	1.00	No scale inefficiency
katete b. sec	0.60	rural	0.60	DRS
katete day	0.69	rural	0.97	DRS
kaulu	0.88	rural	0.68	DRS
Kawambwa	0.81	rural	0.77	DRS
Kenneth Kaunda	0.73	rural	0.44	DRS
Kitwe boy's High Sch	1.00	urban	1.00	No scale inefficiency
Laura Centre High	0.35	urban	0.99	IRS
Limulunga day sch	0.80	rural	0.87	DRS
Loloma Day sch	0.27	rural	0.82	DRS
Luangwa Sec	0.86	rural	0.52	DRS
Luanshya boys High	0.68	urban	0.73	DRS
Lubushi Seminary	1.00	rural	0.73	constant
Lubuto Sec	0.56	urban	0.53	DRS
Lubwe Girls sec	0.82	rural	0.71	DRS
Lukulu sec sch	0.91	rural	0.95	DRS
lumezi day sec	0.54	rural	0.98	DRS
lundazi day sec sch	1.00	rural	0.41	constant
lundazi high sch	0.65	rural	0.64	DRS
Lunga Day Sch	0.69	rural	1.00	constant

Lusaka High Sch	0.76	urban	0.96	DRS
lusuntha day high	1.00	rural	0.64	constant
Luwingu High Sch	0.70	rural	0.51	DRS
Lwamu Day Sch	1.00	rural	1.00	No scale inefficiency
Maamba Sec	0.88	urban	0.65	DRS
Mabel Shaw Sec	0.73	rural	0.54	DRS
Macha Sec	0.84	rural	0.91	DRS
madzimoyo day sec	0.10	rural	0.98	DRS
Maheba High Sch	0.56	rural	0.66	DRS
Makeni Islamic	0.97	urban	0.70	DRS
Malundu	0.94	urban	0.62	DRS
Masala Sec	0.72	urban	0.52	DRS
Masuku Sec	0.81	rural	0.91	DRS
Matero boys Sec	1.00	urban	0.85	constant
Mazabuka Girls	0.87	urban	0.57	DRS
Mbala High Sch	0.62	rural	0.59	DRS
Metropolitan	1.00	urban	1.00	No scale inefficiency
Mindolo Sec	0.50	urban	0.87	DRS
minga day sec	1.00	rural	1.00	No scale inefficiency
Monze Sec	0.85	rural	0.62	DRS
Mpatamatu High	0.55	urban	0.58	DRS
Mpelembe Sec Sch	0.97	urban	0.53	DRS
Mpika Boys High	1.00	urban	0.56	DRS
Mpongwe high	0.75	rural	0.66	DRS
Mporokoso High Sch	0.52	rural	0.56	DRS
Mufulira high Sch	0.62	urban	0.44	DRS
Mukasa Seminary	1.00	urban	0.88	constant
Mukinge girls sch	0.77	rural	0.56	DRS
Mukuba Sec	0.85	urban	0.49	DRS

Mumbwa High Sch	0.75	urban	0.38	DRS
Mutanda Sec	1.00	rural	0.96	constant
Muyombe high Sch	0.44	rural	0.83	DRS
Muzi High Sch	0.71	urban	0.81	DRS
Mwense	0.56	rural	0.85	DRS
Mwenzo Girls High	0.59	rural	0.59	DRS
Mwinilunga Sec Sch	0.85	rural	0.94	DRS
Naboye Sec	0.92	urban	0.69	DRS
Nambala High sch	0.66	rural	0.55	DRS
Namwala Sec	0.83	rural	0.56	DRS
Nangano day	1.00	rural	1.00	No scale inefficiency
ndeke High Sch	0.98	urban	0.75	DRS
Ng'ona Day Sec	0.31	rural	0.91	DRS
Njase Girls	0.86	urban	0.56	DRS
Nkulumashiba Sec	0.52	urban	0.68	DRS
nyimba sec	0.65	rural	0.81	DRS
Olympia	1.00	urban	1.00	No scale inefficiency
Parklands High Sch	0.78	rural	0.73	DRS
Pemba Sec	1.00	rural	1.00	No scale inefficiency
petauke day sec	0.49	rural	0.98	DRS
petauke sec	0.65	urban	0.79	DRS
Roan Antelope high	0.59	urban	0.73	DRS
Rodes Park Sec Sch	0.94	urban	0.63	DRS
Roma Girls Sec	0.96	urban	0.52	DRS
Rusangu Sec	0.86	rural	0.82	DRS
Sacred heart Convent	1.00	urban	0.71	constant
Samfya Sec	1.00	rural	1.00	No scale inefficiency
Sanje High Sch	1.00	rural	0.89	constant

Senanga sec sch	0.78	rural	0.60	DRS
Sikalongo Sec	0.64	rural	0.62	DRS
Solwezi Day sec Sch	0.76	rural	0.96	DRS
SpringBoard	1.00	urban	0.87	constant
St Emonds Sec	0.94	urban	0.68	DRS
St Josephs Sec	0.99	rural	0.45	DRS
St Marks Sec	0.84	rural	0.50	DRS
St Marys Sec	0.98	urban	0.77	DRS
St Raphaels Sec	1.00	urban	0.89	constant
St. Andrews High	1.00	urban	0.76	constant
St. john's sec sch	1.00	urban	0.95	constant
st. lukes high sch	0.48	rural	0.66	DRS
st. mary's jnr. Semi	1.00	rural	1.00	No scale inefficiency
St. Mary's Sec Sch	0.77	rural	0.50	DRS
st. monica's sec sch	1.00	urban	0.68	constant
St.francis	0.89	rural	0.53	DRS
ST.marys sec	1.00	urban	1.00	No scale inefficiency
Twashuka Sec Sch	0.69	urban	0.77	DRS
Twingi High Sch	0.70	rural	0.96	DRS
UCZ sefula sec sch	0.69	rural	0.68	DRS
vubwi day sec sech	0.56	rural	0.99	IRS
Zambezi Day Sec Sch	0.58	rural	0.83	DRS
Zimba Sec	0.80	urban	0.63	DRS

Appendix A8	Comparison of DEA and SFA Ranks for ENROLMENT Efficiency of Secondary Schools					
position	**SFA (EXP) RESULTS for ENROLMENT**			position	**DEA (BCC) RESULTS for ENROLMENT**	
	schools	te			unit name	score
1	Samfya Sec	0.966194		1	Anoya Zulu Day	100.00%
2	Kasisi Girls	0.910884		2	Banani International	100.00%
3	Anoya Zulu Day	0.904572		3	Chindwin High Sch	100.00%
4	ndola Sch For Cont Edu	0.902228		4	Chirundu Sec Sch	100.00%
5	Sanje High Sch	0.896164		5	Chuundu AEAZ	100.00%
6	nyimba sec	0.889963		6	Dagama Sch	100.00%
7	Rodes Park Sec Sch	0.889269		7	Helen Kaunda Sec	100.00%
8	Pemba Sec	0.883752		8	Ibex Hill Sch	100.00%
9	Chindwin High Sch	0.869612		9	kabundi High Sch	100.00%
10	Kalonga High Sch	0.865968		10	kansenshi Sec	100.00%
11	Chinsali Girls	0.861388		11	Kasenga Junior Sec	100.00%
12	Kasama Boys High Sch	0.860465		12	Kasisi Girls	100.00%
13	kabundi High Sch	0.859446		13	Kemuz Pvt Sec	100.00%
14	Highridge	0.859173		14	Kitwe boy's High Sch	100.00%
15	St. john's sec sch	0.853964		15	Lstone Day Sch	100.00%
16	Senanga sec sch	0.851323		16	Lunga Day Sch	100.00%
17	Holycross sec	0.850465		17	lusuntha day high sch	100.00%
18	chama high	0.850315		18	Lwamu Day Sch	100.00%
19	Helen Kaunda Sec	0.849747		19	Mindolo Sec	100.00%
20	hillside girls high	0.849115		20	minga day sec	100.00%
21	Mupapa Pvt Sec Sch	0.848357		21	Nakonde High Sch	100.00%
22	Mufulira high Sch	0.847953		22	Nangano day	100.00%
23	Roan Antelope high	0.845784		23	ndola Sch For Cont Edu	100.00%
24	kansenshi Sec	0.845036		24	Pemba Sec	100.00%
25	Mindolo Sec	0.842017		25	Ponde Day High Sch	100.00%
26	gondar day sec sch	0.84005		26	Samfya Sec	100.00%
27	Chongwe Sec	0.837636		27	Sanje High Sch	100.00%
28	Fatima Girls	0.837624		28	ST.marys sec	96.00%
29	Lwamu Day Sch	0.837214		29	hofmeyer day sec	95.40%
30	kalene Day Sec	0.836634		30	Mwinilunga Sec Sch	93.00%
31	Ibex Hill Sch	0.835171		31	Luanshya boys High	92.80%
32	Bwacha High Sch	0.834948		32	Roan Antelope high	90.90%
33	Chitulika High Sch	0.834398		33	Chiwala Sec	89.60%
34	Mpika Boys High	0.833198		34	Rodes Park Sec Sch	87.90%
35	Luanshya boys High	0.833164		35	gondar day sec sch	86.50%
36	st. monica's sec sch	0.832091		36	Senanga sec sch	85.40%
37	petauke sec	0.831573		37	Kasama Boys High Sch	85.30%
38	chadiza day sec	0.828798		38	Mufulira high Sch	84.90%

39	St Marys Sec	0.827908		39	ndeke High Sch	84.70%
40	Canisius Sec Sch	0.827785		40	Kalulushi Sec	84.20%
41	lundazi high sch	0.827249		41	petauke sec	84.00%
42	Kalulushi Sec	0.827053		42	Chamboli sec	83.00%
43	kantanshi Sec	0.825741		43	Mumbwa High Sch	82.70%
44	Mbala High Sch	0.823541		44	Chifubu High Sch	82.60%
45	Luangwa Sec	0.823065		45	Highridge	82.60%
46	Chifubu High Sch	0.8208		46	Kalonga High Sch	80.00%
47	St Raphaels Sec	0.818643		47	Mwense	79.80%
48	Zimba Sec	0.818189		48	Maiteneke	79.60%
49	Twashuka Sec Sch	0.817921		49	nyimba sec	79.60%
50	Chiwala Sec	0.817408		50	Monze Sec	79.40%
51	Arakan	0.817202		51	Chinsali Girls	78.50%
52	minga day sec	0.816716		52	Chikola Sec	77.90%
53	Lunga Day Sch	0.815543		53	lundazi high sch	77.90%
54	Chirundu Sec Sch	0.815022		54	Bwacha High Sch	77.60%
55	Mitanto Sec	0.814263		55	hillside girls high	77.60%
56	Solwezi Day sec Sch	0.814021		56	kalene Day Sec	76.30%
57	lundazi day sec sch	0.813975		57	chadiza day sec	76.00%
58	lumezi day sec	0.813344		58	Namwala Sec	75.40%
59	Butondo High Sch	0.81244		59	Arakan	75.00%
60	Chambishi Sec	0.812351		60	mphamba day sec	75.00%
61	Mukuba Sec	0.81161		61	Chongwe Sec	74.70%
62	Mutanda Sec	0.811353		62	kantanshi Sec	74.60%
63	Mwense	0.810298		63	Mbala High Sch	74.20%
64	Francis Davidson	0.809328		64	Mpelembe Sec Sch	72.90%
65	Chipepo Sec	0.808779		65	St. john's sec sch	72.80%
66	St. theresa girls High sch	0.808586		66	vubwi day sec sech	72.30%
67	Nkulumashiba Sec	0.806577		67	Masala Sec	72.00%
68	Lukulu sec sch	0.806414		68	lundazi day sec sch	70.60%
69	Chililabombwe Sec	0.805704		69	Lubuto Sec	70.50%
70	Chipempe	0.805223		70	Twashuka Sec Sch	70.20%
71	Lstone Day Sch	0.804421		71	Mpatamatu High Sch	69.90%
72	mphamba day sec	0.803193		72	Butondo High Sch	69.70%
73	Chamboli sec	0.801148		73	Holycross sec	68.50%
74	Matero boys Sec	0.80102		74	Mitondo	68.00%
75	Raphael Kombe GH SC	0.800495		75	Chingola High Sch	67.70%
76	ndeke High Sch	0.799754		76	St. Andrews High Sch	67.60%
77	St Emonds Sec	0.798333		77	Mukuba Sec	67.40%
78	Lubuto Sec	0.798228		78	Chambishi Sec	67.30%
79	Luwingu High Sch	0.798016		79	Chipepo Sec	66.50%
80	katete day	0.797127		80	Francis Davidson	66.50%
81	Mumbwa High Sch	0.795912		81	Mpika Boys High	66.10%
82	Maamba Sec	0.794898		82	Chavuma Day Sec Sch	65.50%

83	Kasempa Day Sec Sch	0.794463		83	Chililabombwe Sec	65.10%
84	St Josephs Sec	0.794277		84	Canisius Sec Sch	65.00%
85	Chingola High Sch	0.793201		85	chadiza high schh	64.90%
86	Chikola Sec	0.792883		86	Njase Girls	64.50%
87	Sekela High	0.79246		87	Zambezi Day Sec Sch	64.50%
88	Dagama Sch	0.791646		88	Mutanda Sec	64.10%
89	St. Andrews High Sch	0.790701		89	Mitanto Sec	63.30%
90	Chibombo High Sch	0.790071		90	chama high	63.10%
91	Njase Girls	0.789944		91	Fatima Girls	62.70%
92	Mpatamatu High Sch	0.789371		92	Luwingu High Sch	62.70%
93	Namwala Sec	0.788437		93	Ibenga Girls Sec	62.40%
94	Kasempa Boys sec sch	0.788348		94	Chibombo High Sch	61.90%
95	vubwi day sec sech	0.788293		95	Rusangu Sec	61.90%
96	Chingola Sch for Con	0.788052		96	Nkulumashiba Sec	61.70%
97	St Marks Sec	0.786621		97	St Emonds Sec	61.70%
98	Mwinilunga Sec Sch	0.78556		98	Solwezi Day sec Sch	61.50%
99	Lubwe Girls sec	0.784893		99	St Marys Sec	61.00%
100	ST.marys sec	0.784674		100	kaulu	60.60%
101	chisale day	0.783911		101	Malela Sec	60.60%
102	Kawambwa	0.783033		102	Muleya High Sch	60.50%
103	feni sec sch	0.780291		103	Zimba Sec	59.90%
104	Kabunda Girls High Sch	0.778722		104	Isoka High Sch	59.70%
105	Mpongwe high	0.776798		105	Kawambwa	59.70%
106	Kabanga Christian	0.776289		106	Muzi High Sch	58.80%
107	Caritas Convent Sec	0.77623		107	Lukulu sec sch	57.80%
108	Muzi High Sch	0.77612		108	Chankawa Sec	57.70%
109	Chavuma Junior Sec	0.77589		109	Kasempa Day Sec Sch	57.70%
110	Limulunga day sch	0.775011		110	Chikankata Sec Sch	57.60%
111	Chavuma Day Sec Sch	0.773778		111	Kenneth Kaunda High	57.60%
112	Roma Girls Sec	0.772698		112	Chitulika High Sch	57.20%
113	Malela Sec	0.772006		113	Matero boys Sec	57.00%
114	Mukonchi High Sch	0.771383		114	St Josephs Sec	56.80%
115	Chankawa Sec	0.771179		115	lumezi day sec	56.40%
116	Monze Sec	0.770957		116	katete b. sec	56.20%
117	Masala Sec	0.770598		117	Mupapa Pvt Sec Sch	56.00%
118	Mukinge girls sch	0.769184		118	Luangwa Sec	55.70%
119	Laura Centre High Sch	0.768782		119	petauke day sec	55.70%
120	Muf.Sch.For Cont.Edu	0.766693		120	St Raphaels Sec	55.40%
121	Kabompo Sec sch	0.76622		121	madzimoyo day sec	55.30%
122	madzimoyo day sec	0.763909		122	Maamba Sec	55.10%
123	Mpelembe Sec Sch	0.762028		123	St Marks Sec	54.60%
124	Zambezi Day Sec Sch	0.761981		124	Kasempa Boys sec sch	54.50%
125	katete b. sec	0.761212		125	Sekela High	54.50%
126	St. Mary's Sec Sch	0.761148		126	st. monica's sec sch	54.50%

127	Kemuz Pvt Sec	0.760183		127	Laura Centre High Sch	54.00%
128	chadiza high schh	0.757297		128	St. theresa girls High sch	53.50%
129	chassa sec	0.75696		129	Mporokoso High Sch	53.40%
130	St.francis	0.754549		130	Sikalongo Sec	53.30%
131	Parklands High Sch	0.754172		131	Kabompo Sec sch	53.20%
132	Maheba High Sch	0.753634		132	feni sec sch	53.10%
133	Sikalongo Sec	0.752139		133	Kalabo sec	52.80%
134	Mazabuka Girls	0.751981		134	Parklands High Sch	52.80%
135	Mwenzo Girls High	0.751653		135	katete day	52.50%
136	Mabel Shaw Sec	0.749734		136	Mukonchi High Sch	52.20%
137	Mporokoso High Sch	0.748229		137	Raphael Kombe GH SC	51.80%
138	Rusangu Sec	0.746872		138	Mukinge girls sch	51.70%
139	Liberty High Sch	0.746394		139	Chipempe	51.50%
140	Olympia	0.745263		140	Chipembi Girls High	50.80%
141	Mitondo	0.744669		141	Mabel Shaw Sec	50.80%
142	Isoka High Sch	0.743337		142	Mpongwe high	50.70%
143	Kafue Sec Sch	0.740767		143	SpringBoard Academy	49.90%
144	Banani International	0.740288		144	Leopards Hill	49.40%
145	UCZ sefula sec sch	0.740058		145	Kafue Sec Sch	49.30%
146	Kenneth Kaunda High	0.739905		146	Nambala High sch	48.40%
147	Muleya High Sch	0.737965		147	Muf.Sch.For Cont.Edu	47.80%
148	Leopards Hill	0.736944		148	St.francis	47.70%
149	SpringBoard Academy	0.735469		149	UCZ sefula sec sch	47.50%
150	emusa day sch	0.730932		150	St. Mary's Sec Sch	47.30%
151	Ibenga Girls Sec	0.730124		151	Jiundu day sec sch	47.20%
152	Maiteneke	0.727388		152	Muyombe high Sch	46.50%
153	Kalabo sec	0.723953		153	Caritas Convent Sec	46.30%
154	Chipembi Girls High	0.721052		154	Mwenzo Girls High	45.90%
155	Muyombe high Sch	0.721047		155	Roma Girls Sec	45.70%
156	Nangano day	0.718655		156	Lubwe Girls sec	45.40%
157	petauke day sec	0.716691		157	chassa sec	45.00%
158	Kitwe boy's High Sch	0.71365		158	Chingola Sch for Con	44.90%
159	st. mary's jnr. Semi	0.710734		159	Kabanga Christian	44.60%
160	Ng'ona Day Sec	0.704312		160	Maheba High Sch	44.60%
161	Loloma Day sch	0.703673		161	Chavuma Junior Sec	44.00%
162	Chikankata Sec Sch	0.703165		162	Limulunga day sch	43.90%
163	Ponde Day High Sch	0.703071		163	Mazabuka Girls	42.90%
164	Mukasa Seminary	0.701845		164	Kafue Day Sch	42.80%
165	ST.Steven's sec Sch	0.697127		165	Kabunda Girls High Sch	42.40%
166	Twingi High Sch	0.695934		166	chisale day	42.30%
167	kaulu	0.693782		167	mfuwe day sec	42.30%
168	Kafushi High Sch	0.684846		168	Kafushi High Sch	42.00%
169	Kafue Day Sch	0.681194		169	emusa day sch	41.60%
170	Kasenga Junior Sec	0.681046		170	Loloma Day sch	41.50%

171	lusuntha day high sch	0.678711		171	st. mary's jnr. Semi	41.40%
172	Macha Sec	0.677515		172	Lukwesa High Sch	41.20%
173	Lusaka High Sch	0.670596		173	Liberty High Sch	39.70%
174	hofmeyer day sec	0.667616		174	Nkrumah	39.40%
175	Masuku Sec	0.665851		175	Macha Sec	39.20%
176	muchinga High Sch	0.665527		176	Satung C-OP Sch	38.80%
177	Chati High Sch	0.662714		177	nyanje day sec	38.50%
178	Nkrumah	0.660635		178	Ng'ona Day Sec	37.10%
179	Lubushi Seminary	0.656047		179	Olympia	37.10%
180	Chuundu AEAZ	0.651857		180	Lusaka High Sch	36.60%
181	nyanje day sec	0.621568		181	Chikuni Girls Sec	36.10%
182	Sacred heart Convent	0.618371		182	Chati High Sch	36.00%
183	Highland Sec	0.612576		183	Twingi High Sch	35.30%
184	Nambala High sch	0.609154		184	chama day high sch	34.90%
185	chama day high sch	0.602095		185	Mukasa Seminary	34.50%
186	Makeni Islamic	0.595715		186	Masuku Sec	34.40%
187	st. lukes high sch	0.590117		187	muchinga High Sch	33.90%
188	Lukwesa High Sch	0.584105		188	Chika High Sch	31.60%
189	Metropolitan	0.581709		189	Livingstone High Sec	30.30%
190	Chika High Sch	0.580832		190	Ebernezer Sec Sch	27.80%
191	Ebernezer Sec Sch	0.572472		191	ST.Steven's sec Sch	27.80%
192	Satung C-OP Sch	0.565527		192	Makeni Islamic	27.00%
193	Livingstone High Sec	0.561952		193	Lubushi Seminary	26.90%
194	Tum Sec School	0.536916		194	Metropolitan	26.90%
195	Jiundu day sec sch	0.525993		195	Highland Sec	26.70%
196	Nakonde High Sch	0.49973		196	st. lukes high sch	26.40%
197	mfuwe day sec	0.464254		197	Sacred heart Convent	25.40%
198	mwase day high sch	0.463592		198	Tum Sec School	21.30%
199	Malundu	0.413021		199	Malundu	17.00%
200	Chifundo jr &High Sch	0.356275		200	mwase day high sch	17.00%
201	Chikuni Girls Sec	0.15524		201	Chifundo jr &High Sch	11.00%

Appendix A9: Comparison of pass rate and enrolment rate

		Enrolment-rate	pass-rate
	Unit name	Score	Score1
1	Anoya Zulu Day	100.00%	100.00%
2	Chindwin High Sch	100.00%	100.00%
3	Dagama Sch	100.00%	100.00%
4	Ibex Hill Sch	100.00%	100.00%
5	Kasisi Girls	100.00%	100.00%
6	Kitwe boy's High Sch	100.00%	100.00%
7	lusuntha day high sch	100.00%	100.00%
8	Lwamu Day Sch	100.00%	100.00%
9	minga day sec	100.00%	100.00%
10	Nangano day	100.00%	100.00%
11	Pemba Sec	100.00%	100.00%
12	Samfya Sec	100.00%	100.00%
13	Sanje High Sch	100.00%	100.00%
14	Helen Kaunda Sec	100.00%	80.20%
15	Lunga Day Sch	100.00%	69.10%
16	kansenshi Sec	100.00%	67.90%
17	kabundi High Sch	100.00%	56.00%
18	Mindolo Sec	100.00%	50.00%
19	ST.marys sec	96.00%	100.00%
20	hofmeyer day sec	95.40%	100.00%
21	Mwinilunga Sec Sch	93.00%	84.70%
22	Luanshya boys High	92.80%	68.00%
23	Roan Antelope high	90.90%	58.70%
24	Chiwala Sec	89.60%	63.00%
25	Rodes Park Sec Sch	87.90%	94.40%
26	gondar day sec sch	86.50%	80.70%
27	Senanga sec sch	85.40%	77.80%
28	Kasama Boys High Sch	85.30%	42.30%
29	Mufulira high Sch	84.90%	61.60%
30	ndeke High Sch	84.70%	97.70%
31	Kalulushi Sec	84.20%	44.60%
32	petauke sec	84.00%	64.80%
33	Chamboli sec	83.00%	75.80%
34	Mumbwa High Sch	82.70%	74.70%
35	Highridge	82.60%	61.40%
36	Chifubu High Sch	82.60%	60.60%
37	Kalonga High Sch	80.00%	57.80%
38	Mwense	79.80%	55.60%
39	nyimba sec	79.60%	64.70%

40	Monze Sec	79.40%	85.20%
41	Chinsali Girls	78.50%	93.00%
42	lundazi high sch	77.90%	64.90%
43	Chikola Sec	77.90%	55.50%
44	Bwacha High Sch	77.60%	54.00%
45	hillside girls high	77.60%	53.70%
46	Choma Sec	76.50%	75.00%
47	kalene Day Sec	76.30%	100.00%
48	Namwala Sec	75.40%	83.30%
49	Arakan	75.00%	87.60%
50	Chongwe Sec	74.70%	94.50%
51	kantanshi Sec	74.60%	78.20%
52	Mbala High Sch	74.20%	61.70%
53	Mpelembe Sec Sch	72.90%	97.30%
54	St. john's sec sch	72.80%	100.00%
55	vubwi day sec sech	72.30%	56.40%
56	Masala Sec	72.00%	72.30%
57	Naboye Sec	71.10%	92.00%
58	lundazi day sec sch	70.60%	100.00%
59	Lubuto Sec	70.50%	56.10%
60	Twashuka Sec Sch	70.20%	68.50%
61	Mpatamatu High Sch	69.90%	55.40%
62	Butondo High Sch	69.70%	54.70%
63	Holycross sec	68.50%	95.20%
64	Chingola High Sch	67.70%	57.00%
65	St. Andrews High Sch	67.60%	100.00%
66	Mukuba Sec	67.40%	84.50%
67	Chambishi Sec	67.30%	62.20%
68	Francis Davidson	66.50%	90.50%
69	Chipepo Sec	66.50%	52.30%
70	Mpika Boys High	66.10%	99.50%
71	Chavuma Day Sec Sch	65.50%	90.40%
72	Chililabombwe Sec	65.10%	84.80%
73	Canisius Sec Sch	65.00%	91.40%
74	chadiza high schh	64.90%	48.30%
75	Njase Girls	64.50%	86.10%
76	Zambezi Day Sec Sch	64.50%	58.00%
77	Mutanda Sec	64.10%	100.00%
78	chama high	63.10%	51.10%
79	Fatima Girls	62.70%	98.50%
80	Luwingu High Sch	62.70%	69.90%
81	Ibenga Girls Sec	62.40%	91.90%
82	Rusangu Sec	61.90%	85.60%
83	Chibombo High Sch	61.90%	72.20%

84	St Emonds Sec	61.70%	94.30%
85	Nkulumashiba Sec	61.70%	51.70%
86	Solwezi Day sec Sch	61.50%	75.80%
87	St Marys Sec	61.00%	97.50%
88	kaulu	60.60%	87.60%
89	Zimba Sec	59.90%	80.40%
90	Kawambwa	59.70%	80.70%
91	Isoka High Sch	59.70%	58.30%
92	Muzi High Sch	58.80%	70.90%
93	Lukulu sec sch	57.80%	90.80%
94	Chankawa Sec	57.70%	75.80%
95	Kasempa Day Sec Sch	57.70%	49.00%
96	Chikankata Sec Sch	57.60%	82.90%
97	Kenneth Kaunda High	57.60%	72.50%
98	Chitulika High Sch	57.20%	97.70%
99	Matero boys Sec	57.00%	100.00%
100	St Josephs Sec	56.80%	98.80%
101	lumezi day sec	56.40%	54.10%
102	katete b. sec	56.20%	60.40%
103	Luangwa Sec	55.70%	85.90%
104	petauke day sec	55.70%	48.80%
105	St Raphaels Sec	55.40%	100.00%
106	madzimoyo day sec	55.30%	9.70%
107	Maamba Sec	55.10%	88.40%
108	St Marks Sec	54.60%	83.50%
109	st. monica's sec sch	54.50%	100.00%
110	Kasempa Boys sec sch	54.50%	62.90%
111	Laura Centre High Sch	54.00%	34.80%
112	Mporokoso High Sch	53.40%	52.20%
113	Sikalongo Sec	53.30%	64.40%
114	Kabompo Sec sch	53.20%	53.70%
115	feni sec sch	53.10%	85.00%
116	Parklands High Sch	52.80%	77.70%
117	Kalabo sec	52.80%	37.20%
118	katete day	52.50%	69.20%
119	Mukinge girls sch	51.70%	77.20%
120	Chipempe	51.50%	100.00%
121	Chipembi Girls High	50.80%	89.90%
122	Mabel Shaw Sec	50.80%	73.00%
123	Mpongwe high	50.70%	74.50%
124	SpringBoard Academy	49.90%	100.00%
125	Kafue Sec Sch	49.30%	96.30%
126	Nambala High sch	48.40%	65.50%
127	St.francis	47.70%	88.70%

128	UCZ sefula sec sch	47.50%	69.40%
129	St. Mary's Sec Sch	47.30%	77.00%
130	Muyombe high Sch	46.50%	43.50%
131	Caritas Convent Sec	46.30%	97.60%
132	Mwenzo Girls High	45.90%	58.50%
133	Roma Girls Sec	45.70%	95.80%
134	Lubwe Girls sec	45.40%	81.80%
135	chassa sec	45.00%	91.80%
136	Kabanga Christian	44.60%	72.00%
137	Maheba High Sch	44.60%	56.10%
138	Chavuma Junior Sec	44.00%	52.60%
139	Limulunga day sch	43.90%	79.80%
140	Mazabuka Girls	42.90%	86.80%
141	Kafue Day Sch	42.80%	80.50%
142	Kabunda Girls High Sch	42.40%	71.40%
143	chisale day	42.30%	30.00%
144	Kafushi High Sch	42.00%	67.80%
145	emusa day sch	41.60%	62.20%
146	Loloma Day sch	41.50%	26.70%
147	st. mary's jnr. Semi	41.40%	100.00%
148	Macha Sec	39.20%	83.80%
149	Olympia	37.10%	100.00%
150	Ng'ona Day Sec	37.10%	30.70%
151	Lusaka High Sch	36.60%	75.80%
152	Chikuni Girls Sec	36.10%	100.00%
153	Chati High Sch	36.00%	35.80%
154	Twingi High Sch	35.30%	69.90%
155	Mukasa Seminary	34.50%	100.00%
156	Masuku Sec	34.40%	81.00%
157	Makeni Islamic	27.00%	97.10%
158	Lubushi Seminary	26.90%	100.00%
159	Metropolitan	26.90%	100.00%
160	Highland Sec	26.70%	83.40%
161	st. lukes high sch	26.40%	48.30%
162	Sacred heart Convent	25.40%	100.00%
163	Malundu	17.00%	94.30%