Technical Efficiency and Total Factor Productivity of Primary Schools in Kenya

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Declaration

I, the undersigned hereby declare that this project is my original work and that it has never been submitted for any purpose at this or any other University or Institution of Higher Learning. Duly acknowledgements have been made in instances where other people's work has been used. I am solely responsible for any errors contained herein.

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Dedication

To my parents (Francis and Nancy Kanina) for your love, support and always believing in me.

To my late friend Joan Migwi, all my knowledge in economics cannot help me understand your sudden demise. In you i had a great friend.

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Coming this far would have remained only but a dream had it not been for the precious gift of earlier education. This therefore makes me heavily indebted to my parents, who had to sacrifice so much just to make sure their lastborn attains good education. For this, I salute you.

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List of Acronyms

AE	Allocative Efficiency
AP	Average Product
DEA	Data Envelopment Analysis
DFA	Distribution Free Analysis
EFA	Education for All
FDH	Free Disposal Hull
FPE	Free Primary Education
GDP	Gross Domestic Product
GER	Gross Enrolment Rate
GoK	Government of Kenya
KCPE	Kenya Certificate of Primary Education
KSH	Kenya Shilling
MDGs	Millennium Development Goals
MP	Marginal Product
MoE	Ministry of Education
NER	Net Enrolment Rate
PTR	Pupil Teacher Ratio
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TFA	Thick Frontier Analysis
TFP	Total factor productivity
TPR	Teacher Pupil Ratio
UPE	Universal Primary Education

Abstract

This study evaluates the technical efficiency and the changes in total factor productivity of public primary schools Kenya grouped into 72 districts. The approaches used are the data envelopment analysis (DEA) and DEA-based Malmquist productivity index. In addition, a second-stage tobit regression is estimated to determine the possible causes of inefficiency. Mean scores in the Kenya Certificate of Primary Education (KCPE) examination are used as output while gross enrolments, pupil-classes ratio and pupil-teacher ratio are used as inputs. In the second stage, a dummy variable to capture the location of the district is included in the model.

The results indicate that the mean efficiency score of the 72 districts is 90.8 percent. The overall technical efficiency of the 72 districts ranges from 70 to 100 percent with 10 of the districts being technically efficient. The variable returns to scale DEA values indicate that on average, schools can improve their performance by 9.2 percent using their current level of inputs. The Malmquist productivity index shows that there is an increase in total factor productivity by 2.2 percent over the entire period. The productivity gains was as a result of technological change

The analysis of Tobit regression shows a negative significant relationship between Pupil Teacher Ratio is and efficiency thus high pupil teacher ratio is associated with inefficiency. This may be attributed to congestion that minimizes pupil teacher contact therefore the quality is compromised. Districts located in urban areas are found to perform better than their rural counterparts. This may be due to the differences in the socio-economic factors which may be more favourable in urban regions than in rural regions.

The study recommends that government policy should be geared towards improving the pupil teacher ratios. The rising levels of enrolment should be addressed by increasing the number of classes as well as the number of teachers. Teacher motivation is important in achieving these goals. This may be done through better terms of employment and also awards and recognition. The teaching of pupils in shifts should also be explored to help cope with the increasing enrolments and thus ensure that all children of school going age get a place in school without compromising quality.

1 Introduction

1.1 Background

Evidence globally suggests that education is an effective and catalytic vehicle for national development. According to the World Bank, education imparts people with the right attitude and skills giving them an equal opportunity to make a decent living. It is must therefore be given attention in the countries' quest for the realization of the Millennium Development Goals (MDGs), (World Bank, 2011)[1].

Kenya among other sub-Saharan African countries emphasized on the importance of education in the development of African continent in 1999. In this regard, African governments committed to provide their citizens with quality and relevant education (UNESCO, 1999)[2]. This was then endorsed in the Dakar framework for action (UNESCO, 2000)[3] where countries committed to achieve Education for All (EFA) by 2015. The Sessional Paper No.1 of 2005 on a policy framework for education, training and research (GOK, 2005), provided the policy direction for the implementation of Free Primary Education (FPE) to enable achievement of Universal Primary Education (UPE). Indeed, in the year 2010, education was enshrined as a basic right in the constitution of Kenya.

1.11 Free Primary Education in Kenya

Free Primary Education (FPE) in Kenya was introduced in 2003. Under the scheme, the government disburses Ksh 1,020 per pupil per annum. In addition, there is a school feeding programme limited to the arid and semi-arid areas (GOK, 2012a). The main objectives of FPE are to improve access and equity; enhance completion rates and improve quality and relevance of education (GOK, 2012a).

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1 http://go.worldbank.org/F5K8Y429G0

2 http://www.unesco.org/education/wef/en-docs/findings/Africa.pdf

3 http://unesdoc.unesco.org/images/0012/001211/121147e.pdf

Since the implementation of FPE, the primary education sector has experienced a tremendous growth both in enrolment and completion rates. Enrolment in Public primary schools increased from 5,925,355 in 2002 to 6,905,355 pupils in 2003, an increase of 980,000 pupils. This further rose to 7,122,407 in 2004, 7,260,118 in 2006 and 7,639,000 in 2008. Completion rate rose from 68 percent in 2003 to 81 percent in 2007 while transition rate rose from 46 percent in 2002 to 60 percent in 2006 (GOK, *nd*, GOK, 2009 and GOK, 2008).

The pupil classes ratio increased from 34.4 in 2003 to 35.5 in 2007. In 2005, the pupil classes ratio ranged from 32.0 in Eastern Province to 45.6 in Nairobi Province. The number of teachers increased from 172, 424 in 2002 to 178,622 in 2003, an increase in 3.5 percent. The national Pupil Teacher Ratio (PTR) increased from 34 in 2002 to 45 in 2008 but regions such as North-eastern recording very high PTR of 62 despite the Kenya's standard PTR of 40 (GOK, *nd* and GOK, 2009).

According to (GOK, 2012a), though the sector has witnessed a major growth, it has faced a number of challenges. Some of the challenges include: (1) congested classrooms; (2) very high pupil teacher ratio in some regions; (3) poor infrastructure; (4) High morbidity due to HIV/AIDs that have led to decrease in the number of teachers as well as increase in the number of orphans in school; (5) high poverty levels that negatively affect the retention rate; (6) high levels of corruption that have led to embezzlement of funds meant for FPE and (7) the high cost of operations where significant amount of resources are used in seminars and workshops. These challenges if not well addressed will jeopardise the achievements of the objectives of FPE.

1.12 Trend in Education Expenditure

Education sector in Kenya consumes a significant portion of the total government budget. The budgetary resources in this sector have been growing in real terms maintaining an average of 20 percent share of the budget. In 2010/2011 financial year, the budgetary allocation to the education sector was Ksh 201 billion increasing to 216 billion in the year 2011/2012 and Ksh 233 billion in 2012/2013. In 2012/13 FPE share was Ksh 8.3 billion while teacher salaries amounted to Ksh 118.7 billion which was a growth of 9.3 percent from the previous year (GOK, 2012b). The level of education expenditure is quite high and is expected to continue rising with the increase in enrolments. Table 1 shows the trend in education spending for the last 9 years. The spending has increased by about 45 percent in real terms over the period 2003/04 to 2011/12. This calls for proper utilization of the resources so as to maximize on the positive gains from the sector.

Table 1.1: Trend in education spending

	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Education Expenditure in Billions (Ksh)	74.6	83.4	96.2	108.6	126.2	141.6	166.1	201.1	216.6
Education Expenditure as a % of Govt. Spending	19.8	22	22.2	21.3	19	20.4	20.6	20	22.1
Primary Education Spending	42.65	42.17	44.25	48.04	49.64	47.83	44.42	40.58	
per capita spending-primary education, Ksh	4945	5812	6251	6862	7463	7831	8306	8537	

Source: GOK, KENAO Audited Appropriation Accounts

The Kenya Vision 2030 lays out the country's roadmap of becoming a middle income economy by the year 2030. For the country to achieve this status, education will play a key role in building the necessary human capital needed for industrialisation as well as linking the sector with the other sectors of the economy (GOK, 2007). The education sector is therefore the bedrock on which the country will hinge on for socio-economic and political prosperity.

However, with increased budget allocation and rapid expansion, a fundamental question among policy planners in the education sector is whether primary education sub-sector is utilising the resources efficiently. Given that information on the level of efficiency in primary schools is lacking, it is necessary to establish whether the sub-sector is efficiently utilizing the scarce resources.

1.2 Problem Statement

The introduction of FPE in Kenya has led to a significant increase in access to primary education. As a result, government expenditure in the sector has also been rising over time. The sector has faced a number of challenges such as diversion of funds to seminars, workshops and consultancy services; lack of adequate infrastructure; shortage of teachers and high poverty levels. Although these challenges have compromised the retention rates, the country has made major strides towards achieving Education for All by 2015.

Despite the achievements in the FPE, the question in the minds of policy makers and planners is whether the sector could have achieved more outputs in terms of better performance in the examinations with the resources already allocated. There is a likelihood that the achievements made could have been attained with fewer resources or more outputs could have been realized. However, studies on efficiency of schools in Kenya are almost non-existent and very little is known about the efficiency in which different schools utilize the existing resources to generate the requisite outputs. To the best of my knowledge, there have not been attempts to examine the technical efficiency of primary schools yet it's imperative that the schools use the limited resources as efficiently as possible. This study aims to fill this knowledge gap.

1.3 Study Objectives

The study aims at determining the extent to which public primary schools are utilizing available resources to produce maximum outputs. The specific objectives of the study are to:

1. Evaluate the technical efficiency of public primary schools in Kenya;
2. Assess the total factor productivity changes of primary schools in Kenya; and
3. Based on 1 and 2 suggest policy implications for improving technical efficiency in public primary schools.

1.4 Justification of the Study

Ergulen & Torun (2009) argued that efficiency in education is important given that resources are scarce and a robust education system is the foundation of economic prosperity. However, studies on efficiency of schools in Kenya are almost non-existent. The only available study by Abagi and Odipo (1997) examined the internal efficiency of primary schools whose measure is the completion rate using a process approach. The study did not address technical efficiency of schools but only looked at the basic school processes. Ngware et al., (2007) on the other hand only analysed the factors determining performance of primary schools in Kenya.

For the education sector to make significant contribution to the country's growth and development, it must operate efficiently amidst of scarce resources and many competing needs. Inefficiency in this sector will frustrate goals set in the Vision 2030 and thus the need to examine the efficiency of public primary schools and deal with any issues that lead to inefficiency. Improved efficiency curtails wasteful use of resources and enables the Country to achieve the national education goals without compromising the quality of outputs. There is the need to identify the best practice schools that would be emulated by the inefficient schools.

Knowledge of efficiency levels as well as the possible causes on inefficiency in this sector will assist in formulation of government policies that will guide in allocation of resources. Through the use of Data Envelopment Analysis (DEA) the study will analyse the inputs and outputs in the sub-sector and this will help current and future researchers in understanding the operations in the sector.

1.5 Organization of the Study

The rest of the project is organised as follows: Chapter two reviews both the theoretical and empirical literature relevant to the study. Chapter three outlines the methodological approach that has been employed in this study. This includes the description and analysis of data, estimation methods and how and why we have employed them. Chapter four presents results of the study and interpretation. Finally, Chapter five gives a summary of the study, conclusions and policy implications.

2 Literature Review

There are two main methods used in the literature to measure technical efficiency, the Data Envelopment analysis (DEA) and the Stochastic Frontier Analysis (SFA). DEA measures relative efficiency through the use of linear programming techniques and thus it's a non-parametric approach while SFA requires the specification of the functional form of the production function to estimate technical efficiency Coelli et. al (1998). This study will draw on the two approaches to measure technical efficiency of primary schools in Kenya.

2.1 Theoretical Literature

Technical efficiency

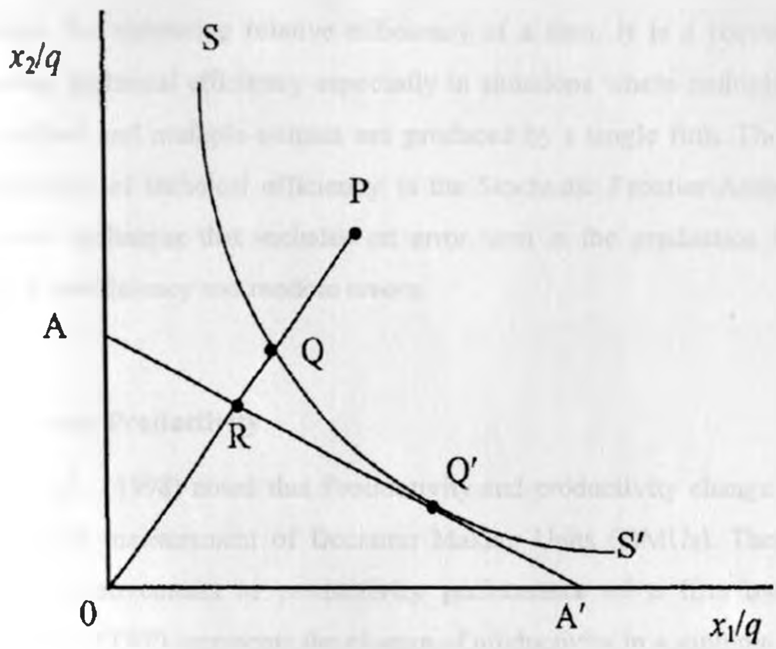
Economic theory of production defines the maximum attainable level of output from a given set of inputs. Production function depicts the production process that should be maximized so as to achieve the best possible level of output. In a two-input case, a general production function may be specified as follows:

$Q=f(X_1, X_2)$

Where Q is the quantity of a firm's output, X_1 and X_2 are the amounts of input 1 and input 2 respectively that are used in the production of Q. The average product (AP) of a firm's input is the level of output per unit of variable input employed in production while Total Factor productivity (TFP) refers to the average product of all inputs used in production. The marginal product (MP) of a firm's input is the change in output resulting from an additional input holding other inputs constant. The theory of production is concerned with the range of output for which the MP is positive since this is the efficient part of the production function (Varian, 1992).

According to Farrel (1957), efficiency refers to the ability of a decision making unit to produce the largest attainable output from a given set of inputs. Technical inefficiency thus represents the amount by which inputs could be reduced without reducing the amount of output. This is illustrated in figure 1; according to Coelli et. al, (1998), the technical inefficiency of this firm is represented by the distance QP, which is the amount by which all inputs (X_1 and X_2) could be proportionally reduced without reducing the output. This is represented by the ratio ***QP/OP***, which represents the percentage by which all inputs could be reduced.

Figure 1: Efficiency of production



Source: Coelli et. al, (1998)

The technical efficiency (TE) of a firm is measured as;

TE_P=OQ/OP=1-QP/OP, which denotes the ratio of the minimal input required to the actual input use given the input mix used by P. It takes the value between zero and one, and hence provides an indicator of the degree of inefficiency of a firm. A value of one implies that a firm is technically efficient for example at point Q, which lies on the efficient isoquant (Coelli et. al, 1998).

AA' is the isocost line. It represents the minimum cost of producing one unit of output given the prices of inputs. Q' is both allocative and technically efficient. The allocative efficiency for a firm at point P is given as $AE_P = OR/OQ$. The ratio RQ/OQ represents the cost reduction that would occur if a firm allocated at point P were to operate at an allocative efficient point as school Q' (Coelli et. al, 1998).

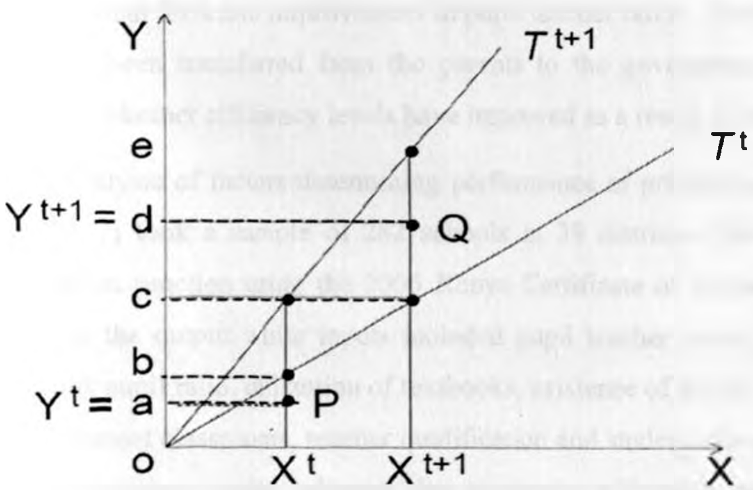
In recognizing the role played by human error in production and also the complexity of production process, Farrel argued that specifying the theoretical maximum attainable level of production is daunting task and thus efficiency is better measured by comparing a firm's performance with the best achievement from a homogenous unit. This argument formed the basis of Data Envelopment Analysis (DEA).

DEA was first developed by Charnes, Cooper and Rhodes in 1978 as a linear programming technique for measuring relative efficiency of a firm. It is a commonly used method for evaluating technical efficiency especially in situations where multiple factors of production are involved and multiple outputs are produced by a single firm. The other method used in measurement of technical efficiency is the Stochastic Frontier Analysis (SFA) which is a regression technique that includes an error term in the production frontier that represents technical inefficiency and random errors.

Total Factor Productivity

Coelli et al., (1998) noted that Productivity and productivity change are important parts of performance measurement of Decision Making Units (DMUs). They defined productivity change as movements in productivity performance of a firm over time. Total Factor Productivity (TFP) represents the change of productivity in a multiple input-output firm. It is the average product of all inputs used in production. The concept of TFP index is illustrated in figure 2.

Figure 2: Output-Based Malmquist Productivity Index



Source: Eyob (2000)

X and Y are the observed inputs and outputs respectively. T^t and T^{t+1} are the production technology in period t and t+1 respectively. For a firm producing at point P in period t and at point Q in period t+1, Malmquist Productivity Index is computed as the ratio of the Farrel technical efficiency in period t+1 to that in period t. This is expressed as:

$$Efficiency\ change = \frac{0d/0e}{0a/0b}$$

The technical change is the geometric mean of the shift in technology evaluated at x^{t-1} and the shift in technology evaluated at x^t .Thus,

$Technical\ change = \left(\frac{0d/0c}{0d/0e} \times \frac{0a/0b}{0a/0c}\right)^{1/2}$, which is a combination of both efficiency and technical change.

2.2 Empirical Literature

Abagi and Odipo (1997) used a process perspective to analyse the basic school processes of a sample of a hundred and twenty primary schools in Kenya to determine their efficiency. The results found that the Kenyan primary education system was inefficient. These inefficiencies were mainly as a result of teachers' poor time management, low pupil teacher ratio and a curriculum that was too wide. In their study, the attitude of the teachers, school environment, poverty and socio-cultural factors were also found to influence efficiency. Many reforms have however taken place since the study was undertaken especially in curriculum reduction by more than 50% and improvement in pupil teacher ratios. The burden of paying school fees has also been transferred from the parents to the government. It would be important to examine whether efficiency levels have improved as a result of these reforms.

In an analysis of factors determining performance of primary schools in Kenya, Ngware et al., (2007) took a sample of 282 schools in 39 districts. They developed an educational production function using the 2006 Kenya Certificate of Primary Education (KCPE) mean score as the output while inputs included pupil teacher ratio, pupil toilet ratio, class size, textbook pupil ratio, utilization of textbooks, existence of school feeding programme, number of permanent classrooms, teacher qualification and student characteristics among others. The OLS regression results indicated that textbooks utilization, teacher characteristics, school facilities and existence of school feeding programme had a major effect on students' performance in the KCPE. Pupil teacher ratio had a negative effect on performance while students from poor areas as well as existence of school feeding programme were positively related to KCPE scores.

Mancebon and Malinero (2000) used DEA to assess whether UK schools were efficient and the bases of inefficiency. Using test scores as outputs and a number of variables reflecting school, home and teacher characteristics as inputs, the results from the sample of 176 schools had a mean efficiency score of 78.50 percent. The least efficiency score was 41.7 percent while 8 of the schools were technically efficient. The proportion of students eligible for free meals which reflects the poverty situation was found to be the main cause of inefficiency. Through the use of logit regression to explain the cause of inefficiency, parental support was found to be positively related to efficiency. Religious orientation was also significant with the Church of England schools being more efficient than other schools. The effect of teacher pupil ratio and the size of the school were not significant in explaining inefficiency levels.

Chakraborty et al., (2001) used both SFA and two-stage DEA to determine the technical efficiency of 40 school districts in the state of Utah, USA. The study classified inputs into those that the school can control and those beyond the control of the school while outputs were examination results. Under the assumption of half normal distribution in SFA, the mean efficiency score was 85.8 percent with the highest score being 99.1 percent and the least score 62.5 percent. On the other hand, the assumption of exponential distribution in SFA gave a mean score of 89.7 with the highest and the lowest scores being 98.1 percent and 67.2 percent respectively. The percentage of population with high school education was found to have a positive significant effect on efficiency while student teacher ratio was negatively related to efficiency. The simple Variable Returns to Scale (VRS) DEA indicated that 23 school districts were technically efficient while the least efficiency score was 67.3 percent. In explaining efficiency, the two-stage DEA model showed that socioeconomic and environmental variables were important in explaining changes in efficiency. The results were consistent with those of Mancebon and Malinero (2000) where socioeconomic variable like the percentage of poor students in a school negatively influenced efficiency.

Mizala et al., (2002) also using DEA and SFA estimated technical efficiency of schools in Chile. Using mean scores in mathematics and Spanish examinations as output and a number of schools, student and teacher characteristics as inputs, the SFA results revealed that the average school efficiency was 93.18 percent with a range of 73.04 percent to 98.19 percent. The DEA results indicated that the mean efficiency score was 93.9 percent with a range of 53 to 100 percent. Both models explained that the size of the school, school's locality, student teacher ratio and level of education of the parents were significant in explaining the efficiency levels of the schools while teachers experience did not have any effect. The findings also showed that private schools performed better than public schools.

Portela and Camanho (2007) used DEA in a sample of 22 secondary schools in Portugal. Student entry behaviour, parents' literacy level and teachers' remuneration were used as inputs while retention and completion rates as well as mean scores on final examination were the outputs. The results indicated that the mean efficiency score of schools assessed on the viewpoint that they are converting all their resources into students' achievement was 98.6 percent. When schools were evaluated on the viewpoint that they promote students' achievement given the characteristics of the students, the efficiency score was 94.8 percent. When schools were assessed using common factor weights, the mean efficiency score was 93.4 percent. The study concluded that teacher characteristics were the most important variables in explaining inefficiency in the schools.

Denaux (2007) also used DEA to evaluate the technical efficiency of 153 schools in the state of Georgia. The inputs used were student teacher ratio, teacher's experience and number of students under school feeding programme while outputs were graduation rate and examination scores. The results indicated that urban county schools were 93 percent efficient while the rural schools were 88 percent efficient. When second stage Tobit regression was used to explain the differences in efficiency scores, the results showed that inhabitants' level of education and white pupils were positively related to efficiency. The results of this study were consistent with those of Mizala et al., (2002), Mancebon and Malinero (2000) and Chakraborty et al., (2001) where students' socioeconomic background are important in explaining inefficiency.

Rassouli-Currier (2007) also using DEA and second stage Tobit regression analysed the efficiency of 354 school districts in Oklahoma. Examination scores were used as output while inputs were categorized into school controlled and non-school controlled. The mean efficiency score under VRS was 91 percent, and 82 percent under CRS. The results of the tobit regression were consistent with those of Denaux (2007), Mizala et al., (2002), Mancebon and Malinero (2000) and Chakraborty et al., (2001) where family environment and socio economic variables are the factors explaining variation on efficiency. The size of the school district and student teacher ratio were found to have negative and positive effect on efficiency respectively. However, teacher characteristics had no effect on efficiency, an observation that was also made by Mizala et al., (2002).

Tyagi et al., (2009) used DEA method to assess the technical efficiency of 348 schools in Uttar Pradesh state of India. The inputs used were school facilities, teacher characteristics, student teacher ratio, parents' literacy levels and school attendance while scores in language, environmental studies and mathematics examinations were used as outputs. When all inputs and output variables were used in the model, a typical school in Uttar Pradesh had an efficiency score of 70.58 percent with a minimum score of 19.4 percent. Contrary to the results of Mizala et al., (2002) and Rassouli-Currier (2007), teachers' characteristics were found to have a major effect on efficiency while the effect of pupil teacher ratio and average school attendance were found to have small effect on efficiency. However, parent characteristics were also found best to explain inefficiency which is consistent with the mentioned studies.

DEA was also used by Hu et al., (2009) to examine the efficiency of 58 primary schools in Beijing. The examination results in Chinese, mathematics and English were used as outputs while inputs included student teacher ratio, teaching experience, teacher qualifications as well as remuneration. Under the Constant Returns to Scale (CRS), 29 schools were technically efficient and the mean efficiency score was 90 percent. When VRS was assumed, 34 schools were found to be technically efficient and the average score was 95 percent. Consistent with Portela and Camanho (2007) and Tyagi et al., (2009), teacher characteristics including their remuneration were positively correlated to efficiency. Other findings of the study were that there exist a negative relationship between student teacher ratio and efficiency of Beijing schools.

By classifying inputs into home, student and school characteristics and results in the science examination as outputs, Mancebon et al., (2010) used DEA to examine efficiency of Spanish high schools. The mean efficiency score of publicly subsidized private schools (PSPS) was 91.9 percent while that of public schools (PS) was 92.5 percent. Unlike the studies by Mancebon and Malinero (2000) and Mizala et al., (2002) public schools performed better than subsidized private. Though Hu et al., (2009) found a negative relationship between student teacher ratio and efficiency, the effect of this ratio was insignificant in Chile but class size displayed a negative relationship. Consistent with Chakraborty et al., (2001), Rassouli-

Currier (2007) and Denaux (2007), characteristics beyond school control greatly influenced efficiency.

Agasisti et al., (2012) in effort to examine efficiency of Italian schools used two-stage DEA on a sample of 1062 schools in the Lombardy region. In their study, examination scores in reading and mathematics were used as outputs and a wide range of inputs including the pupil teacher ratio, teacher characteristics and home variables. The mean efficiency score was 80 percent. The results of the tobit regression indicated that higher efficiency scores were associated with students with better socioeconomic background thus emphasizing on the roles of factors beyond school control in explaining efficiency.

2.3 Overview of the Literature

The literature reviewed indicates that the most common used output in efficiency analysis of schools is the scores in a given exam at the end of the period. Inputs have a wide range but could be generally classified as those that the school can control and those beyond the control of the schools. Inputs can further be broken into those reflecting teachers' ability, school inputs, student and finally the family background of the student as well as the surrounding region. Results show that all these factors have an effect on efficiency with factors beyond school control taking more weight than the other factors. Pupil-teacher ratio and teacher characteristics were also found significant in most of the studies.

3 Methodology

This chapter describes the analytical framework, methodology and data used in the study. It also describes the data used in the study.

3.1 Measurement of Efficiency

Farrel (1957) defined efficiency as the ability of a decision making unit to produce the largest attainable output from a given set of inputs. The author distinguished allocative efficiency from technical efficiency with the former being the success of a DMU in choosing the inputs that the minimize cost of production while technical efficiency is the unit's ability to produce the maximum level of outputs. Technical inefficiency thus represents the amount by which inputs could be reduced without reducing the amount of output. The focus of this study is on technical efficiency because getting the data on the input prices which are required to measure allocative efficiency is a difficult task in a school setting and when done, the prices might not reflect the true cost of production.

According Coelli et al., (1998), estimation of technical efficiency can either be in favour of the inputs or outputs. Evaluation that focuses on the inputs measures the DMU's success in decreasing the level of inputs without affecting the level of production. It is a ratio of the least possible input required to the actual level of input used. On the other hand, output focused efficiency is interested in increasing the outputs without any variation on the level of inputs. It is the ratio of the actual amount of output produced to the optimal level of output attainable. Both measures produce similar results if the nature of production technology exhibits constant returns to scale. The values of technical efficiency range between zero and one, with a score of one indicating that a DMU is fully efficient.

3.2 Approaches to Measurement of Technical Efficiency

Measurement of technical efficiency is done through estimating the production frontier. The models for estimating the production frontier are the parametric models which make use of statistical modelling and non-parametric models which make use of linear programming Coelli et al., (1998). Parametric models consist of stochastic frontier analysis (SFA), thick frontier analysis (TFA) and the distribution free analysis (DFA). Non-parametric models on the other hand consist of data envelopment analysis (DEA) and free disposal hull (FDH) (Kibaara, 2005).

3.2.1 Stochastic Frontier Analysis

In the reviewed literature, Chakraborty et al., (2001) and Mizala et al., (2002) used both SFA and two-stage DEA to determine the technical efficiency of school in Uttar and Chile respectively. Stochastic Frontier Analysis (SFA) is a parametric model in which a non-negative error term related to technical inefficiency is deducted from the systematic random error term accounting for statistical noise. The assumption underlying this model is that the composite error term is symmetric independently distributed. The main advantage of SFA is the ability to handle statistical noise. However, it requires restrictive assumptions about the structure of production technology and also requires additional information /assumptions to allow multiple outputs.

3.2.2 Data Envelopment Analysis

DEA was formulated by Charnes Cooper and Rhodes as a non-parametric linear programming model for measuring relative efficiency of homogenous organization units called Decision-Making Units (DMUs). DEA identifies the best performing DMU within the sample and uses their combination of inputs and outputs to estimate the production possibility frontier. Performance of other DMUs is then estimated relative to the best practice DMU(s). The estimation of performance is based on the efficiency of a DMU in utilization of the existing resources to generate the optimal output. It is therefore a ratio of DMU's total outputs to total inputs. Technical inefficiency means that a DMU is producing less output per input or is using more inputs per output as compared to the DMUs on the production possibility frontier Charnes et al., (1978).

Coelli et al., (1998) noted that the main advantages of DEA are the ability to handle multiple inputs and outputs and it does not require a specification model relating inputs to outputs. However, he argued that it is a deterministic model thus difficult to conduct statistical tests of inefficiency and the structure of production technology and also its non-stochastic nature makes it impossible to capture random noise thus regarding any deviation from the frontier as inefficiency.

Following the model by Charnes et al., (1978) and used by Mizala et al., (2002), Zere (2000) to determine the efficiency of a target schools in district **d** , we solve the following equation:

$$\max h_d = \sum_{r=1}^{s} u_r y_{rd} \quad \text{..........} \quad 3.2$$

Subject to

$$\sum_{i=1}^{m} v_i x_{id} = 1$$

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

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

Where

n-the 72 districts whose primary schools will be evaluated

m-the total number of inputs

s –the total number of outputs

h_d –technical efficiency of schools in district d

U_r-vector of output weights to be determined by the solution to the LP problem

V_i-vector of input weights to be determined by the solution to the LP problem

Y_{rd}-amount of output r for schools in district d

X_{id}-amount of input i used by schools in district d

The first constraint indicates that the weighted sum of inputs for the particular district equals one while the second one implies that all districts operate on or below the frontier. Solving this linear programming problem we obtain the efficient production for the schools in each district and the efficiency index.

The model by Charnes et al., (1978) assumes constant returns to scale (CRS). Returns to scale refer to the changes in output as a result of change in all inputs by the same proportion. CRS implies that output changes by the same proportion as the change in inputs and thus the size of the schools in the districts is irrelevant when measuring efficiency since all schools are deemed to be operating at their best scale size. However, size is an important factor in this analysis and thus the assumption of variable return to scale (VRS) which allows the level of outputs to inputs to vary with the size of the schools is more binding. Banker et al., (1984) added an intercept term to the Charnes et al., (1978) model to take care of the returns to scale.

3.3 The Malmquist Productivity Index

The Malmquist TFP index is measure of total factor productivity. The index is constructed by measuring the radial distance of the observed output and input vectors in period t and t+1, relative to a reference technology (Eyob, 2000). Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify a behavioural objective. Output oriented TFP index focuses on the maximum level of outputs that could be produced using a given input vector and a given production technology relative to the observed level of outputs. Since Malmquist productivity index can be defined using the technology of period t as well as that of period t+1, it is defined as the geometric mean of the two indices based on periods t and t+1 technologies. It is estimated as the ratios of distance functions of observations from the frontier (Coelli et al, 1998)

To measure the total factor productivity, Fare et al., (1994) specified the output oriented Malmquist productivity change index as:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$

Fare et al., (1994) further decomposed the Malmquist index into two parts:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right] \times \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$

Where,

$$\left[\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right] = Efficiency\ change$$

and

$$\left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2} = Technological\ change$$

Where the subscript indicates output-orientation, M is the productivity of the production point (x^{t+1}, y^{t+1}) relative to the earlier production point (x^t, y^t) and D is the output distance while x^t and y^t are the inputs and outputs respectively. When M is greater than 1, productivity is improving in that the DMU delivers a unit of output in period *t+1* using fewer inputs compared to period *t*. and is therefore more efficient in period *t+1* than in period *t*.

3.4 Determinants of Inefficiency

DEA generates efficiency scores but does not explain the possible causes of inefficiency. Reviewed studies have shown that factors like class size, student teacher ratio, socioeconomic factors, environmental factors, location and school ownership may influence efficiency of schools. Borrowing from Chakraborty et al., (2001), Denaux (2007), Rassouli-Currier (2007) and Agasisti et al., (2012), the study will use two-stage DEA to identify the factors influencing inefficiency in the schools.

In the DEA second stage, DEA efficiency scores in the first stage are transformed into inefficiency scores and used as the dependent variable which is regressed on the inputs and other external variables to determine the possible causes of inefficiency in the DMUs under study. According to Eyob (2000), a tobit regression model is preferred because the efficiency scores are truncated between 0 and 1and thus the dependent variable is limited in nature.

From Greene (2004), the tobit model is defined as follows:

$$y_i^* = \beta_i x_i + u_i$$

$$y_i = y_i^* \ if \ y_i^* > 0$$

$$y_i = 0 \ if \ y_i^* \leq 0$$

Where $u_i \sim N(0, \sigma^2)$

y^* is a latent (unobservable) variable.

y_i is the observed inefficiency score

β_i is a $Kx1$ vector of unknown parameters which determines the relationship between the independent variables and the latent variable.

x_i is a $Kx1$ vector of explanatory variables

The model to be estimated takes the form:

$$ineff = \beta_0 + \beta_1 des + \beta_2 pcr + \beta_3 ptr + \beta_4 lc + \varepsilon_i$$

Where:

ineff is the inefficiency score computed as (1/DEA score)-1

des is the District enrolment Size

pcr is the pupil classes ratio

ptr is the pupil teacher ratio

Lc is the location dummy and is 1 if urban and 0 if otherwise

The residuals of the Tobit model separate the effects of these factors and measure pure technical efficiency that is bounded between -∞ and 1. Hence, the higher the value of the residual, the better is the performance of the schools in the district.

3.5 Data type and sources

The choice of variables for efficiency analysis has remained an important issue due the multiple inputs and outputs that are involved. Reviewed literature on school efficiency has widely used examination scores as output while inputs include a wide range of variables reflecting teacher characteristics, student characteristics, home environment and socio-economic variables.

The data consists of 75 districts. However 3 districts had missing variables and were dropped from the study. The study used inputs reflecting characteristics of the school and test scores as the main output. This is heavily borrowed from the literature and also due to availability of these variables and the non-availability of others reflecting equally important outcomes of schooling, such as pupils' attitudes, the quality of their daily lives whilst at school, teacher characteristics and socioeconomic variables.

Table 3.1 Input and output set

Variables		Description
Inputs	**(i)DISTRICT SIZE**	This refers to the total number of pupils in a district
	(ii)PUPIL-CLASSROOM RATIO	This is the number of pupils per classroom in a district. It's computed by dividing the total number of pupils in the district by the number of classrooms in the district. Classes refer to the sessions in place an average enrolment of 40 pupils.
	(iii)PUPIL TEACHER RATIO	This is the average number of pupils per teacher. Its computed by dividing the total number of pupils in a district by the number of teachers in the district The data on teachers refers to teachers who are engaged in teaching and excludes those performing non-teaching duties
Output	**KCPE MEAN SCORES**	This is the districts' average KCPE scores. **NB:** The mean scores used in this paper are the raw scores which are the actual scores by the students before standardisation. KNEC standardises the raw marks to standard marks to allow for differences in difficulty and in the extent to which marks scatter. The difficulty among the papers is measured in terms of the mean raw marks scored by all candidates while the differences in scatter are measured in terms of the standard deviation. This process entails converting the raw marks of each paper in the KCPE examination so that the mean and standard deviation of each of the papers are identical.

Source: Author's

4 Empirical Results

4.1 Introduction

This chapter presents the empirical results of the study. The results are divided into descriptive analysis, technical efficiency, determinants of inefficiency and total factor productivity growth.

4.2 General characteristics of output variable and enrolments

Table 4.1 gives a general overview of the output variable (KCPE mean scores) and the gross enrolments. KCPE mean scores[4] have remained significantly low over the period since the total mark for the examination is 500. Over the entire period, North Eastern province recorded the lowest mean mark of 139 in 2003 while the highest mean mark was 207 in Nairobi in 2006. At the National level, the mean score has been fluctuating with the best year being 2006 which recorded 193 marks. Enrolment has been increasing over the entire period from 6.9 million in 2003 to 7.4 million in 2007. Eastern, Rift Valley, Western and Nyanza provinces have had the highest share with each of them registering more than one million pupils. Rift Valley province enrolled 1.9 million pupils' while North Eastern had the lowest in 2007.

Table 4.1: KCPE scores and enrolment by province

Province	KCPE MEAN SCORES					PROVINCE SIZE (Gross Enrolment)				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Coast	178	175	182	185	183	459285	526638	536896	550908	581562
Central	172	170	180	189	183	849472	851347	833402	811490	802922
Eastern	173	159	181	191	182	1288678	1348938	1357517	1355595	1336687
Nairobi	190	188	195	207	198	192832	203061	196659	193209	201000
Rift Valley	178	178	189	199	192	1723887	1773881	1868081	1914292	1975180
Western	178	178	191	202	196	1046399	1095215	1104549	1082715	1151191
Nyanza	169	173	184	193	189	1281364	1258890	1263860	1273614	1303258
North eastern	139	148	160	178	179	64438	67437	73258	78295	89156
National	**172**	**171**	**183**	**193**	**188**	**6906355**	**7122407**	**7234199**	**7260118**	**7440956**

Source: GOK (2009)

[4] The mean efficiency scores are the absolute total scores divided by the enrolments

4.3 Technical Efficiency

The technical efficiency scores were derived by imposing the assumption of variable returns to scale. The TE was estimated using DEAP 2.1 software. The mean technical efficiency score for the 72 districts is 90.8 percent implying that on average, the schools in each district could increase their output by 9.2 percent using the existing level of inputs. The overall technical efficiency of the 72 districts ranges from 70 to 100 percent with 10 of the sampled districts being technically efficient. This implies that the 10 districts are operating on the production frontier and therefore cannot increase their output without an increase in their current level of inputs. Table 4.2 gives a summary of these scores by provinces and districts.

Table 4.2: Summary of Efficiency scores by provinces and districts

Province	Total No.of Districts	Mean Efficiency Score	No. of Districts in the 70-89 efficiency score range	No. of Districts in the 90-99 efficiency score range	Technically efficient Districts
Coast	7	0.96	1	4	2
Central	8	0.89	5	2	1
Eastern	11	0.90	6	3	2
Nairobi	1	0.99	0	1	0
Rift Valley	20	0.94	5	11	4
Western	8	0.92	3	5	0
Nyanza	13	0.88	10	3	0
North Eastern	4	0.80	3	0	1

4.3.1 Distribution of technical efficiency scores by province

The data used in this study was compiled when the country was using the Provincial system of administration. To this end, the Country was divided into 8 provinces. The technical efficiency scores of each of the 72 districts are grouped into their respective Provinces as provided in the subsequent tables.

Table 4.3: Coast Province

District	Code	vrste	scale		peers	peer weights
Taita Taveta	1	0.91	0.80	drs	46 42	0.357 0.643
Kilifi	2	0.97	0.61	drs	42	1
Tana River	3	1.00	0.94	irs	3	1
Lamu	4	1.00	1.00	-	4	1
Kwale	5	0.88	0.67	drs	42	1
Mombasa	6	0.99	0.71	drs	46 42	0.404 0.596
Malindi	7	0.94	0.70	drs	42 46	0.679 0.321
	Mean	0.96	0.78			

As shown in table 4.3, Coast province has 7 districts. The mean technical efficiency score for all the districts in coast province is 96 percent which is higher than the overall mean of 90.8 percent. This means that schools in coast province could improve their performance in KCPE scores by 4% at the current level of inputs. Tana River and Lamu districts are technically efficient. Regarding the scale efficiency, only Tana River is operating at increasing returns to scale, thus Tana River should expand both inputs and outputs in order to be scale efficient while Lamu exhibits constant returns to scale thus Lamu is operating at its optimal scale size. The rest of the districts operate at decreasing returns to scale and thus an increase in their inputs would lead to a less than proportionate increase in output.

Regarding peer groups[5] for the inefficient districts, Baringo (42) and Koibatek (46) districts serve as peer for Taita Taveta, Mombasa and Malindi Districts. Taita Taveta is more comparable to Baringo with a weight of 64.3 percent followed by Koibatek which has a weight of 35.7 percent. Mombasa and Malindi are also more comparable to Baringo with a weight 59.6% and 67.9% respectively than to Koibatek which has a weight of 40.4 percent and 32.1 percent respectively. Kwale and Kilifi districts have Baringo district as their peer with a weight of 100 percent. This means that districts in Coast province can improve their performance without an increase in the inputs.

Table 4.4: Central Province

District	Code	vrste	scale		peers	peer weights
Nyandarua	8	0.87	0.72	drs	42	1
Nyeri	9	0.91	0.75	drs	42	1
Kirinyaga	10	0.93	0.71	drs	42	1
Maragua	11	0.82	0.65	drs	42	1
Kiambu	12	0.87	0.64	drs	42	1
Thika Mun	13	1.00	1.00		13	1
Thika	14	0.87	0.67	drs	42	1
Murang'a	15	0.88	0.78	drs	42	1
	Mean	**0.89**	**0.74**			

[5] These are districts which act as role models, they are more efficient but have a similar input-output mix of to the inefficient districts and thus referred to as peers

Table 4.4 shows the performance of the 8 districts in Central province. The mean technical efficiency score of districts in central province is 89 percent which is lower than the overall mean of 90.8 percent. This means that schools in central province could improve their performance in KCPE scores by 11 percent using their current level of inputs. Only Thika Municipality district is technically efficient and is also operating at its most productive size while the rest operate at decreasing returns to scale with technical efficiency scores ranging from 82 to 93 percent. This means that all the districts apart from Thika Municipality should scale down their operations since any increase in their inputs would translate to a less than proportionate increase in output.

Baringo district (42) serves as a peer for all the inefficient districts in central province and is a very close peer with a weight of 100 percent. This means that inefficient districts in central province have a similar mix of input-output levels to that of Baringo but Baringo has higher output levels relative to that of these districts thus these districts can emulate Baringo to be able to improve their performance.

Table 4.5: Eastern Province

District	Code	vrste	scale		peers	peer weights
Machakos	16	0.90	0.76	drs	42	1
Kitui	17	0.84	0.82	drs	42	1
Embu	18	0.91	0.77	drs	42 46	0.609 0.391
Meru	19	0.85	0.84	drs	42	1
Isiolo	20	1.00	1.00		20	1
Makueni	21	0.98	0.78	drs	42	1
Meru South	22	1.00	0.98	drs	22	1
Nyambene	23	0.84	0.69	drs	42	1
Mwingi	24	0.86	0.80	drs	42	1
Moyale	25	0.85	0.89	drs	31 13 72	0.461 0.477 0.062
Mbeere	26	0.89	0.95	drs	46 42 4	0.549 0.352 0.098
	Mean	**0.90**	**0.84**			

Table 4.5 shows results of the 11 districts in Eastern province. Isiolo district is both scale and technically efficient thus it cannot improve its performance without an increase in its inputs. The mean efficiency score for Eastern province is 90 percent which is slightly lower than the

overall mean score of 90.8 percent. Thus on average, schools in Eastern province can improve their performance by 10 percent using the existing level of inputs. All the inefficient districts operate at decreasing returns to scale meaning they experience diseconomies of scale and thus they should scale down their inputs. Meru South district though fully technically efficient is also experiencing decreasing returns to scale and thus the need to scale down both its inputs and outputs in order to be scale efficient.

Regarding the peer groups for the inefficient districts, Baringo (42) district is again predominant in Eastern province with 6 of the districts having it as a very comparable peer with a weight of 100 percent. However Embu district has both Baringo and Koibatek (46) districts as its peers but it is more comparable to Baringo with a weight of 60.9 percent than to Koibatek which has a weight of 39.1 percent. Mbeere district has Koibatek as its close peer with a weight of 54.9 percent followed by Baringo which has a weight of 35.2 percent while Lamu district (4) serves as its very distant peer with a weight of 9.8 percent. Moyale district has a unique peer combination of Kitale Municipality (31), Thika Municipality (13) and Ijara (72) districts. However, it is more comparable to Thika Municipality with a weight of 47.7 percent, followed by Kitale Municipality with a weight of 46.1 percent while Ijara is a very distant peer with a weight of 6.2 percent.

Table 4.6: Nairobi Province

District	Code	vrste	scale		peers	peer weights
Nairobi	27	0.99	0.51	drs	42	1

Nairobi province has one district which is the Nairobi district. On average, schools in this district are 99 percent efficient meaning that they can increase their performance by 1 percent at their existing level of inputs. They also experience diseconomies of scale since they are operating at decreasing returns to scale. This means that the schools in this district should scale down their operations in order to operate at the optimal scale size.

Regarding the peer side, Baringo (42) district is Nairobi's very close peer with a weight of 100 percent. Thus, the Schools in Nairobi district have an input-output mix like that of

Baringo thou their output is lower than Baringo. They can therefore emulate Baringo so as to raise their performance.

Table 4.7 shows results for Rift valley province which is the largest of all the 8 provinces. The 20 districts in this province have a mean efficiency score of 94 percent. This implies that they can increase their performance by 6 percent without altering the levels of inputs. The performance of this province is above average as shown by the mean score which is higher than the overall mean score of 90.8 percent. Four of the districts are technically efficient among them Baringo and Koibatek which have been peers in the earlier analysed provinces. Three districts operate at the optimal scale size while the inefficient districts as well as Koibatek which is fully efficient operate at decreasing returns to scale. This region is largely experiencing diseconomies of scale and should decrease its inputs in order to operate at optimal size.

Table 4.7: Rift Valley Province

District	Code	vrste	scale		peers	peer weights
Turkana	28	0.99	0.89	drs	31 46 20	0.153 0.779 0.068
Samburu	29	0.94	0.91	drs	31 46 20	0.193 0.314 0.493
Trans Nzoia	30	1.00	1.00		30	1
Kitale Mun	31	1.00	1.00		31	1
West Pokot	32	0.93	0.77	drs	46 42	0.005 0.995
Nakuru Mun	33	0.95	0.68	drs	46 13	0.928 0.072
Eldoret Mun	34	0.96	0.70	drs	13 46	0.491 0.509
Bomet	35	0.84	0.69	drs	42	1
Uasin Gishu	36	0.95	0.73	drs	42	1
Kericho	37	0.91	0.70	drs	42	1
Nandi North	38	0.93	0.79	drs	42	1
Laikipia	39	0.89	0.84	drs	46 42	0.007 0.993
Kajiado	40	0.96	0.82	drs	42 46	0.760 0.240
Narok	41	0.85	0.81	drs	42	1
Baringo	42	1.00	1.00		42	1
Keiyo	43	0.99	0.87	drs	42 46	0.209 0.791
Trans Mara	44	0.84	0.68	drs	42	1
Marakwet	45	0.94	0.88	drs	46 42	0.844 0.156
Koibatek	46	1.00	0.93	drs	46	1
Buret	47	0.84	0.66	drs	42	1
	Mean	**0.94**	**0.82**			

The most inefficient districts in Rift Valley are Bomet, Transmara and Buret with a score of 84 percent. These three districts can improve their performance by 16 percent without increasing their inputs. They should also emulate Baringo (42) which serves as their peer with a weight of 100 percent. Laikipia, Kajiado, Keiyo and marakwet districts have Baringo and Koibatek districts as their peers. However, laikipia and kajiado are more comparable to Baringo with a weight of 99.3 and 76 percent respectively. Koibatek is more distant peer with a weight of 0.7 and 24 percent respectively. On the other hand, Keiyo and Marakwet districts are more comparable to koibatek with weights of 79.1 and 84.4 percent respectively. Baringo is a distant peer of Keiyo and Marakwet with weights of 20.9 and 15.6 percent respectively. Turkana and Samburu districts have Kitale Municipality (31), Isiolo (20) and Koibatek (46) districts as their peers but Turkana is more comparable to Koibatek with a weight of 77.9 percent while Samburu is more comparable to Isiolo with a weight of 49.3 percent.

Table 4.8: Western Province

District	Code	vrste	scale		peers	peer weights
Busia	48	0.96	0.67	drs	42	1
Bungoma	49	0.91	0.57	drs	42	1
Kakamega	50	0.94	0.68	drs	42	1
Vihiga	51	0.89	0.68	drs	42	1
Mt.Elgon	52	0.87	0.76	drs	42 46	0.171 0.829
Teso	53	0.88	0.71	drs	42 46	0.324 0.676
Lugari	54	0.95	0.69	drs	42 46	0.900 0.100
Butere /Mumias	55	0.96	0.66	drs	42	1
	Mean	**0.92**	**0.68**			

Western Province has 8 districts. The mean efficiency score for this province is 92 percent and all the districts are inefficient and do not operate at the optimal scale size as indicated by the decreasing returns to scale meaning that they experience diseconomies of scale. Busia, Bungoma, Kakamega, Vihiga and Butere/Mumias districts have Baringo (42) as their peer with a weight of 100 percent. Baringo and Koibatek (46) districts serve as peers for Mt. Elgon, Teso and Lugari districts though the three districts are more comparable to Koibatek than to Baringo.

Table 4.9: Nyanza Province

District	Code	vrste	scale		peers	peer weights
Kisumu	56	0.87	0.89	drs	46 42	0.605 0.395
Kisumu Mun	57	0.95	0.63	drs	46 42	0.308 0.692
Kisii	58	0.81	0.76	drs	42	1
Homa bay	59	0.89	0.74	drs	42	1
Siaya	60	0.92	0.69	drs	42	1
Nyamira	61	0.82	0.85	drs	42	1
Migori	62	0.87	0.70	drs	42	1
Kuria	63	0.88	0.78	drs	46 42	0.879 0.121
Suba	64	0.89	0.89	drs	42 46	0.062 0.938
Rachuonyo	65	0.88	0.71	drs	42	1
Gucha	66	0.81	0.74	drs	42	1
Bondo	67	0.90	0.84	drs	42 46	0.930 0.070
Nyando	68	0.92	0.73	drs	42	1
	Mean	**0.88**	**0.77**			

Table 4.9 shows the technical efficiency scores for districts in Nyanza province. This province has 13 districts with a mean efficiency score of 88 percent which is below the national mean score. None of the districts in this Province is fully efficient and all operate at decreasing returns to scale. Baringo and Koibatek districts are also serve as the only peers in this province with Baringo taking the lead in 10 of the 13 districts.

Table 4.10: North-Eastern Province

District	Code	vrste	scale		peers	peer weights
Garissa	69	0.74	0.87	drs	13 46 31	0.771 0.134 0.095
Wajir	70	0.74	0.86	drs	31 46 20	0.535 0.156 0.309
Mandera	71	0.70	0.71	drs	13 46	0.598 0.402
Ijara	72	1.00	1.00		72	1
	Mean	**0.80**	**0.86**			

North Eastern province has 4 districts with a mean efficiency score of 80 percent which is the least in all provinces. Only Ijara district is fully efficient while the other 3 have very low scores below 75 percent and are operating at decreasing returns to scale thus experiencing diseconomies of scale.

Regarding the peers for the inefficient districts, Thika Municipality (13) serves as a peer for Garissa and Mandera with weights of 77.1 and 59.8 percent respectively, Isiolo (20), Kitale Municipality (31) Koibatek (46).

4.4 Malmquist total factor productivity index

The estimated indices of the output-oriented Malmquist productivity change index are as shown in Table 4.11. The mean TFP change index of 1.022 indicates that on average, over the entire period, the increase in TFP is 2.2 percent. The sector experienced a sharp decrease in productivity between 2006 and 2007. The most significant improvement in productivity is in 2005.

TFP change is a product of TE change and Technological change. Of the two components, technological change is has a greater impact on the productivity gains. Thus on average, the technological change index eliminates the negative effects caused by the contraction of efficiency change. Hence, technological change helps generate the improved productivity growth. In addition, since TE change is a product of pure technical efficiency and scale efficiency, the decline in TE change is as a result of both scale and pure efficiency decline.

Table 4.11: Malmquist TFP Index Summary of Annual Means; 2003-2007

Year	TE change	Technological Change	Pure Efficiency change	Scale efficiency Change	TFP change
*2004	1.014	0.947	0.996	1.017	0.960
2005	1.002	1.243	1.026	0.976	1.244
2006	1.013	1.022	0.996	1.017	1.035
2007	0.957	0.923	0.975	0.982	0.884
Mean	**0.996**	**1.027**	**0.998**	**0.998**	**1.022**

*Note that 2004 refers to the change between 2003 and 2004.

4.5 Econometric analysis of the determinants of inefficiency

Statistical analyses are performed using STATA 11 statistical software. A Tobit model left censored at 0 is estimated. The regression results are presented in Table 4.12.

The district enrolment has a negative coefficient of 0.0000004 and is statistically significant at 5% level of significance. This means that enrolment is negatively related to inefficiency.

Thus higher enrolment levels are associated with higher level of efficiency. The coefficient of pupil classes ratio has a negative coefficient but it is not significant. Pupil teacher ratio is significant at 5% level and has a positive coefficient of 0.004. This means that high pupil teacher ratios are associated with inefficiency. This is plausible given that high pupil teacher ratios are associated with congestion and low quality of teaching. The location of district is significant at 5% level and has a negative coefficient of 0.08 meaning that an urban district is more efficient than a rural district. Thus schools in urban districts perform better than their rural counterparts. This may be attributed to the differences in the socio-economic factors which from the reviewed literature have a significant effect on efficiency

Table 4.12: Estimation results for Tobit model

Variable	Coefficient	t-ratio
Constant	0.0011358	0.02
Enrolment	-0.0000004	-2.03
PCR	-0.0001538	-0.34
PTR	0.0035018	3.17
Urban	-0.0839994	-2.41

5 Conclusion and Policy Recommendations

5.1 Conclusion of the Study

Education is a key instrument for the Country's social-economic development. It's therefore necessary that investment in this sector attain maximum possible benefits. This study analysed the TE of primary schools in Kenya aggregated at the district level. The study sought to determine the efficiency scores of the schools and determine the possible causes of inefficiency. Pupil teacher ratio, pupil classroom ratio and school size were used as inputs while mean absolute scores in KCPE examination was used as output.

Huge investments have been made in the Kenya's education sector in effort to achieve UPE by 2015 and also as part of the commitments made in the Dakar framework for action in 2000 to achieve EFA by 2015. Assessment of the efficiency in the education sector is critical not only to ensure attainment of UPE but also to ensure that the resources allocated to the sector are efficiently utilized to achieve desired results.

The study applied two-stage DEA to assess the performance of primary schools grouped in 72 districts for the period 2003 to 2007. Using DEA and assuming VRS, the mean efficiency score of the 72 districts is 90.8 percent with scores ranging from 70 percent to 100 percent. The VRS DEA values indicated that on average, if schools fully utilize their inputs, their efficiency scores would rise by 9.2 percent.

The Malmquist DEA shows that there is an increase in total factor productivity by 2.2 percent. The productivity gains were attributed to technological change since there was a contraction in the efficiency change over the period.

The analysis of Tobit regression shows that size of the district measured by enrolments is positively related to efficiency though the coefficient is very small. This means that schools with higher number of students perform better than schools with lower enrolments. This may imply that enrolments on its own does not negatively impact efficiency but the other factors associated with high enrolments such as congestion and high PTR may affect efficiency. Pupil classes ratio is insignificant in explaining efficiency. This may be because the data on the number of classes reflect the sessions that have an average enrolment of 40 pupils as opposed to the physical classrooms and thus the sessions on their own may not have any impact on efficiency. Pupil teacher ratio is significant and is positively related to inefficiency. Thus high pupil teacher ratio is associated with inefficiency. This is due to congestion and thus pupil teacher contact is minimal therefore the quality is compromised. The location of district has a significant effect on efficiency with urban districts being negatively related to inefficiency. Thus schools in urban districts are more efficient than their rural counterparts. This may be explained by evidence from the reviewed literature where urban schools are more efficient due to the more favourable socio-economic factors that prevail in urban centres as compared to the rural regions.

5.2 Policy Implications

The study demonstrates that public primary schools in Kenya are technically inefficient. DEA methodology helps in suggesting the magnitudes by which inputs and outputs could be varied to make the inefficient schools efficient. Since the study took the output oriented approach, schools can improve their performance by 9.2 percent without altering their current levels of input. Given that there is increasing enrolments over the period of study, and that the numbers of classrooms and teachers have not been increasing in tandem, it can therefore be argued that the districts are really doing well judging from the mean efficiency scores.

The analysis of tobit regression shows a negative relationship between efficiency and pupil-teacher ratios. This therefore calls for an increase in the number of teachers in primary schools. Government policy should be geared towards improving the pupil teacher ratios since high pupil teacher ratios compromise delivery of content and teacher pupil contact which eventually affects the quality and which is reflected in the poor examination scores.

The decreasing returns to scale in the operations of most of the schools may be a justification for downsizing the operations in most of the schools. However, the need for improved access to primary education coupled with the right to basic education for all Kenyans overrides this argument and thus schools should strive to perform better in the midst of various challenges.

To achieve the overall goal of access and equity to primary education without affecting the quality of education, the rising levels of enrolment should be addressed by increasing the number of classes as well as the number of teachers. Teacher motivation is important in achieving these goals. This may be done through better terms of employment and also awards and recognition. The teaching of pupils in shifts should also be explored to help cope with the increasing enrolments and thus ensure that all children of school going age get a place in school without compromising quality.

The increase in TFP by a small margin is a challenge to the governments' effort to improve access and equity in primary education. This calls for the need to address any issues related to efficiency for the sector to maximize on the benefits of FPE. Since some of the schools are efficient yet they are operating at an environment fairly similar to that of the inefficient schools, policy makers should set targets and monitor efficiency changes over time for all schools with a view of implementing interventions aimed at increased efficiency in the use of resources and thus improved performance at no additional costs.

5.3 Limitation of the study

The major limitation of the study is the availability of data to analyse other possible causes of inefficiencies in the schools and thus no data to analyse the effect of socio economic variables as well as environmental variables on efficiency. Other limitations include the use of aggregated data in districts yet the some decisions are made at school level and also the assumption that the surveyed districts are homogenous which might not always hold.

5.4 Areas for further research

The areas for further research in this field include analysis of individual schools as well as comparing private and public schools to determine whether there are differences in efficiency scores. An analysis of the environmental, socio-economic and demographic that may explain inefficiency is important for policy formulation.

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