

**TECHNICAL EFFICIENCY ANALYSIS OF PUBLIC ROAD TRANSPORT
PROVIDERS IN NAIROBI-KENYA**

This research project is my original work and has not been presented for an award in any form.

[Handwritten signature] Date: 7/8/2015

Githinji Andrew Kiiru

B.A (Economics and Sociology)

GITHINJI ANDREW KIIRU

We confirm that this research project has been developed by the student named above.

[Handwritten signature] Date: 7/8/2015

Prof. M. Ngũgĩ (PhD)

Department of Economics and Statistics

Kenyatta University

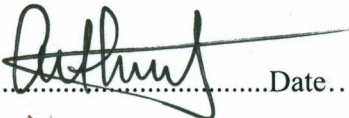
**A research project submitted to the department of econometrics and statistics
in partial fulfillment of the requirements for the award of the degree of
masters of economics (econometrics) of Kenyatta University.**

June 2015.

Kenyatta University

DECLARATION

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

Signature..........Date..... 9/8/2015

Githinji Andrew Kiiru

B.A (Economics and Sociology)

K102/21340/2012


We confirm that this research project has been developed by the student under our supervision.

Signature..........Date..... 9/8/15

Dianah M. Ngui (PhD)

Department of Econometrics and Statistics,

Kenyatta University

Signature..........Date..... 9/8/2015

AfloniaNyambura (PhD)

Department of Econometrics and Statistics,

Kenyatta University

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NOTES

NOTC

OLS

ESV

STCO

TE

Modified Ordinary Least Squares

Ministry of Transport and Communications

National Transport and Safety Authority

Ordinary Least Squares

Home Services Station

Standardized Credit Cooperative

Stochastic Frontier Analysis

Technical Efficiency

LIST OF ABBREVIATIONS

AATP	Africa Association of Public Transport
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
CDF	Cumulative Distribution Function
ML	Maximum Likelihood
MOLS	Modified Ordinary Least Squares
MOTC	Ministry of Transport and Communications
NTSA	National Transport and Safety Authority
OLS	Ordinary Least Squares
PSV	Public Service Vehicle
SACCO	Saving and Credit Cooperative
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency

OPERATIONAL DEFINITION OF TERMS

Road density: The ratio of the length of a county total road network to a county's land area.

Public transport: These are privately owned buses and matatus that are available to the public, charge set fares, run on fixed routes and are managed as a fleet i.e. SACCO

Efficiency: Is the success with which an organization uses its resources to produce output i.e. the degree to which the observed use of resources to produce outputs of a given quality matches the optimal use of resources to produce output given inputs.

Technical efficiency: is the ability of a firm to obtain maximum output from a given set of inputs

Owner: Means the corporate body in whose name the public service vehicle is registered.

Public transport SACCO: Means the corporate body with operational responsibility over the public service vehicle on a day to day basis either as owner of the vehicle or pursuant to the terms of a contract or franchise agreement with the registered owner of the vehicle.

Data Envelopment Analysis: A linear programming model that measures efficiency levels of firms that have multi-input and multi-output variables. It is non-parametric.

Stochastic Frontier Analysis: This is a parametric model where the regression line passes on top of the observations thus forming a frontier.

assessment of efficiency levels of passenger transport operators. It is being opportunistically used to assess the public transport operators. It is a statistical method that allows management of firms the possibility to find out ways to and planning for improvements across the sector to save budget. Public transport sector is a key sector in any country that aims at reducing the burden of a rapid growing population. Applying a better production of efficient, fair and optimal road transport services is essential to meet the growing urban, suburban transport demand and hence improve the quality of life. It is important to evaluate the current efficiency levels of transport providers in Nairobi. Despite the massive returns to scale, the policy concern by road users is still either of higher number of public transport services to use either in cars or transport with walking being a major mode of transport. It is crucial to measure the technical efficiency of public transport operators to understand how much their level of efficiency means to give a realistic guideline on potential efficiency improvements. The study used stochastic frontier to determine the level of operations that offer public transport to meet in Nairobi. Stochastic frontier analysis was used to estimate efficiency levels. To achieve their objectives the study used data from 43 public transport SACCOs that met the set requirements of the study during the study period. The results revealed that there were huge differences in technical efficiency that ranged from 58.52% for the most efficient to 10.12% for the least efficient firm. Operators of 10 SACCOs were found to be efficient. The study also revealed that high carrying vehicles were more efficient with a mean of 88.17%. Firms that operated 4 routes were more efficient with a mean of 81.17%. The study therefore concluded that there are significant technical efficiency challenges in transport providers that continually pose a threat to the well-being of citizens in transport system. The study recommends the need to invest in low capacity buses because they are more efficient compared to high capacity buses.

ABSTRACT

Measurement of efficiency levels of passenger transport helps in identifying opportunities that enhance the public transport performance. This will facilitate effective and efficient management of fleets that provide public road transport and planning for interventions in case the sector needs improvement. Public transport sector is a key social facility that aims at improving the welfare of a region inhabitants. Across developing countries provision of efficient, fair and impartial road transport in urban areas with an ever increasing population, increasing transport demand and limited resources is a challenge. Therefore there is great need to evaluate the current efficiency levels of transport providers in Nairobi. Despite the massive reforms in the Kenya public transport by road there is still evidence of higher number of people in Nairobi opting to use other means of transport with walking being dominant. This study sought to measure the technical efficiency of public transport SACCOs in Nairobi and compare their levels of efficiency in order to give a practical guideline on potential efficiency improvements. The study used stratified sampling in data collection from the operators that offer public transport by road in Nairobi. Stochastic frontier analysis was used to estimate efficiency levels. To achieve these objectives the study used data from 44 public transport SACCOs that had met the set requirements of NTSA during the study period. The results revealed that, there was a huge difference of technical efficiency that ranged from 98.32% for the most technically efficient firm to 27.86% for the least efficient firm. Analysis of SACCOs with respect to the vehicles they operate revealed that high carriage vehicle were more technically efficient with a mean of 68.27%. Firms that operated fourteen seater vehicle were the least efficient with a mean of 54.53%. The study therefore concluded that there exists diverse technical efficiency challenges in transport provision that continually pose threats to the achievement of efficient transport system. The study recommends the use of high sitting capacity buses because they are more efficient compared to low sitting capacity vehicles.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Transport is the backbone of urban life. It is a factor which determines the design and socio-economic development of an area. Mobility and accessibility provided by the transport system have been playing a major role in shaping countries, influencing the location of socio-economic activity, the size and form of cities and the style and pace of life by facilitating trade, allowing access to people and resources and enabling greater economies of scale, worldwide and throughout history (Zuidgeest, 2005). Transport contributes to the well-being of a nations citizens by providing access to job opportunities and enhancements to security of its users (World Bank, 2002).

According to KIPPRA (2010) road transport plays a significant role in the Kenyan economy accounting for 80% of the land transport demand. Road transport sector in Kenya can be analyzed by monitoring county road density. This is because road density gives a clear indication of an area accessibility, which is the ease with which goods and services can transported. With high accessibility economic and social development are enhanced. Therefore it can be assumed a county with higher road density will be highly competitive because its goods, services and economic activities can easily be reached with reduced production cost and better space interaction. According to KIPPRA (2010) while a county may have sufficient road density it will not necessarily be competitive if its road conditions are bad. In Kenya, public transport by road is the primary mode of passenger transport, linking remote areas

with the rest of the country and is provided by private bus operators. Whereas the government of Kenya has invested to a large extent in transport infrastructure it has failed to invest in public transport by road (KIPPRA, 2010). The organization of public transport by road activity in the country has been centered on privately owned companies.

According to Africa Association of Public Transport (2010), it is not possible to serve the urban population efficiently with low capacity transport because the populations have been increasing and hence the notion of mass transport should be a top priority. Most of the African countries including Kenya are faced by the challenge of incorporating the existing informal modes of transport into more efficient, effective and feasible formal transport systems rather than increase the collective transport market share which is already quite high. Well managed formal public transport is efficient in terms of passengers carried and energy used (IBID). However, public transport by road efficiency is hindered by the poor conditions of road infrastructure as is the case in much of Africa. Due to poor road conditions informal transport units that can adapt very easily to such conditions are encouraged to develop.

Urban public transport in developing countries lack quality transport infrastructures, mismatch between demand and supply, and rate of traffic road accidents is high. These problems are associated with trends such as urban population growth and growth of cities (Transafety, 1998). Transport providers must consider influences of these trends and purpose of transport trip, spatial and temporal distribution of trips, travel mode splits and costs on mobility for sustainability of social economic and environmental factors (Murray et al, 1998). The public road transport in Kenya is a

unique system in that the Ministry of Transport has no responsibility to determine transport quantity (including management of routes), quality and price, and to regulate the fleet's performance. This makes the public transport providers preferences overshadow the welfare of the citizens. Also the public transport road users are left with no voting power when the regulations fail.

1.1.1 Kenya public road transport policy reforms

In Kenya's public transport, the most significant transformation was the introduction of Government reforms in 2003 (Michuki rules). Key changes included: fitting all public service vehicles and commercial vehicles whose weight limit does not exceed the 3,048 kilograms with speed governors to limit speed up to 80 kilometers per hour; fitting of seat belts on all public service vehicles; employment of drivers and conductors on permanent basis; indication of route details and painting of a yellow band on Matatus for purposes of easy identification; re-testing of drivers after every two years; and approval of all driver's identification by the police (MOTC, 2004). The measures did not only streamline the industry but also increased competitiveness by encouraging more private investors to join the industry (Kumba, 2005). Consequently, these changes have reduced costs and associated risks of doing business in the industry.

Though the public transport sector has gradually adopted the reforms, it has been accompanied by increased road traffic accidents which threaten its performance. The leading accident causes include reckless driving, non-roadworthy vehicles and the poor conditions of the roads. In October 2003, MOTC listed Legal Notice No. 161 with the aim of regulating PSV sub-sector with its specific objectives being: reduce

accidents caused by over speeding; improve the safety of commuters; ensure responsibility, accountability and competency of drivers and conductors; eliminate illegal drivers, conductors and criminals that had infiltrated the industry; facilitate identification of vehicles and restrict their operation to authorized routes (MOTC, 2004). As a result of implementation of the provisions of Legal Notice No. 161, the number of cartels and illegal groups has reduced and placed management of PSV's in the hands of their owners.

National Transport and Safety Authority (2013), issued a legal notice that sought to improve and regulate the services and operations of PSV's with the following provisions; a vehicle shall not be licensed to operate as a PSV unless the owner or the operator of the vehicle is a corporate body whose principle objective is the operation of PSV having met the following conditions, a minimum of thirty (30) licensed and serviceable vehicles; have in its employment a staff complement which must include at a minimum, a driver in respect to each PSV and an inspector of each route on which PSV operates, an office manager, an accounts clerk and a qualified mechanic. A corporate firm is required to submit to the authority an inventory of the facilities and equipment available to it for the operation of the PSV and list of staff; the proposed route to be serviced and timetable of services to be provided with an indication of the proposed departure and arrival times, intended stop and pickup points; the proposed fare structure showing charges for off peak and peak times and a statement as to whether the PSV is to be used to provide long distance passenger services in order to acquire an operation license.

The NTSA legal notice of 2013 has so far being implemented nationally and the findings of this study made an attempt to provide a general overview of the status of registered public transport providers within Nairobi County. Within the last decade public road transport had yielded compelling success with the adoption of the rules and regulations (Michuki rules) which were meant to improve operations and efficiency of PSV's. This study therefore sought to determine whether indeed the operators are technically efficient having adopted the said rules.

1.1.2 Public transport in Nairobi

Nairobi's master plan was prepared in 1970 and since then Nairobi has not received adequate attention in having a long term plan given its rapid development. Nairobi has experienced a rapid population growth since 1969. This growth and development of the city has not been planned effectively and integrated (Omwenga, 2008). This means that the city transport system has not been well planned and integrated into the overall city growth and development structure (Omwenga, 2011). Although at the moment the county administration has made attempts to prepare short term plans, Nairobi has continuously experienced transport challenges which emanate from poor road network, limited car parking space, congestion and high costs of fuel.

The population growth rate for Nairobi averaged between 4.7 and 4.8 per cent for the past four decades. In developing countries the average population growth rate is 3.4 percent annually and the world urban annual population growth rate is 1.8 percent. Comparing these rates it proves that Nairobi has a very high population growth rate. Since 1969 the population of Nairobi has continued to rise as shown by figure 1.1.

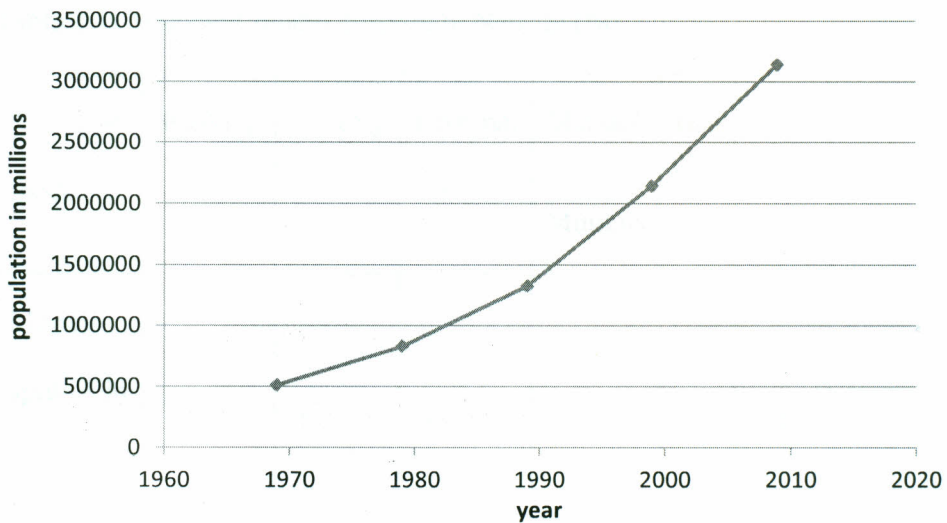


Figure 1.1: Population of Nairobi

Source: population census reports 1969, 1979, 1989, 1999 and 2009.

With such a high population growth, it threatens provision of efficient public transport services as there will be delays as people struggle to utilize the available PSV's. According to JICA (2006) residents of Nairobi have developed a great need of personal mobility with increased ownership and use of automobiles on the inadequate infrastructure facilities which cannot handle the increased capacity of residents and PSV's especially during peak hours.

According to King'ori (2007), Nairobi travel demand rate is 2.5 trips per person per day. Most of the road trips in Nairobi city are made on foot; which can be attributed to inefficient and inadequate transport services to meet the demand or because transport services are expensive (IBID). There are various modes of urban transport in Nairobi which include; private cars, taxi, matatus/minibuses, walking, institution buses and others.

Table 1.1: Transport modal purpose in Nairobi (%)

Transport mode	Walking	Cycling	Personal car	Matatu/Minibus	Bus	Train	Institution bus	others
Modal split in percent	47	1.2	15.3	29	3.7	0.4	3.2	0.2

Source: King'ori, 2007

Walking dominates the Nairobi city urban transport with 47% although the Non-Motorized-Traffic facilities in the city are not properly and adequately developed. Matatu/mini-bus have a total share of 29% with bus having a low split of 3.7%. There has been an increased use of private cars 15.3%, institute buses takes about 3.2%, with two wheeled modes i.e. bicycles and motorcycles, railway and others taking 1.20%, 0.40% and 0.20% respectively (JICA, 2006).

The commuter train is not widely used because it's only limited to a few areas which are, from Nairobi to Ruiru, Kahawa, Kikuyu and Athi for only two services daily and from Nairobi to Embakasi and Syokimau for three services daily and no service on Saturdays, Sundays and public holidays. This leaves minibuses/matatu as the main mode of motorized urban public transport in Nairobi. But public transport system is totally inadequate to meet the rising demand as it is still dominated by walking as a means of mobility. PSV's as a means of transport in Nairobi city are also inefficient as is evident from the common heavy congestion and long delays in the bus terminus.

1.2 STATEMENT OF THE PROBLEM

Public transport by road plays a major role in providing short as well as long distance mobility in Kenya. Public transport is important for citizens' mobility and it is a fundamental component in the quality of life available to citizens (Garcia, 2009). Public transport is one of the social facilities which are provided with the aim of improving social welfare. One of the major challenges faced today is the improvement of quality of service in urban public road transport system in order to make them efficient, competitive and attractive to more passengers. The public transportation network should have regular schedules, be safe and guarantee quality service and efficient resource utilization (Nzuve, 2012).

Public transport services in Nairobi should be efficient in order to meet the high demand for passenger transport. Since the introduction of the reforms in the transport sector the actual levels of efficiency have not been determined. Thus the need to evaluate current public transport efficiency to identify opportunities and deficiencies as the cost of maintaining, expanding and extending public transport service is very high and mostly unaffordable. The aim of this study was to assess the technical efficiency of public transport providers in Nairobi using the stochastic frontier analysis.

1.3 RESEARCH QUESTIONS

- (i) How efficient are public road transport SACCOs in Nairobi?
- (ii) Is there disparity in technical efficiency across different public road transport SACCOs in Nairobi?

(iii) What is the potential for efficiency improvement in public road transport in Nairobi?

1.4 MAIN OBJECTIVE

The main objective of this study was to measure and compare the efficiency of firms providing public road transport in Nairobi, Kenya.

1.5 SPECIFIC OBJECTIVES

The study sought to:

- (i) Measure each registered SACCO technical efficiency using stochastic frontier approach.
- (ii) Compare the technical efficiency of different public transport SACCOs in Nairobi.
- (iii) Provide a practical guidance on efficiency improvements to corporate firms providing public road transport in Nairobi.

1.6 SIGNIFICANCE OF THE STUDY

The significance of this study was justified by the increased growth of population in Nairobi and its increased expansion in the form of new estates. It was also justified by the need of transforming Nairobi city to a 24 hour economy which makes a strong public transport be of great importance in order to facilitate the mobility of citizens.

The importance of analyzing efficiency in the transport industry derives from the need that public transport providers have to maintain their effectiveness, performing well in relation to alternative means of transport and increasing their market share by upgrading their productivity. In this environment, identifying the inefficient unit is of paramount importance particularly if it can suggest ways of improving performance and converging towards the best practice.

1.7 LIMITATIONS OF THE STUDY

The main limitation of this research is that it did not consider competition, contribution and effect of the service provided by taxi mode of transport. The research assumes that only registered public transport providers with the transport licensing board offer public transport. This ensured only PSV's that have complied with the rules and have given efficiency a priority were studied.

1.8 ORGANIZATION OF THE STUDY

This study consist of five chapters. Chapter one has introduced the study and its objectives. In chapter two, relevant theoretical and empirical literature are reviewed and the overview of literature is presented. The research design and methodology are presented in chapter three. Chapter four gives the results of data analysis. Finally chapter five highlights the summary, conclusions, policy recommendations and areas of further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews literature on efficiency measurement. Specifically, this chapter presents a review of theoretical literature on microeconomic foundation relating to technical efficiency measurement, empirical literature relevant to public transport on the based on theoretical literature and the SFA model to be assumed shall be discussed

2.2 THEORETICAL LITERATURE

This section focused on the production function and total economic efficiency which comprises of technical and allocative efficiency with much emphasis on technical efficiency which this project sought to address.

The term efficiency in economics is used to refer to the comparison between the observed values of outputs and inputs with the optimal values of the outputs and inputs used in the production process (Tsamboulas, 2012). It requires the producer to make the best use of a resource in order to be economically efficient (Jarbouli, 2013). A DMU's total economic efficiency is divided into two components: allocative efficiency; which reflects the minimum level of inputs a firm can use in order to produce a specific level of output given their respective prices and technical efficiency which reflects the scale up to which firms can achieve a maximum output given set of inputs (Farell, 1957). According to Koopmans (1951) there are two

approaches in measurement of technical efficiency: input oriented and output oriented approach.

According to Koopmans (1951), a feasible output-input vector is technically efficient if, and only if, no increase in any output or decrease in any input is feasible. If the output vector is held constant the input vector will be technically efficient if, and only if, no reduction in any input is feasible. And if the input vector is constant, the output vector will be technically efficient if, and only if no increase in any output is feasible. Sections 2.3.1 and 2.3.2 discuss these two approaches respectively based on single output production frontiers.

2.3 PRODUCTION FUNCTION

The simplest and most common way to describe the technology of the firm is the production function. It represents the maximum output that can be produced using a given set of inputs.

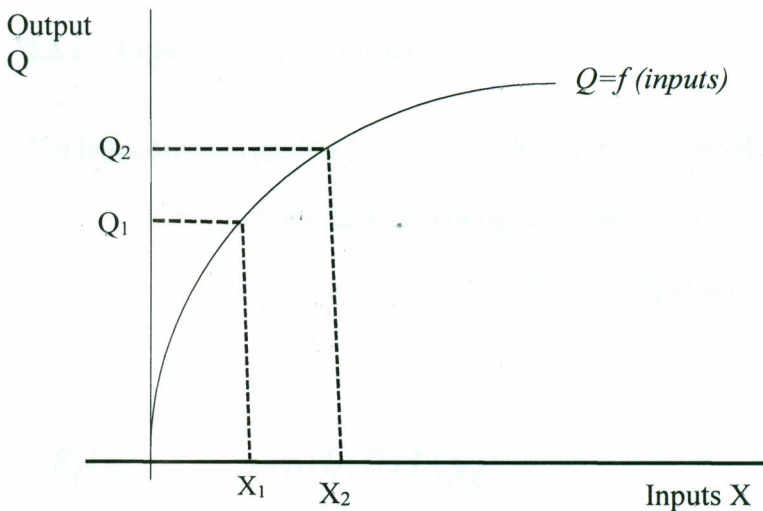


Figure 2.1: Graphical representation of a production function
Source: author

Given any sets of inputs say x_1 , the maximum possible Q is Q_1 , for x_2 is Q_2 . The area below the production function represents the set of feasible production plans or the production possibilities set. We assume that there exists a general function $f(Z)=0$ where Z is real valued, M-dimensional vector containing both inputs used and quantity produced in a given time period. We would further represent the function as $f(Z_1, Z_2, \dots, -Z_6, -Z_7)$. Where a positive sign represents an output and a negative represents inputs. Such a function is referred to as the *Net-put vector*.

The equation can be re-written as; $f(y,x)=0$ where is X an N-dimensional vector of non-negative inputs and Y is an (M-N) dimensional vector of non-negative outputs.

The explicit form of the above equation expresses the vector of outputs as a function of the vector of inputs, that is $y=f(x)$. If the highest level of output is isolated from the net-put vector, and expressed as a function of a given set of inputs, it provides the production $y_i=f(x)$ where y_i is a unique level of output and x is a given set of inputs.

2.3.1 Input oriented approach

The input oriented approach assumes a firm produces a single output using two inputs for simplicity purpose and assuming constant returns to scale (Farell, 1957). According to Debreu (1951) and Farell (1957), an input oriented measure of technical efficiency is given by:

$$TE_I(y, x) = \min\{\theta: \theta x L(y)\} \dots \dots \dots (2.1)$$

This is a measure of technical efficiency in terms of equiproportionate contraction of all inputs. If no equiproportionate contraction of all inputs is feasible then that input vector is said to be technically efficient.

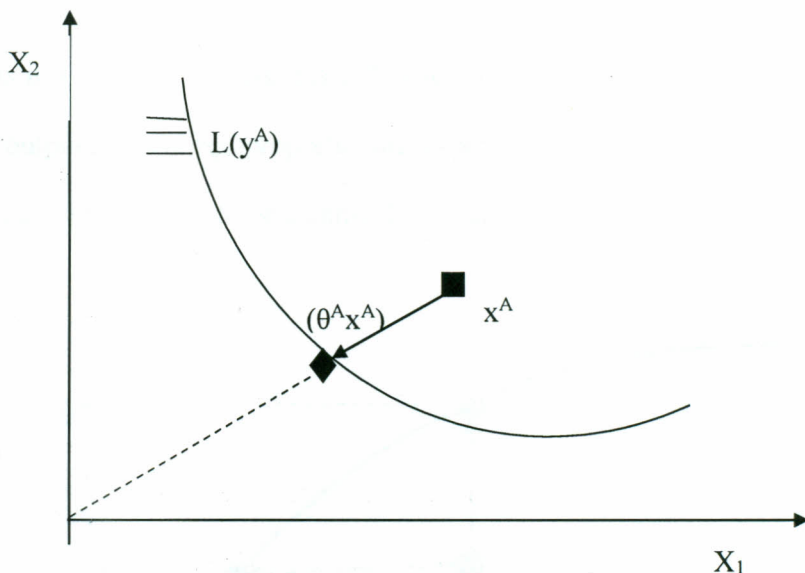


Figure 2.2: Input oriented measure of technical efficiency

Source: author

Figure 2.2. uses an input set $L(y)$ and its isoquant to illustrate the input oriented measure of technical efficiency (TE_I) which measures the maximum radial contraction in X^A that enables continued production of y^A , and $TE_I(x^A, y^A) = \theta^A < 1$, since $\theta^A x^A \in \text{isoq } L(y^A)$. The $TE_I(y, x)$ is non-increasing in x , homogenous of degree -1 in x and is invariant with respect to the units in which y and x are measured.

2.3.2 Output oriented approach

The output oriented approach assumes a firm produces a single output using two inputs for simplicity purpose and assuming constant returns to scale (Farell, 1957).

According to Debreu (1951) and Farrell (1957), an output oriented measure of technical efficiency is given by:

$$TE_O(x, y) = [\max\{\phi: \phi y \in P(x)\}]^{-1} \dots\dots\dots (2.2)$$

This is a measure of technical efficiency in terms of equiproportionate expansion of all outputs. If no equiproportionate expansion of all outputs is feasible then that output vector is said to be technically efficient.

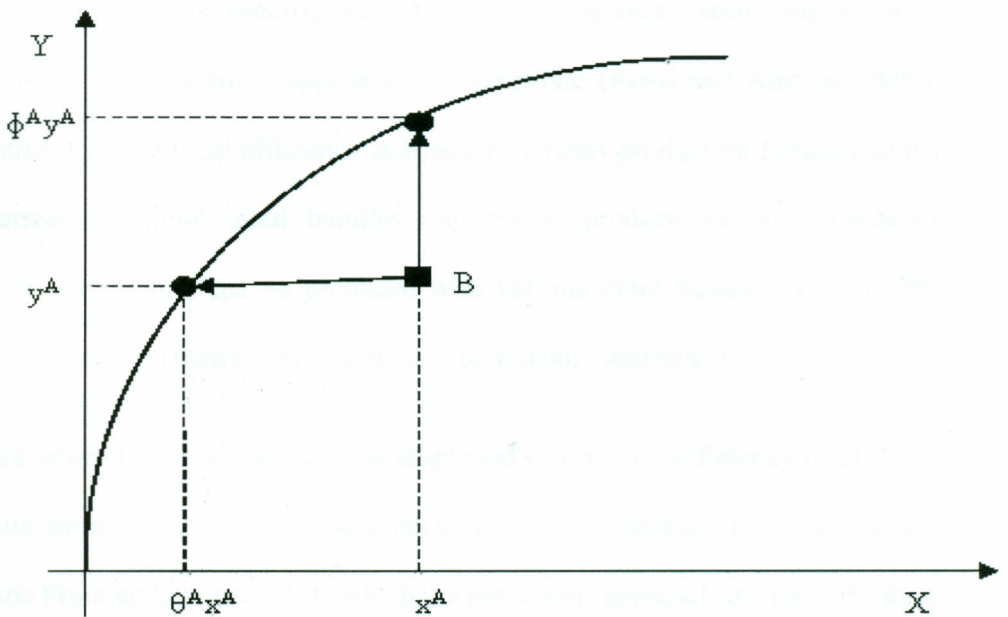


Figure 2.3: Input and output measure of technical efficiency

Source: author

Figure 2.3 uses the production frontier $f(x)$ to illustrate both measures of technical efficiency. A producer using x^A to produce y^A is technically inefficient, since it operates beneath production frontier $f(x)$. $TE_I(y^A, x^A)$ measures the maximum contraction of x^A that enables continued production of y^A , and $TE_I(y^A, x^A) = \theta^A < 1$, since $y^A = f(\theta^A x^A)$. $TE_O(x^A, y^A)$ measures the reciprocal of the maximum expansion

of y^A that is feasible with x^A , and $TE_O(x^A, y^A) = (\phi^A)^{-1} < 1$, since $\phi^A y^A = f(x^A)$. The output approach measure of technical efficiency $TE_O(x, y)$ satisfies the following properties: it is non-decreasing in y , homogenous of degree +1 in y and invariant with respect to the units in which x and y are measured.

According to Kumbhakar and Lovell (2000), technical efficiency reflects the ability of a firm to maximize output given a set of inputs (out-put oriented), or minimize input use in the production of given output (input oriented). The choice of different orientations depended on specific sector features, for instance a sector whose output is exogenous, input oriented approach is appropriate (Rossi and Ruzzier, 2000). Measurement of technical efficiency is based on a firms production frontier, which characterizes minimum input bundles required to produce various outputs or maximum outputs that can be produced with various input bundles. Thus a firm operating at point B (figure 2.3) is said to be technically inefficient.

There are several methods that can be employed to estimate efficiency of DMU's, which are broadly classified as parametric and nonparametric. They include the Stochastic Frontier Analysis (SFA) which is a parametric approach and takes the form of a stochastic model and the Data Envelopment Analysis (DEA) which is non-parametric. DEA method was developed by Farell (1957), Färe (1958) and Charnes (1978). It is a linear programming approach that connects observed combinations of best practice which result to a convex production possibility frontier. According to Boame (2004), while DEA approach does not require the specification of the underlying relationship, it does not account for random noise and hypothesis test and statistical inferences cannot be conducted for the estimated efficiency scores.

SFA on the other hand allows an assumption for stochastic relationship between inputs and outputs. It does not attribute the differences from the estimated production frontier specifically to inefficiency only but also to random noise in the data. Also SFA allows for hypothesis testing and making of statistical inferences of the efficiency measures. Based on these reasons this study used stochastic frontier analysis in measurement of technical efficiency across transport providers in Nairobi.

2.3.3 Stochastic production frontier

SFA is a method for frontier estimation that assumes a given functional form for the relationship between inputs and an output. Specification of this functional form provides a basis for using econometric techniques for estimation.

Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) proposed independently the stochastic production function model which took the form of a log linear Cobb-Douglas

$$\ln q_i = x_i' \beta + v_i - u_i \dots \dots \dots (2.3)$$

q_i is the output, x_i a vector of relevant input variables, v_i is a random error term that accounts for statistical noise and u_i is a non-negative technical inefficiency component of the error term.

This model allows for technical inefficiency and they also acknowledge the fact that random shocks outside the control of the producer can affect the output. The great quality of stochastic production frontier models is that the impact on output of shocks due to variation in labor and machinery performance, erratic weather and just plain

luck can at least in principle be separated from the contribution in variation in technical efficiency.

The equation 2.3 is a stochastic production function because the output values are bounded from above by the stochastic (random) variable $\exp(x_i'\beta)$ in this case the cob-douglas stochastic frontier takes the form:

$$q_i = \exp(\beta_0 + \beta_i \ln x_i + v_i - u_i) \dots \dots \dots (2.4)$$

When output and input of two firms A and B are plotted and where the deterministic component of the model has been drawn to reflect the existence of diminishing returns to scale. Firm A uses the input level X_A to produce quantity Q_A , while firm B uses the input level X_B to produce quantity Q_B . If there were no inefficiency effects ($U_A=0$ and $U_B=0$, where U_A and U_B are the inefficiency effects of firm A and B respectively) then frontier outputs would be given as:

$$q_A^* = \exp(\beta_0 + \beta_i \ln x_A + v_A) \dots \dots \dots (2.5)$$

$$q_B^* = \exp(\beta_0 + \beta_i \ln x_B + v_B) \dots \dots \dots (2.6)$$

The frontier output for firm A lies above the deterministic part of the production frontier only because the noise effect is positive, ($v_A > 0$), while the frontier output for firm B lies below the deterministic part because the noise effect is negative. The observed output for firm A lies below the deterministic part of the frontier because the sum of the noise and inefficiency is negative i.e. $v_A - u_A < 0$. Observed outputs

can only lie above the deterministic part of the frontier when the noise effect is positive and larger than the inefficiency effect.

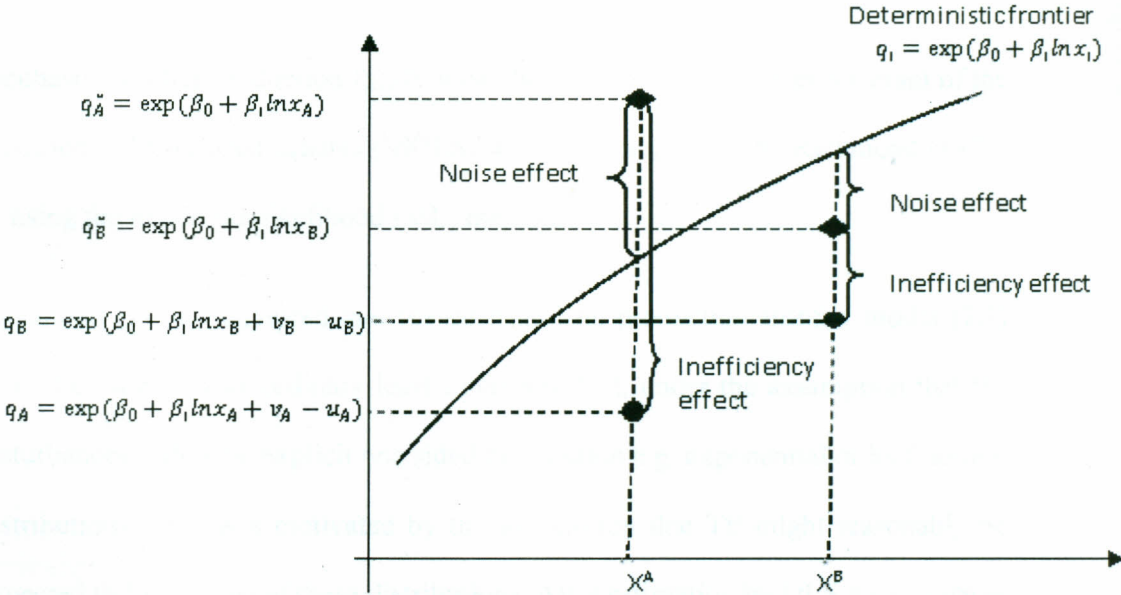


Figure 2.4: The stochastic production frontier

Source: author

The most common output oriented measure of TE is the ratio of observed output to the corresponding stochastic frontier output;

$$TE_i = \frac{q_i}{\exp[x_i' \beta + v_i]} \dots \dots \dots (2.7)$$

$$TE_i = \frac{\exp[x_i' \beta + v_i - u_i]}{\exp[x_i' \beta + v_i]} \dots \dots \dots (2.8)$$

$$TE_i = \exp(-u_i) \dots \dots \dots (2.9)$$

This measure of TE takes the values between zero and one. It measures the output of the i^{th} firm relative to the output that could be produced by a fully efficient firm using the same input vector.

Stochastic frontier production function can be estimated using either a variant of the modified ordinary least squares (MOLS) which was suggested by Richmond (1974) or using the maximum likelihood (ML) method.

Richmond (1974) suggested that the deterministic production frontier model (2.3) could be estimated by ordinary least squares (OLS), under the assumption that the disturbances follow an explicit one sided distribution e.g. exponential or half normal distributions. This was motivated by the assumption that TE might reasonably be expected to follow one of these distributions. After estimation by OLS the estimated intercept is shifted up or “modified” by the mean of the assumed one sided distribution:

$$\hat{\beta}_0^{**} = \hat{\beta}_0 + E(\hat{u}_i) \dots \dots \dots (2.10)$$

And,

$$-\hat{u}_i^{**} = \hat{u}_i - E[\hat{u}_i] \dots \dots \dots (2.11)$$

The OLS residuals are used to provide consistent estimates of TE of each producer. The MOLS procedure is easy to implement. However there is no guarantee that the modification of OLS shifts the estimated intercept up by enough to ensure that all producers are bounded from above by the estimated production frontier. Since if a producer has sufficiently large positive OLS residual it is possible that $[\hat{u}_i -$

$E(\hat{u}_i)] > 0$ for the producer. This causes the problem of having TE being greater than unity. It's also possible that MOLS shifts the estimated intercept so far up that no producer is technically efficient. Finally the MOLS is parallel to the OLS regression, since only OLS intercept is modified. This implies that the structure of "best practice" production technology is the same as the structure of the central tendency production technology. This would be undesired since best practice technology ought to be permitted to differ from that production function technology down in the middle of the data where producers are less efficient.

The ML is asymptotically more efficient than MOLS estimator. Coelli (1995) found ML estimator to be more significantly better than MOLS when contribution of technical inefficiency effects to total variance is large. Although MOLS is not as computationally demanding as ML method which requires numerical maximization of the likelihood function, the distinction has lessened in recent years with the availability of softwares such as frontier version 4.1, limdep version 7.0.(Sanjay, 2006). Given this findings the ML estimator was used in preference to the MOLS estimator.

2.4 EMPIRICAL LITERATURE

Sanjay (2004) compared efficiency across India state transport undertakings. The STU's were operating in a regulated environment and they were imposed with many qualitative as well as quantitative constraints on their production. Their study sought to verify how efficient were the STU's? Using 23 STU's for the year 2000-2001, the study estimated a stochastic frontier production function using maximum likelihood

method. The results of this study showed a huge disparity in TE across STU's that ranged from 56.15% to 98.99%. The average TE scores of the sample STU's was found to be 84.22%. Their main conclusion was that given the size distribution of the sample STU's and their working environment, the potential gain in production efficiency for most of them was very high.

This study sought to satisfy similar curiosity as little is known about the efficiency levels in the Kenya public road transport. This study is also similar with Sanjay study because it focuses on technical efficiency across the firms that operate vehicles within Nairobi. The current study is also similar because it sought to estimate a stochastic frontier production function using maximum likelihood method.

Lawrence (2006) scrutinized the probable sources of poor performance for non-storable transport services, in an attempt to distinguish service ineffectiveness from technical inefficiency. The study measured the performance of railways that produce passenger and freight services by two stochastic distance function approaches. A stochastic input distance function with an inefficiency effect was defined to evaluate technical efficiency; whereas a stochastic consumption distance function with an ineffectiveness effect was introduced to assess service effectiveness. The study examined 39 worldwide railway systems over eight years (1995–2002). The inputs vector contained number of passenger cars, number of freight cars, and number of employees, while the outputs vector contained passenger train-kilometers and freight train-kilometers, and consumptions contain passenger-kilometers and ton kilometers. The findings showed that railways' technical inefficiency and service ineffectiveness are negatively influenced by gross national income per capita, percentage of

electrified lines, and line density. Contrary to Lawrence study that used multiple outputs with multiple inputs this study sought to use a single output and multiple inputs by use of an input orientation in technical efficiency measurement.

Erwin (2008) using a stochastic production frontier sought to measure technical efficiency of Taipei bus transit in Taiwan with adjustment of accidents. The study investigated ten (10) Taipei bus transit carriers over the period 2001-2006. The inclusion of accidents adjustment was based on assumption that occasionally a transport provider produces accidents which are fatal, serious and/or slight injuries or property loss and thus failure to account for negative effects of accidents on outputs of the transport provider, would lead to misleading interpretation of the results obtained. The study revealed that the ranks of technical efficiency when accidents are considered had significant difference from that without accounting for accidents. To the management of these carriers it implied that they should level up their productive efficiency not only by means of decreasing the inputs and/or increasing the desirable outputs, but also come up with ways of improving their safety records. Following the same approach to technical efficiency measurement the study included fuel as input. This project did not to use accidents as inputs as it's not about unraveling inefficiency but the state of technical efficiency.

Odeck, (2008) analyzed the performance of ferries operating along the Norwegian road networks because ferries were of critical importance to the trunk road system. Ferries acted as links in to the road system by transporting vehicles across fjords. However, in Norway ferries were subsidized by the government because their operations were always at a loss. For the purpose of establishing potential of

efficiency and productivity improvement it was of great importance for the government authorities that were operating these ferries to conduct an assessment of the ferries performance and come up with alternative subsidy regimes. The study estimated the technical efficiency and productivity of the providers using the stochastic frontier approach to efficiency measurement followed by Malmquist productivity indices. Technical inefficiency effects were modeled as external factors of each specific ferry by considering the areas of operation or the year at which the ferry was constructed. The data used were from the accounting period 2003–2005 and are comprised of 82 ferries. The findings revealed that there was big potential for efficiency improvements among ferry operators, which were ranging between 19% and 20%. There was a significant impact of external factors on efficiency and ferry productivity had increased by approximately 2% over the period of study which was mainly due to advanced efficiency changes. This showed that ferries had a tendency to improve their efficiency, but fail to adopt technologies for the reason that they were too old.

Walter (2009) evaluated cost efficiency in German road transport. Using a stochastic frontier the study revealed that a high degree of tramcar utilization and high degree of outsourcing influence the efficiency predictions positively. The average efficiency levels laid between 0.849 and 0.942 which depended on the panel data model applied and accounting for unobserved heterogeneity and heterogeneous output variables for the companies that were studied. The levels of inefficiency corresponded to a savings potential between 1.4 and 4.43 billion Euros for the 254 observations of the 39 companies studied between 1997 and 2006.

Agarwal et al (2010) investigated for scale and technical efficiencies of public transport operators in India. The study used a sample of 35 Indian transport operators. It made an attempt to provide an overview of the general status of the State Transport Undertakings (STUs) in terms of their productive efficiencies for the years 2004-05 to 2007-08. The study applied the new slack DEA Model with categorical DMUs (STUs transported in Rural, Hill and Urban area) because DEA can handle multiple inputs and multiple outputs and doesn't require any specific assumptions about the functional form between inputs and outputs. In this particular study fleet size, total staff and fuel consumption were considered as inputs and passenger kilometers as output. Technical efficiency scores obtained were on average equal to 83.26%. The study concluded that performance of the STUs has not improved over the earlier three years and has improvement in the last year but still very far from the optimal level. Further, results of sensitivity analysis reveal that by and large, efficiency scores are robust and stable.

This project sought to satisfy similar curiosity on the state of technical efficiency of transport operators in Nairobi but by applying the SFA model by specifying a Cobb-Douglas production function. This project is similar to the study because similar inputs and outputs were employed.

Jarboui et al (2013) measured the technical efficiency of 54 public road transport operators and by investigating the degree to which various factors influence efficiency levels in these firms. The study made an attempt to provide an overview of the general status of different operators in 18 countries. Stochastic Frontier Analysis (SFA) methods were applied to the sample over a twelve year period from

2000 to 2011. The study's empirical results indicated that investment, operating profit and firm size have a significant influence on technical efficiency levels. The findings of this study showed that technical efficiency level of public road transport operators varies between 0.458 and 0.95. The study also found that large-size operators with more investment capacity tend to be more technically efficient than small-size operators. And finally, operators from developed countries are technically more efficient than those of developing countries. This study not only borrows Jarboui definition of inputs and outputs but also derives motivation from their work as the transport sector has experienced change in regulation. However this study did not focus on the sources of inefficiency.

2.5 OVERVIEW OF LITERATURE

The above literature review has given an in-depth analysis to the theoretical underpinning in measuring technical efficiencies of transport service providers' using both DEA and SFA. The theoretical literature analysis describes the simple approaches to estimation of efficiency by bench marking other DMUs against the best practicing one in the sample. The empirical literature has furthered insights on related studies done with a view to show the gap left.

In all reviewed studies, SFA is the predominant method in estimating technical efficiencies in transport sector. The SFA method is a parametric mechanism that seeks to identify the most efficient DMU among a pool of homogenous units and further attempts to benchmark the others by assigning efficiency scores less than 1. However, this method runs under the assumption that there exists a decision making

unit that is efficient even though it is practically impossible to attain full efficiency according to theory, (Coelli *et al*, 2005). The SFA method has been widely used in estimating efficiency of firms and has been used in transport policy development by institutions and scholars. This study employed SFA in its efficiency analysis.

Apart from Sanjay, (2004) and Agarwal, (2010) that attempted to measure efficiency of regulated but privately owned transport facilities, all the other studies have concentrated on government subsidized public transport in different parts of the world. Justifications for the inclination of the studies towards government owned transport sector are scanty. There are fewer studies that exhibit allocative efficiency although DMU's may be interested in knowing by how much inputs should be mixed while their price levels are known. Based on these studies, this project sought to evaluate and analyze technical efficiency of corporate bodies that provide public transport by road in the capital city of Kenya-Nairobi out of which policy recommendations can be drawn.

The estimation of technical efficiency of the corporate that provide public transport by road was conducted by assuming a log-linear Cobb-Douglas production function. This is because of it has enough parameters to provide a first order differential approximation (flexible). Though at first it's not linear in parameters, taking logarithms of both sides yields an equation which is linear in parameters. Finally it is a simple functional form i.e. the principle of parsimony.

The literature reviewed affirms the choice for the variables to be used in this study. The studies reviewed have entirely depended on inputs and output variables for the

The production function in equation 3.1 is associated with several properties that underpin much of the econometric analysis in this study. The value of $f(x)$ is a finite non-negative real number such that it can produce at least zero output and that there is no free lunch. The production of positive output is impossible without the use of at least one input which guarantees that finite input cannot produce infinite output.

The production function is non-decreasing in inputs which implies if the production function is continuously differentiable, the marginal products are non-negative. And finally any linear combination of the vectors X^0 and X' will produce an output that is no less than the same linear combination of $f(x^0)$ and $f(x')$ which confirms the law of diminishing marginal productivity.

3.4 EMPIRICAL MODEL

Assuming that $f(x_i; \beta)$ takes the log linear Cobb-Douglas form equation 3.1 can be written as:

$$\ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i \dots \dots \dots 3.2$$

Where v_i is the two sided error component, other variables are as defined earlier

Following Aigner and Lovell (1977) equation 3.2 can be modified to a stochastic model as follows:

$$\ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i \dots \dots \dots 3.3$$

Where Y_i is an output vector of effective bus kilometres, X_{ni} is an input vector comprising fleet size, labour and fuel consumption for the i^{th} firm, β 's are parameters

to be estimated and u_i is a non-negative random variable associated with technical inefficiency.

v_i 's are independently and identically distributed normal random variables with zero means and variances $\sigma_v^2 (v_i \sim iidN(0, \sigma_v^2))$ while u_i 's are independently and identically distributed non-negative half normal random variables with scale parameter $\sigma_u^2 (u_i \sim iidN^+(0, \sigma_u^2))$. That is, the probability density function (pdf) of each u_i is a truncated version of a normal random variable having zero mean and variance σ_u^2 . V_i accounts for random factors such as strikes, measurement errors and combined effects of unspecified input variables. U_i represents variables that are linked with the inefficiency of the firm under consideration. This study used the half normal distribution. Since the firms were ranked on the basis of the predicted technical efficiencies and the rankings are robust to the distributional choice, the principle of parsimony favours the simpler half-normal rather than the exponential or gamma distributions.

Aigner, Lovell and Schmidt (1977) parameterized the log likelihood function for the half normal model in terms of:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \dots \dots \dots 3.4$$

$$\lambda^2 = \sigma_u^2 / \sigma_v^2 \geq 0 \dots \dots \dots 3.5$$

Using this parameterization, the log likelihood function is:

$$\ln L(y | \beta, \sigma, \lambda) = -\frac{N}{2} \ln \left[\frac{\pi \sigma^2}{2} \right] + \sum_{i=1}^N \ln \Phi \left[-\frac{\varepsilon_i \lambda}{\sigma} \right] - \frac{1}{2\sigma^2} \sum_{i=1}^N \varepsilon_i^2 \dots \dots \dots 3.6$$

Where y is a vector of log outputs; $\varepsilon \equiv v_i - u_i = \ln y_i - x_i' \beta$ is a composite error term; and $\Phi(x)$ is a cumulative distribution function (cdf) of the standard normal variable evaluated at X . To find the maximum likelihood estimates of β , σ and λ , equation 3.6 is maximized with respect to the parameters. These estimates are consistent as $N \rightarrow +\infty$.

Since we have the estimates of ε which has the information of u , if $\varepsilon_i > 0$ chances are that u_i is not large which suggests that this producer is relatively efficient. However if $\varepsilon_i < 0$ chances are that u_i is large, which suggests that this producer is relatively inefficient. The information on u_i is obtained from the conditional distribution of u_i given ε_i . Jondrow et al (1982) obtained the following results of a point estimator for u_i ;

$$E(u_i | \varepsilon_i) = \sigma_* \left[\frac{\phi(\varepsilon_i \lambda / \sigma)}{1 - \Phi(\varepsilon_i \lambda / \sigma)} - \left[\frac{\varepsilon_i \lambda}{\sigma} \right] \right] \dots \dots \dots 3.7$$

Where $\sigma_* = \sqrt{\sigma_u^2 \sigma_v^2} / \sigma$ and $\phi(\cdot)$ is the density function of a standard normal random variable. Once the point estimates of u_i are obtained TE of each producer can be obtained by Battese and Coelli (1988) technical efficiency estimator given by:

$$TE_i = E(\exp\{-u_i\} | \varepsilon_i) \dots \dots \dots 3.8$$

$$= \left[\frac{1 - \Phi(\sigma_* - u_{*i} / \sigma_*)}{1 - \Phi(-u_{*i} / \sigma_*)} \right] \exp \left\{ -u_{*i} + \frac{1}{2} \sigma_*^2 \right\} \dots \dots \dots 3.9$$

The stochastic frontier production function for the firms is estimated as defined in equation 3.3.

3.5 DEFINITION AND MEASUREMENT OF VARIABLES

VARIABLE	DEFINITION	MEASUREMENT	DATA SOURCE
FLEET SIZE	Registered number of buses on road of a SACCO (I_{th} firm). This represents the capital input.	In numbers	NTSA data
FUEL CONSUMPTION	fuel consumed by vehicles operated by each SACCO	In litres.	corporates
TOTAL NUMBER OF STAFF	total number of employees working in a SACCO	In numbers	NTSA data
EFFECTIVE BUS KILOMETRES	Distance covered by the fleet in a SACCO	number of trips a vehicle takes in a specified route multiplied by the kilometres of that route	corporates

3.6 STUDY AREA AND THE TARGET POPULATION

The study area was in Kenya and the targeted population were corporate firms that provide public transport by road in Nairobi. The justification for this area is basically for the need of an efficient public transport system. This study was meant to develop better awareness about the distribution strength and weaknesses of the public transport provision. NTSA will have an awareness of transport operators and can identify where feeder services are required to alleviate the problem of inefficiency and finally the Nairobi city County government will get insight into the operational characteristics of transport services.

As indicated in the background of this project, high population growth, and high demand for public transport by road and with decreasing government subsidy to public transport sector are compelling factors to unravel the efficiency levels of firms that provide public road transport services within the city.

3.7 POPULATION SIZE

According to The Republic of Kenya, (2014) the National Transport and Safety Authority, (NTSA) oversees 640 full-fledged corporates that operate across the country. The NTSA oversees 44 corporates which operate within Nairobi county and its environs. Data was collected from all firms that operate within Nairobi because the data is available and the area is manageable to transverse.

3.8 DATA TYPE AND SOURCE

Data collected was quantitative. This included numeric measures of inputs and outputs. The source of the data were the corporate records and the Ministry of Transport and Communication which provided summary of registered PSV corporate, their location, contacts and vehicle capacity.

3.9 DATA ANALYSIS

Collected data was tabulated before analysis began. Thereafter, with the aid of FRONTIER version 4.1, which is a computer application for analyzing efficiency scores using SFA, data was optimized and hence technical efficiency scores obtained.

This section highlights descriptive statistics for effective vehicle kilometers, fuel consumption, size of SAFCA and labour. Table 4.1 shows the mean and standard deviation for the output and input variables.

Table 4.1: Mean and Standard Deviation for Output and Input Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
Vehicle kilometers	11407.5	116990.5	1700	1500000
Fuel	1711.25	12817.15	0.95	78702
SAFCA	36	89.15	32	992
Labour	344	105.81	100	1000

CHAPTER FOUR

RESEARCH FINDINGS

4.1 INTRODUCTION.

The research findings on technical efficiencies of the public service vehicle SACCOs are described in this section. There are various statistical tools used in the analysis to emphasize the outcome of the results. Although this study sought to give outcomes on technical efficiencies, the SFA process further gives insightful results that researchers can use for further policy recommendations and studies. Such results seek to show the theoretical consistencies in the behavior of various microeconomic variables such as inputs and outputs. These results as discussed in this chapter show individual firm performances in terms of input and output mixes.

4.2 DESCRIPTIVE STATISTICS

This section highlights descriptive statistics for effective vehicle kilometres, fuel consumption, size of SACCO and labour. Table 4.1 shows the mean and standard deviation for the output and input variables.

Table 4.1: Mean and Standard Deviation for Output and Inputs (n=44)

Variable	Mean	Std. Dev.	Minimum	Maximum
Vehicle kilometres	235433.6	116990.6	1775202	140309871
Fuel	13793.25	12847.14	8395	78702
Size	136	69.16	52	662
Labour	268	105.61	102	1050

Source: Own calculations

The figures in table 4.1 shows that for all inputs and output under consideration the standard deviation is lower than the mean. These finding implies that Transport SACCOs in Nairobi have a low level of heterogeneity. The low standard deviation shows heterogeneity in the scale of operations by the SACCOs.

Table 4.2 shows the correlation between inputs and output. SACCOs are unique in the sense that they have to increase some inputs such as labour in order to cover more effective vehicle kilometres. Avkiran (1990) showed that correlations can also be used to show appropriateness of variables

Table 4.2: Kendall's rank correlations between output and inputs

	Vehicle kilometre	fuel	labour	size
Vehicle kilometre	1.0000			
fuel	.7738** (0.0000)	1.0000		
labour	.6871** (0.0001)	.6321** (0.0000)	1.0000	
size	-.4387** (0.0001)	-.3097** (0.0031)	-.5127** (0.0000)	1.0000

**significant at 5% level; p-values in parentheses.

Source; Own calculations.

Table 4.2 shows that there is positive correlation between the various inputs and outputs. That is the variables chosen as outputs and inputs move in the same direction except for size of the firms. These results reinforce the fact that PSV have to increase inputs such as labour in order to cover more kilometers. The high positive correlation shows that the variables chosen are appropriate for estimating the performance of SACCOs.

Table 4.3: ML estimates of stochastic production frontier.

variables	Coefficient.	Std. Err.	z	P>z
fuel	0.7523541	0.0815465	9.23	0.000
labour	0.3079452	0.1562264	1.97	0.049
Size	-0.1018678	0.05584	-2.01	0.044
constant	2.21	0.1022058	21.71	0.000
/lnsig2v	-5.735759	0.9574865	-5.99	0.000
/lnsig2u	-2.80598	0.3390555	-8.28	0.000
sigma_v	0.0568193	0.0272018		
sigma_u	0.2458607	0.0416802		
sigma2	0.0636759	0.018804		
lambda	4.327065	0.0619473		

Source: Own calculations.

Based on the cross-sectional data used, the MLEs for the assumed half normal distribution of the inefficiency term in the frontier model are shown in table 4.3. From table 4.3 the log likelihood function for the full stochastic frontier model where inefficiency is assumed to be half normal is calculated to be 21.673931. The likelihood ratio test statistic for testing the absence of the technical inefficiency effects from the frontier is calculated to be 5.70. This value is significantly higher than the critical value, 3.8415 at 5% level of significance for the degree of freedom is equal to 1. Hence the null hypothesis of no technical inefficiency effects among SACCOs is rejected. The output from frontier includes estimates of the standard deviations of the two error components, σ_v (sigma_v) and σ_u (sigma_u). In the log likelihood, they are parameterized as $\ln\sigma_v$ and $\ln\sigma_u$, and these estimates are labeled /lnsig2v and /lnsig2u in the output. Frontier also reports two other useful parameterizations. The estimate of the total error variance, $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$ is labeled sigma2, and the estimate of the ratio of the standard deviation of the inefficiency component to the standard deviation of the characteristic component, $\lambda = \sigma_u/\sigma_v$ is

labeled lambda. Using the half normal results reported in table 4.3 the test statistic $Z=4.327/0.06194=69.85$ this value exceeds the critical value $Z_{0.95} = 1.645$ so null hypothesis is rejected that there are no inefficiency effects (Coelli *et al*, 2005).

The signs of the coefficients of the SFA models are consistent with expectations: the coefficients of inputs are estimated to be positive except size which had a negative coefficient. The result implies that there is a positive relationship between the fuel and labour used and public transport operators' production. The estimated coefficients of number of the firm labour and fuel consumption are positive and significant at the 5% level. This result indicates that labour and fuel are key factors of public transport production and therefore, any increase in these inputs will yield positive returns. This results imply that for a firm to increase its effective vehicle kilometres both its size and fuel consumption will increase. The estimated coefficient of size utilized is negative and significant at 5%. This result shows that by increasing size there is no way effective vehicle kilometers will increase but in terms of productivity the effective vehicle kilometers will be reducing. This can be explained by the fact that the kilometers to be covered are now shared between the numbers of vehicles operating in a certain route.

Table 4.4: Returns to scale.

Vehicle kilometre	coefficient	Std. error	z	p> z
(1)	.9584314	.142351	6.78	0.000

Source; own calculations.

The sum of the coefficients is significantly less than one, so this production function exhibits decreasing returns to scale. If we doubled the number of vehicles, fuel and workers, we would obtain less than twice as much output. This results are similar to Odeck (2008) which revealed that doubling of the number of ferries in Norway would not produce a double output.

4.3 TECHNICAL EFFICIENCY

A total of 44 firms that provide public transport services within Nairobi were used. The efficiencies of the SACCOs with brief discussions on the technical efficiency scores and the averages are given in the preceding discussion. Table 4.5, table 4.6 and table 4.7 shows technical efficiency scores of SACCOs with fourteen seater capacity vehicles only, all seater vehicles and buses only vehicles respectively.

TABLE 4.5: Technical efficiency scores of SACCOs with vehicles of 14 passenger sitting capacity only

sacco	efficiency scores	rank	SIZE	size rank
1	73.81%	43	159	13
2	45.04%	39	102	22
3	53.00%	24	253	3
4	81.68%	41	85	26
5	46.99%	34	199	10

6	50.64%	30	69	33
7	35.83%	42	79	28
8	53.51%	22	223	8
9	47.97%	32	120	20
10	56.84%	15	102	23
Mean efficiency=54.53%				

Source: own calculations

Table 4.5, reveals a marked variation of technical efficiencies across the SACCOs with vehicles of 14 passenger sitting capacity, from 81.68% for the most technically

efficient firm to 35.83% for the least technically efficient firm. This implies that SACCO 4 has realized 81.68% of the production possibility for a fully efficient SACCO having comparable input values whereas SACCO 7 could do so up to a level of 35.83%. This indicates that most of the SACCOs still have ample scope to improve their technical efficiency.

TABLE 4.6: Technical efficiency scores of SACCOs with all passenger seater vehicles

sacco	efficiency scores	rank	SIZE	size rank
11	27.86%	44	70	32
12	46.26%	37	82	27
13	46.94%	35	174	11
14	47.17%	33	163	12
15	53.39%	23	246	6
16	66.43%	10	59	40
17	91.52%	4	74	30
18	71.63%	8	662	1
19	49.06%	31	132	16
20	55.11%	17	291	2

21	51.73%	27	145	14
22	53.92%	20	250	4
23	52.96%	25	210	9
25	58.25%	13	55	43
27	45.98%	38	65	36
28	62.46%	12	71	31
29	81.85%	6	67	34
30	51.36%	28	133	15
31	44.76%	40	78	29
32	57.26%	14	60	38
Mean technical efficiency=57.27%				

Source: own calculations

Table 4.6, reveals a marked variation of technical efficiencies across the SACCOs with vehicles of 14 passenger sitting capacity and more than 14 passenger sitting capacity, from 91.52% for the most technically efficient firm to 27.86% for the least

technically efficient firm. This implies that SACCO 17 has realized 91.52% of the production possibility for a fully efficient SACCO having comparable input values whereas SACCO 7 could do so up to a level of 27.86%. This indicates that most of the SACCOs still have ample scope to improve their technical efficiency.

TABLE 4.7: Technical efficiency scores of SACCOs with buses only

sacco	efficiency scores	rank	SIZE	size rank
33	46.29%	36	115	21
34	56.36%	16	66	35
35	52.43%	26	122	18
36	50.65%	29	122	19
37	53.99%	19	227	7
38	54.38%	18	59	39
39	78.69%	7	56	42

40	63.44%	11	98	24
41	98.32%	1	130	17
42	83.62%	5	61	37
43	53.59%	21	247	5
44	70.68%	9	94	25
24	96.85%	2	58	41
26	96.55%	3	52	44
Mean technical efficiency=68.27%				

Source; own calculations.

Table 4.7, reveals a marked variation of technical efficiencies across the SACCOs with vehicles of more 14 passenger sitting capacity, from 98.32% for the most technically efficient firm to 46.29% for the least technically efficient firm. Agarwal (2010) quantified firms in India and showed a disparity of technical efficiency that ranged 56.23% and 97.46%. In this current study, it implies that SACCO 41 has realized 91.52% of the production possibility for a fully efficient SACCO having comparable input values whereas SACCO 33 could do so up to a level of 46.29%. This indicates that most of the SACCOs still have ample scope to improve their technical

efficiency. Sanjay (2004) compared STUs in India which showed a great variations in technical efficiency of different size STUs.

The prime objective of this study was to quantify the technical efficiency prevailing in public transport SACCOS that operate within Nairobi County. A stochastic frontier production function for the cross-sectional data by using the method of maximum likelihood was estimated. Table 4.5, table 4.6 and table 4.7 reveals a marked variation of technical efficiencies across the SACCOS, from 98.32% for the most technically efficient firm to 27.86% for the least technically efficient firm. This implies that SACCO 41 has realized 98.32% of the production possibility for a fully efficient SACCO having comparable input values whereas SACCO 11 could do so up to a level of 27.86%. The study found that SACCO 41, 17 and 42 which were of different sizes in ranks were the most efficient. SACCO 7 and 11 similarly having different sizes were the least efficient. This indicates that most of the SACCOS still have ample scope to improve their technical efficiency.

The mean technical efficiency was highest for SACCOS that operated vehicles that were of more than 14 passenger sitting capacity at 68.27%. This was followed by SACCOS with both 14 seater vehicle capacity and more than 14 passenger sitting capacity at 57.27%. SACCOS with only 14 passenger sitting capacity were the least efficient with an average technical efficiency of 54.53%. Sanjay (2004) in a study across STU's showed a huge disparity of technical efficiency which their study concluded that given size and distribution potential for improvement of technical efficiency was high. This could be explained by the vehicles failure to reach

destinations, illegally changing of routes or stiff competition they face from high vehicle sitting capacity vehicle which are more reliable.

The average technical efficiency score for all SACCOs was 55.69%. The intuition behind these average is that all the SACCOs would averagely be expected to reduce their use of inputs by 45.31% percent. In other words the SACCOs have exceeded their resource use by 45.31%. Technical efficiency for fifteen out-off the forty four SACCOs studied had their scores above average. The remaining twenty nine SACCOs had their technical efficiency scores being below average with fourteen with an estimated efficiency of below 50 %.

Table 4.8 Kolmogrov Smirnov test for similarity of distribution in different sitting bus capacity

Group	14 seaters only SACCOs	All seater SACCOs	Buses only
14 seaters only			
All seater SACCOs	0.996		
Buses only	0.086	0.062	

Source: authors own calculations (2015)

The similarity of efficiency distribution between the various sitting capacity vehicles was done using non-parametric KS statistic. The null hypothesis was that there was no difference between the distributions of any category of vehicles under consideration. The KS test showed a maximum difference of 0.15, 0.48 and 0.33 with

corresponding probability values, p , of 0.996, 0.086 and 0.062 respectively (table 4.8). the KS test revealed that there was a systematic difference between the distributions of efficiency scores for SACCOS that operated fourteen seater compared to SACCOS that operated buses only at 10% level of significance. Similarly there is a significant difference between the efficiency scores of all seater SACCOS and those that operated buses only. This could be attributed to the fact that SACCOS that operate low carriage vehicles were even less efficient.

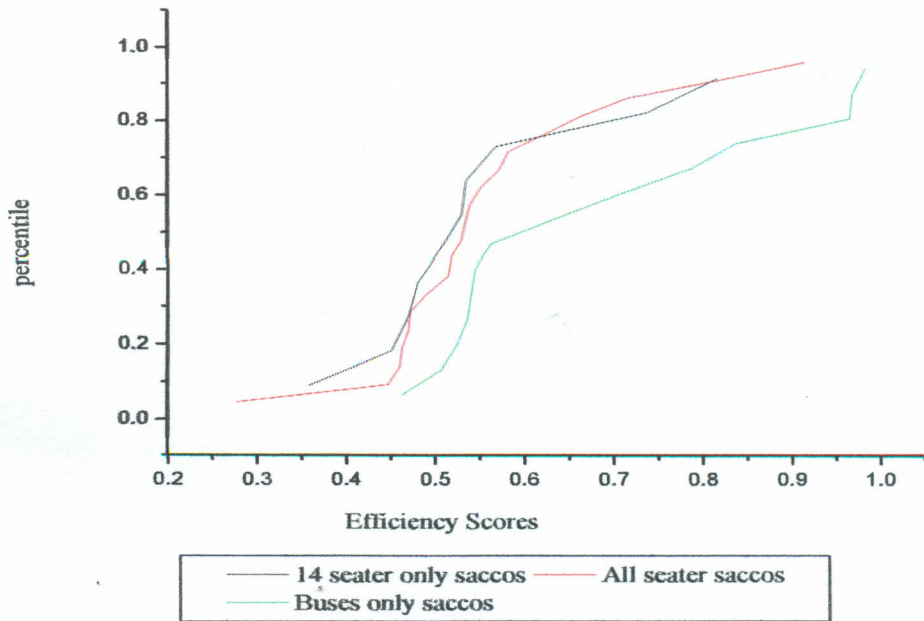


Figure 4.1: KS-test comparison percentile plot for efficiency scores for fourteen seater SACCOS, All seater SACCOS and only Buses SACCOS.

Source; own calculations.

Figure 4.1 shows there is a systematic difference between the distributions for fourteen seater SACCOS only & all seater SACCOS and buses only SACCOS, since the distribution curve for buses only SACCOS does not overlap the distributions curves for fourteen SACCOS and all seater SACCOS. The figure further shows that

efficiency scores for buses only SACCOs dominate all other SACCOs. This means buses only efficiency scores are larger at all points compared to fourteen seater and all seater SACCOs. Moreover, figure 4.1 shows that the distribution curves for fourteen and all seater SACCOs cross at various points implying that there is no systematic difference between the fourteen and all seater SACCOs.

CHAPTER FIVE

SUMMARY CONCLUSION AND POLICY IMPLICATIONS

5.1 INTRODUCTION

In this chapter, a concise summary of the results is given briefly and recommendations cited. The chapter further suggests policy implications anchored on the findings of this study. Areas for further research are also proposed.

5.2 SUMMARY

The public transport sector has been a focal point for address by all stake holders. Kenya has, in the efforts to enhance its public transport sector systems, laid down policies that seek to address efficient, accessible, safe and affordable transport services to its citizens. Major transport oriented policies have been instituted to govern the health sector while social research has been enhanced to avail new public transport facts and modify the existing ones. These milestones have not gone without challenges that continually pose threats to the achievement of an efficient transport system. Such challenges have been lack of efficient pricing, infrastructural rigidities and a general dishonoring of the laid policies. The most recent challenge is implementation of the cashless pay system which the PSV operators have adopted with quite a slow pace.

This study estimated the performance of public transport SACCOs in terms of their technical efficiency scores. The study used output orientation to estimate the efficiency scores using the parametric SFA approach. Relevant literature was

revisited in order to clearly show the gap. To obtain the technical efficiency scores Cobb Douglas production function was estimated.

A total number of 44 SACCOs owned by private companies were used for analysis of technical efficiency of transport system in Nairobi. Number of employees per SACCO, fleet size per SACCO and fuel consumption were assumed to be key components of vital input data while effective vehicle kilometres depicted the output set. Data from the ministry of transport, individual firms and Kenya Revenue Authority transport department were collected, organized and analyzed to obtain the results.

The findings from an output oriented SFA revealed that mean technical efficiency was 55.69 percent. The mean technical efficiency for fourteen seater SACCOs was 54.53 percent. Firms that had both fourteen seater and buses recorded a mean technical efficiency of 57.27 percent and SACCOs that operated buses only had the highest level of technical efficiency of 68.27 percent. At least 12 SACCOs (27.7 percent) of the SACCOs were less than 50 percent efficient. The rest 32 had efficiency scores varying between 0.5 and 1.

5.3 CONCLUSIONS

This study concludes that there exists very diverse efficiency challenges in the Nairobi public transport provision that continually pose threats to the achievement of efficient transport system. The Michuki rules envisioned efficient, safe and accessible transport system across the country as a whole although technical inefficiency in the transport sector present hardships in attaining the same. Other policies like that of

NTSA 2013, has so far been undergoing implementation but at a very slow rate. It's therefore fundamental for Kenya, in particular the capital city Nairobi, to find avenues to avail to her population an efficient public transport system.

Efficiency is one of the components of a vibrant transport system that cannot be overlooked. In its conclusion, this study has found out that there exists inefficiencies among SACCOs that provide public transport in Nairobi which maybe cause increased operational costs.

5.4 POLICY IMPLICATIONS

In light of the study findings, the following recommendations are made:

PSV SACCOs have been revealed to have inefficiencies in their operations. This is depicted by the inputs that they employ. Inputs are not fully utilized hence their output is always understated. As a policy recommendation, all SACCOs must find avenues to make optimal use of all available inputs by probably increasing monitoring and evaluation practices and subjecting workers to performance contracting. This will compel all human resource to be gainfully utilized for the betterment of the SACCOs. SACCOs that operate vehicles that have high sitting capacity are better than those that operate small sitting capacity vehicles. Therefore the transport authorities should continue with the efforts to encourage the use of high capacity vehicles.

5.5 AREAS OF FURTHER RESEARCH

Technical efficiency is just a partial of total economic efficiency. This study proposes other measures of efficiency on transport sector in Kenya. Secondly, it would be informative for other researchers to endeavor in using the DEA method to estimate

technical efficiency and draw comparisons with the results of this study. Thirdly, the extension of this study to include the determinants of efficiency would be a preferable research area. Fourthly, since SACCOS are not only in Nairobi and efficient transport is required in other areas, further research would take into consideration the estimation of their efficiency. Lastly, where cost data is readily available for transport providers, further researches would revolve around cost, allocative and profit efficiencies of the public service vehicles.

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