DETERMINANTS OF TECHNICAL EFFICIENCY OF TECHNICAL TRAINING INSTITUTIONS IN KENYA

PHILIP KINARA

A Research Project Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Masters of Arts in Economics, in the School of Economics, University of Nairobi.

November, 2014

DECLARATION

This is my original work and has not been presented for any degree award in any other university.

Philip Kinara

X50/64163/2011

Signed ....

Date: 18/11/2014

This Research Project has been submitted for examination with our approval as university supervisors:

Prof. Damiano Kulundu

Signed...

Date: 18/11/2014

Dr. Urbanus Kioko

Signed...

Date: 18/11/2014

DEDICATION

To Fifi, Sandy and Angela for your unending love and unfettered inspiration.

ACKNOWLEDGEMENT

I would like to thank my supervisors Prof. Damiano Kulundu and Dr. Urbanus Kioko for their dedicated support and guidance in the research work leading to this paper. Their incisive scholarly input was the driving force to the conclusion of this work.

My heart felt gratitude to all the institutions that provided information and data made this research a reality. The magnitude of your help cannot be quantified and is an epitome of the power of sharing information.

Lastly, appreciation goes to my work colleagues for making the office the genesis of interest for this work.

ABSTRACT

In light of the concerted efforts by government to revamp the Kenyan system of TVET education, the study evaluates technical efficiency of public TVET institutions using Data Envelopment Analysis. Specifically, the study analyses the efficiency of 34 TVET institutions based on available input data on expenditure, teaching staff and enrollment and output data on number of graduates and mean pass rates. The efficiency scores are then regressed against selected variables to determine their effect on efficiency. Secondly, the study also examines total factor productivity change in these institutions using the Malmquist Index using data for 5 years from 2008 to 2012.

The results from the data envelopment analysis suggest that a large number of the TVET institutions are not efficient because they have efficiency scores of less than 1. Moreover, findings from the efficiency scores suggest the TVET colleges could improve performance by 32% using the same resources. In addition, mean annual total factor productivity growth was positive and increased by 42.2 per cent and was entirely due to technical change accounting for 38.2 per cent.

The study recommends that policies to ensure effective management and operations of TVET institutions should be implemented. This may include greater decentralization of the management structures of public TVET institutions to give college managers more discretion in allocation of resources. Secondly, we recommend that the assessment system in TVET institutions should be restructured to ensure improvement in the low pass rates by implementing a competency based assessment framework which is more valid to skills development. Lastly, the study recommends enhanced and equitable funding of rural based institutions to ensure that they operate optimally and are at par with urban based TVETs.

TABLE OF CONTENTS

DECLARATION i
DEDICATION ii
ACKNOWLEDGEMENT iii
ABSTRACT iv
LIST OF TABLES vii
LIST OF FIGURES viii
ABREVIATIONS ix

CHAPTER ONE: INTRODUCTION 1
1.1 Background 1
1.2 Technical and Vocational Education and Training (TVET) in Kenya 2
1.3 Trends in expenditure in TVET education 3
1.4 Challenges facing TVET in Kenya 3
1.5 Problem Statement 4
1.6 Study Objectives 5
1.7 Justification of the Study 6
1.8 Organization of the Study 6

CHAPTER TWO: LITERATURE REVIEW 7
2.1 Theoretical Literature Review 7
2.1.1 Technical efficiency 7
2.1.2 Measurement of Technical Efficiency 8
2.1.3 Data Envelopment Analysis 10
2.1.4 Total Factor Productivity 11
2.2 Empirical literature review 11
2.2.1 Technical efficiency and Total Factor Productivity in education 12
2.2.2 Overview of the literature 14

CHAPTER THREE: METHODOLOGY 16
3.1 Introduction....16
3.2 Methodology....16
3.2.1 Data Envelopment Analysis....16
3.2.2 Malmquist Index....18
3.2.3 Tobit regression....18
3.3 Definition and Measurement of Variables....19
3.3.1 Input variables....19
3.3.2 Output variables....20
3.3.3 Environmental Variables....20
3.4 Sources of Data and the scope of the study....21

CHAPTER FOUR: ANALYSIS OF RESULTS AND DISCUSSION 22
4.1 Introduction....22
4.2 Preliminary analysis of Data....22
4.3 Technical Efficiency scores....23
4.4 Total factor Productivity....25
4.5 Determinants of Technical Efficiency....26

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS....29
5.1 Summary and Conclusion....29
5.2 Policy recommendations....30

REFERENCES....31

LIST OF TABLES

Table 1-1: Trends in public expenditure in TVET..3
Table 4-1: Descriptive statistics for Input and Output variables 22
Table 4-3: Efficiency Scores...24
Table 4-4: Malmquist Index Summary of Annual Means 25
Table 4-5: Bootstrapped Tobit Regression results...27
Table 4-6: Marginal Effects After Tobit Regression 27

LIST OF FIGURES

Figure 2-1: Total factor productivity and the production frontier 9
Figure 4-1: Decomposition of Total Productivity Index.. 26

ANNEXES

Table A1: Malmquist Index Summary of Firm Means……………………………34
Table A2: Summary of Output Slacks……………………………………………….35

ABREVIATIONS

CDTL	Catering Development Training Levy
DEA	Data Envelopment Analysis
DFA	Deterministic Frontier Approach
DMU	Decision-Making Unit
FDSE	Free Day Secondary
FPE	Free Primary Education
GDP	Gross Domestic Product
GOK	Government of Kenya
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examination Council
KPI	Key Performance Indicator
MI	Malmquist Index
NITA	National Industrial Training Authority
PCA	Principal Component Analysis
SET	Science Technology and Innovation
SFA	Stochastic Frontier Approach
TSC	Teachers Service Commission
TVET	Technical and Vocational Education and Training
TVETA	Technical Vocational Education and Training Authority
USD	US Dollar

CHAPTER ONE: INTRODUCTION

1.1 Background

Education is recognized as a fundamental pillar of human rights, democracy, sustainable development and peace. Therefore governments and households alike, invest massively to ensure that education becomes accessible to all throughout life so that society reaps the maximum benefits of investing in education. Indeed, the numerous studies on the benefits on education have consistently found positive social and private returns to education at all levels. In Kenya policy documents have identified provision of accessible, quality and relevant education as a key foundation for spurring development and social cohesion. The Kenya vision 2030 emphasizes the need to provide critical skills required to drive the various sectors of the economy.

The sessional paper no 1 of 2005 on education and training classified education and training in Kenya into three distinct levels, basic education, Technical and Vocational Education and Training (TVET) and University Education. Basic education covers primary and secondary education, University education covers degree awarding institutions while TVET covers all the vocation and technical training institutions. TVET is targeted to impart technical and vocational skills which are expected to impact on employment, poverty reduction and by extension social cohesion.

The Dakar Framework for Action on Education for All not only envisaged provision of education for all, but also aimed at imparting life skills to both children and adults through vocational training. In addition the introduction of Free Primary Education (FPE) and Free Day Secondary (FDSE) subsidy programs by the Government of Kenya (GoK) means that the expected graduates from the successive primary and secondary school cohorts will require to attend further training so that they can be prepared to join the job market to which TVET provides an avenue.

The African Union in its Plan of Action for the Second Decade of Education for the period 2006 – 2015[i] recognises the importance of TVET as a means of empowering individuals to take control of their lives and recommends the integration of vocational training into the general education system. The Kenya government has therefore given attention to provision of TVET through increased resource allocation and institutional reforms.

The GoK has progressively increased resource allocation to public TVET institutions during the first medium term period of the Vision 2030 as a strategy to enhance skills development in the country.

Policy makers therefore, need to ensure that the available resources for skills training are allocated in the most efficient way possible to achieve the desired objective- a pool of skills that will attract appropriate and relevant investment.

1.2 Technical and Vocational Education and Training (TVET) in Kenya

TVET education in Kenya is comprised of 2 National Polytechnics, 43 Technical Training and Institutes of Technology Institutions managed by the Ministry of Education, Science and Technology, private Technical Training Institutions and specialized Training Colleges managed by a host of ministries in other areas which include water, health, tourism, labour and roads.

The TVET subsector is governed by the respective government departments which set policy, accredit and fund the TVET institutions under their purview. The National Industrial Training Authority (NITA) established under the Industrial Training Act 2012 oversees the Industrial training levy that is used to administer in-service TVET training in Kenya. The TVET Act 2013 established the TVET Authority (TVETA), the TVET fund and the TVET curriculum assessment and certification board as a way of streamlining management in TVET in the country.

Presently the Kenya Institute of Curriculum Development (KICD) oversees development of curricular for TVET while Kenya National Examination Council (KNEC) administers examination. In addition students all take examination from other accredited examination bodies.

1.3 Trends in expenditure in TVET education

To support TVET the government through the responsible ministries provide grants for recurrent and capital expenditure in public TVET institutions. Total expenditure on recurrent stood at KES 2.6 billion in 2005/6 which was the same level of funding in 2007/2008 financial year. Expenditure on development rose from KES 284 million to KES 3.58 billion in 2011/12.The government also provides bursaries to needy students pursuing TVET education as an affirmative action towards equity in education.

Table 0-1: Trends in public expenditure in TVET

	2007/08	2008/09	2009/10	2010/11	2011/12
Recurrent					
Technical	2,607.03	3,815.30	2,885.12	3,162.30	2,604.10
Youth Polytechnics and Training	775.33	1,272.60	981.20	2,098.10	2,152.50
Development					
Technical	284.00	1,412.00	1,088.30	3,139.00	3,580.70
Youth Polytechnics and Training	1,131.93	1,383.00	1,476.06	1,957.76	1,578.00

Source: GOK, KENAO Audited Appropriation Accounts.

1.4 Challenges facing TVET in Kenya

Despite the growth in the TVET sector, both in enrolment and funding, the sector faces a number of challenges including poor perception that has made the sector branded as a choice of last resort for those who fail to attain test grades required to join university education.

Granted, the progress made over the last decade in enhancing access, retention, quality, completion rates and gender parity in education and training is remarkable. Nonetheless the TVET sector continues to face many challenges. These include: an insufficient number of trainers with pedagogical competency, inadequate number of TVET centres, limited availability of customized teaching and learning materials, limited industry participation and inadequate research support services. Other challenges include poor geographical distribution of TVET institutions, low enrolment for females in Science Engineering and Technology (SET) courses and unfriendly environment for people with special needs. Furthermore there is uncoordinated admission of students to TVET institutions. There is also low enrolment in TVET institutions due to the high cost of technical training and lack of awareness. The result is that most trainees end up in cheap alternative programmes whose graduates do not acquire the requisite skills necessary for the job market.

Although public investment in technical and vocational education has been on an upward trend in the last decade, the paucity of skilled human resources in Kenya is a problem that has persisted over the last decade. Biggs and Srivastava (1995) in a survey of companies in Zimbabwe, Ghana and Kenya found that Kenyan manufactures did not have adequate technical staff at diploma and certificate level. The Kenya Vision 2030 and the Sessional Paper No 14 on education and training of 2013 also identify the mismatch in skills training as a challenge to the country's development objectives.

Public financing supports school based TVET education which is thought to be expensive and ineffective. According to Walther, (2006) despite the fact that TVET in Africa consumes between 67% to 267% of GDP per capita it only accounts to about 5% of the annual injection into the labour market. In Kenya, data form the Ministry of Education, Science and technology shows that the per capita expenditure in TVET was approximately USD 1824 (KES 162,336) in 2010 well above the per capita GDP of USD 1600 (KES 142,400).Like the other levels of education significant proportion of the high cost of TVET is as a result of teacher salaries and administrations costs.

1.5 Problem Statement

The Government of Kenya has committed to provide relevant and adequate skills and competencies in strategic disciplines by 2020 (GoK 2012b). To achieve this the government has supported the growth of the TVET sector by increasing resource allocation and providing incentives for investment and participation in skills training in the country. The government has therefore set the annual increase in number of TVET graduates as a Key Performance Indicator (KPI) for the TVET sector (GoK, 2009).

As a remedy to this problem the Sessional Paper No 2 of 2014 on education and training in Kenya proposes the use of unit cost to determine the cost of provision of TVET education. Linking financing of TVET to the unit cost requires policy makers to account for the recurrent (teacher salaries, teaching materials, administration costs and costs of student upkeep) and development costs (expenditure on teaching and learning equipment, institutional infrastructure and research activities) as the basis for determining the unit cost.

Moreover, the cost of internal efficiency (inefficiency) must be accounted for to ensure that the limited resources are optimally allocated so that students do not pay the cost of inefficiency in public TVET institutions. It is therefore, incumbent upon policy makers to isolate causes of inefficiency in public institutions to ensure they deliver optimum outcomes from the available resources.

In spite of the increasing focus on TVET, no evaluation of efficiency in higher education institutions and specifically TVET institutions has been done so far. In Kenya; studies on efficiency in education have focused mainly on secondary and primary education. For Instance, Kanina (2012) analyzed technical efficiency and total factor productivity in primary schools in Kenya while Abagi and Odipo (1997) analyzed efficiency of primary schools in Kenya. Needless to say the institutional structure of TVET institutions in Kenya is different from the primary and secondary schools. As a result, conclusions drawn from studies of efficient in these schools may not be valid for TVET institutions. The study, therefore presents analysis of technical efficiency of public TVET institutions and its determinants and total factor productivity changes over the period 2008 -2012.

1.6 Study Objectives

The aim of this study is to examine the determinants of technical efficiency in public TVET institutions in Kenya. The specific objectives of the study are to:

1. Analyse technical efficiency in public TVET institutions in Kenya;
2. Analyse total factor productivity in in public TVET institutions in Kenya;
3. Determine the factors that affect technical efficiency of public TVET institutions in Kenya;
4. Based on 1, 2 and 3 present policy suggestions for improving technical efficiency in TVET training in Kenya.

1.7 Justification of the Study

Public training institutions play a major role in development of skills in Kenya and Africa as a whole. Public training caters for the more costly technical training and provides geographical equity (Johansson and Adams 2004). However, poor quality and mismatch of training offered and the skills demanded in the market are problems that have beleaguered public training institutions. Limited resources allocation has slackened the development of TVET institutions with a large proportion of the public budget being allocated to teachers' salaries and other administrative costs. However the last decade has seen increasing allocation of resources to public TVET institutions in Kenya.

Limited studies have been conducted to determine the efficiency of public TVET institutions despite the increasingly large per capita expenses incurred. The establishment of the industrial training levy, the TVET fund and the Catering Development Training Levy (CDTL) is a cursor to government policy to raise more resources towards training. It is therefore incumbent upon policy makers to examine the most efficient ways to allocate these resources for skills development.

This study will provide insight on the internal efficiency in the running of public training colleges. Efficiency and productivity measures help provide performance metrics by which higher education institutions can be evaluated. Finally, the study will provide policy recommendations for enhancing efficiency in the development of TVET in Kenya.

1.8 Organization of the Study

The next chapters of this thesis are organised as follows: chapter two presents a review the theoretical and empirical literature pertinent to the study, chapter three gives the outline the methodology that has been used in this study which is the description and analysis of data, estimation methods and the rationale for their use. Chapter four presents results of the study and interpretation. Finally, chapter five gives a summary of the study, conclusions and policy implications.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents pertinent literature about technical efficiency of higher education institutions. It presents reviews that are related to the study and the theory upon which it is based.

2.1 Theoretical Literature Review

2.1.1 Technical efficiency

The study of efficiency is based on the Theory of Modern Efficiency Measurement which is attributed to Farrell (1957). Using an application to agricultural production in the United States, Farrell presented a measure of productive efficiency which he classified into allocative and technical efficiency. Allocative efficiency occurs when decision-making units (DMUs) utilize or the available limited resources for maximum output and technical efficiency refers to DMUs' capacity to obtain maximum output with a given level of inputs.

Technical efficiency is use of productive resources in the most technologically efficient way. It implies the highest possible output from a combination of a set of inputs Charnes and Cooper (1985). Koopmans (2006) extended the definition of technical efficiency to mean the ability to produce the same output at least one input less or to use the same inputs to produce at least one output more. Another measure of technical efficiency following Debreu (1951) and Farrell (1957) thus defined technical efficiency as one minus the maximum equi-proportionate reduction in all inputs that still allows the production of given outputs. A value of one indicates technical efficiency and a score less than unity indicates the severity of technical inefficiency.

Bowles (1970) uses the production function concept in education institutions and considers education as a production process in which school resources, student attributes and other environmental variables are inputs employed to yield a vector of education outputs. Hanushek (1971, 1979) and Summers and Wolfe (1977) contend that environmental factors need to be factored in the education production function as inputs because of their influence on the outcome s of the educational process.

In education, technical efficiency refers to the relationship between the inputs employed like finances, staff employed, equipment and the expected education outcome, Worthington (2001). In the reviewed literature educational outcomes are identified as standardized test scores in reading mathematics, and writing Chakraborty, Biswas, Lewis (1999). Worthington (2001) also included graduates employment rates, initial salaries and acceptance into higher education institutions.

2.1.2 Measurement of Technical Efficiency

Lovell (1993) brought forth the measurement of efficiency of a DMU as the ratio of its output to its input. Nevertheless efficiency varies depending on the technology adopted, production technique and the diverse environments in which DMUs operate Porcelli (2009). In the output based measure of technical efficiency, the output is maximized given the inputs. The Timmer Index, Timmer (1971) is one of the measures of output-based technical efficiency which is the ratio of the actual level of output to the possible output based on a given set of inputs. On the other hand, input oriented measure of technical efficiency input is minimized given the output. The measure of the efficiency of all inputs to a production process is referred to as Total Factor Productivity.

Figure 0-1: Total factor productivity and the production frontier

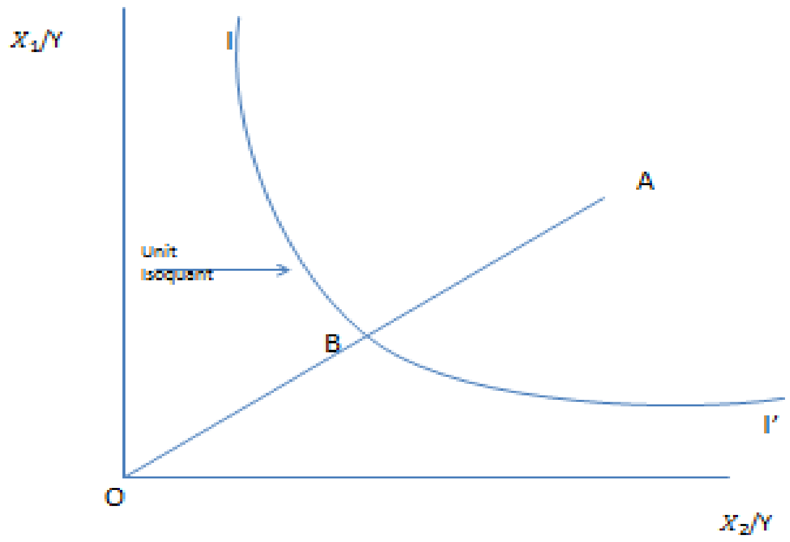


Figure 1 presents Farrell's theory of the production frontier involving the original input and output values. The horizontal axis denotes the inputs, X, employed in producing the output, Y. For the input-output values on the left the production frontier (II^1), DMUs do not attain the maximum output possible for the inputs employed. Point A shows the technical efficiency of the DMU which produces output, y, with inputs, x, and is calculated as $\frac{y}{y''}$, where y" is the output B on the productivity frontier. DMUs with output values below the production frontier are technically inefficient.

With increased interest in studying production efficiency of firms, a number of techniques have been developed; econometric approaches which attempt to determine the absolute economic efficiency of DMUs against predetermined threshold, and the mathematical programming approach which seek to evaluate the efficiency of DMU relative to other DMUs in the same industry.

Econometric approaches includes the 'stochastic frontier approach' (SFA) and the 'deterministic frontier approach' (DFA)[1] . Barrow (1991), Bates (1997) and Sengupta (1987) are some of the studies that employed these techniques in analyzing efficiency. The most popular linear programming tool is known to as 'data envelopment analysis' (DEA)[2]. DEA analyses economic efficiency of a given DMU compared to the performance of other DMUs with homogeneous products rather on some pre-set threshold of performance.

2.1.3 Data Envelopment Analysis

This study uses DEA to analyse technical efficiency of technical training colleges in Kenya. The choice of DEA for this study is because it possesses features that make it appropriate for application to education institutions.

An appealing aspect of DEA is that it allows analysis of multiple-input multiple output production technologies Medwittz, Diamond (1990) without requiring price or cost data. Also, the various input and output factors need not have the same measurement units because DEA is invariant to scaling of variables. This is essential in organizations in the public sector where data on costs is usually minimal. According to Abbott, et al., (2001) technical efficiency is perhaps the only valid assessment of performance of tertiary institutions.

The DEA methodology helps to identify inefficient DMUs as well as the sources and amounts of inefficiency of inputs and/or outputs. Most significant is that DEA evaluates the efficiency of a production unit relative to a group of similar units and is therefore not restricted by the assumptions that all the units under analysis use similar technology. This allows researchers to compare efficiency of peer institutions and therefore rank performance of education institutions.

---

[1] DFA assumes that all deviations from the estimated frontier r represent inefficiency

[2] Charnes and Cooper (1961) give detailed exposition on the contributions to both theory and application in the development of linear programming and DEA.

2.1.4 Total Factor Productivity

Total Factor Productivity (TFP) refers to the share of DMUs output that is not determined by the level of input utilization in the production process. Building from the coubb- douglas production function the TPF can be represented as follows:

$$TFP_t = \frac{Y_t}{K_t^{\propto} L_t^{\beta} M_t^{\mu}}$$

Where Y is output, K is capital, L is labour and M is materials and supplies. $\propto$, β and μ are the respective output elastities for K, L and M.

TFP is mainly determined by the intensity and efficiency of operations of a DMU, Comin (2006). According to (Hulten e.tal, 2001) changes in TPF is influenced by innovations, organizational dynamics and attitudes in the society that affect demand behavior. Comin (2006) observes that by linking total factor productivity we can theoretically deduce that TPF is determined by changes in innovation, investments in research and development, skilled labour and changes in the market size among other reasons.

Solow (1956) showed that country innovations may explain the differences in their per capita incomes technology may generate. This was also demonstrated by Hall and Jones (1999). The analogy of firm level differences in TPF can be drawn from these postulations. Malmquist (1953) proposed the Malmquist index as a measure of TPF. The Malmquist index has found most widespread use in the measure of TPF. Fare et.al (1994), attributes this popularity to the fact that the index can easily be decomposed into the various components of TPF. Forsund (1990) further demonstrated the index as a product of technical change and technical efficiency changes.

2.2 Empirical literature review

DEA has been used in numerous studies technical efficiency. Of particular interest to this study, many studies on efficiency in education have adopted DEA as a preferred tool. Given its nonparametric basis, considerable room is given on the specification of inputs and outputs. This is deemed useful in education production function where the assumption of profit maximization does not necessarily hold, Worthington (2001).

However, erroneous data or excluding of inputs and outputs has been thought to distort the accuracy of results Smith and Mayston (1987).

2.2.1 Technical efficiency and Total Factor Productivity in education

Available empirical analysis of efficiency of higher education using DEA exists. Abbott and Doucouliagos (2001) used DEA to estimate technical and scale efficiency in universities in Australia. Athanassopoulos (2001) and Shale (1997) and Madden et al., (1997), Dyson, 2000; Worthington, 2001; Johnes, 2006; also investigated efficiency in Universities[3] .

Cunha and Rocha (2012) used DEA technique to measure the comparative efficiency of higher education institutions in Portugal. Their analysis looked at public universities, public polytechnics and some faculties of University of Porto. Their results suggest most of the institutions may be operating inefficiently contributing to a significant waste of public resources.

Kanina (2012) in a study on Technical efficiency and total factors productivity of public primary schools in Kenya suggests that: schools can improve their performance (test scores) by 9.2 percent using their current level of inputs. Giménez, et al., (2007) also suggest that developed countries, could increase their performance of schools with less resources than those currently deployed.

Muvawala and Hisali (2012), in their study on technical efficiency in Uganda's primary education out those private and urban schools are relatively more efficient than public and rural schools. They found out that private schools would to improve learning outcomes without increasing spending and improvements in learning outcomes for government-aided schools will require increased resources.

Mizala et al., (2002) in a study on the technical efficiency of schools in Chile, established that private fee-paying schools are the most efficient, followed by private subsidized and public schools lending credence to the postulation that increased

[3] Abbott and Doucouliagos (2001) and Worthington (200) provide in-depth review of findings of studies on efficiency in higher education.

spending could increase efficiency in schools. However, Hanushek (1996) shows that U.S schools have had great increases in resources with very small improvement in outcomes. He therefore concludes that the failure to realize improved performance despite the increased resources proves inefficiency.

Johnes et al., (2008) measured the research performance of Chinese higher education institutions using data envelopment analysis. The study finds that mean research efficiency is higher in comprehensive universities compared to specialist universities. This suggests that differences in the institutional characteristics explain for differences in efficiency.

Tanja & Heikki (1996) applied DEA and tobit analysis to determine differences in efficiency in secondary schools in Finland. The study finds that single-sex schools out-perform co-educational schools; that teacher quality (in terms of both qualifications and experience) has positive effect on efficiency; that public schools perform poorly compared to private sector schools; that rural schools are more efficient than urban schools; size positively affects efficiency; and that the lower the socio-economic status of a school's neighborhood, the lower the school's efficiency. This study confirms the influence of environmental variables on the performance of education institutions.

Similarly, Johnes et al., (2010) found out that student attributes such as sex, ethnic and age are significant in determining efficiency levels of schools and are in fact more important than staff related variables. However, teacher characteristics like teacher salary and ethnicity have been found to have significant influence on efficiency of schools.Adkins and Moomaw (2005) found that school district size, teacher education and experience, and teacher salary affect the technical efficiency of schools in Oklahoma.Wolszczak and Parteka (2011) concluded that the size of the education institution, the number of faculties and funding sources among the important factors that affect performance of Higher Education Institutions across European countries .

The study of efficiency in higher education institutions has found importance in light of lack of empirical evidence to support the expected influence of increased investment in inputs on education outcomes, Worthington (2001) which Mayston

1996 argued was because schools capitalized on the demand for education and the willingness to pay for it rather than the outcomes.

Flegg (2004) used the Malmquist approach to assess the productivity of 45 British universities. Their results showed that that total factor productivity increased by 51.5% between 1980 and 1993. The concluded that and that most of this increase was due to outward shift in the efficiency frontier suggesting increase in availability of inputs and technological progress.

Kanina (2012) using the Malmquist productivity index demonstrated that there was an increase in total factor productivity by in primary schools in Kenya 2.2 percent over. These gains in productivity gains were also attributed to technological change.

Recent studies have also shown that managerial skills and practices have impact on firm productivity. Bloom and Van Reenen (2007) in a study on medium level industries in the US showed that managerial practice is a predictor of a firm's productivity and competiveness.

In addition, Ruggiero (2000) shows environmental variables have a significant impact on the provision of public services. He observed that lack of control for these variables would lead to bias in the estimates of returns to scale.

2.2.2 Overview of the literature

The importance of measuring efficiency of production units is evident from the fore-going review of literature. The extension of technical efficiency in measurement of performance of education institutions has also found wide application. However studies on efficiency of middle level colleges are limited and none exists for Kenya.

In the reviewed literature, many studies on technical efficiency have employed data envelopment analysis as a tool for analysis. Preference for DEA is based on its non-parametric nature which makes it possible for application to education institutions where prices are not available. Other approaches in measurement of efficiency include the 'stochastic frontier approach' (SFA) and the 'deterministic frontier approach'

(DFA). The input and output data is calculated in DEA to provide efficiency scores with the most efficient unit having a score of 1 and the less efficient unit have scores less than one.

Most studies have found that public schools operate below their efficiency level and could increase output at current resource levels. The studies also single out student, teacher and school characteristics as key determinants of efficiency in schools. Other environmental variables that affect efficiency of educational institutions include geographical location, age or years of operation of the institutions and household incomes of parents.

It is evident for the literature that total factor productivity has been growing over time in educational institutions. Findings from reviewed studies show that most of the change in productivity has been explained by changes in technology and account for the variations in productivity in different institutions. The effects environmental variables are also apparent.

In the second stage, efficiency scores calculated in DEA are used as the dependent variable and are regressed against environmental variables to determine their impact on efficiency. Tobit regression has been employed in second stage data envelopment analysis (DEA). This is explained by the fact that the efficiency scores have an upper bound of 1 for the most efficient unit. Hoff (2008) concluded that the tobit is appropriate in second stage DEA models and that OLS may also replace tobit as an adequate second stage DEA model.

From the foregoing it is evident that studies have been conducted on efficiency of various categories if higher education institutions. However, the study has not come across literature on efficiency of TVET institutions in Kenya. The study addresses this gap.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter provides a review of the research methodology used in this study. The chapter expounds on how the relevant data and information is used to address the research objectives and questions will be collected, presented and analysed.

3.2 Methodology

3.2.1 Data Envelopment Analysis

DEA is a nonparametric method for measuring efficiency attributed to Charnes, Cooper and Rhodes (2007). It is a linear programming model, assuming no random mistakes, used to measure technical efficiency of production units. Efficient firms are those that produce a certain amount of outputs while spending a given amount of inputs, or use the same amount of or fewer inputs to produce a given amount of outputs, as compared with other firms in the test group.

The DEA formulation can incorporate both input-reducing and output-augmenting orientations as well as constant and variable returns to scale. The study will present only the input-reducing orientation. The output-increasing orientation is analogous and derived similarly. However, different results are obtained from the two orientations under the variable returns to scale assumption (Fare and Lovell (1978)).

The DEA methodology gives us a tool to estimate "relative" efficiency of a chosen entity in a given group of units and criteria. In analyzing efficiency we look at a number of n productive units (colleges):DMU_1, DMU_2, …, DMU_n. Each unit produces s outputs while employing m inputs. The input matrix can be therefore be written as X = (x_{ij}, i = 1, 2, …, m, j=1, 2, …, n) and an output matrix Y = (y_{ij}, i = 1, 2, …, s, j= 1, 2, …, n). The efficiency rate of such a unit can then be generally expressed as:

$$\frac{sum\ of\ outputs}{sum\ of\ inputs} = \frac{\sum_{i=1}^{s} u_i\, y_{iq}}{\sum_{j=1}^{m} v_i\, x_{jq}}$$

Where:

$v_{j,} j = 1,2 \dots . m,$ are weights to jth input and $u_{j,} i =$

$1,2 \dots . s,$ are weights to ith input

In the DEA model, we evaluate *n* DMUs, where each DMU takes *m* different inputs to produce *s* different outputs. The principle of DEA models in measuring the efficiency of a DMU is based on maximizing its efficiency rate of that DMU. However, this is tied to the condition that the efficiency measure of any other units in the group must not exceed a value of 1.

This study uses the output oriented CCR model following Charnes and Cooper and Rodhes (1978)) which could be written as follows:

maximise $g = \emptyset + \in (e^T s + e^T s^-)$

Subject to $Y\beta - S^+ = \emptyset Y_q$

$X\beta + S^- = X_q$

$\beta, S^+, S^- \geq 0$

Where

i. g is the efficiency
ii. $\emptyset$ is the efficiency rate of the DMUs in the model.
iii. $\beta = (\beta_1, \beta_2 \ldots, \beta_n), \beta \geq 0,$
iv. β is a vector of DMUs, S^+ and S^- are input and out variables that are added, and $\in > 0,$

The following inference can be drawn from the model:

1. The DMU is CCR efficient if the optimal value of the objective function in model equals one i.e g* = 1.
2. If the value of the function is has a value exceeding one, the DMU is inefficient.
3. The variable $\emptyset$ implies output should be increased to achieve efficiency.

The model assumes constant returns to scale. However, in efficiency analysis, variable returns to scale can also be considered. The goal of DEA analysis to determine the efficiency rate of the DMUs reviewed and also to determine values for inputs *X* and outputs *Y* for an inefficient unit. After reaching these values, the unit would arrive at the threshold of efficiency.

3.2.2 Malmquist Index

The output-oriented DEA-Malmquist Index is used to gauge the total factor productivity change (TPFC) in the decision making units over the period under the study. This can be expressed as ratio between the indices for changes inputs changes in outputs due to technology over the period of observation.

$$TFPC = \left[\frac{d_s(q_s, x_t)}{d_s(q_t, x_t)} \frac{d_t(q_s, x_s)}{d_t(q_t, x_t)} \right]^{0.5}$$

The value for TFPC is the Malmquist Index and a figure greater than one indicates TFP while figures less than one mean that TFP dropped.

The total factor productivity change can be decomposed into efficiency change and technical change.

3.2.3 Tobit regression

In the second stage, efficiency scores calculated in DEA are used as the as the dependent variable and are regressed them on environmental variables to determine their impact on efficiency.

Tobit regression will employ in second stage data envelopment analysis (DEA). In the second stage of the analysis the efficiency score obtained from the first stage will be regressed against the efficiency determining variables. These are institution size, geographical location and the average cost of operating the institution. To enhance robustness of the model we add number of staff, recurrent expenditure and development expenditure as explanatory variables.

The model for estimating the determinants of efficiency can be specified as follows:

$$\boldsymbol{\sigma = \beta_0 + \beta_1 x + \beta_2 \mu + \beta_3 \gamma + \beta_4 \rho + \beta_5 \theta + \varepsilon}$$

Where:

x is the size of the institution measured by the total enrollment;

μ is the the geographical location which takes a dummy variable with the value 1 if the institutions is located n an urban area and zero if otherwise;

β_3, β_4 and β_5 are number of staff, recurrent expenditure and development expenditure respectively;

$\boldsymbol{\varepsilon}$ is normally independently distributed with mean, zero, and variance δ^2.

We then estimate the marginal effects from the tobit regression to establish the effect of the explanatory variables on efficiency.

3.3 Definition and Measurement of Variables

3.3.1 Input variables

The inputs used in the study are teaching staff in the TVET institutions, student enrolment, recurrent funds and capital funds.

i. Teaching Staff

Teaching staff is measured by the full time teachers employed by the Teachers Service Commission (TSC). It must be noted that some colleges in addition employ contractual teaching staff to augment the TSC. The decision to employ contractual staff is purely discretionary to the management of the institutions and is directly dependent on the revenue of the college. Because of this reason, this category of teaching staff is left out of the analysis.

ii. Enrolment

Student enrolment is measured by the number of annual full time enrollment in the TVET institutions over the period of study. This is based on annual returns provided by these institutions to the ministry of education science and technology.

iii. Recurrent funding

Recurrent funding is measured by the annual public appropriations to each of the colleges that are voted for administration, operations and maintenance. This includes wages for staff employed by the institutions. This data was derived for the government's annual appropriations accounts provided by the National Treasury, disbursement schedules in the ministry of education, science and technology.

iv. Development funding

Recurrent funding is measured by the annual public appropriations voted for capital investments. This includes infrastructure development and acquisition of training equipment.

3.3.2 Output variables

The outputs in the model are the number students graduating annually and the annual percentage mean pass rates based on test scores obtained from the technical and business examination administered by the Kenya National Examination Council(KNEC).

(i) No of graduates

The numbers of graduates used in the study is given by the number of diploma graduates for each year as reported by the institutions for the period under study.

(ii) percentage mean pass rates

This is measured by the average pass rates for students who sat for KNEC examinations in their respective subjects of study. This calculated by finding the percentage of students who obtained passes from the total number who were entered for examinations by the institutions.

3.3.3 Environmental Variables

(i) Location

The study introduced a dummy variable for the location of the institutions. The dummy variable takes a value of 1 if the institution is located in an urban locality and 0 if it is based in a rural area. Urban area in this study is defined based on the Kenyan national census definition of areas with population above 2000 with built up areas and transport systems.

(ii) Size of the institution

Size of institution is measured by the institutions enrolment. The enrolment is measured by the numbers of students in the institutions and taken as a suitable proxy for the size of the institution.

3.4 Sources of Data and the scope of the study

The study uses secondary data collected for 34 public TVET institutions for the period 2008 to 2012. The data on expenditure was collected from annual appropriation reports provided by the National Treasury, audited from accounts of public TVET institutions from the Ministry of Education Science and Technology. Data on test scores from the Kenya National Examination Council (KNEC) and data on teachers from the Teachers Service Commission (TSC).The study excluded data from 9 TVET institutions which were either converted to university colleges or were just recently established between 2010 and 2012.

This study examines technical efficiency in 34 public technical training institutions that were in existence in 2010. Institutions that were established after the year 2010 have been left out because of lack of sufficient data available for this study. The choice of the 2010 is based on the fact that appropriation reports for government expenditure and audited accounts for more recent years are also not readily available to provide data on expenditure which is a key in out for these study.

The scope of the study is limited to public institutions offering TVET training under the purview of the ministry of education science and technology. It must be recognized that other public institutions under other ministries and all private TVET providers have been excluded due to limitation on available data, time and resources available of collect such data.

CHAPTER FOUR: ANALYSIS OF RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the analysis of efficiency scores in 34 public technical training institutions in Kenya under variable and constant return to scale. This analysis is done for the period 2008 and 2012 where efficiency score of one indicate efficient DMUs and scores of less than one indicates levels of inefficiency. The analysis then presents results of the results of DEA-based Malmquist methodology which examines total factor productivity in the DMUs over the period of analysis.

4.2 Preliminary analysis of Data

The study looks at 34 TVET institutions over a period of 5 years (170 observations). It is observed that the institutions pass rate is at 55.91 with average annual grandaunt number of 310. The average number of students per institutions is 1112. It is also observed the least student enrolment 25 while the highest enrolment is 4882 students. This illustrates the wide variation that exists in the size of the institutions. This is also observed in staffing and both development and recurrent expenditures. An analysis of the descriptive statistics is presented in Table 4.1.

Table 0-1: Descriptive statistics for Input and Output variables

Variable	Obs	Mean	Std. Dev.	Min	Max
staff	170	77.57647	40.48168	5	188
enrolment	170	1112.90	915.7853	25	4,882
Recurrent exp	170	28,500,000	26,700,000	9,179,000	134,000,000
Development exp	170	28,300,000	36,300,000	422,504	205,000,000
No of graduates	170	310.98	238.35	8	1220
% pass	170	55.92	11.72	28.5	100

4.3 Technical Efficiency scores

The analysis of data to obtain efficiency scores was executed using the DEAP program Coelli, T (1996). The program is run under the output orientation Multi-Stage DEA instruction mode for 34 DMUs over the 5 year period from 2008 to 2012.

Under the assumption of constant returns to scale output oriented model, the study finds that the average efficiency score for the DMUs is 0.681. This implies that TVET institutions could have improved their performance by 32% using the current resources. Out of the 34 institutions 11 are found to have technical efficiency score of 1 which imply that they operate efficiently when gauged with their peers. 23 institutions are found to be inefficient with scores of less than unity. These institutions when assessed under variable returns to scale have scores of less than 1 on scale efficiency suggesting that they operate below capacity. On average the mean scale efficiency is 0.757 suggesting that public TVET institutions have 24.6% unused capacity.

Table 0-2: Efficiency Scores

	DMU	CRS Technical Efficiency	VRS Technical Efficiency	Scale Efficiency	
1	Bumbe TTI	0.37	0.37	0.99	irs
2	Bushiangala TTI	0.32	0.40	0.81	drs
3	Coast IT	0.53	0.6	0.88	drs
4	Eldoret NP	0.952	1	0.95	irs
5	F CKaimosi	1	1	1	-
6	Gusii IT	1	1	1	-
7	Kabete TTI	1	1	1	-
8	Kaiboi TTI	1	1	1	-
9	Kiambu IST	1	1	1	-
10	Kisumu Polytechnic	1	1	1	-
11	Kitale TTI	0.762	1	0.76	irs
12	KTTC	0.641	0.671	0.95	drs
13	Masai	0.378	0.663	0.56	drs
14	Mathenge	0.712	0.8	0.89	drs
15	Mawego TTI	0.939	1	0.93	drs
16	Meru TTI	0.177	0.591	0.29	drs
17	Michuki TTI	0.156	0.601	0.26	drs
18	Mombasa TTI	0.165	0.636	0.26	drs
19	Nairobi TTI	0.177	0.8	0.22	drs
20	NEP TTI	0.246	1	0.246	drs
21	Nkabune TTI	1	1	1	-
22	Nyandarua IT	0.707	1	0.707	drs
23	Nyeri TTI	0.606	1	0.606	drs
24	Ol lessos TTI	0.922	1	0.922	drs
25	PC KTTI	1	1	1	-
26	RIAT	1	1	1	-
27	Rift Valley IST	0.337	0.929	0.363	drs
28	Rift Valley TTI	0.334	0.936	0.357	drs
29	Rwika	0.649	0.965	0.673	drs
30	Sang'alo IT	1	1	1	-
31	Siaya IT	1	1	1	-
32	Sigalagala TTI	0.644	1	0.644	drs
33	Thika TTI	0.451	1	0.451	drs
34	Wote TTI	0.977	1	0.977	drs
	Mean	**0.681**	**0.881**	**0.757**	

4.4 Total factor Productivity

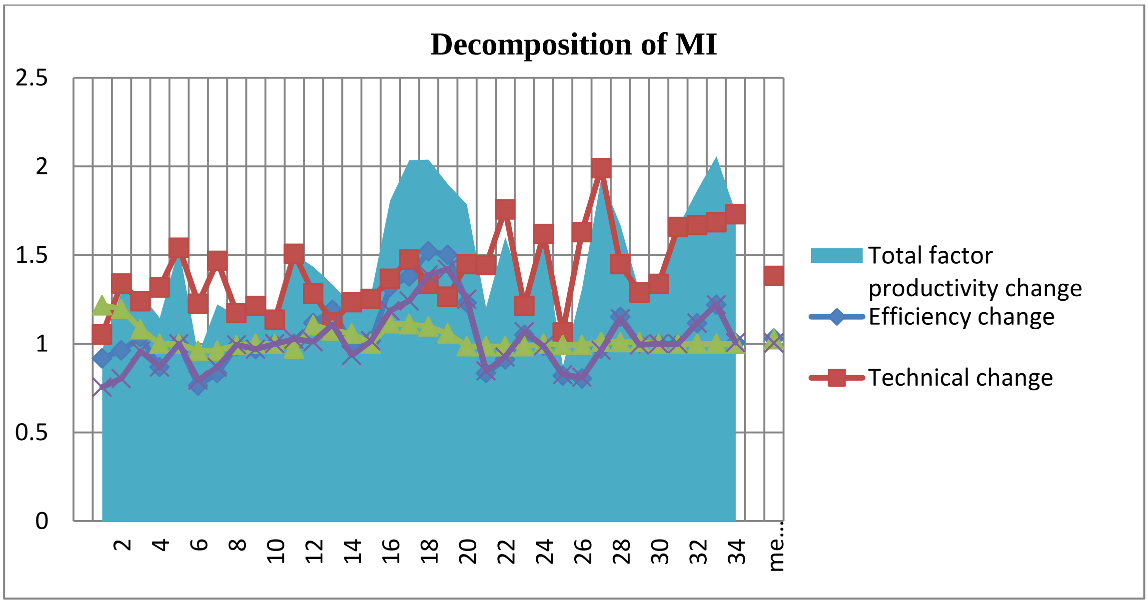
To determine total factor productivity is assessed by computing the Malmquist Index (MI).The results of the MI indicate that the mean annual total factor productivity growth was positive and increased by 42.2 per cent. This growth was entirely due to technical change accounting for 38.2 per cent .This suggests that the marginal of the change in productivity is explained by changes in innovations by the TVET institutions. The pure efficiency change indices measure the contribution of management and improved operations to total productivity which increased marginally from 1.047 per cent in 2009 to 1.049% in 2011 but decreased to 96.3% in 2012. The results suggest that the quality of managers and the management system in public TVET deteriorated. The summary results for the Malmquist index are presented in Table 4.

Table 0-3: Malmquist Index Summary of Annual Means

Year	Efficiency change	Technical change	Pure efficiency change	Scale efficiency change	Total factor productivity change
2009	1.03	1.149	1.047	0.984	1.184
2010	1.234	1.877	1.048	1.177	2.317
2011	0.957	1.605	1.049	0.912	1.535
2012	0.922	1.053	0.963	0.957	0.971
mean	**1.029**	**1.382**	**1.026**	**1.003**	**1.422**

At the individual form level majority of the institutions achieved positive changes in productivity with TFP indices above 1 except Bumbe, Kaimosi and PC Kinyanjui TTIs which have indices below unity. The results also show that the technical change was positive for all the institutions and was the major contributor to product productivity change over the period of study. Figure 4.1 presents the patterns of the decompositions of the Malmquist Index.

Figure 0-1: Decomposition of Total Productivity Index



The detailed factor productivity indices for the 34 institutions are presented in Annex 1.

4.5 Determinants of Technical Efficiency

To examine the determinants of technical efficiency we regress the efficiency scores against technical efficiency contextual variables. These variables are size which is proxied by enrolment number of the institutions and location which is dummy variable taking the value 1 for urban and 0 for rural locations. To address bias and serial correlation of the efficiency estimators in the model we employ bootstrap technique proposed by Simar and Wilson (2007) the tobit-censored regression model to accommodate the fact that DEA efficiency estimates are bound between 0 and 1. We then conduct a marginal effects analysis to estimate the marginal effects of the regressors on efficiency.

A test of collinearity on the dependent variables established correlation of 0.6007 between the dependent variables .This suggest significant influence between the predictor variables. Tobit regression models are unstable under strong collinearity. To address this problem we run the principal component analysis (PCA) on the predictor variables to decompose the correlation between these variables. The PCA yields principal components of the predictor variables with zero correlation. The results of the bootstrapped tobit model are presented in Table 4.4 and the marginal effects in table 4.5

Table 0-4: Tobit Regression results on Determinants of Efficiency

Log likelihood-7.2981097 Number of obs 170 Replications 100 Wald $chi^2(5)$ 213.07 Prob > chi^2 0 Pseudo R^2 0.9231				
Efficiency	Observed Coefficients	Bootstrap Std. Err.	z	P>z
Staff	-0.0005586	0.0006047	-0.92	0.356
Recurrent expenditure	-6.26E-09	7.73E-10	-8.1	0
Development expenditure	-1.71E-09	5.08E-10	-3.36	0.001
Size	-0.0620367	0.0222504	-2.79	0.005
Location(Urban)	0.0790926	0.0186361	4.24	0
_cons	0.9623473	0.0573262	16.79	0
/sigma	0.1955251	0.0109983		

Obs. summary: 0 left-censored observations

40 right-censored observations at efficiency>=1

Table 0-5: Marginal Effects after Tobit Regression

Margins, dydx(*)		Number of obs170			
Average marginal effects Model VCE : Bootstrap		Expression : Linear prediction			
dy/dx w.r.t. : staff, recurrentexp developmentexp size location					
		Delta-method			
	dy/dx	Std. Err.	z	P>z	[95%Conf
staff	-0.0005586	0.0006047	-0.92	0.356	-0.00174
Recurrent	-6.26E-09	7.73E-10	-8.1	0	-7.78E-09
Development	-1.71E-09	5.08E-10	-3.36	0.001	-2.70E-09
Size	-0.0620367	0.0222504	-2.79	0.005	-0.10565
Location	0.0790926	0.0186361	4.24	0	0.04256

Results on Determinants of Efficiency

(i) Size and Number of staff

The results suggest that the size of institutions is likely to reduce the efficiency of TVET institutions in Kenya by a marginal 0.062 points. This is consistent with Badunenko (2008) and Mengistae (1995) who find that size does not have strong effect on efficiency. Similarly, the effect of staff on efficiency is minimal explaining only for -0.000559 change in efficiency. This suggests increasing the numbers of teaching staff in TVET institutions may not directly lead to improved performance could be as result of other exogenous factors.

(ii) Location

The results obtain a coefficient 0.079 for location suggesting urban locations are likely to increase technical efficiency of TVET institutions. This finding is consistent Muvawala and Hisali (2012) and Tanja & Heikki (1996) who show that urban localities have positive influence on efficiency of education institutions. This could be explained by the likelihood that urban institutions will attract high calibre staff and students with higher qualifications than their rural counterparts. In addition urban institutions have much better facilities.

(iii)Recurrent and development expenditure

The results suggest that increased funding is likely to decrease the efficiency in TVET institutions. This is similar to findings by Hanushek (1996) in regard to funding of public universities in the US. This could be explained by the fact that the increase in public funding has not led to immediate increase in the number of graduates and pass rates in these instructions.

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary and Conclusion

Revitalization of TVET training is a key programme of the public TVET sector in Kenya that led to increased public funding of public technical training colleges over the period 2008 to 2012. Efficiency of TVET institutions is acritical component of management of the TVET sector. The study examined the level of technical efficiency, total factor productivity and determinants of technical efficiency and of TVET institutions in Kenya using the DEA approach.

The study established that TVET institutions in Kenya are operating inefficiently with a mean technical efficiency score of 0.681 implying that TVET institutions could increase performance by 32% using the same inputs that are employed currently. The study also finds that TVET institutions are on average operating at 24.6% below capacity. We conclude that efficiency and productivity has not improved with the increased public funding to TVET institutions.

In addition, using the Malmquist Index the study shows an annual total factor productivity growth was positive. This growth was entirely due to technical change. This suggests that the marginal of the change in productivity is explained by changes in innovations by the TVET institutions. The inference is that TVET institutions should leverage on innovations and technology to drive their productivity. In addition the drop in pure and scale efficiency changes indicates deteriorating contribution of management and improved operations to total productivity. The results suggest that public TVET institutions work on the quality of managers and the management system.

Lastly, the results suggest that the size of institution, number of teaching staff and public expenditure have marginal negative effect on efficiency of TVET institutions in Kenya. These findings suggest that increased resource allocation to these institutions has not improved efficiency and productivity. This implies that participation in TVET training has not grown in tandem with increases expansion of facilities.

5.2 Policy recommendations

From the foregoing conclusions we propose policy recommendations pertinent to the study. Policies to ensure effective management and operations of TVET institutions should be implemented as step towards enhancing efficiency and productivity. This may include greater decentralization of the management structures of public TVET institutions to give college managers more discretion in allocation of resources.

Secondly, we recommend that future investment in TVET should focus on quality aspects of TVET like building capacity of trainers and provision of modern teaching equipment to improve quality training. This funding should be enhanced for rural based institutions to bring them at par with urban based institutions.

In addition, strategies should be put in place to rebrand TVET as a preferred choice for those seeking training as a measure towards increasing participation. This may include enhancing student financing scheme for TVET students and enhanced linkage with industry.

Lastly, we recommend that the examination assessment system in TVET institutions should be restructured to ensure improvement in the low pass rates by implementing a competency based assessment framework which is more valid to skills development.

REFERENCES

Abagi, O. and Odipo, G. (1997). Efficiency of Primary Education in Kenya: Situational Analysis and Implications for Educational Reform, Institute of Policy Analysis and Research, Nairobi.

Abbott , M. and Doucouliagos, C. (2001).The Efficiency of Australian Universities. A Data Envelopment Analysis. *Economics of Education Review 22 (2003)* 89–97.

Adams, A.V. and R.K. Johanson (2004). Skills Development in Sub-Saharan Africa, World Bank, Washington DC.

Batra, G. (2002). Training,Technology and Firm Level Competitiveness, Evidence from the World Business Environment Survey for Latin American and the Caribbean, World Bank Backround Paper, Washington, D.C.

Biggs,T. M. S. and Srivastava, P. (1995). Technological Capabilities and Learning in African Enterprises, World Bank Technical Paper 288.

Fare, R., Grosskopf S. and Lovell, C. A. K (1994). Production Frontiers. Cambridge University Press, New York, 1994.

Flegg A.T., et.al(2004). “Measuring the Efficiency of British Universities: A Multi-Period Data Envelopment Analysis.” *Education Economics* 12(3): 231-249

Forsund, F. R. (1990): The Malmquist productivity Index. Memorandum 28/90, Department of Economics, University of Oslo.

Gime´nez, V., Prior, D. and Thieme, C. (2007). Technical Efficiency, Managerial Efficiency and Objective Setting in the Educational System. *Journal of the Operational Research Society*, 58, 996–1007.

Grifell, T. E and Lovell, C. A. K. (1995). “A Note on the Malmquist Productivity Index.” Economics Letters 4: 169-175.

Hanushek E. A. (1996). "Rationalizing School Spending: Efficiency, Externalities and Equity, and their Connection to Rising Costs," Wallis Working Papers WP2, University of Rochester - Wallis Institute of Political Economy.

Hanushek, E.A. (1971). Teacher Characteristics and Gains in Student Achievement: Estimation Using Micro Data. Am. Econ. Rev. 61, 280-288.

Hanushek, E.A. (1979). "Conceptual and Empirical Issues in the Estimation of Education Production Functions". *Journal on Human Resource.* 14, 351-388.

Hulten, C. R.,et.al (2001). New Developments in Productivity Analysis: Chapter: Total Factor Productivity: A Short Biography; Sponsored by: National Bureau of Economic Research. University of Chicago Press. pp. 1–54. Retrieved 4th October 2014: URL http://www.nber.org/books

Johnes et al., (2010) Bulletin of Economic Research, Volume 62, Number 1, January 2010, pp. 1-30(30): Wiley-Blackwell

Kanina, J.W. (2012). Technical Efficiency and Total Factors Productivity of Primary Schools in Kenya, University of Nairobi.

Kirjavainen, T. and Loikkanent A. (1996). "Efficiency Differences of Finnish Senior Secondary Schools: An Application of DEA and Tobit-Analysis," Discussion Papers 570, The Research Institute of the Finnish Economy.

Lee, C. A. and Ronald, L. M. (2005) Determinants of Technical Efficiency in Oklahoma Schools: A Stochastic Frontier Analysis, Oklahoma State University.

Mariana, C. and Vera, R. (2012). The Efficiency of Public Higher Education Institutions in Portugal: An Exploratory Study.

Mengistae, T. (1995) Age-Size Effects in Productive Efficiency: A Second Test of The Passive Learning Model Centre for the Study of African Economies, Institute of Economics and Statistics ,University of Oxford.

Mizala, A., Romaguera, P. and Farren, D. (2002). The Technical Efficiency of Schools in Chile, Center for Applied Economics, Department of Industrial Engineering, University of Chile.

Muvawala, J. and Hisali, E. (2012). "Technical Efficiency in Uganda's Primary Education System" *The African Statistical Journal*, Vol. 15,(69-84) .

Nicholas Bloom & John Van Reenen, 2007. "Measuring and Explaining Management Practices Across Firms and Countries," The Quarterly Journal of Economics, MIT Press, vol. 122(4), pages 1351-1408, November.

Porcelli, F. (2009). Measurement of Technical Efficiency: A brief survey on parametric and non-parametric techniques.

Summers. A. and Wolfe, B. (1977). Do Schools Make a Difference. *American Economic Review*. 67, 639-652.

Timmer C. P. (1971). “Using a Probabilistic Frontier Production Function to Measure Technical Efficiency” *Journal of Political Economy,* Vol. 79: 4(776-794). The University of Chicago Press URL: http://www.jstor.org/stable/1830828. Accessed on 22/06/2014 04:49.

Walther, R. (2006). The Financing and Costs of TVSD- The Case of Africa Third International Congress on TVET Shanghai 13 16 May 2012 http://www.unesco.org/education/TVET2012/parallel-sessions-day1/3/R-Walther.pdf *accessed on 22nd June 2014 9.30am.*

Wolszczak, D. J. and Parteka, A. (2011). Exploring universities' efficiency differentials between countries in a multi-year perspective: an application of bootstrap DEAand Malmquist index to Italy and Poland, 2001-2011. Faculty of Management and Economics, Gdansk University of Technology, ul. Narutowicza 11/12, 80-233 Gdańsk, Poland.

Worthington, A. (2001). An Empirical Survey of Frontier Efficiency Measurement Techniques in Education. *Journal on Education Economics* Vol. 9 3(245-268).

ANNEXES

Table A1: Malmquist Index Summary of Firm Means

Firm	Efficiency change	Technical change	Pure efficiency change	Scale efficiency change	Total factor productivity change
1	0.918	1.052	1.216	0.755	0.966
2	0.963	1.339	1.197	0.804	1.29
3	1.036	1.24	1.082	0.958	1.285
4	0.869	1.318	1	0.869	1.145
5	1	1.542	1	1	1.542
6	0.764	1.226	0.961	0.795	0.937
7	0.834	1.467	0.961	0.867	1.222
8	0.988	1.173	0.993	0.994	1.159
9	0.97	1.213	1	0.97	1.177
10	1	1.136	1	1	1.136
11	1	1.507	0.974	1.026	1.506
12	1.118	1.283	1.105	1.011	1.434
13	1.192	1.12	1.074	1.109	1.334
14	0.988	1.234	1.057	0.934	1.219
15	1.016	1.253	1	1.016	1.273
16	1.322	1.367	1.115	1.186	1.807
17	1.379	1.475	1.11	1.242	2.035
18	1.522	1.338	1.097	1.387	2.038
19	1.502	1.265	1.057	1.421	1.901
20	1.231	1.45	0.985	1.25	1.785
21	0.834	1.444	0.985	0.846	1.204
22	0.911	1.758	0.985	0.925	1.601
23	1.051	1.213	0.985	1.067	1.274
24	0.987	1.618	1	0.987	1.597
25	0.82	1.064	0.993	0.826	0.872
26	0.804	1.63	0.993	0.81	1.311
27	0.972	1.991	1.011	0.962	1.936
28	1.151	1.449	1.009	1.141	1.668
29	1.002	1.288	1.009	0.993	1.291
30	1	1.338	1	1	1.338
31	1	1.658	1	1	1.658
32	1.116	1.67	1	1.116	1.865
33	1.221	1.685	1	1.221	2.057
34	1.006	1.73	1	1.006	1.74
mean	**1.029**	**1.382**	**1.026**	**1.003**	**1.422**

Table A2: Summary of Output Slacks

DMU	Out Put		DMU	Out Put	
	No of Graduates	**Mean Pass rate**		**No of Graduates**	**Mean Pass rate**
1	0	0	18	0	0
2	0	0	19	0	0
3	0.385	0	20	1.194	0
4	0.669	0	21	0	0
5	0	0	22	0	2.209
6	0	0	23	0	0
7	0	0	24	0	0
8	0	0	25	0	0
9	0	0	26	0	0
10	0	0	27	0	2.014
11	0	0	28	0	0
12	0	0	29	0	0
13	0	0	30	0	0
14	0.511	0	31	0	0
15	2.21	0	32	0	3.565
16	0	1.894	33	0	2.125
17	0	0	34	0	0

Mean output slack of number of graduates: 0.146

Mean Output Slack for mean pass rate: 0.347