Journal of Social Sciences

Original Research Paper

Government Expenditure and School Efficiency and Productivity Change: A Case of Public Primary Schools in Kenya

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Article history
Received: 28-11-2018
Revised: 01-03-2019
Accepted: 16-04-2019

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Abstract: Education management is a more labor intensive process previously measured by level of school enrolment and education quality with low or no concern on productivity and efficient resource utilization. Trends in increasing government allocation to education sector demonstrate a positive impact on enrolment, education quality and efficiency levels determined in the study. However, there was a gap on how government expenditures impacted school technical efficiency in public primary schools. To determine schools' technical efficiency and relative determinants; this study used data from the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) data which evaluated class six performance for 3 times periods (2000, 2004, 2012). In the analysis, Data Envelopment Analysis (DEA) and Two Stage Least Squares are applied. Results revealed that technical efficiency scores in 8 provinces were lower in 2004 compared to 1997 but increased in 2007 with productivity change exhibiting same trends. Input change for enrolment and school amenities affected overall output. Class-pupil and pupil–toilet ratio, distance from small town, dispensary, bookshop and secondary school as well as class type contributed negatively to efficiency scores. Class-book ratio, government expenditure, playfield availability and class numbers contributed positively to efficiency. The results showed that schools located near main road and library had positive relationship to level of efficiency. On policy, expenditures should be increased towards quality classes and more qualified teachers who are high determinants efficiency.

Keywords: School Performance, Efficiency, Productivity, Government Expenditure

Introduction

Background

The principal measure of school performance in Kenya has primarily been the amounts allocated to the primary education sector and the qualification pupils achieve in the Kenya Certificate of Primary Education Examinations (KCPE). In most cases, education management is more labour intensive, hence productivity and efficiency utilization of available resources including human resource, school infrastructures should be considered as a key indicator of school performance (Fishlow, 1995; Odusola, 1998; Persson and Tabellins, 1994; Muyanga *et al*., 2010). In the seminal work on human capital development by Becker, Mincer and Schultz in the 1960's, there has been increased interest on investment in the education sector with respect to technical efficiency which should be considered in primary level of education (Lucas, 1988; Mincer, 1974).

Although existing studies have established existence of an effect of government expenditure on enrolment and quality of education, very little have been undertaken on school efficiency levels as an indicator of quality of education (Aghion and Howitt, 1988; Alesina and Rodrik, 1994; Benhabib and Spiengel, 1994; Lucas, 1988; Romer, 1990; Nelson and Phelps, 1966; Bowers and Urick, 2011). This study seeks to answer a critical question on how expenditures by the government affect school technical efficiency.

DOI: 10.3844/jssp.2019.29.39

The question at hand explains a prescribed hypothesis that measurement of school performance by increase in human capital inherent in labour productivity leads to productivity that is triggered towards output equilibrium levels to enhance enrolment levels, quality of education and efficiency levels. The hypothesis is as a results of neoclassical growth theory discussions (Mankiw *et al*., 1992; Bold *et al*., 2011; Mazar *et al*., 2007; Cohen and Dupas, 2010).

Trends in Financing Public Primary Education in Kenya

Marginally, the increasing enrolment across the years demonstrated a level of investment in an economy that affected almost all sectors which signaled a positive growth in education expenditures accounting for only 1.1% of GDP (Republic of Kenya, 2005). The explained trend in financing are demonstrated in Fig. 1.

The positive changes in school enrolments may translate to high levels of inefficiency on the utilization of resources if not checked. The resultant outcome would be low enrolment, high drop outs, grade repetition, low completion and poor transition rates (Bedi *et al*., 2002; Kimalu *et al*., 2001; Bold *et al*., 2011; Nyamoita, 2013; Lee *et al*., 2005).

Technical Efficiency in Primary Schools

Technical efficiency analysis evaluates how well resources are utilised in a school (Hanushek and Woessman, 2008). It also explains the use of productive resources in the most optimal technology and efficient way resulting to the highest possible output from a combination of a set of inputs. In a school setting production inputs including household's socio-economic levels, school type, school size, geographical index and pupil–teacher ratio (Charnes and Cooper, 1985; Koopmans, 2013; Kwabena and Appiah, 2004; Mizala and Rumaguera, 2000; Nyamoita 2013; Mizalla and Rumaguera, 2000; Worthington, 2001).

Data Sources and Analysis

Secondary data used in the study was collected from the United Nations Education, Scientific and Cultural Organization (UNESCO) - the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) I, II and III for the years 2000, 2004 and 2012 and Statistical Abstracts for the year 1996/7 to 2014/15 using school based cross-section survey approach for class 6 pupils and covered the 8 regions in Kenya. The study also covered several characteristics including pupil characteristics, school-based characteristics as well as teacher and households' characteristics respectively. Data on government expenditure and respective enrolment for the years was collected from different statistical abstracts covering the period around 2000 before the introduction of Free Primary Education (FPE), 2004 representing one year after the introduction of FPE and 2012 representing a rather stable period after the implementation of FPE programme. Relevant variables specific to the study were extracted from the data set, coded and applied in analysis non-parametric measure for technical efficiency measurement using Data Envelopment Analysis Programme (DEAP) model. Causes of inefficiency were determined through a second stage analysis by applying censored Tobit regression model using STATA

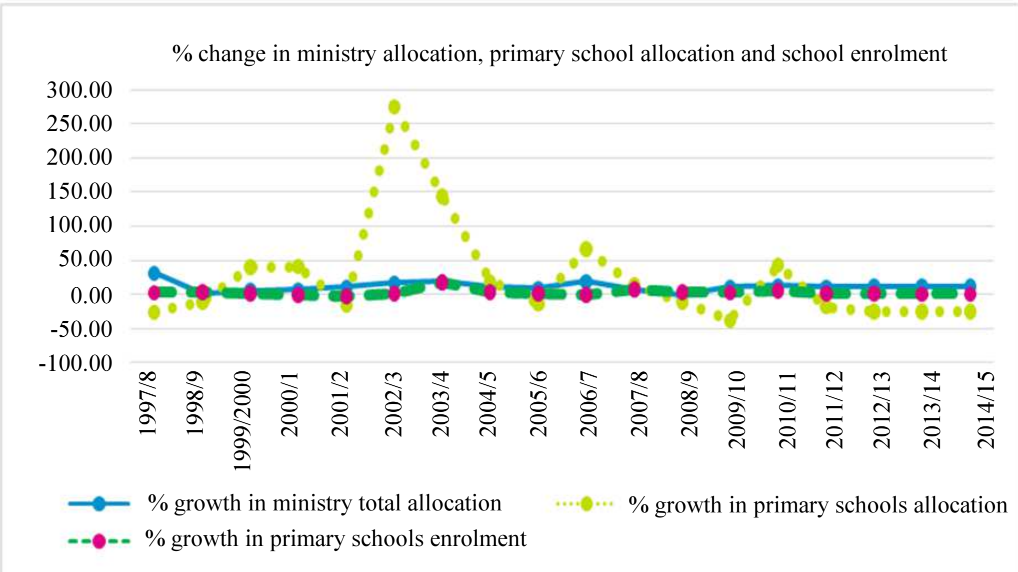

Fig. 1: Percentage Growth in Ministry of Education Allocation, Primary Education Allocation and School Enrolment, *Source: Republic of Kenya, 1998-2007*

Reviewed Literature

Theory of Production and Primary Education

Empirical Literature on Theory of Production

Studies on technical efficiency use either DEA or Stochastic Frontier Analysis for efficiency measurement. The studies adopted various inputs among them teacher-pupil ratio, pupil gender, school expenditures, household characteristics and partly school characteristics. In addition, school outputs used in the studies comprised of subject scores attained during impact evaluation. The output was found in all studies except for Abagi and Odipo (1997) who used school completion levels. A limitation in the studies found that, final year test scores used were biased because evaluation was done at a time when pupils were conditioned to take an examination which in most instances provided the biased scores. The analysis used in the studies to achieve these results included Stochastic Frontier Analysis (SFA) which included censored regression model and DEA approach.

SFA model was often not used in most of the studies as it worked well with a few inputs and outputs thus DEA model is applied due to its capacity to convert inputs and outputs into a single measure of efficiency. The measure of efficiency would be for each decision making unit comprising of multiple inputs and outputs without requirement for homogeneous measurements (Kanina, 2013; Kwabena and Appiah, 2004; Mizala and Miguel, 2007; Nyamoita, 2013; Kirigia *et al*., 2000). In all the studies reviewed, only one Kanina (2013) used TSLS to establish determinants of efficiency. Learning from the reviewed literature, this study adopted DEA model for analysis of technical efficiency measurement. The results provided comprehensive results for technical efficiency change, technological change and scale efficiency. In this study, censored Tobit model for TSLS analysis is used to establish the determinants of efficiency.

Mathematics Literature on Theory of production

Production function in a school setting provides a means of understanding overall process by estimating effects of given inputs that are used to achieve the expected school performance incorporating input factors and expected outputs. The model adopts cobb-douglas output function that applies translog framework for a school output with k inputs is presented as:

$$\ln y = \alpha + \sum_{k=1}^{k} \beta_k \ln x_k + \frac{1}{2}\sum_{k=1}^{k}\sum_{m=1}^{k} \gamma_{km} \ln x_m \qquad (2.1)$$

Equation 2.1 provides a translog multiple output cost for k inputs to l outputs. Further, the equation provides the analysis of translog model as:

$$\begin{aligned} \ln C &= \alpha + \sum_{k=1}^{k} \beta_k \ln w_k \\ &+ \frac{1}{2}\sum_{k=1}^{k}\sum_{m=1}^{k} \gamma_{km} \ln w_k \ln w_m + \sum_{s=1}^{L} \delta_s \ln y_s \\ &+ \frac{1}{2}\sum_{s=1}^{L}\sum_{t=1}^{L} \varphi_{st} \ln y_s \ln y_t + \sum_{k=1}^{K}\sum_{s=1}^{L} \theta_{ks} \ln w_s \ln y_{st} \end{aligned} \qquad (2.2)$$

Equation 2 relaxes restrictions on demand elasticities and elasticities of substitution with the translog translating the function to a monotonic condition expressed as (Salvanes and Tjotta, 1998):

$$s_k = \frac{\partial \ln c}{\partial \ln w_k} = \beta_k + \sum_{m\gamma km} \ln w_m \geq 0, k = 1 \qquad (2.3)$$

where, $k = 1$ are non-negative factor shares

The concavity condition of the model is also given as:

$$\Gamma = [\gamma km], S = diag[s_k] and\ s = [s_1, s_{2,...,} s_k]^T \qquad (2.4)$$

When technical efficiency is integrated in the input-output model, production is therefore defined as the process of transformation of a set of inputs denoted by $x \in \Delta_k^+$ in to a set of outputs $y \in \Omega_M^+$. The production transformation process presented as $T(y, x) = 0$ where 0 normalises the natural view, where an input requirement set is expressed as:

$$L(y) = \{x : (y, x) is producable\} \qquad (2.5)$$

where, $L(y)$ is the vector of output y.

Efficiency is thus explained in the production model defined by the isoquant:

$$I(y) = \{x : x \in L(y) and \lambda x \notin L(y) if\ 0 \leq \lambda < 1\} \qquad (2.6)$$

whose boundary on the input requirement set is set as:

$$\begin{aligned} &ES(y) = \{x : x \in L(y)\}\ and \{x' \notin L(y)\} \\ &for\{x'\}\ when \{x_k' \leq x_k \forall k\}\ and \{x_k' < x_j\ for some j\} \end{aligned} \qquad (2.7)$$

The equation 2.10 is presented in Fig. 2.

The Fig. 2 shows that $X^A = (x_1^A, x_2^A)$ is on the isoquant, but it is not the efficient subset. This is because there is a slack in x_2^A. X^B which has both $I(y)$ and $ES(y)$. The distinction between these two sets are applicable in the Data Envelopment Analysis (DEA model). According to Farrell (1957) the measure of efficiency may not be equated to 1 if some levels of inefficiency are exhibited and $TE(y, x) \neq 1$. In this case, TE would be θ and thus $0 \leq \theta \leq 1$ therefore the level of inefficiency is $1-\theta$ as presented in Fig. 3.

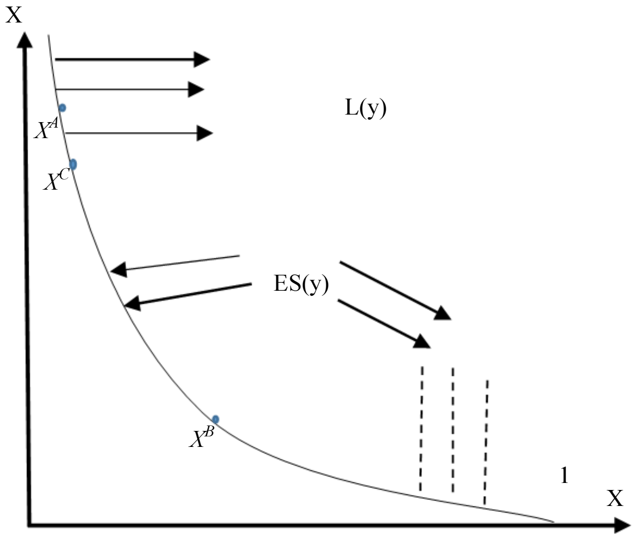

Fig. 2: Technical Efficiency Input requirement

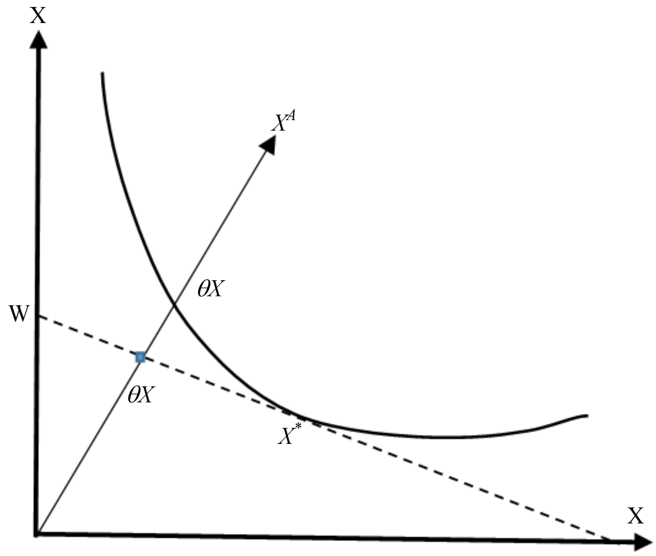

Fig. 3: Technical and Allocative Inefficiency

The Debreu–Farrell production model outlined in Fig. 3 is expressed as:

$$y_i = f(x_i, \beta) TE_i \quad (2.8)$$

Where:

$$0 < TE(y_i, x_i) \leq 1 .$$

In the equation, β is the vector of parameter in the production vector of parameters estimated. The production model discussed is linear in logs of the variables expressed as:

$$\ln y = \ln f(x_i, \beta) + \ln TE_i = \ln f(x_i, \beta) - \mu_i \quad (2.9)$$

where, $\mu_I \geq 0$ is a measure of technical inefficiency.

The assumption outlined holds given that:

$$\mu_i = -\ln TE \approx 1 - TE_i, \; thus \; TE_i = \exp(-\mu_i) \quad (2.10)$$

A study by Sherperds (1953) outlines that input distance function expressed as:

$$D_I(y,x) = \max\left\{\lambda : \left[\frac{1}{\lambda}\right] X \in L(y)\right\} \text{and } D_I(y,x) \geq 1 \quad (2.11)$$

is presented on the isoquant set of *xs* where:

$$D_I(y,x) = 1.$$

Further analysis by Debreu (1951) and Farrell (1957) found that input-oriented technical efficiency given as:

$$TE(y,x) = \min\{\theta : \theta x \in L(y)\} \quad (2.12)$$

The equation 2.12 is solved as:

$$TE(y,x) \leq 1 \quad (2.13)$$

and therefore technical efficiency is defined as:

$$TE(y,x) = \frac{1}{D_I(y,x)} \quad (2.14)$$

In a school environment, the adopted theory of production applies various technical efficiency measurements (Abagi and Odipo, 1997; Afonso and Aubyn, 2006; Charnes *et al*., 1978; Charnes and Cooper, 1985; Grosskopf *et al*., 1997; Muvawala and Hisali, 2012; Nyamoita, 2013). This includes the modern efficiency measurement that begins with Farrell's (1957) work, who drew upon the work of Debreu (1951) and Koopmans (1951). Further, Lovell (1993) notes that technical efficiency in a school setting is given as the ratio of outputs to the number of inputs utilised as presented in Fig. 4.

The Fig. 4 presents Farrell's theory of the production frontier which involves original input and output values. The horizontal axis denotes the amounts of inputs, X, utilised to produce output, *Y*. When input-output values are utilised, on the production frontier (π), then schools do not attain the maximum possible output. As indicated in Point A, the technical efficiency of a given school producing output, *y*, from inputs *X* can be calculated as $\frac{y}{y^{"}}$ where *y*" is the quality of output *B* on the production frontier.

DEA Model of Estimating Efficiency

Non-parametric approaches use linear programming approaches and frequently apply Data Envelopment Analysis (DEA) for analysis which is superior to Ratio Analysis, Stochastic Frontier Measurement and Regression Analysis). The DEA strength include: (1) Ability to convert inputs and outputs into a single measure of efficiency for each school, (2) DEA handles multiple inputs and outputs without requirement for homogeneous measurements, (3) DEA can adjust for exogenous variables that are outside control of firms management, (4) DEA does not require specific functional form relating inputs to outputs, so as to compute the efficiency of a school and (5) DEA focuses on observed best practice frontier unlike stochastic frontier models which focuses on central tendency properties (Bowlin, 1996; Burgess, 1998; Charnes *et al*., 1978; Coelli, 1996).

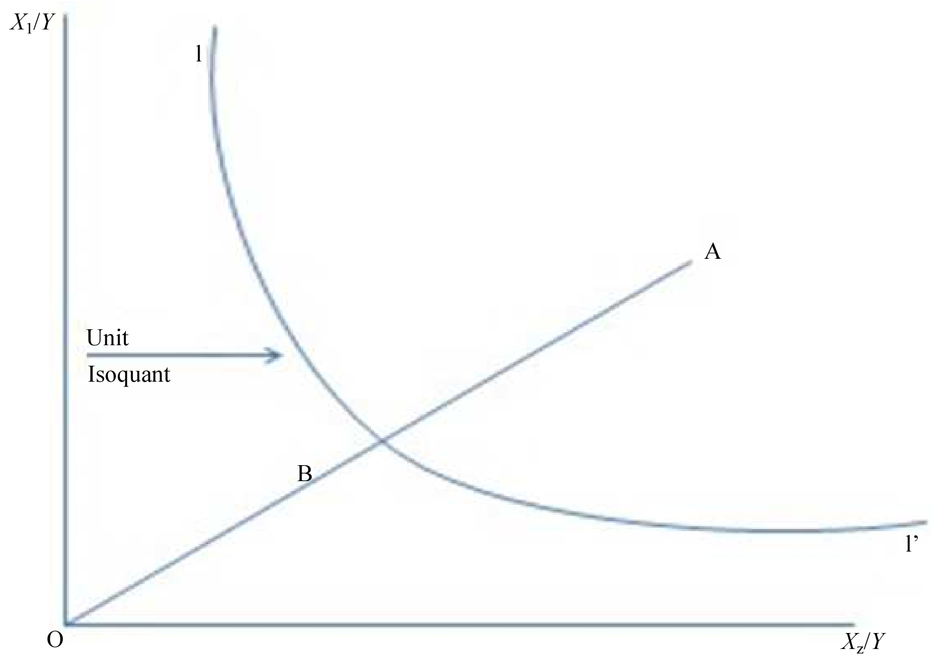

Fig. 4: Technical Efficiency and the production frontier

Methodology

Production Theory and Government Expenditure

The education production function discuss school operations in skill development from a cobb-Douglas model form expressed as:

$$Q = AE^{\alpha}R^{\beta}\,\forall\alpha+\beta\leq 1 \tag{3.1}$$

where, Q are the inputs to school score depended on school characteristics; (A) are school characteristics; (E) student characteristics and (R) government expenditure with parameters α, β being elasticities.

Given its pioneer framework, the model therefore formed a basis of productivity model, adoption of either a deterministic, stochastic or panel data model, the equation adopts output (Y) and product of a known function of a vector X, which is defined by Aigner and Chu (1968; Lovell and Schmidt, 1977; Pitt and Lee, 1981) as:

$$Y_i = f(x_i:\beta)\exp(-\mu_i), i = 1,2,...N \tag{3.2}$$

Where:

- Y_i = The possible production level for ith sample function.
- $f(x_i$: $\beta)$ = A suitable function of the vector
- x_i = The number of inputs for ith school/firm and of unknown parameters
- μ_I = The non –negative random variable with school specific functions which contribute to the ith school not attaining maximum efficiency of production.
- N = Represent the number of schools involved in a cross-sectional summary of the education sector
- Y_i = Bounded above by the deterministic quantity $f(x_i$: $\beta)$ hence Equation 3.2 is deterministic production function with inequality relationship given as:

$$Y_i \leq f(x_i:\beta), i = 1,2,...N \tag{3.3}$$

From the production model in equation 3.39, technical efficiency expressed from the deterministic function model in equation 3.38, using output in the i^{th} school is given as:

$$Y_i^* = f(x_i:\beta) \tag{3.4}$$

and thus technical efficiency is expressed as:

$$\begin{aligned} TE_i &= \frac{Y_i}{Y_i^*} \\ &= f(x_i:\beta)\exp\frac{(-\mu_i)}{f(x_i:\beta)} \\ &= \exp(-\mu_i) \end{aligned} \tag{3.5}$$

DEA Model for Technical Efficiency Measurement

In the model definition, consider n schools and each uses m inputs such that $x_{ij}(i = 1,\ldots,m)$ to produce s outputs $y_{rj}(r = 1,\ldots,s)$ assuming that all inputs and outputs are non-negative in a Production Possibility Set (PPS). Under the Constant Returns to Scale (CRS) assumption, the PPS is derived as:

$$P_c = \left\{(x,y)\mid x\geq\sum_{j=1}^{n}\lambda_j x_j, y\leq\sum_{j=1}^{n}\lambda_j y_j, \lambda_j\geq 0, j=1,...,n\right\} \tag{3.62}$$

where, x_j and y_j are the input vectors and output vector of $school_j$ respectively.

Adopting the Charnes *et al.* (1978) CCR model, the radial proportional change of inputs or outputs is indicated as:

$$\begin{aligned} &\theta^* = \min\theta \\ &s.t\sum_{j=1}^{n}\lambda_j x_{ij}\leq\theta x_{ik}, i=1,...,m, \\ &\sum_{j=1}^{n}\lambda_j y_{ij}\geq x_{ik}, i=1,...,s, \\ &\lambda_j\geq 0, j=1,...,n, \theta\, free \end{aligned} \tag{3.7}$$

where, the optimal solution of θ^* is efficiency score. In this paper, a school was said to be efficient if $\theta^* = 1$ and inefficient if $\theta^*<1$.

Further, let X be a $m*k$ matrix of inputs that are constructed from a vector of inputs, x_i, in k schools. Thus Y denote a $n*k$ matrix of outputs, y_i, of the k schools. The output-oriented Variable Returns to Scale (VRS) frontier is thus expressed as:

$$\begin{aligned} &Min\theta \\ &\theta,\lambda \\ &Subject\ to - y_i/\theta - Y\lambda\geq 0 \\ &x_i - X\lambda\geq 0\ kI'\lambda = 1\ \lambda\geq 0 \end{aligned} \tag{3.84}$$

where, $k1$ is a $N*1$ vector of $1s,\lambda$ is and a $k*1$ vector of weights while θ is the output distance measure which is between 0 and 1. In this respect, 1/θ are the levels of efficiency scores by which output of i^{th} school could be expanded while keeping input quantities constant (Coelli, 1996). The variables for efficiency determination are outlined in Annex Table 1.

Determinants of Inefficiency

The empirical censored Tobit model that was used to establish determinants of efficiency in equation 3.8 was adopted from Breusch *et al.* (1989; Cameron and Trivedi, 2010; Woodridge, 2002); taking the form:

$$y = \begin{cases}1 & if\ y>0\\ 0\end{cases} \tag{3.9}$$

where, y is the inefficiency score that had been achieved from equation 3.9.

By introducing a latent variable y_i^* then:

$$E\left(y_i^* | x\right) = x_i' \ \beta$$
$$y_i^* = x_i' \ \beta + \varepsilon_i$$
$$\varepsilon_i \approx i.i.d.N\left(0, \sigma^2\right) \quad (3.10)$$
$$y_i = \begin{cases} y_i^* & if \ y_i^* > 0 \\ 0 & y_i^* \leq 0 \end{cases}$$
$$and \left\{x_i, y_i\right) : i = 1, 2, .3\}$$

where, x_i are the various variables used to determine the levels of efficiency levels in the model.

The censored observation then became:

$$pr\left(y_i = 0\right) = pr\left(y_i^* \leq 0\right)$$
$$= pr\left(\varepsilon_i \leq -x_i' \ \beta\right) = pr\left(\frac{\varepsilon_i}{\sigma} \leq -\frac{x_i' \ \beta}{\sigma}\right) \quad (3.11)$$
$$= \varphi\left(-\frac{x_i' \ \beta}{\sigma}\right) = 1 - \varphi\left(\frac{x_i' \ \beta}{\sigma}\right)$$

The variables used to determine the determinates of inefficiency are presented in Annex Table 2.

Findings

Summary Statistics

The summary statistics adopted school as the unit of analysis which were sampled across based on the pre-devolution administration locations as shown in Table 1.

Table 1 shows the number of schools sampled for the study were 174, 173 and 181 for years 2000, 2004 and 2012 respectively. The Table 2 represents the mean and standard deviations for government expenditures in the eight provinces for the period 2000, 2004 and 2012.

Table 2, shows the mean amount of government expenditure in three time periods covered by the study reduced for central, Coast, Eastern, Nyanza, Rift valley and Western Provinces but increased for Nairobi and North Eastern Provinces across the period. The overall mean government allocation per school increased between 2000 and 2004 with the establishment of FPE and dropped significantly after the FPE programme stabilised in 2012.

Input and Output Target Change in Technical Efficiency

Levels of technical efficiency change in outputs and inputs were explained by schools exhibiting decreasing returns to scale (drs), Increasing Returns to Scale (IRS) and/or constant returns to scale (crs) presented in Table 3.

Table 1: Number and percentage of schools sampled

Year	2000	2004	2012	Mean	Standard deviation
Coast	22 (12.6%)	18(10.4%)	15(8.3%)	18.3	3.51
Central	35(20.1%)	24(13.9%)	23(12.7%)	27.0	6.00
Eastern	24(13.8%)	23(13.3%)	22(12.2%)	23.0	1.00
Nairobi	19(10.9%)	19(10.98%)	15(8.3%)	17.7	2.30
Rift Valley	24(13.8%)	28(16.2%)	38(20.99%)	30.0	7.20
Nyanza	20(11.5%)	23(13.3%)	34(18.8%)	25.0	7.40
Western	15(8.62%)	24(13.9%)	22(12.2%)	20.0	4.72
North Eastern	15(8.6%)	14(8.1%)	12(6.6%)	13.7	1.53
Total	174	173	181	176.0	4.35

Source: Authors Computation Based on SACMEQ Survey data

Table 2: Mean government expenditure

	2000		2004		2012	
Province	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Central	1,030,890	660,276.2	769,811.8	296,505.6	480,274.6	220,284.8
Coast	939,129.5	752,259.7	737,702.0	356,629.7	703,215.3	361,027.2
Eastern	569,264.0	287,237.9	530,759.0	256,185.5	413,787.2	217,930.1
Nairobi	1,205,449	364,168.5	1,216,258.0	398,010.6	1,282,608	552,954.5
North Eastern	826,018.7	478,641.5	1,058,135.0	643,337.2	171,800.5	32,021.6
Nyanza	543,366.1	339,848.0	518,805.4	405,103.6	484,393.8	254,402.5
Rift valley	663,115.8	264,743.3	650,955.2	273,526.7	610,123.5	337,802.0
Western	867,895.6	556,341.1	7,080,391.0	342,887.2	723,979.5	357,703.4
Total Mean	5,614,238		1,2562,818		4,870,182	

Source: Authors Computation Based on SACMEQ Survey data

Determinants of (in) Efficiency in Technical Efficiency

To estimate the determinants of efficiency, second stage analysis was carried out using Tobit model where the dependent variable included levels of inefficiency which were either 0 or 1 (u_i = (1-*effieicny*) and results presented in Annex, Table 3.

Technological Change in Technical Efficiency

The Solow model on productivity analysis $Y = AK^{\alpha}L^{\beta}$ was applied to account for effects in total output if inputs were used to determine a measure of technological dynamism as presented as overall efficiency change, the technological efficiency change, scale efficiency change, pure technological efficiency and aggregated TFP in Table 4.

Table 3: Technical efficiency change, output and input change levels

Efficiency levels at province levels						Output change		Input change				
Province	Year	CRSTE	VRSTE	SCALE	Levels of scale	Arithmetic average score change	Reading average score change	Total enrolment change	Government expenditure change	Toilets change	Total classes change	Total teachers change
Central	2000	0.790	1.000	0.790	drs	-	-		-	-	-	-
	2004	0.746	0.981	0.760	drs	11.102	36.797	-0.892	-	-6.518	-1.083	-0.787
	2012	0.900	1.000	0.900	drs	-	-	-	-	-	-	-
Coast	2000	1.000	1.000	1.000	-	-	-	-	-	-	-	-
	2004	0.828	0.978	0.846	drs	16.500	12.800	-75.5	-97,273.3	-	-2.1	-0.7
	2012	1.000	1.000	1.000	-	-	-	-	-	-	-	-
Eastern	2000	0.793	0.997	0.795	drs	1.727	1.742	-5.46	-	-0.375	-	-1.932
	2004	1.000	1.000	1.000	-	-	-	-	-	-	-	-
	2012	1.000	1.000	1.000	-	-	-	-	-	-	-	-
North Eastern	2000	0.947	0.988	0.958	drs	6.167	8.667	-142	-42,978	-	-	-1.167
	2004	0.843	0.973	0.866	drs	15.200	21.200	-426	-548,284.8	-	-5.0	-6.2
	2012	0.676	1.000	0.676	drs	-	-	-	-	-	-	-
Nairobi	2000	0.627	0.100	0.627	drs	-	-	-	-	-	-	-
	2004	0.629	1.000	0.629	drs	-	-	-	-	-	-	-
	2012	0.488	1.000	0.488	drs	-	-	-	-	-	-	-
Nyanza	2000	1.000	1.000	1.000	-	-	-	-	-	-	-	-
	2004	1.000	1.000	1.000	-	-	-	-	-	-	-	-
	2012	1.000	1.000	1.000	-	-	-	-	-	-	-	-
Rift valley	2000	1.000	1.000	1.000	-	-	-	-	-	-	-	-
	2004	0.877	0.946	0.927	drs	31.778	50.444	-45.22	-57,659.33	-0.778	-	-0.556
	2012	0.793	0.936	0.848	drs	36.794	48.458	-90.315	-83,609.27	-	-	-
Western	2000	0.884	0.940	0.940	drs	33.333	37.834	-10.5	-139,064	-	-	-0.333
	2004	0.892	0.955	0.935	drs	25.800	28.800	-96	-123,474	-	1	-0.8
	2012	0.693	0.895	0.774	drs	60.224	63.656	-132.525	-123,384.7	-	-1.888	-

*** p<0.01, ** p<0.05, * p<0.1; Standard errors in parentheses **Source:** Authors Computation Based on SACMEQ Survey data

Table 4: Technological efficiency analysis for 8 provinces (2000, 2004 and 2012)

Province	Year	Efficiency change	Technical efficiency change	scale efficiency change	Pure technological efficiency	Total factor productivity
North Eastern	2004	0.814	0.789	1.034	0.7880	0.643
	2012	1.030	0.897	0.942	1.9420	0.925
	Mean	0.916	0.842	0.987	0.9280	0.771
Central	2004	0.935	0.985	1.000	0.9350	0.921
	2012	1.256	***	1.019	1.2320	***
	Mean	1.084	***	1.010	1.0740	***
Coast	2004	0.908	1.147	1.009	0.9000	1.042
	2012	0.926	1.014	0.923	1.0030	0.939
	Mean	0.917	1.079	0.923	0.9500	0.989
Eastern	2004	0.914	1.22	0.974	0.9390	1.115
	2012	1.096	1.026	1.019	1.0750	1.125
	Mean	1.001	1.119	0.996	1.0050	1.12
Nairobi	2004	1.050	227.837	1.005	1.0450	239.211
	2012	0.716	1.506	0.937	0.7640	1.078
	Mean	0.867	18.521	0.970	0.8930	16.055
Nyanza	2004	0.849	1.163	0.957	0.0888	0.988
	2012	1.211	0.855	1.061	1.1420	1.035
	Mean	1.014	0.997	1.007	1.0070	1.011
Rift valley	2004	0.795	0	0.939	0.8470	0
	2012	1.127	0.853	1.058	1.0650	0.961
	Mean	0.946	0	0.997	0.9490	0
Western	2004	1.251	0.902	1.060	1.1800	1.128
	2012	0.984	0.48	0.989	0.9960	0.736
	Mean	1.109	0.821	1.024	1.0840	0.911

Source: Authors Computation

DOI: 10.3844/jssp.2019.29.39

Conclusions and Policy Recommendations

Conclusion

Efficiency analysis shows that there exit a process change from inputs to outputs that had greater impact to VRSTE compared to CRSTE in the three year period. Efficiency results both at VRSTE and CRSTE dropped across the three time period but with varied levels in different provinces and these depended on input and output levels as well as on levels of FPE stabilization. These results conformed to Charnes *et al*. (1978) and Liu and Mills (2007) who identified efficiency to depend on levels of inputs and outputs in different time periods.

Thus, for a school to remain technically efficient, it should have an input and output target. The inputs and output changes in the analysis provided either the number of inputs that should be reduced or added to make schools in various provinces efficient as explained by various scale efficiencies. Referring to the Solow model productivity analysis $Y = AK^{\alpha}L^{\beta}$ which accounted for effects in total output when inputs were controlled for to determine a measure of technological dynamism; the trends in efficiency change were evident within technical efficiency change, scale efficiency change, pure technical efficiency and total factor productivity that declined between 2000 and 2004 but improved between 2004 and 2012 (Table 2). From a Tobit model, second stage regressions results were criticised by their likelihood for biasness on small samples with a proposal to apply alternative and inference procedures (Afonso and Anbyn, 2006).

Schools characteristics analyzed against inefficiency scores showed that class-pupil ratio, pupil –toilet ratio, pupil-teacher ratios, school distance from small town, dispensary, bookshop and secondary school as well as class types contributed negatively to efficiency. These results also showed high statistical significance at both 99, 95 and 90% levels respectively in 2012 when it was assumed that the FPE programme had stabilized.

Policy Implications

Borrowing from the Ugandan case where Muvawala and Hisali (2012) compared the efficiency of government and primary schools, there was evidence that as outlined by Grosskopf *et al*. (1997), private schools were more efficiently operated. If the school operational efficiency were adopted in most provinces, these could lead to reduced expenditure by up to 30% and still achieve the same outcomes.

From the Ugandan case, efficiency interventions introduced in the context of current resource allocations to primary education would result in a mere 1% improvement in learning outcomes. However, in the Kenyan case, the levels of efficiency would change between 12.5-15.1% of school performance and this would improve learning outcomes greatly. In order to adopt findings of this study, the government should set up a taskforce to establish the unit cost of education from the basic school levels to university level. The taskforce should also provide the unit cost of teacher capacity development as well as the efficiency models to be adopted in all school types disaggregated by school location. This model can be analyzed from the Computable General Equilibrium (CGE) model that shows the macro-economic impact of government investment in various sectors.

Acknowledgment

This study makes ackonowdegment to the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) and the United Nations Education, Scientific and Cultural Organization (UNESCO) for allowing the use of the data collected from their work in this study. The SACMEQ based data formed a bulk of the data used in the study. Other data were from the Kenya National Examinations Council (KNEC) and the Kenya National Bureau of Statistics (KNBS).

Author's Contributions

The authors to this study have made great contribution to efficiecny analysis in the education sector. This is well notable because most of the efficiency studies have been undertaken in the health, manufacturing and banking sector. The study sets precedence for further studies in determining efficiencies in education environment. The main author developed the publication with the supporting authors contributing in model alignment and revision of the paper.

Ethics

This paper has been undertaken with highest level of indepedence and originality. All the iformation provided in the study is the responsbility of the author.

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