ANALYSIS OF EFFICIENCY IN PUBLIC HOSPITALS IN TANZANIA

By

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A Thesis/Dissertation Submitted in Partial/Fulfillment of the Requirements for an Award of Masters of Science in Project Planning and Management of Mzumbe University

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CERTIFICATION

We, the undersigned certify that we have read and hereby recommend for acceptance by Mzumbe University a dissertation entitled Analysis of Efficiency in Public Hospitals in Tanzania, in a partial fulfillment of the requirements for award of the degree of Master of Science in Project Planning and Management (MSC.PPM) of Mzumbe University

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DEDICATION

This dissertation report is dedicated to my lovely Husband, Mr Hamad S. Muya and my gorgeous young brother, Daud M Fumbwe.

ABBREVIATIONS AND ACRONYMS

AFRO	AFRICA Regional Office
BCC	Banker, Charness and Cooper
CCR	Charness, Copper and Rhodes
CHF	Community Health Fund
CHMT	Council Health Management Team
CRS	Constant Return to Scale
CRSTE	Constant Return to Scale Technical Efficiency
CSSC	Christian Social Service Commission
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DHIS2	Districts Health Information System
DMOs	District Medical Officers
DMUs	Decision Making Units
GOT	Government of Tanzania
HIS	Health Information System
HIV	Human Immune deficiency Virus
HRH	Human Resources of Health
HSSP	Health Sector Strategic Plan
MDGs	Millennium Development Goals
MMAM	Mpango wa Maendeleo wa Afya ya Msingi
MoHCDGEC	Ministry of Health, Community Development Gender Elderly and Childrens
MOHSW	Ministry of Health and Social Welfare
MPI	Malmquist Productivity Index
MPSS	Most Productive Scale Size
NBS	National Bureau of Statistics
NCDs	Non Communicable Diseases
NHIF	National Health Insurance Fund
NHFPC	National Health and Family Planning Commission
NIHA	National Institute of Hospitals Administration

NSSF	National Social Security Fund
NTDs	Neglected Tropical Diseases
PHC	Primary Health Care
PHSDP	Primary Health Service Development Programme
PMO-RALG	Presidents' Office –Regional Administration and Local Government
QALYs	Quality Adjusted Life Years
RHMTs	Regional Health Management Teams
SACCOS	Savings and Credit Cooperatives Society
SARA	Service Availability and Readiness Assessment
SDGs	Sustainable Development Goals
SFA	Stochastic Frontier Approach
SHIB	Social Health Insurance Benefits
URT	United Republic of Tanzania
VAHs	Volunteering Agency Hospitals
VRS	Variable Return to Scale
VRSTE	Variable Return to Scale Technical Efficiency
WHO	World Health Organisation

ABSTRACT

For the past two decades, Tanzania has implemented various policies that aim to improve the performance of health sector and health status of every citizen. These efforts and policies had direct impact on improving health sector and achieving Millennium Development Goals (MDGs). Despite various efforts to improve health sector, the sector is still faced with various challenges, one among is inefficiency.

The purpose of this study was to estimate efficiency of public hospitals in Tanzania for the year 2016. Specifically, the study sought to determine technical efficiency, scale efficiency and identifying factors influencing efficiency. To achieve the objectives, the study employed Data Envelopment Analysis (SFA), Stochastic Frontier Approach (SFA) and Tobit regression model on secondary data for the regional and district hospitals obtained from the Ministry of Health, Community, Development, Gender, Elderly and Children (MoHCDGEC). The study used medical staff and beds as input variables, and outpatients and inpatients as output variable. Results from DEA revealed that average technical efficiency of district hospitals and Regional referral hospitals was 69.3% and 90.7% respectively while findings from SFA depicted average efficiency score of 58% and 55% for Regional referral hospital and District hospitals respectively. In scale efficiency, 21.05% of District hospitals were efficient and 43.75% of Regional referral hospitals were scale efficient. On the other hand, Tobit regression results revealed that nurse, medical doctors, clinical officers and medical attendant are important factors in hospital production process, and they have influence on efficiency of public hospitals

Lastly, the study concludes that Ministry of Health, Community, Development, Gender, Elderly and Children (MoHCDGEC), and other concerned ministries and stakeholders need to take measures to improve efficiency as the study depicted inefficiency in public hospitals. Estimation of efficiency in public hospitals should be conducted regularly and reallocation of resources is necessary to be done in public hospitals.

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CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.1 Background

Sub Saharan Africa faces the problem of inefficiency in allocation and utilisation of health sector resources, Tanzania makes no exception thus it is important for Tanzania to attain a high level of efficiency in health sector. To achieve a Tanzania vision of 2025, improvement of efficiency in the health sector is essential. Regular estimation of efficiency is a strategy to support improvement of efficiency and can solve various challenges facing health sector, as well as improve provision of health services.

Before independence, various health services were established and available in urban areas. Major public hospitals were in urban areas, and rural areas had few religious organisations' hospitals (URT, 1990). Hence those living in urban areas had better access to health services than those living in rural areas (United Republic of Tanzania 1990). After independence, Arusha declaration of 1967 was the first prepared document intended to equalize opportunities and accessibility of health services to all people (URT, 2003). The social equity policy of Arusha declaration aimed at providing social services to areas where majority lived. Hence more services directed to rural areas where 90% of the total population lived. However, the policy gave more priority to Preventive health services than Curative services. To offer health service to as many people as possible, Tanzanian government provided one dispensary to serve between 6,000 and 10,000 people, and one health center to serve about 50,000 people. Moreover during the same period the government trained medical personnel to meet the generated demand, and still continues with various efforts to improve health sector.

Despite the achievements made by the Arusha declaration and various government efforts, provision of health services in urban areas remained static (URT, 2003). Since services were highly directed in rural areas, health services in urban areas deteriorated and did not meet the need of the population (United Republic of

Tanzania 2003). Currently 70.5% of the population is in rural areas and the remained 29.5% is in urban areas (URT, 2012).

Tanzania vision of 2025 formulated in 1998 is an update vision of Arusha declaration. It is a document that provides direction and a philosophy for a long term development. By 2025 Tanzania desires to achieve a high quality livelihood for its citizens, peace, stability and unity, god governance, a well-educated learning society and a competitive economy capable of producing sustainable growth and shared benefits (United Republic of Tanzania, 1998).

The vision of 2025 also recognizes health as a priority sector which contributes to a higher quality livelihood for all Tanzanians. The vision is expected to be achieved through access to quality primary health care for all, access to quality reproductive health service for all individuals of appropriate ages, reduction in infant and maternal mortality rates, universal access to clean and safe water, life expectancy comparable to the level attained by typical middle income countries, food self-sufficiency and food security, gender equality and gender empowerment. Additionally, government and development partners' fund should concentrate on increasing inputs, such as infrastructure, equipment, drugs and vaccines to improve service delivery (United Republic of Tanzania 1998).

As continuous progress government of Tanzania in 1993 commenced a health sector reform process, to better utilisation of health resources and improvement in access to Primary Health Care (PHC). GOT introduced various private financing mechanisms such as CHF, NHIF and SHIB, these were introduced in the form of user fees in public health facilities and private health insurance schemes. These mechanisms pooled resources in effort to improve health services and alleviate financial risk to individuals. In 1990 The Community Health Fund (CHF) was introduced by GOT with the intention to serve poor and those living in rural areas. In 2001 National Health Insurance Fund (NHIF) was introduced for the intention of serving civil servants. More financing mechanism was introduced by the GOT including Social Health Insurance Benefits (SHIB), under the National Social Security Fund (NSSF), private insurance and other micro insurance schemes. These financing reforms intended to improve availability and accessibility of health care to all groups of people in Tanzania both those living in rural areas and urban areas. Notwithstanding the aim of health sector reform, the biggest challenge of these health schemes is inefficiency. 41% are paying out as benefits, and members who are in urban areas are more likely to utilise outpatient care from various private facilities. It is as well recognized that the health financing architecture is fragmented, which means that individual health insurance schemes are covering different population segments, rather than combining them. Thus they do not yet achieve efficiencies in scale and cross subsidization by creating one joint risk and financial pool, (PMO-RALG, 2013).

Tanzania health policy aims to improve health of all citizens especially those at risk, and increase life expectancy. This is through provision of health services that meet the needs and demand of all citizens in the country. With the present national health policy, strategies, reforms and vision, steps forward achievements have been seen. As results of the efforts between 1999 and 2010 infant mortality fell from 99 to 51 per 1,000 live births, while under five mortality declined from 147 to 81 per 1,000 live births. Despite such progress health outcomes are still lower than the expected level of Tanzania economic development (MoHSW, 2013). According to Health Sector Strategic Plan (HSSP) 2015, Tanzania has made notable gains in achieving Millennium Development Goals. Indicated by the reduced under five and infant mortality, increased Life expectancy at birth from 51 to 61 years, and HIV prevalence has fallen from 7.1% in 2003 to 5.1% among adults.

With regards to the achievement of the Millennium Development Goals (MDGs) in Tanzania, Some goals have not been achieved as the target is not reached. Maternal mortality and neonatal rate has just declined but the target of maternal mortality ratio is 298 per 100,000 live per birth hence this goal is not achieved. The major causes of morbidity and mortality are communicable disease, maternal newborn, childhood illness, another important condition that neglected tropical diseases (NTDs), Non Communicable Diseases (NCDs) and malnutrition (WHO, 2016). Despite these entire progresses health sector faces challenges in resource mobilization, transparency, social accountability, weak health system and financial access.

Apparently the Government of Tanzania is committed in giving priority to the health sector, as evidenced by the increase in the government budget for health sector since 2000/2001 (from Tsh 80.7 billion to 639 billion). In addition per capital health spending has increased from about Tsh 13209 billion in 2006/2007 to estimated Tsh 16932.68 billion in 2008/2009, 8.9% of the discretionary budget to health in financial year 2013/2014, and Tsh 20462.8 billion in 2014/2015. Likewise, in financial year 2015/2016 GOT allocated a total of TZS 1,821 billion to the health sector, which is equivalent to 8.1% of the government's total budget of TZS 22,495 billion (URT, 2015).

This shows that in both nominal and real terms, Government of Tanzania's resource allocation to health has increased over time especially in the last two budgets. Tanzania resource allocation is on par with other African countries but lower than the Abuja Declaration threshold and Health Sector Strategic Plan IV (2015-2020). Despite all these achievements, one of the key barriers to improvement in quality and access of health service is the lack of effectiveness and efficiency in health financing. GOT allocates 9% of its overall budget to health nearly 60% of this budget is financed on budget by the development partners, not to count the resources received as general budget support.

Tanzania operates under a decentralized health system which is organised in three functional levels: district or primary level, regional or secondary level, and referral or tertiary level. District councils are mandated for planning, implementation, monitoring and evaluation of health services. Each council has a District Medical Officer (DMO) who heads the Council Health Management Team (CHMT). DMOs are accountable and answerable to the District Executive Director, as the head of the council. CHMTs are responsible for provision of services in dispensaries, health centers and district or district designated hospitals. Regional Health Management Teams (RHMTs) are responsible for interpreting health policies at the regional level. Moreover, the Ministry of Health and Social Welfare (MoHSW) is currently known as Ministry of Health, Community, Development, Gender, Elderly and Children (MoHCDGEC). The ministry is responsible for policy formulation, supervision and regulation of all health services throughout the country, as well as playing a direct role in the management of tertiary health services.

The decentralization approach improves governance and management of responsibilities and capacities at the health facility level. Moreover it strengthens the voice of citizens in health service delivery and management. Furthermore much emphasize is kept on performance management at all levels of the sector so as to increase outputs and impact. Primary Health Service Development Programme (PHSDP) 2007 - 2017 is a reform programme initiated by the Government to address weakness in the provision of health care in primary level facilities. PHSDP 2007 – 2017 is in Swahili popular known as Mpango wa Maendeleo wa Afya ya Msingi (MMAM).

The Government of Tanzania recognizes that regardless of the good network of primary health facilities, access to health care is still a challenge for parts of the population. Some people lives more than 10 kilometers from the nearest health facility. To improve access to health services as a target MMAM programme has been ensuring that every village has a dispensary and every ward has a health center.
MMAM programme focuses on strengthening the health system, rehabilitation, human resource development, referral system, increasing health sector financing and improving the provision of medicines, health care waste management, sanitation, equipment and supplies.

Meanwhile not all health facilities offers the necessary basic health services, since The 2012 Service Availability and Readiness Assessment (SARA) for Tanzania showed that primary health care service availability varied considerably. Services that were available in less than 30% of facilities included antiretroviral therapy for HIV, basic surgery, cardiovascular and chronic respiratory infection services, diabetes services, blood transfusion and advanced delivery services. In addition remote rural areas are still disadvantageous compared to urban areas and health issues of women are not adequately addressed to cover their needs. Furthermore, health system referral is weak though regional referral hospitals are in place in almost all regions, they are challenged by insufficient availability of key clinical staff, sufficient fund and necessary medicines.

Generally in Tanzania, public health care services delivery is constrained by both a shortage and inequitable distribution of skilled Human Resources of Health (HRH). The number of health personnel (Professionals) available to provide quality health services in dispensaries, health centers, district level hospitals, regional referral hospitals and national zonal and specialized hospitals is 63,447 and the shortage was estimated to be 82,007 or about 56.38% (Chitama and Maluka, 2015). Notwithstanding the increase in investments, the health sector still faces various challenges such as unequal access and coverage to health services, low quality, inefficient delivery of services, and inadequate management capacity.

1.2 Statement of the Problem

Estimation of hospitals efficiency is crucial for the evaluation of health policy initiatives and comparative health analysis (Biorn et al, 2003). Improvement in efficiency of hospitals may result in large savings in healthcare expenditures, which could be devoted to expand access to preventive, promotive, curative and rehabilitative services and improve quality of care. To work in hand with the Tanzania Health policy of improving health of all citizens, it is necessary for the health sector to perform efficiently.

The available empirical evidence has shown that there is inefficiency in health sector specifically public hospitals in Tanzania. This is indicated by scarce resources for health improvement, low ratio of physician to population where there was estimated shortage of 58.4% in 2015 and inefficient health system (Simon, 2015). Furthermore, there is lack of efficiency and effectiveness on health financing (HSSP IV, 2015) as 60 percent of the health budget comes from development partners. On the other hand, Bwana and Raphael (2015) analyzed technical efficiency of Volunteering Agency Hospitals in Tanzania, and found that there are no improvements of efficiency in VAHs as the efficiency level declined from 2009 to 2012. Likewise, Bwana (2015) examined technical efficiency of Tanzania teaching hospitals and revealed that teaching hospitals are operating below their optimal size by average of 17.6%

Hence, it is evident that a there is inefficiency in hospitals. Furthermore it is unclear about the precise level of efficiency both technical and scale in public hospitals, and factors that influence efficiency in public hospitals in Tanzania. Thus this study has filled the gap by estimating technical efficiency, scale efficiency, and identifying factors influencing efficiency using Data Envelopment Analysis (DEA), Stochastic Frontier Approach (SFA) and Tobit Regression Analysis on the secondary data of public hospitals for the year 2016.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study was to analyze efficiency in Public hospitals in Tanzania

1.3.2 Specific Objectives

i. To determine level of technical efficiency in public hospitals
ii. To determine level of scale efficiency in public hospitals
iii. To identify factors influencing technical efficiency in public hospitals

1.4 Research Questions

This study addressed the following research questions

i. What is the level of technical efficiency in public hospitals in Tanzania?
ii. What is the level of scale efficiency in public hospitals in Tanzania?
iii. What are the factors influencing efficiency in public hospitals in Tanzania?

1.5 Significance of the Study

This study contributes towards providing the information on the efficiency level in the public health sector in Tanzania. Also adds valuable information of the efficiency in public hospitals to the necessary stakeholders who are concerned with reviewing, managing and auditing the performance of public hospitals in Tanzania. In addition, the understanding of efficiency levels enable health planners and policy makers to determine more appropriate ways to allocate health sector resources, and to maximize the returns from the present investment. Furthermore the study adds value on the literature of public hospital efficiency using both parametric and non-parametric methods to estimate efficiency.

1.6 Organization of the Dissertation

The study is organized into six chapters.. Chapter one presents the introduction to the study, statement of the problem, research questions and objectives, scope of the study and significance of the study. Chapter two presents the literature review relevant to this study where both theoretical and empirical as well as the theoretical framework and conceptual frame work. Chapter three presents the research methodology which includes research design, data collection methods, variables and their description, and the estimated model. Chapter four presents the findings of the study, chapter five discusses the findings. Lastly, chapter six concludes and give out the policy implications.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the theoretical literature review, empirical literature review, theoretical framework and conceptual framework. The chapter also provides a clear understanding of efficiency, approaches to estimate efficiency, related theory, limitations, and recommendations made by previous researchers.

2.2 Theoretical Review

2.2.1 Concept of efficiency

Efficiency is a state or quality of being efficient, it can be explained as a demand that the preferred goals are achieved with the minimum use of the available resources. Efficiency indicates a level of performance that portrays lowest amount of inputs used in creation of highest amount of outputs. It is a measurable concept that can be determined by using the ratio of useful output to total input.

$$\text{Efficiency} = \text{outputs}/\text{inputs}$$

Efficiency of hospitals can be estimated involving technical efficiency, scale efficiency, and cost efficiency. Technical efficiency identify in physical terms the best possible combination of factor inputs to produce a given outputs in health system. It is the physical relation between resources (such as labour, capital or equipment) and health outcome (such as number of admission, numbers treated, and waiting time) or the final health outcome such as Quality Adjusted Life Years (QALYs), (Nunamaker, 1985). Scale efficiency shows the managerial ability to choose the optimum size of the hospital, as hospital size may result into having efficiency or inefficiency. Scale efficiency can be decreasing return to scale or increasing return to scale. Decreasing return to scale occurs when the hospital is large compared to the volume of activities conducted by the hospital. Whereas increasing return to scale occurs when the hospital is too small for the activities conducted (Zere, 2000).

Efficiency can be measured by parametric and non-parametric approaches. Parametric approach involves Stochastic Frontier Approach (SFA) and non-parametric approach involves Data Envelopment Analysis (DEA). Charness *et al.* (1978) proposed DEA as an approach for the measurement of efficiency of Decision Making Units (DMUs) such as hospitals, and Banks. Jat and Sebastian (2013) revealed that SFA and DEA are the most common and favored methods for the estimation of efficiency in health care organizations. To improve reliability of efficiency it is best to use both parametric and non-parametric approaches in the analysis as each have its strength and weakness (Ferrier and Lovell, 1990).

2.2.2 Data Envelopment Analysis (DEA)

DEA is a non-parametric approach of estimating efficiency that uses linear programming techniques. It does not need an explicit functional form and can construct the frontier from the observed input-output ratio. Charness, Cooper and Rhodes (1978) formulated the first DEA model which is mathematically expressed as

$$\mathrm{Max}_{\theta,}\, \lambda^{\theta} \qquad 2.1$$

Subject to

$$X\lambda \leq x_0$$

$$\theta y \leq Y\lambda$$

$$\lambda \geq 0$$

Where X is an n output by I input matrix with columns x_i, Y is an m by I output matrix with columns y_i and λ is an I by 1 intensity vector. In the DEA problem the performance of a producer is evaluated in terms of his ability to expand its output vector subject to the constraints imposed by best observed practice. If radial expansion is possible for a producer, its optimal $\theta > 1$ while if the radial expansion is not possible its optimal $\theta = 1$.

The second version of DEA was suggested by Banker, Charness and Cooper (1984) to relax the assumption of Constant Return to Scale (CRS), (Sena, 2003). DEA is a non-parametric approach which has various benefits such as implicit in the mathematical programming approach which makes it attractive on a theoretical level.

Also the formulation of production correspondence relating inputs to outputs and the substantial freedom is given to the specification of outputs and inputs, (Korir, 2010).

DEA has two categories of envelopment surface which are known as Constant Return to Scale (CRS) and Variable Return to Scale (VRS) and it can either be input oriented model or output oriented model. With input oriented model an inefficient unit is made efficient through the proportional reduction of its inputs, whereas the outputs proportions are held constant. In output oriented model, the outputs are expanded as far as possible while controlling the inputs, (Martic *et al*, .2009).

Moreover, DEA has been an appropriate measure for the estimation of efficiency in hospitals, since the price data is difficult to find and multi output production is relevant. Furthermore DEA need fewer assumptions about the form of production technology.

2.2.3 Stochastic Frontier Approach (SFA)

SFA is a parametric approach that measures efficiency by using econometrics techniques. It constructs a smooth parametric frontier and allows for the possibility of modeling and measurement error. Apparently SFA appeals to economic theory when considering the shape of the frontier and statistical criteria that might be used to differentiate the appropriateness of alternative functional relationships for particular data set (Jat and Sebastian, 2013).

SFA is of advantageous as it considers stochastic noise in data and allows statistical testing of hypotheses concerning production structure and degree of inefficiency. Furthermore the method controls random shocks to the production and measurement error in the inputs and outputs. The disadvantage part of SFA is that, it needs an explicit imposition of a particular parametric functional form, representing the underlying technology and an explicitly distribution assumption for the inefficiency terms (Hossain, Kamil and Mustafa, 2012).

In addition stochastic production frontier estimate diverge from the best production function with extra error term which shows the inefficiency in the production. Thus with SFA firm is made to be technically inefficient relative to the frontier. Meanwhile the error term captures the randomness outside the control of the firm and randomness under the control of the firm, (Korir, 2010). Through the specification of frontiers as stochastic, it is possible to conduct statistical estimation and inference.

2.2.4 Production Theory

Production theory explains the relationship of inputs and outputs, which is transformation of inputs to output. Production is concerned with creation of output from a given set of input where inputs are those things employed in the production process and outputs are the results of production process. The rationale of production theory in this study comes, in view of the fact that hospitals' production process involves various inputs which create hospitals outputs and affect efficiency of hospitals. Inputs used in hospital production process are medical doctors, nurses, medical attendants, clinical officers, laboratory technicians, surgeons, nonmedical staffs, and beds. Whereas outputs used in hospital production are inpatients, outpatients, surgeries and consultations. Mathematically it is expressed in terms of a production function. Production function is a function which shows a relationship between outputs and inputs, presenting maximum output that can be produced from a given set of inputs (Maddala and Ellen, 1989).

Production function is usually expressed as

$$Q = f(x_1, x_2, x_{3.......}x_n) \qquad 2.2$$

Whereby

Q = maximum amount of output

$x_{1,}\, x_{2,}\, x_{3.....}x_n$= amount of various inputs used

The production function in equation 2.2 shows Q as representative of hospital output (inpatient, outpatients) and $f(x_1,\ x_2,\ x_{3,}\ x_n)$ as representatives of hospitals inputs (Medical staff and beds) which can also be referred as social, economic or institutional factors. Inputs are labour and capital used in the production process, where the maximum level of output depends on the quantities of inputs (labour and capital) employed. Technical efficient is obtained if maximum level of output is obtained from the given set of inputs. However A production function defines a technically efficient method of production such that producer cannot reduce one input and maintain the same level of output at the same time without increasing one or more inputs. Firm is said to be efficient if it cannot produce more output with the same inputs or cannot obtain same output with less input used. Hospital is the firm that have multiple inputs and outputs. As a firm, hospital combines human, financial and information resources as multiple inputs to create services as multiple outputs with the intention to improve health or quality of life outcomes. Therefore this study determines scale and technical efficiency. Furthermore it addresses the influence of these inputs in the hospital's efficiency and assess their significance in influencing efficiency of public hospitals.

2.2.5 Theoretical Framework

Understanding the production technology in the health sector is necessary for the analysis of efficiency in public hospitals. Cobb-Douglas is the most common form used as it ensures that the production function is quasi-concave in the second stage of production.

The production technology of i^{th} hospital using j inputs, is characterized by a production function in the following form

$$y_i = A\sum_{j=1}^{m} x_j^{\beta_j} e^{v-u} \ , \qquad (2.2)$$

Where y_i is the output of the i^{th} hospital and x_j is the input used. With the assumption of the two-input case, the cost minimization problem subject to the output becomes

$$z_i = w_1 x_1 + w_2 x_2 + \lambda(y_i - A x_1^{\beta_1} x_2^{\beta_2} e^{v-u}) , \qquad (2.3)$$

Where w_j is the input price for the input j .

The first-order conditions from the composite function becomes as follows

$$\frac{\partial z}{\partial x_1} = w_1 - \lambda \beta_1 A x_1^{\beta_1 - 1} x_2^{\beta_2} e^{v-u} = 0 , \tag{2.5}$$

$$\frac{\partial z}{\partial x_2} = w_2 - \lambda \beta_2 A x_1^{\beta_1} x_2^{\beta_2 - 1} e^{v-u} = 0 , \tag{2.6}$$

$$\frac{\partial z}{\partial \lambda} = y_i - A x_1^{\beta_1} x_2^{\beta_2} e^{v-u} = 0 , \tag{2.7}$$

From the equation 2.5 and 2.6, solution for cost minimization for the hospital that operates allocatively efficient is obtained as follows

$$\frac{x_1}{x_2} = \frac{\beta_1 w_2}{\beta_2 w_1} , \tag{2.8}$$

For the hospital that is allocatively inefficient, equation 2.8 does not hold, (Korir, 2010). In order to capture for the inefficiency, equation 2.8 is modified as

$$\frac{x_1}{x_2} = \frac{\beta_1 w_2 e^{\varepsilon_j}}{\beta_2 w_1} \rightarrow x_2 = \frac{\beta_2 w_1 e^{-\varepsilon_2}}{\beta_1 w_2} , \tag{2.9}$$

The factor demand equation for x_1 is obtained by substituting equation 2.10 into equation 2.2 and solving as follows:

$$y = A x_1^{\beta_1} \left[\frac{\beta_2 w_1 e^{-\varepsilon_2}}{\beta_1 w_2} \right]^{\beta_2} e^{v-u} , \tag{2.10}$$

Simplification of the equation gives

$$x_1 = A^{\frac{-1}{\beta_1+\beta_2}} \left(\frac{\beta_1}{\beta_2}\right)^{\frac{\beta_2}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{-\beta_2}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_2}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}}$$

$$= \beta_1 \left(A\beta_1^{\beta_1} \beta_2^{\beta_2}\right)^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{-\beta_2}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_2}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} \qquad (2.11)$$

The factor demand equation for x_2 is obtained as follows from the equation 2.10

$$x_2 = \frac{\beta_2 w_1 x_1 e^{-\varepsilon_2}}{\beta_1 w_2}$$

$$= \frac{\beta_2 w_1 \beta_1 \left(A\beta_1^{\beta_1} \beta_2^{\beta_2}\right)^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{-\beta_2}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_2}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} e^{-\varepsilon_2}}{\beta_1 w_2}$$

$$= \beta_2 \left(A\beta_1^{\beta_1} \beta_2^{\beta_2}\right)^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{\beta_1}{\beta_1+\beta_2}} w_2^{\frac{-\beta_1}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_2}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} e^{-\varepsilon_2} \qquad 2.12$$

The general equation for factor demand for any j input can be specified as follows:

$$x_j = \beta_j \left[A \prod_{j=1}^{m} \beta_j^{\beta_j} \right]^{\frac{-1}{\sum_{j=1}^{m}\beta_j}} y^{\frac{1}{\sum_{j=1}^{m}\beta_j}} \left\{ \prod_{j=1}^{m} \left(\frac{w_s}{w_j}\right)^{\frac{\beta_j}{\sum_{j=1}^{m}\beta_j}} \right\} e^{\frac{\beta_j\varepsilon_j}{\sum_{j=1}^{m}\beta_j}} e^{\frac{-(v-u)}{\sum_{j=1}^{m}\beta_j}} e^{-\varepsilon_j} \qquad 2.13$$

J= 2, 3....., m.

The cost function for the two input case is obtained as follows

$$c(w_1 w_2 y) = w_1 x_1 + w_2 x_2$$

$$= \beta_1 \left[A\beta_1^{\beta_1} \beta_2^{\beta_2}\right]^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{\beta_1}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_j}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} +$$

$$\beta_2 \left[A\beta_1^{\beta_1} \beta_2^{\beta_2}\right]^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{\beta_1}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_j}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} \varepsilon_j$$

$$= \left(\beta_1 + \beta_2 e^{-\varepsilon_j}\right) \left[A\beta_1^{\beta_1} \beta_2^{\beta_2}\right]^{\frac{-1}{\beta_1+\beta_2}} y^{\frac{1}{\beta_1+\beta_2}} w_1^{\frac{\beta_1}{\beta_1+\beta_2}} w_2^{\frac{\beta_2}{\beta_1+\beta_2}} e^{\frac{\beta_2\varepsilon_j}{\beta_1+\beta_2}} e^{\frac{-(v-u)}{\beta_1+\beta_2}} \qquad 2.14$$

J=2

2.3 Empirical Literature Review

To have clear understanding of efficiency estimation, and the existing research gap, the study reviewed conducted studies on estimation of hospital efficiency and conducted studies on estimation of other Decision Making Units (DMUs) such as banks, or other sectors than health sector.

2.3.1 Studies on Hospitals efficiency estimation

Li and Dong (2015) conducted a study on measuring and benchmarking technical efficiency of public hospitals in Tianjin, China. This study employed Bootstrap DEA approach to estimate technical efficiency and explore the benchmarking mechanism for further efficiency improvement and learning. The study measured efficiency of the selected 14 third grade public general hospitals and data for year 2012 were collected from National Institute of Hospital Administration (NIHA), National Health and Family Planning Commission of the People's Republic of China (NHFPC). To avoid double counting problems or mixing allocative and technical efficiency in the selection of output/input indicators, the study used number of beds and number of staff as input indicators whereas number of diagnostic visits and number of discharged inpatients employed as output indicators.

The study revealed that there were 8 hospitals with efficiency score of 1 using the traditional Banker, Charnes and Cooper (BCC) model. The new score of the efficiency revealed that 5 hospitals had excellent performance, 1 hospital had average performance, and 5 hospitals had average performance with ample scope for improvement. Furthermore 2 hospitals needed to improve performance and 1 hospital needed urgent improvement. The study used Bootstrap since it improves accuracy of the estimated efficiency score. Despite the strength of Bootstrap DEA used, the study had some failures as all environment factors were considered as random factor in estimation of efficiency score. Moreover the study could estimate efficiency using DEA in first stage and using SFA in the second stage and traditional BCC DEA model in the third stage to re estimate efficiency.

Rezaei *et al.* (2016) conducted a cross-sectional and retrospective study that estimated the technical efficiency of 12 teaching hospitals affiliated with Kurdistan

University of Medical Sciences in Iran during the year 2007 to 2013. Their study used SFA technique to estimate the technical efficiency of the teaching hospitals, using four inputs and one output. Inputs used are number of beds, number of physicians (general and specialist), number of nursing staff, number of other staff members (non-medical staff and other medical staff except nursing and physicians). While output used are inpatient admissions.

The study found that performance of hospitals of the Kurdistan University of Medical Sciences was better than in 2013 than in 2007. Moreover the overall performance of the hospitals over the 5-year study period was not appropriate, and about 33% of the inputs variables such as nurses and other hospital staff members was not used. However, the study used only number of inpatient admission as output and SFA model to estimate efficiency. Hence the present study used both inpatients and outpatients admission as output. In addition the current study used DEA and SFA methods for estimating efficiency.

Hamidi, (2016) measured efficiency of government hospitals in Palestine using Stochastic Frontier Approach. The study's objectives were to estimate technical efficiency and quantify the effects of number of beds, doctors, nurses and non-medical staff on technical efficiency. The study collected data from the ministry of health, for the period of 6 years from 2006 to 2012 for 132 observations. The author used number of doctors, number of nurses, number of beds, and number of nonmedical staff as inputs. Nevertheless the number of admitted patients, average length of stay, number of hospital days, number of operations and number of outpatient visits were outputs variable used. Furthermore the study revealed that average technical efficiency was 55% and medical doctors and nurses are important factor in hospital production. However the study used only SFA to measure efficiency of government hospitals, despite that it is borrowed to the current study to analyze efficiency of public hospitals in Tanzania.

Flokou *et al*. (2017) applied Data Envelopment Analysis to measure efficiency of public hospitals in Greece between 2009 to 2013 years following the financial crisis of 2007-2008. Specifically, their study intended to examine the efficiency of public hospitals for a sample of 107 Greek NHS hospitals over the period of 2009–2013 collected from Ministry of Health and Welfare. The study used inputs such as hospital beds, physicians and other health professionals. Considering hospitalized cases, surgeries and outpatient visits were outputs variable The Study used 2 year window DEA model for the assessment of technical and scale efficiency as well as identification of return to scale. Moreover the study analyzed sources of productivity change between first and last year of the study by using the Malmquist Productivity Index. The study found some improvement in technical and scale efficiency at the end of 5 year of the financial crisis period. However, the study did not use parametric approach in the estimation of efficiency. The present study addressed this gap Through the use of SFA, DEA and Tobit to the estimation of efficiency in Tanzania

The efficiency analysis of Healthcare facility in Nigeria conducted by Lawanson, (2015) revealed consistently decline of pure technical efficiency for the period 2010 – 2012. Input variables used in the study were number of beds, number of nurses and number of physician, whereas the output variable used in the study were number of inpatients, number of outpatients and number of maternal and child care. The study used DEA to estimate technical and scale efficiency of 52 public and private (secondary hospitals). Furthermore it revealed the magnitude of input reduction and output increase that may be required for the inefficiency hospitals to perform efficiently. The study used systematic random sampling for the 52 health facilities which involved 3 public health facilities and 49 private health facilities. The structured questionnaires were employed to collect information on inputs and outputs variables from the facilities, analyzed using DEAP version 2.1 with an assumption of input oriented model. Moreover the study used only DEA to estimate efficiency, involving both private and public healthcare. In addition, the study used primary data as questionnaires were administered in each facility to collect information on the variables used in the study. Thus the current study in Tanzania estimated efficiency using DEA, SFA and Tobit on the secondary data obtained for the year 2016.

Zere (2000) evaluated technical efficiency and productivity of public sector hospitals in South Africa using non parametric techniques of Data Envelopment Analysis

(DEA) and Malmquist Productivity Index (MPI). The study involved sample of 86 hospitals, using recurrent expenditure and bed size as inputs, and inpatient days and outpatient visit as output. Data for the study covered the year 1992/1993 – 1997/1998 drawn from annual statistical publications of the department of health, provincial administration of the Western Cape, which includes the Western Cape, Northern and Eastern provinces.

In the analysis the study used input-output models, constant and variable return to scale models of DEA to compute the efficiency score and Malmquist Productivity Index to assess changes in the productivity, using Data Envelopment Analysis programme, version 2.1 (DEAP 2.1). The study revealed that only 12.8% of hospitals operate efficiently and there is technical inefficiency level of 35% to 47% which indicates that significant amount of resources are being wasted. Also half of hospitals have decreasing return to scale, where level II hospitals had 78.9% and level III hospitals had 58.3%. The MPI for the sampled hospitals shows that there is a decline of 12.1% of total factor productivity during the covered period. Nevertheless the study failed to use parametric approach of estimating efficiency and further determine the influence of efficiency. Hence, the current study in Tanzania estimated efficiency using both parametric and non-parametric approaches to estimate efficiency, and Tobit regression on identifying influences of efficiency.

Samsudin *et al.* (2016) examined efficiency of public hospitals in Malaysia using DEA to determine efficiency score and Tobit model to identify the possible determinant of inefficiency. The study employed three inputs (number of doctors, nurses and beds) and four outputs (number of inpatients, outpatients, surgeries and deliveries). The study used data for 25 public hospitals, and concluded that the efficiency level for the hospitals with specialist and without specialist is high with an average of 90%. The study further revealed that admission rate, number of outpatient per doctor and type of the hospital has influence on the efficiency. Notwithstanding the use of only DEA in estimating efficiency, the current study borrowed it to estimate efficiency of public hospitals in Tanzania.

Osei *et al.* (2005) conducted an exploratory study to estimate technical efficiency of public district hospitals and health centers using Data Envelopment Analysis in Ghana. The objectives of the study were to estimate the relative technical efficiency and scale efficiency and to demonstrate policy implications for health sector policy makers. The study used data for 2000, from a random sample of 21 public health centers using a WHO African Regional Office (WHO/AFRO). The health centre DEA model had a total of 6 variables: 4 outputs and 2 inputs. The four outputs for each individual health centre were the number of child deliveries, the number of fully immunized children under the age of 5 years, the number of other maternal and childcare visits, and the number of outpatient curative visits. Whereas the two used inputs were, the number of technical staff (this included medical assistants, nurses and paramedical staff) and the number of support or subordinate staff (including cleaners, drivers, gardeners, watchmen and others.

The finding of the study revealed that eight hospitals 47% were technically inefficient, ten hospitals 59% were scale inefficient, three health centers (18%) were technically inefficient, and eight health centers (47%) were scale inefficient. However, the study involved only 3.7% of health centers and 22% of district hospitals hence results of the study cannot be generalized to the entire hospitals and health centers in Ghana. Moreover the study failed to identify factors that influence inefficiency in hospitals in Ghana, and used only non-parametric approach to estimate efficiency.

Sama and Bihkongnyuy (2016) conducted a study to assess the technical efficiency of public hospital in Cameroon, by using DEA. The study used panel data set obtained from the National Institute of Statistics involving 109 public health facilities for the period 2002 – 2003. The study intended to identify the actual level of efficiency in public hospitals and determine the way efficiency varies by the type of health facilities and urban health facilities respectively. The study examined efficiency level of public hospital in terms of their ability to use minimum or fixed quantity of resources to produce as much as possible. Thus the study revealed high level of inefficiency within public hospitals in Cameron, where rural health facilities were generally less efficient than semi urban health facilities and urban health facilities respectively. However the study used output oriented model with the assumption that hospitals have fixed resources, whereas not every hospitals' resources are fixed. The present study used both input oriented DEA model and SFA to estimate efficiency.

Bertrand (2012) analyzed the determinants of efficiency of public hospitals in Cameroon using non parametric approach (DEA) and censored Tobit model to analyze sources of inefficiency. The study used data drawn from the national survey on public expenditure and beneficiary satisfaction in the health sector. The study employed beds, medical staff, paramedical staff, administrative staff and technicians as inputs. Output variables were consultations, Admission, cumulative days of hospitalization, number of medical tests and number of maternal and child care. The study revealed that Integrated Health Centers and sub division medical centers are more efficient than District hospitals. In addition, the inefficient rate is explained more by the occupation rate of hospital beds, the cost of health care and the degree of specialization. Besides the use of non-parametric approach in estimation of efficiency, and censored Tobit model to analyze sources of inefficiency, the study failed to use Parametric approach SFA in estimating efficiency.

Korir (2010) used DEA and SFA to measure hospital efficiency in Kenya. The study intended to estimate the level of efficiency and analyze the trend of efficiency during the covered period of 1995 to 2000 years. The study obtained Secondary data from Ministry of Health headquarters, the Health Information System (HIS) department and the Health Care Finance Division and the ministry of Finance. Besides SFA, the study employed input orientation DEA with the assumption of constant returns to scale to estimate efficiency. The study employed recurrent expenditure and actual number of beds as inputs variable. While inpatients and outpatient visits were outputs variable used in the study.

The study found that constant returns to scale assumption was associated with a lower technical efficiency level than variable returns to scale assumption. The results from both SFA and DEA revealed that hospitals as a group used resources inefficiently. The SFA gave an average cost efficiency level of 1.3431, which implies that the average cost of sample hospitals was above the minimum by 34.31%. On the other hand, the DEA approach produced efficiency scores that indicated that hospitals average cost was 27.40% and 34.695% higher than fully efficient level, under variable returns to scale and constant returns to scale, respectively. However the study was constrained in the use of DEA approach in estimation of efficiency levels for the period 1995 – 2000 due to the unavailability of time series data on inputs and inputs prices. With regard to both technical efficiency and allocative efficiency, the study included prices of inputs. However the study failed to identify factors that influence efficiency in public hospitals in Kenya.

Irungu (2012) analyzed efficiency of public hospital in Kenya for year 2008 to 2011, using both DEA and SFA methods to measure efficiency of level 4 and level 5 public hospitals. In analyzing the determinants of efficiency, the study employed Tobit regression model using efficiency scores generated from DEA and SFA results.
The result obtained from DEA showed that level 5 general hospital technical efficiency range from 85.82% to 100% and 90.97% to 100% for level 4 public hospitals. Moreover the results from SFA on cost efficiency for level 5 public general hospitals ranged from 63.79% to 92.92% and from 55.71% to 83.83% for level 4 public hospitals. It was also revealed that increases in antenatal clinic visits reduce technical and cost efficiency for level 5 hospitals and increase cost efficiency for level 4, increase in recurrent expenditure reduce cost efficient in both level 4 and 5 public hospitals, and increase in number of doctors increase cost efficiency for level 4 public hospitals while increase in nurses results to increase in cost efficiency in level 5 public general hospitals. Thus, the present study borrows the methodology in the estimation of technical efficiency in public hospitals in Tanzania considering regional referral hospitals and district hospitals.

Mujas, Asbu and Junoy (2016) used Data Envelopment Analysis and Tobit regression Approach to estimate efficiency of Referral hospitals in Uganda. The specific objectives of the study were to estimate the technical and scale efficiency of regional referral hospitals in Uganda in Financial Year 2012/2013. Second, estimate the magnitudes of output increases of the same quality that would have been required to make relatively inefficient hospitals more efficient. Third, determine the impact of institutional and/or contextual/environmental variables on hospital inefficiencies.

The study was a cross sectional study using secondary data. Data for the study were collected as reported by Ministry of Health in the annual health sector performance report for the covered period. Based on completeness of data inputs used in the study were total number of medical staff and hospital beds, outputs used were outpatient department visits and in-patient days. The Study used excel programme in data entry and later exported into STATA 13, and conducted data analysis in two stages using STATA 13. An output-oriented model with Variable Returns to Scale (VRS) estimated the individual hospital efficiency scores. The study revealed that three hospitals 18% was CRS technically efficient, other three hospitals (18%) were scale technical efficient, also eight hospitals (47%) were VRS technically efficient. Therefore the overall sample average of pure technical efficiency score was 91.4% and the lowest pure technical efficiency score was 52.4%. The estimated technical efficiency, scale efficiency, revealed that output needed to increase to achieve efficiency and determined influence of inefficiency. However, the study used only DEA to estimate efficiency with assumption of output oriented model.

Bwana and Raphael, (2015) examined technical efficiency of Tanzania teaching hospitals by using Data Envelopment Analysis (DEA). The study used sample of 16 teaching hospitals for the period 2009 -2013 and data drawn from the annual hospital reports for the period under study. In addition the study adopted variable return to scale (VRS) and output-oriented model in evaluating efficiency. They employed beds and employees as inputs variables, while discharged patients, outpatients' visits, number of admissions and number of surgeries were output variables. The result implies that over the study period private teaching hospitals in Tanzania were operating below their optimal size by an average of 17.6 %. However, the study involved only private teaching hospitals and employed sample of only 16 teaching hospitals, hence the findings cannot be generalized to all teaching hospitals in Tanzania. Moreover the study estimated efficiency of private teaching hospitals by using DEA and failed to apply parametric approach in efficiency estimation.

In the similar study Bwana (2015) evaluated technical efficiency of Volunteering Agency Hospitals in Tanzania through determining the scale efficiency and establishing how inefficiency can be reduced in VAH. The study adopted inputs oriented model, whereas outpatient visits, inpatient days and surgical operation performed were outputs variable. The inputs variables employed were full time employees and hospital beds. Data for the study were partly from the library of the Christian Social Services Commission (CSSC) headquarter in Dar es Salaam, and some of the data have been achieved from the annual reports of the respective hospitals under the study. The study found that there were no improvement in the efficiency of VAHs in Tanzania, since in 2009 the technical efficiency scores was 59.79% and in 2012 it was 55.08%. The result indicated that VAHs are becoming inefficient in managing their resources. However the study failed to use both parametric and non-parametric approaches in estimating efficiency. Additionally it considered only Volunteering Agency Hospitals.

2.3.2 Estimation of efficiency in other sectors

Kidane *et al.* (2013) conducted a study on agricultural inputs and efficiency in Tanzania small scale agriculture. They conducted their study in Tabora region with the main objective of estimating relative efficiency of tobacco production when compared with other three crops namely, maize, groundnut and rice. SFA was an approach used to estimate efficiency with a reason that it has the ability to differentiate error term. It differentiate error term between the one representing inefficiency component and effects of factors beyond control of the farmer and the random error term representing inefficiency due to farmer’s specific behavior. Data for the study were from household farmers collected by Tanzania National Bureau of Statistics (NBS) in 2007/2008 agriculture census survey.

Results of the study revealed that modern inputs such as fertilizer, high variety seeds, credit availability and marketing outlet are the determinants of technical efficiency in tobacco production. Moreover the study revealed that there is misallocation of resources in favor of tobacco at the expense of maize, rice and groundnut and that tobacco production appears to be inefficiently and costly undertaking. The production of tobacco was also revealed to worsen the already low health status of Tanzania.

Marwa (2015) conducted an empirical investigation on performance of Savings and Credit Cooperatives (SACCOS) in Tanzania. The study used Data Envelopment Analysis with bootstrap approach to estimate efficiency, and it addressed three questions as follows, how efficient are SACCOS in Tanzania? Are they sustainable and profitable? And what drives their performance in terms of efficiency and sustainability? The study involved primary and secondary data. Secondary data for the study drawn from the ministry of cooperatives and food security, and the regional headquarters of the cooperatives audit and supervision corporation. Primary data was from managers, board members and regulators through face to face interview. The study revealed that average efficiency score is 32% and recommended firms to expand their scale of operation and those firms operating beyond optimal scale need to downsize. The study also found that performance of SACCOs is constrained by the limited capital, low level of education to the members, and effective leadership.

Ally, (2013) analyzed efficiency of commercial banks in Tanzania using Data Envelopment Analysis (DEA) for seven years from 2006 to 2012. The study used input oriented DEA model, analyzing both CCR and BCC models. The case of the study was Regional and Small commercial banks, using three inputs and two output. The inputs were total deposits, number of employees and total expenses, while the outputs were total loan and total interest income. The study revealed that the overall mean efficiency is 90.4% implying that for banks to perform efficiently they could decrease the level of inputs by 9.6%. The study recommended the inefficient banks to minimize the use of inputs resources while maintaining same level of output.

2.4 Overview of the Literature

From the reviewed studies it is observed that approaches to estimate efficiency are DEA and SFA, and the mostly used approach is DEA. Most studies used Malmquist Productivity Index to measure the productivity and Tobit regression analysis to identify factors that influence efficiency or inefficiency.

In estimating efficiency various inputs and output variable has been used. The mostly used inputs for hospitals' efficiency estimations are number of beds, number of medical staff, recurrent expenditure, number of non-medical staff, administrative staff and technicians. The mostly used output variable in estimating hospitals' efficiency are number of diagnostic visits, number of discharged inpatient, inpatient admission, surgeries, outpatient visits, number of child deliveries, number of maternal and child care visits and number of medical tests. The inputs variables such as staff (medical, non-medical, administrative technicians, etc) were used to represent labour and number of beds were used to represent capital. Also some studies such as of Zere (2000) and Korir (2010) used recurrent expenditure as proxy for quantities of inputs in hospitals. The reviewed variable used in these studies have been useful in selecting variables to be used in current this study, where the study used medical staff and bed as inputs, outpatient and inpatient as inputs. In addition SFA was used to estimate technical efficiency. Whereas DEA estimated scale and technical efficiency and Tobit regression identified factors influencing efficiency.

2.5 Research Gap

It is evident that there has been various efficiency study conducted on other sectors and health sector, however there are few studies on efficiency of hospitals in Tanzania (Bwana 2015: Bwana & Raphael 2015). Yet, the available studies on health sector have not analyzed the efficiency of public hospitals Tanzania, and the methodology used is only DEA. The first study conducted by Bwana (2015) considered Faith Based organizations where the study evaluated technical efficiency of Volunteering Agency Hospitals in Tanzania, and used only DEA in the analysis of technical efficiency, thus failed to check on the scale efficiency and factors that can influence efficiency. The second study of Bwana and Raphael (2015) on Tanzania teaching hospital also failed to use other methodology than DEA. This study filled the literature gap in Tanzania by using both parametric and non-parametric in estimating efficiency of public hospitals.

2.6 Conceptual Framework

The conceptual framework shows dramatically the production process of the hospitals which uses various inputs to produce outputs. Hospital as a firm has multiple inputs and multiple outputs. The production processes of hospitals involve the use of multiple inputs such as labour (medical staff) and capital (beds) to produce multiple outputs (inpatients and outpatients). The production process of hospital can be influenced by number of factors that cannot be controlled by the hospital managers and may manipulate the efficiency of the production process. These factors can either be institutional factors or environmental factors. Figure 2.1 shows the relationship between hospitals inputs, outputs as the production process and the mediating factors that may affect the production process.

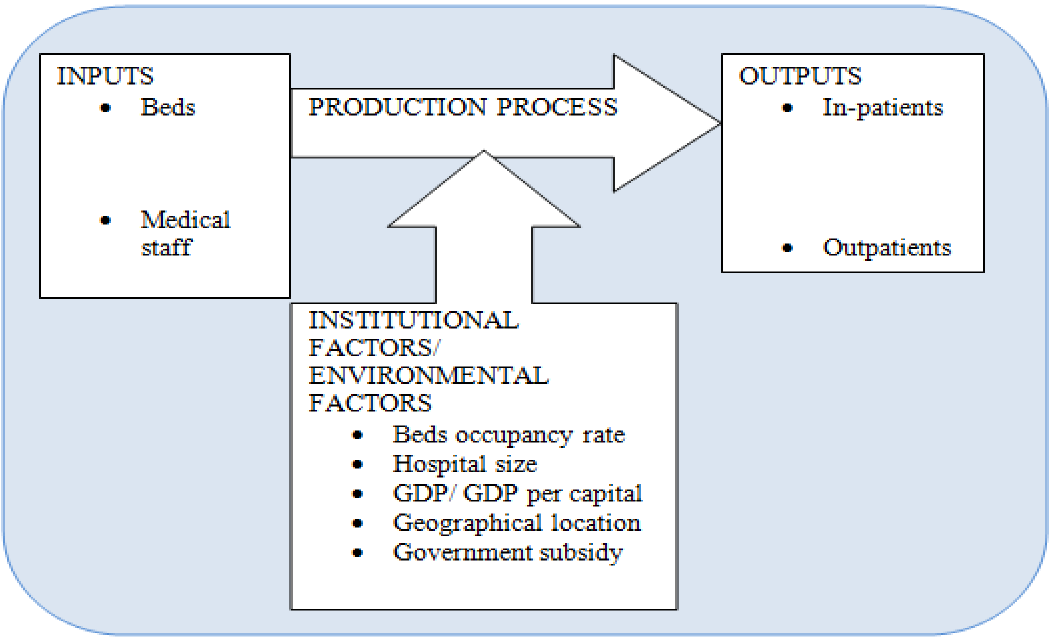


Figure 2.1: Hospitals production process

Source: researcher’s own construction (2018)

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology and describes how the study was conducted. The chapter shows Research design, study area, units of analysis, variables and their measurements, estimated models, types and sources of data and, data collection methods that were used in the research study.

3.2 Research Design

The objective of the study is to measure efficiency of public hospitals, so this study is a non-experimental research adopting a panel design as it allows cross sectional study. The study is a Quantitative research and quantitative data collected for each selected hospital. However no analysis done in selecting hospitals, hospitals selection based on data availability and the homogeneous of the inputs and outputs variables. The study ended up using regional referral hospitals and district hospitals in Tanzania mainland. The results of the analysis of the quantitative data were used to make generalization for the entire public health sector in Tanzania.

The SFA and DEA were used to estimate efficiency since they are the appropriate methods for estimating efficiency of public hospitals.

3.3 Study Area

The study was conducted in Tanzania mainland. Hence the data obtained are from public hospitals both district and regional referral hospitals available in Tanzania mainland.

3.4 Study Population and Unit of Analysis

The study population for this study was all public hospitals in Tanzania mainland, where district hospitals and regional referral hospital were used as representative of all public hospitals. The unit of analysis was each public owned hospital, either district or regional referral hospitals.

3.5 Estimation of Research Models

The intention of the study is to measure efficiency by using both parametric and non-parametric approaches, which are SFA and DEA. The following are the estimated SFA and DEA's models used in the study.

3.5.1 Stochastic Frontier Model

A production function of any producer firm can be briefly stated as:

$$y_i = f(x_i, \beta), \qquad (3.1)$$

But since production of a firm can be affected by the degree of efficiency, and it can result to less production as it was supposed to produce.

$$y_i = f(x_i, \beta)\varepsilon_i, \qquad (3.2)$$

where ε_i stands for the level of efficiency in a firm, and it ranges between 0 and 1. If the value of ε_i is equal to 1, a firm could attain the optimal output given the technology used in the production. If $\varepsilon_i \leq 1$, the firm has not used the most of the x_i input. With the assumption that output is positive $y > 0$, the degree of technical efficiency is also positive $\varepsilon_i > 0$.

Output is said to be subjected to random shocks as can be affected by various factor out of the firm control hence

$$y_i = f(x_i, \beta)\varepsilon_i \exp(v_i), \qquad (3.3)$$

Applying the natural logarithm on both sides results to

$$\ln y_i = \ln[f(x_i, \beta)] + \ln \varepsilon_i + v_i, \qquad (3.4)$$

Since public hospitals as provider of health services is a firm with multiple inputs, its production function is summarized in natural logarithms as follows

$$\ln y_i = \ln \beta_0 + \sum_{j=1}^{k} \beta_j \ln(x_{ji}) + v_i - u_i, \tag{3.5}$$

y_i is the public hospital service output (inpatients, outpatients treated), x_{ji} is a vector of quantities of j inputs used by the i^{th} hospital (number of beds, number of medical staff i.e. medical doctors, nurses, clinical officers, medical attendant), β_0 and β_j are unknown parameters to be estimated, $u_i = -\ln \varepsilon_i$ is a non-negative one sided error term associated with the technical inefficiency, and v_i is a random shocks, that can capture variation in hospital output due to factors outside its control.

3.5.2 Data Envelopment Analysis Model

DEA involves input oriented model and output oriented model, this study adopted input oriented model as public hospital have control over inputs used in production process than the output obtained. Moreover inputs orientation score signify the maximum allowed radial reduction of its inputs that is still capable of producing the same level of output. The study also adopted the variable return to scale assumption under the input orientation since variable return to scale is considered suitable in measuring hospital efficiency since public hospitals differ by size, differ in total number of beds, etc.

Therefore from the variable returns to scale, the linear programming problem is stated as:

Mininimize θ

Subject to

$$-y_{jm} + \sum_{j=1}^{M} y_{jm} \lambda_j \geq 0, m = 1,2. \tag{3.6}$$

$$\theta x_{jk} - \sum_{j=1}^{m} x_{jk} \lambda_j \geq 0, k = 1.$$

$$\sum_{j=1}^{M} y_j = 1$$

$\lambda_j > 0$, j= 1, 2.....,M

3.5.3 Tobit Regression Analysis

Tobit regression (censored normal regression) estimates a linear relationship in case of censoring in dependent variable. Tobit regression is appropriate measure of determining factors that influence efficiency. If efficiently operating hospitals have some common characteristics, it is possible to identify the causes of inefficiency.

This analysis referred as the second stage of analysis where the efficiency score from DEA were treated as dependent variable and inputs used were treated as explanatory variables on the score so as to know its influence on the efficiency of hospitals. VRSTE and CRSTE were used as dependant variable, and were right censored at 1 (i.e upper limit of 1 or 100%), considering that DEA score take on values between 0 and 1. The Tobit regression analysis was done using STATA version 13.1, and the following Tobit model was used

$$TOBIT_{CRSTE} = \beta_0 + \beta_1 Beds + \beta_2 Medicaldoctors + \beta_3 Nurse + \beta_4 Medicalattendant + \beta_5 clinicalofficer + ...\varepsilon_j \quad (3.7)$$

$$TOBITvrste = \beta_0 + \beta_1 Beds + \beta_2 Medicaldoctors + \beta_3 Nurse + \beta_4 Medicalattendant + \beta_5 clinicalofficer + ...\varepsilon_j \quad (3.8)$$

CRSTE is the Constant Return to Scale efficiency score

VRSTE is Variable Return to Scale efficiency score

β Is the coefficient whose values cannot be interpreted but the signs are helpful for this study

ε_j Are the disturbance term

3.6 Definition and measurement of variables

Table 3.1: Variables of the study

Inputs Variable	**Description**
Beds	Includes number of beds available in each health facility
Medical staff	Include number of medical doctors, Nurses, clinical officers, and medical attendant
Output Variable	**Description**
Inpatients	Involves number of inpatients or admission recorded by the facility in 2016
Outpatients	Includes total number of outpatient visited the facility in 2016

Source: researcher's own source, (2018)

3.7 Sampling Procedure

In Tanzania there are about 6230 health facilities that are under public ownership, in hierarchical form comprising of national hospital, zonal super specialist hospitals, operating referral hospitals, national super specialist hospitals, regional referral hospitals, designated and operating district hospitals, dispensaries and health centers, (hrfportal, 2018). This study involved all regional referral hospitals and districts hospitals for the year 2016, as it was possible to access data that meets variables suggested. Moreover these hospitals can easily be accessed by the majority of the population and they offer service to majority. Secondary data for each hospital was obtained for the year 2016. The study obtained data for 19 regional referral hospitals, and 119 districts hospitals. Choice of these hospitals is because they provide service to majority of population and they are the biggest consumer of health sector resources. Furthermore considering inputs and outputs that were selected for the study, these hospitals were appropriate. Therefore estimation of efficiency for these hospitals can be generalized for all public hospitals in Tanzania mainland. The choice of the year 2016 was because in this year was possible to obtain all variables that were required to perform analysis compared to other years were there were problem of obtaining data.

3.8 Data Collection

The secondary data were collected from the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), under the Policy and

Planning Department, and Health Management Information System. Source of the data were from the District health Information system (DHIS2) which provided data on various services offered by each hospital available in each district, and the reports on public health facilities. The quantitative data were obtained for both inputs and output variables for the year 2016.

3.9 Data analysis method

Data on inputs variable (beds, number of doctors, nurses, clinical officer, medical attendant) and output variable (inpatient and outpatient) were entered on the Microsoft excel spreadsheet. The data cleaning was done before carrying analysis, hospitals with incomplete data for all variables were omitted, and those with missing values were excluded and remained with hospitals that had data on each variable for the year 2016.

The analysis was done in accordance with the objectives of the study. First objective of the study was done using SFA and DEA approaches for both Regional referral and district hospitals. Second objective was done using DEA approach to estimate scale efficiency of regional referral hospitals and district hospitals. Third objective of determining factors influencing efficiency was done by using Tobit regression analysis. The analysis was conducted for regional referral hospitals and district hospitals, hence the estimates of scale and technical efficiency was done for both Regional referral hospitals and district hospitals.

3.10 Validity and Reliability

Validity is the quality that an instrument used in a research is accurate, correct, meaningful and right. Reliability is the measure of degree or extent to which a researcher instruments yield consistence results of the data after several trials. The two components are important in any research if the research objectives and conclusion regarding the findings are right or wrong.

To guarantee on the validity and reliability the researcher tested for heteroskedasticity, whereby there are variations in error term in each observation. Furthermore stochastic Frontier model was tested to ensure validity Cobb Douglas over translog, also minimized random errors by using statistical means so as to ensure consistence of the results.

CHAPTER FOUR
PRESENTATION OF THE FINDINGS

4.1 Introduction

This chapter is concerned with the presentation of the finding and results of the analysis done including results from Data envelopment analysis, Stochastic Frontier Approach and Tobit Regression analysis conducted for regional referral hospitals and district hospitals. The analysis of the data is presented in several sections starting with the descriptive statistics of the variables from district hospitals and regional referral hospitals followed by the results on the analysis of DEA, the result on the analysis of SFA, and the result of Tobit regression. The analyses were conducted in accordance with the objectives.

4.2 Descriptive Analysis

The researcher used STATA to conduct descriptive analysis. The analysis was done on the variables used in the study for both Regional referral hospital and District hospitals. Table 4.1 shows the descriptive statistics of variables used in the regression analysis of district hospital.

Table 4.1 Descriptive statistics - District hospitals

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Outpatients	45760	94517.97	583	834639
Inpatients	5504	3331.268	591	13492
Beds	325	235.8118	63	1578
Medical doctors	33	105.2745	3	865
Nurse	67	54.22958	1	404
Clinical officers	19	60.63245	2	518
Medical attendant	146	93.65669	23	634

Source: Researcher’s own computation, (2018)

Table 4.2: Descriptive statistics – Regional referral hospitals table 4.2 shows the descriptive statistics of the variables used in the regression analysis of regional referral hospitals

Variable	Mean	Std. Dev.	Min	Max
Outpatients	71507	78184.35	1300	284041
Inpatients	12703	9568.208	820	34346
Beds	517	403.2911	178	1952
Medical doctors	111	325.4025	6	1329
Nurse	135	98.43693	35	428
Clinical officer	59	179.4478	2	731
Medical attendant	185	112.3601	53	482

Source: Researcher's own computation, (2018)

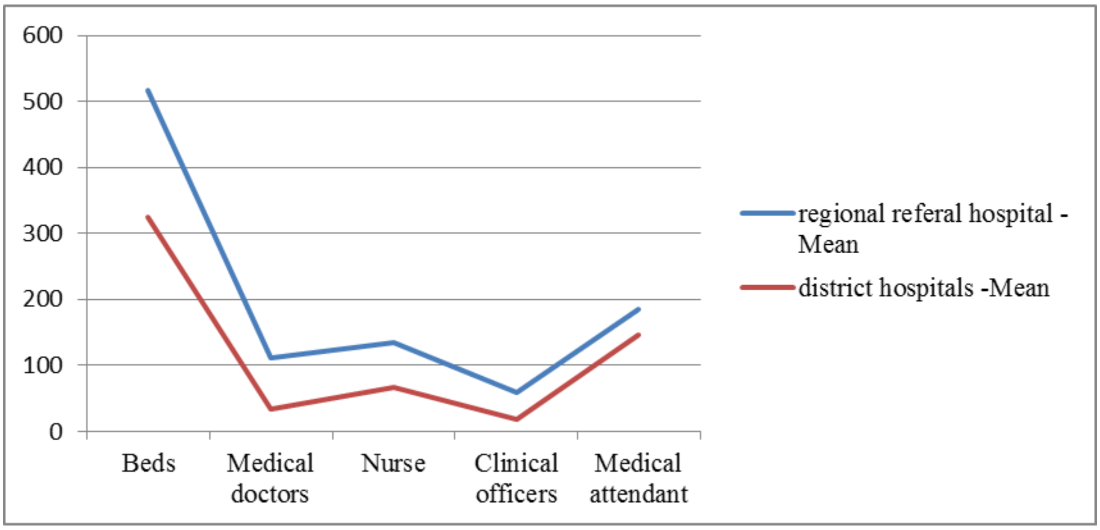
The descriptive statistics of Regional referral hospitals show that for the year 2016 district hospitals provided health services to a large number of people compared to the Regional referral hospitals, since the minimum inpatients and outpatients for regional referral hospitals was 1300 and 820 respectively while for district hospitals was 583 and 591 respectively. Also the maximum inpatient and outpatient for district hospitals was 834,639 and 13492 respectively, while the maximum inpatient and outpatient was 284,041 and 34,346 respectively. In average outpatients for regional referral hospitals was 71507and 45760 for district hospitals, while for the inpatients the average of inpatients was 5504 for district hospitals and 12703 for regional referral hospitals.

This implies that District hospitals are the ones which serves majority of the citizens, this can be a result of the hierarchical structure of the health system as patients are mostly required before going to the regional referral hospitals level to at least pass on the district hospital levels and be referred to the regional hospitals.

Meanwhile the inputs variables of the regional referral hospitals are higher than the inputs variables of the district hospitals. The maximum number of beds in Regional referral hospitals is 1952 which is higher than the maximum number of beds in District hospitals where the maximum number of beds is 1578. Maximum number of medical doctors for Regional referral hospitals is 1329 while for District hospitals is

865. See figure 4.1 showing the average of the inputs variables for both Regional referral hospital and district hospitals. This portrays that regional referral hospitals are provided with high labour and capital in their production process compared to district hospitals. However it can be because of the nature of Regional referral hospitals. Regional referral hospitals are of high rank compared to district hospitals and they are expected to cover what was not possible to be done in the district hospitals. It can as well be because regional hospitals are fewer compared to the district hospitals.

Figure 4.1: Average of the inputs variables



Source: Researcher’s own computation, (2018)

4.3 Technical Efficiency Estimation from Data Envelopment Analysis

4.3.1 Technical efficiency of district hospitals

The variable return to scale assumption with input oriented model in DEAP v2. Employed to obtained efficiency results. The results from DEAP with the summary of variable return to scale technical efficiency, constant return to scale technical efficiency, scale efficiency, return to scales and their mean is attached on the Appendix 3 since the results from DEAP on the district hospital exceeded one page, for more explanation and neatness of the work, summary of efficiency for the district hospitals was tabulated using STATA as depicted in Table 4.3.

From table 4.3 on the results summary of technical efficiency, it is shown that out of 114 district hospitals, 35 (30.7%) of the district hospitals had technical efficiency or efficiency score of 1 and deemed as efficient hospitals. Out of the 35 efficient district hospitals, 23 efficient district hospitals were both CRSTE and VRSTE since they had efficiency score 1 in constant return to scale efficiency and in variable return to scale efficiency, and the remained 12 hospitals were only variable return to scale efficient. Furthermore it is revealed that minimum or the lowest score of Variable return to scale technical efficiency was 0.169 with the highest efficiency score of 1, and the mean variable return to scale technical efficiency was 0.703.

Table 4.3: Summary of Technical Efficiency

variable return to scale technical efficiency score	**Frequency**	**Percentage**	**Cumulative percentage**
0.0-0.50	32	28.07	28.07
0.51-0.70	28	24.56	52.63
0.71-0.99	19	16.67	69.3
1	35	30.7	100
Total	114	100	

Source: Researcher’s own computation, (2018)

Out of 114 district hospitals, it was revealed that 79 (69.3%) of the hospitals were technically inefficient as depict on Table 4.4. Within the 79 inefficient hospitals, 32 (40.51%) hospitals had efficiency score of less than 0.5, 28 (35.44%) hospitals had efficiency score of between 0.51 -070, and the remained 19 (24.05%) inefficient hospital fell under the efficiency score of between (0.71 – 0.99).

Table 4.4: summary of technical inefficient district hospital

TE score	**Frequency.**	**Percentage**	**Cumulative percentage**
0.0-0.50	32	40.51	40.51
0.51-0.70	28	35.44	75.95
0.71-0.99	19	24.05	100
Total	79	100	

Source: researcher’s own computation, (2018)

4.3.2 Technical efficiency estimation of Regional referral hospitals

Due to the problem of data limitations only 19 regional referral hospitals' data were obtained, and after data cleaning the study remained with only 16 regional hospitals. Table 4.5 shows the summary of efficiency estimated by DEAP programme v2.1 with the assumption of variable return to scale and input oriented, including variable return to scale technical efficiency, constant return to scale technical efficiency, scale efficiency and return to scale.

The average score of technical efficiency of Regional referral hospitals was 0.907. The findings further show that 10 (62.5%) regional referral hospitals had efficiency score of 1 and revealed as variable return to scale efficient (VRS-TE). Within 10 efficient regional referral hospitals 7 hospitals were both Constant Return to Scale Efficient (CRS-TE) and Variable Return to Scale Technical Efficient as they had efficiency score of 1 in both sides.

The remained 6 (37.5%) hospitals were termed as technical inefficient as they had efficiency score of less than 1. Within 6 inefficient regional referral hospitals 3 (50%) had efficiency score of between (0.51-0.70) and the remained 3 (50%) hospital had efficiency score of between 0.71- 0.99. The average technical efficiency of regional referral hospital for the year 2016 was 90.7%, meaning that regional referral hospitals would averagely be expected to reduce their use of inputs by 9.3%. Although the actual input to be used or reduced depend on the marginal value of each input provided in the input slacks.

Table 4.5: Results from DEAP efficiency summary- REGIONAL HOSPITALS

Hospital	Efficiency scores			Returns to scale type
	CRS TE	VRS TE	SE	
1	1	1	1	CRS
2	0.732	0.937	0.781	IRS
3	1	1	1	CRS
4	0.648	0.838	0.774	IRS
5	0.428	0.676	0.633	IRS
6	0.267	1	0.267	IRS
7	1	1	1	CRS
8	0.699	0.815	0.858	IRS
9	0.189	0.675	0.28	IRS
10	0.882	1	0.882	IRS
11	1	1	1	CRS
12	1	1	1	CRS
13	1	1	1	CRS
14	0.576	1	0.576	IRS
15	1	1	1	CRS
16	0.3	0.568	0.527	IRS
Mean	0.733	0.907	0.786	

Source: Researcher's own computation, (2018)

4.4 Technical Efficiency estimation from Stochastic Frontier Analysis

The analysis was done using STATA version 13.1. Before proceeding with the regression analysis, first step was to test for the suitable frontier model that will be used in the estimation of efficiency. The functional form tested were Cobb Douglas function and Translog function, the likelihood test of functional form for both outpatients and inpatients as outputs was done and then efficiency was estimated using appropriate frontier model. Three inputs used were beds, medclinoff, and nursemedatt. Medclinoff combines medical doctors and clinical officers, and Nursemedatt combines nurses and medical attendant, this combination was done to enable analysis of technical efficiency considering the frontier model to be used.

Cobb Douglas Function

From the general Cobb Douglas, the following equation 4.1 was tailored for the purpose of this study

$$\ln Q = \alpha_0 + \alpha_1 \ln(beds) + \alpha_2 \ln(medcloff) + \alpha_3 \ln(nursemedatt) \quad (4.1)$$

Where, α_0 is an intercept of the constant term, and α1, α2, α3, are the coefficient parameters estimated and Q represents outputs which are inpatient and outpatient

Translog Function

A Translog function is the generalization of Cobb Douglas function and it is a flexible form providing second order approximation. Translog function gives first order derivatives, second order derivatives and cross second order derivatives. Equation 4.2 was tailored from the Translog function for the purpose of the current study.

Where, Q represents output (inpatient, outpatient), β_0 represent constant term, β1, β2, β3 are the first order derivatives, β4, β5, β6 are the second derivatives and β7, β8 and β9 are cross second order derivatives.

$$\ln Q = \beta_0 + \beta_1 \ln beds + \beta_2 \ln medclinoff + \beta_3 \ln nursemedatt + \beta_4 \ln^2 beds + \beta_5 \ln^2 medclinoff + \beta_6 \ln^2 nursemedatt + \beta_7 \ln beds \ln medclinoff + \beta_8 \ln beds \ln nursemedatt + \beta_9 \ln medclinoff \ln nursemedatt \quad (4.2)$$

Hypothesis test was done to be sure on validity of Cobb Douglas function over Translog function. Since Cobb Douglas function is nested in Trans log function, rejection of null hypothesis

$$H_0 : \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0,$$

Necessitate the use of Translog function, and acceptance of the null hypothesis which reject alternative hypothesis

$$H_1 : \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq \beta_9 \neq 0$$

Support the use of Cobb Douglas function.

After the test, null hypothesis was accepted and that Cobb Douglas is appropriate. As shown in Table 4.6 likelihood ratios is not significant for both outpatient and inpatient, then Cobb-Douglas should be used and not trans-log productions function. Therefore Cobb Douglas function is used in the estimation of frontier model and later obtain technical efficiency.

Table 4.6: shows the regression of the frontiers for both inpatients and outpatients.

Model	Obs	ll(null)	ll(model)	Df	AIC	BIC
Likelihood-ratio	Test			LR chi2(6)	=	2.9
(Assumption: cdo	Nested	In	tlo)	Prob > chi2	=	0.8216
Cdo	128	.	-180.727	6	373.4535	390.5657
Tlo	128	.	-179.278	12	382.5561	416.7804
Likelihood-ratio	Test			LR chi2(6)	=	8.88
(Assumption: cdi	Nested	In	tli)	Prob > chi2	=	0.1806
Model	Obs	ll(null)	ll(model)	Df	AIC	BIC
Cdi	128	.	-143.803	6	299.6061	316.7182
Tli	128	.	-139.364	12	302.728	336.9524

Assumption: Cobb-Douglas nested in Translog production function

Source: Researcher's own computation, (2018)

Results of Analysis of efficiency

The regression was done including all regional referral hospitals and all district hospitals, where dummy variable for Regional referral hospital was generated so as to obtain technical efficiency results of Regional referral hospital. Also the analysis considered inpatient and outpatient variables as two different outputs in the frontier model respectively.

From table 4.7, the findings revealed that in the outpatient variable as component of output, number of medclinoff (Medical doctors and clinical officers) and nursemedatt (nurses and medical attendant) was statistically significant by 1% with coefficient of 0.533 and 0.287 respectively. Where medclinoff had a positive coefficient meaning that it has positive relation to the production of output. While nursemedatt had a negative coefficient, which means it has negative relation to the production of output. This finding implies medclinoff and nursemedatt are important variable in the production process of hospitals considering outpatient as an output. Increase unit of medclinoff result to increase the production process of outpatient by 0.533, and increase in one unit of nursemedatt result to decrease in production process of outpatient by 0.287. Nevertheless beds were statistically insignificant in outpatient's component, meaning that beds are not important variables in the production process of outpatients.

Using inpatients as output (dependent) variable, the study revealed that beds were significant at 1% in inpatient variable with positive coefficient of 0.346, implying that increase in 1% of number of beds will result in 0.346 (34.6%) increase in the production of hospitals measured by number of inpatients. Medclinoff and nursemedatt were both revealed to be statistical insignificant considering inpatient as output variable. However inclusion of number beds in inpatients as component of output reduces the importance of other variables in the production process, also inclusion of number of beds with medical staffs in outpatients output reduces the importance of beds in the production process. With these findings, all inputs variables are crucial in production process of the hospital as hospitals have multiple outputs involving both inpatients and outpatients.

With regards to variance parameters, it was revealed that variance of technical inefficiency sigma_u is 0.821 and 0.606 for outpatients and inpatients respectively. The variance of random error sigma_v was revealed to be 0.653 and 0.5 for outpatients and inpatients respectively. The result for lambda is obtained from dividing sigma_u and sigma_v, which is 1.258 and 1.212 for outpatients and inpatients respectively. As sigma_u is greater than 0 and exceed the value of sigma_v depict presence of technical inefficiency.

Table 4.7: SFA for both outpatient and inpatient

Variables	(1) Outpatient	(2) Inpatient
Lnbeds	0.0236	0.346***
	(0.140)	(0.113)
Lnmedclinoff	0.533***	-0.0353
	(0.104)	(0.0939)
Lnnursemedatt	-0.287***	0.134
	(0.108)	(0.0844)
lnsig2v	-0.853***	-1.387***
	(0.245)	(0.304)
lnsig2u	-0.394	-1.002***
	(0.317)	(0.380)
sigma_v	0.653	0.500
	(0.080)	(0.076)
sigma_u	0.821	0.606
	(0.130)	(0.115)
sigma2	1.101	0.617
	(0.188)	(0.108)
Lambda	1.258	1.212
	(0.182)	(0.174)
Constant	10.55***	6.559***
	(0.925)	(0.733)
Observations	128	128

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's own computation, (2018)

Table 4.8 shows the results of technical efficiency for the outpatients and the inpatients respectively. Using outpatients as dependent variable or output component, the average technical efficiency for Regional referral hospitals is 58% (0.58) and for district hospitals is 55% (0.55). With regards to inpatients, the average technical efficiency is 69% for Regional referral hospital and 61% for district hospital respectively. Results showed that for the regional referral hospitals only 1 hospital considering inpatient variable as output was full efficient hospital and only 2 hospitals considering outpatient as output variable were full efficient hospitals. Taking into consideration of outpatients as output component, 33.3% of regional hospitals obtained efficiency of between 0.71 and 0.99, 38.9% obtained efficiency of between 0.51 to 0.70 and 16.8% obtained efficiency score of less than 0.50.

Considering inpatient as output component 55.6% of the regional referral hospitals obtained efficiency score between 0.71 and 0.99, 27.8% obtained efficiency score of between 0.51 to 0.70 and 11.1% obtained efficiency score of less than 0.50.

Table 4.8: Technical efficiency estimates

	Variable	Mean	Std. Dev.	Min	Max
Combined	TEo	0.55	0.19	0.00	0.86
	TEi	0.62	0.19	0.10	0.88
Regional	TEo	0.58	0.23	0.05	0.83
	TEi	0.69	0.20	0.12	0.88
District	TEo	0.55	0.19	0.00	0.86
	TEi	0.61	0.18	0.10	0.83

Source: Researcher's own computation, (2018)

TEo = Technical Efficiency Outpatients TEi= Technical Efficiency inpatients

4.5 Scale Efficiency Estimation

The scale efficiency for district and regional referral hospitals was estimated using DEAP version 2.1. Results of scale efficiency for district hospitals are too long and exceed one page hence attached on the appendix 3 and here there are only tabulated summary which are attached. DEA results on scale efficiency for Regional hospitals are presented in Table 4.9 since the result are short and does not exceed one page.

4.5.1 Scale efficiency of district hospitals

24 (21.05%) district hospitals had efficiency score of 1, which show scale efficiency of 100%, hence out of 114 district hospital for the year 2016 only 24 district hospitals were scale efficient having the Most Productive scale size for the kind of input- output mix.

Table 4.9: summary of scale efficiency

Scale efficiency score	Frequency	Percent	Cumulative percentage
0.0-0.50	25	21.93	21.93
0.51-0.70	24	21.05	42.98
0.71-0.99	41	35.96	78.95
1	24	21.05	100
Total	114	100	

Source: Researcher's own computation, (2018) The remained 90 (78.95%) district hospitals were scale inefficient, out of 90 inefficient district hospitals 25 hospitals had a scale efficiency of less than 0.5, 24 hospitals had a scale efficiency of between 0.51 – 0.70, and the remained 41 hospitals had efficiency score of between 0.71-0.99. Within 90 inefficient district hospitals, 79 (87.8%) hospitals discovered to have Increasing Return to Scale (IRS) and 11(12.2%) hospitals had Decreasing Return to Scale (DRS). This finding shows that 87.8% of the inefficient district hospitals in Tanzania for the year 2016 were too small for their operation, and were needed to expand their scale of operation. While the 12.2% of the inefficient district hospitals were needed to scale down their operation in order to attain Constant Return to Scale (CRS).

4.5.2 Scale efficiency of Regional referral hospitals

As shown on Table 4.10, the average scale efficiency was 0.786 for Regional referral hospitals. Where out of 16 studied regional referral hospitals, 7 (43.75%) hospitals attained 100% efficiency as they obtained scale efficiency score of 1 and deemed as scale efficient regional referral hospitals for the year 2016. These 7 regional referral hospitals attained the Most Productive Scale Size (MPSS) and hence they obtained Constant Return to Scale (CRS). The remained 9 (56.25%) hospitals were termed as scale inefficient regional referral hospitals as they obtained efficiency score of less than 1, where 2(22.2%) of the hospitals had efficiency score of less than 0.50, 3(33.3%) of the hospitals had efficiency score of between 0.51-0.70 and 4 (44.4%) hospitals obtained efficiency score of between 0.71 – 0.99. The mean scale efficiency score was depicted as 78.6% for the regional referral hospitals for the year 2016. However, all 9 scale inefficient regional referral hospitals had an Increasing Return to Scale (IRS) , meaning that the inefficient hospitals are too small for their operation to operate at their MPSS thus they need to expand their scale of operation so as for them to attain the CRS.

Table 4.10: Results from DEAP efficiency summary

Hospitals	SE	Return to scale type
1	1	CRS
2	0.781	IRS
3	1	CRS
4	0.774	IRS
5	0.633	IRS
6	0.267	IRS
7	1	CRS
8	0.858	IRS
9	0.28	IRS
10	0.882	IRS
11	1	CRS
12	1	CRS
13	1	CRS
14	0.576	IRS
15	1	CRS
16	0.527	IRS
Mean	0.786	

Source: Researcher's own computation, (2018)

4.6 Adjustment on the inputs and outputs variables

Adjustment available on the inputs and outputs variables is revealed on the results of Data Envelopment Analysis as slacks from the analysis conducted by DEAP in estimation of efficiency. Results on slacks for district hospitals are attached on appendix 4 as the table exceeded one page. Results on slacks for Regional referral hospitals are shown on Table 4.12.

4.6.1 Amounts of inputs available for reallocation and output increase potentials in District hospitals

Appendix 4 shows the summary of slacks on inputs and outputs for the districts hospitals in Tanzania. Slacks show resources underuse or overuse at the hospital, and hence enables suggestion on whether there should be adjustment on inputs or outputs used at the hospital so as to attain efficiency. As per 2016 data, 45 (39.5%) of the sampled district hospitals do not require outputs adjustments as they had 0 unit slacks, 24 hospitals requires adjustment on the outpatients only, 6 hospitals require adjustment on inpatient and 39 hospitals requires adjustment on both inpatients and outpatients as an output given by this hospitals.

4.6.2 Amounts of inputs available for reallocation and output increase potential in Regional Referral hospitals

With the presented slacks as shown in Table 4.11, 10 of the regional referral hospitals do not require any adjustment. Two hospitals which are hospital number 4 and hospital number 2 require adjustment on the outpatient by 16779.768 and by 23087.879 respectively. The other two hospitals marked as hospital number 5 and hospital number 8 requires adjustment on the inpatient by 5482.162 and by 2622.338 respectively. The remained two hospitals require adjustment on hospitals number 10 by 7716.948 for inpatient and 36736.866 for outpatient and on hospital number16 by 2277.168 for inpatient and 5947.747 for outpatient.

Table 4.11: Summary of input and output slacks for Regional Referral hospital

Hospitals	Beds	Medical doctors	Nurse	Clinical officer	Medical attend	Inpatient	Outpatient
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	35	4	23	0.000	16780
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	7	25	0.121	32	0.000	23088
5	0.000	7	25	0.121	0.000	5482	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	31	11	7	30	2622	0.000
9	0.000	8	15	0.000	0.000	7716	36737
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0	4	0.000	0.000	2277	5948
Average	0.000	3	7	1	5	1131	5160

Source: researcher’s own computation, (2018)

4.7 Determinants of Efficiency

The third objective of the study was to determine the factors that influence efficiency in district hospitals. This objective is estimated using Tobit regression which is used in case of a censoring in the dependent variable. Following this assumption, the nature of the dependent variable for this objective (the efficiency scores) is bounded between 0 and 1 which makes Tobit model to be relevancy in this analysis. Therefore, the study used technical efficiency scores from DEA both VRSTE and CRSTE as dependant variable and the scores were right censored at upper bound (upper limit of 1 or 100%).

4.7.1 Determinant of factors that influence efficiency

Table 4.12 shows results from Tobit regression analysis, regression 1 shows results using Constant return to scale technical efficiency and regression 3 shows the result of regression using variable return to scale technical efficiency. Regression 2 included robust in constant return to scale technical efficiency and regression 4 included robust in variable return to scale and solved the problem of heteroscedasticity.

Table 4.12: Tobit regression results for the determinant of efficiency

Variables	Regression 1	with robust Regression 2	Regression 3	with robust Regression 4
Beds	-0.000879***	-0.000879***	-0.000602***	-0.000602***
	(0.000135)	(0.000128)	(0.000176)	(0.000162)
Medical doctors	0.00620***	0.00620***	0.00416**	0.00416***
	(0.00155)	(0.000976)	(0.00189)	(0.00142)
Nurse	0.00260**	0.00260**	0.00173	0.00173
	(0.00103)	(0.00119)	(0.00130)	(0.00133)
Clinical officers	-0.00776***	-0.00776***	-0.00568*	-0.00568**
	(0.00252)	(0.00156)	(0.00313)	(0.00225)
Medical attendant	-0.00346***	-0.00346***	-0.00264***	-0.00264***
	(0.000556)	(0.000519)	(0.000683)	(0.000652)
Constant	1.278***	1.278***	0.972***	0.972***
	(0.0636)	(0.0566)	(0.0796)	(0.0847)
Observations	114	114	114	114

Standard errors in parentheses
*** p<0.01, ** p<0.05, *p<0.1

Source: Researchers own computation, (2018) It is evidently clear that all variables used in the study were depicted to be significantly correlated to efficiency of public hospital, meaning that they are important factors that influence efficiency of public hospitals in either negatively or positively way. Variables with positive coefficient signs depict positive relation to the technical efficiency, and that increase in those variables, increases efficiency of public hospital. Whereas a variable with negative coefficient sign implies negative relation to the technical efficiency of public hospitals, thus increase in these variables of negative coefficient sign results to decrease in technical efficiency of public hospitals.

Beds were statistically significant correlated to the constant return to scale technical efficiency at 1% level, with a negative coefficient of 0.000879 implying that beds is significant determinant of efficiency. This influence constant return to scale technical efficiency negatively, which implies that increase in 1unit of bed, will decrease the efficiency score by 0.00879 units holding other variables constant.
In Variable return to scale technical efficiency, beds were significant correlated to Variable return to scale technical efficiency at 1%. The coefficient was 0.000602 with negative sign suggesting that beds are negative and significantly correlated with efficiency and with variable return to scale respectively. This implies that increase in 1 unit of beds holding other variables constant will result to decrease in variable return to scale technical efficiency by 0.00602 holding other factors constant. Therefore beds are important factor in determining the performance and operation of the hospitals.

Medical doctors were statistically significant at 1% level suggesting that medical doctors are significant determinants of efficiency of public hospitals. The coefficient of doctors is positive 0.00620 in CRSTE and 0.00416 in VRSTE implying that Medical doctors influence efficiency (CRSTE, VRSTE) of public hospitals positively. This means that increase (additional) in one unit of medical doctors will result to increase in unit of efficiency score by 0.00620 and 0.00416 for CRSTE and VRSTE respectively holding other factors constant. This is within expectations that hospitals with sufficient number of medical doctors are likely to provide sufficient and appropriate health service holding other factors constant.

Clinical officers are statistically significant at 1% level meaning that it is important determinant of efficiency in public hospitals. However its coefficient is negative, suggesting a negative effect of clinical officers on efficiency. The findings suggest that clinical officers may results to inefficiency of public hospitals if not well considered. The coefficient of clinical officers is -0.00776 in CRSTE and -0.00568 in VRSTE, implying that holding other factors constant an increase in one unit of clinical officers will result to decrease in efficiency score by 0.00776 and 0.00568 in CRSTE and VRSTE respectively

The coefficient of medical attendance was negative and statistically significant at 1% level with coefficients of 0.00346 and 0.0264 for CRSTE and VRSTE respectively. This suggests that medical attendants can lead to inefficiency of public hospitals since high number of medical attendant will result to decrease in efficiency scores. Holding other variables constant one unit increase in medical attendant will result to 0.00346 and 00264 decreases in efficiency score of CRSTE and VRSTE respectively.

Nurses were found to be positive and statistically significant at 1% level in determining efficiency in public hospitals with a coefficient of 0.0026 for CRSTE and 0.00173 for VRSTE respectively. This finding implies that, nurses are positively correlated to the efficiency scores and that additional number of nurses by one unit would increase the CRSTE and VRSTE scores by 0.0026 and 0.00173 respectively while holding other factors constant. Therefore hospital with high number of nurses which is sufficient and appropriate for the needs are likely to have high level of efficiency.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 Introduction

The major objective of this study was to analyze efficiency of public hospitals. This chapter discusses the findings on the technical efficiency, scale efficiency and determinants of efficiency in public hospitals in Tanzania as presented in chapter four, it also give justifications from other studies which are similar to this study.

5.2 Technical efficiency in public hospitals

Based on the findings of the estimation of efficiency from DEA, the average variable return to scale technical efficiency for districts hospital and Regional referral hospital was 69.3% and 90.7% respectively. This finding implies if run efficiently district hospitals and regional referral hospitals could have produced the same amount of output by saving 30.7% and 9.3% of inputs for district and regional referral hospitals respectively.

The average technical efficiency of Regional referral hospitals was revealed to be 90.7%. The findings are similar to that of Samsudin *et al* (2016) who found that public hospitals in Malaysia have technical efficiency of more than 90%. The study also revealed that the technical efficiency of regional hospitals in Tanzania is less compared to the 95.7% technical efficiency of regional hospitals in Kenya revealed by Irungu (2012)

The study depicted that 62.5% of regional referral hospitals operated efficiently in 2016 and only 37.5% were technical inefficient regional referral hospitals. This finding implies that large numbers of regional referral hospitals were technically efficient in 2016.

Moreover, the study found that the average technical efficient is 69.3 % in district hospitals. This finding is similar to that of Cheng *et al.* (2015) who found that the average technical efficiency of 69% for China using DEA approach. However, the technical efficiency of 69.3 for district hospital in Tanzania is less compared to the compared to the technical efficiency of district hospital estimated in Madhya Pradesh using DEA and revealed to be 90% (Jat and Sebastian, 2013). Also out of the studied district hospitals, 69.3% of the hospitals were revealed to be inefficient. Implying that there is high level of inefficiency in district hospitals and few district hospitals 30.7% were operating efficiently.

Therefore it is clearly shown that using DEA in estimation of technical efficiency, Regional referral hospitals are more efficient compared to District hospitals in Tanzania. Thus considering public hospitals in Tanzania 62.5% Regional referral hospitals and 30.7% district hospitals are efficient. Thus there is inefficient in public hospitals

With regard to the results of technical efficiency estimated by SFA, it is revealed that technical efficiency for Regional referral hospitals is 58% while for district hospitals is 55% when considering outpatient as dependant variable, and 69% and 61% for regional and district hospitals respectively considering inpatient as dependant variable. These results are similar to the result of Hamidi (2016) on estimation efficiency of government in Palestine, where average technical efficiency was 55%. Thus technical efficiency results have revealed that regional referral hospitals are more efficient compared to district hospitals. Moreover the result of SFA revealed that inputs variable such as medical doctors, clinical officers, nurses and medical attendant are important variables in hospital production process of outpatients as an output variable. While beds revealed to be an important factor in the production process of inpatients as an output variable. However these result diverse from the result of Hamid (2016) in Palestine, which revealed that nurses and doctors are the only important variable in the production process of hospital outputs, both inpatients and outpatient.

Finally, it is evidenced that results from DEA are not similar to results from SFA since the results of DEA are higher than the results of SFA. Kiadaliri, Jafari and Gerdtham (2013) found similar results as in this study. They found that there are higher efficiency scores for DEA method compared to efficiency scores obtained through SFA in their study conducted in Greece.

5.3 Scale efficiency in Public hospitals

The average scale efficiency was revealed to be 72.9% for district hospitals, and the average scale efficiency for regional hospitals was 78.6%. Results on the average scale efficiency of both Regional and District hospital is less compared to 93.3% average scale efficiency in Eretria, (Kirigia and Asbu, 2013).

In Regional referral hospitals, 43.8% of the hospitals attained the Most Productive scale Size. This result exceeded the 42% of hospitals in Eretria which had Constant Return to scale and attained MPSS as revealed in the study of Kirigia and Asbu (2013). The remained 56.25% of scale inefficient Regional referral hospital had Increasing Return to Scale.

21.05% of the District hospitals attained the Most Productive Scale Size, termed as scale efficient hospital and the remained 78.95% did not attain MPSS and termed as scale inefficient District hospitals. This result of scale inefficient is higher compared to the result on the study conducted in Ghana where 75% of the District hospital where revealed as scale inefficient hospitals (Appiah et al,. 2015). Out of scale inefficient hospitals 87.8% of District hospitals had Increasing Return to Scale, Meaning that this District hospitals need to expand both inputs and outputs. Remained 12.25% of the Scale inefficient district hospitals had Decreasing Return to Scale.

5.4 Inputs and outputs adjustment to attain efficiency in public hospitals

39.5% of the district hospitals do not require any adjustment and 60.5% of the hospitals required adjustment on either outputs increase or inputs reduction. 62.5% of the regional referral hospitals did not require any adjustment and the remained 37.5% of the regional referral hospital required adjustment on either inputs or outputs. The outputs increase and inputs decrease are necessary for these public hospital to run efficiently. This implies that for the inefficient hospitals both district hospitals and Regional referral hospitals need to adjust their inputs or outputs in order to attain efficiency. However, the adjustments are mostly required in district hospitals and less in regional referral hospitals. In average 37.5% of Regional hospitals need to increase their outputs by 1131.164 in inpatients and by 5159.519 in outpatients. On averagely they were required to decrease their inputs by 3.3 in medical doctors, 7.13 in nurses, 0.64 in clinical officers, 5.3 in medical attendant. As a group, 60.5% of district hospitals were required on average to increase inpatients by 735.75 and outpatients by 15517.11, also district hospitals were needed to decrease their inputs such as beds by 1.61, medical doctors by 2.53, nurses by 5.08, clinical officers by 0.51 and medical attendant by11.12. If this adjustment were to be done, all inefficient hospitals would operate efficiently.

5.5 Factors influencing efficiency of public hospitals

Considering findings from table 4.12, it was revealed that all variables used in this study influences efficiency of public hospitals, where the influence can either be on the increase or decrease of the efficiency levels.

5.5.1 Beds

Number of beds was revealed to have negative relation to technical efficiency, and statistically significant at 1%. With the negative relation an increase in a unit of number of beds holding other variable constant will result to decrease in the level of technical efficiency by 0.000879 if CRSTE and by 0.000602 if VRSTE. This result is similar with the result obtained by Cheng et al (2015) where beds were positively related to technical inefficiency, thus increase in beds increases inefficiency and reduces efficiency.

5.5.2 Medical doctors

Number of medical doctors had a statically significance of 1% with a coefficient of positive sign which mean that medical doctors have positive relation to the technical efficiency of public hospital, hence holding other variables constant an increase in number of doctor results to increase in technical efficiency score. If CRSTE a unit increase in medical doctors will result to increase in efficiency score by 0.00620 and if VRSTE a unit increase in medical doctors result to increase efficiency score by 0.00416. Hence this implies that Doctors are important factor in the hosptal production increase in doctor increases efficiency. This finding is parallel to the findings of Hamidi, (2016) on his study of measuring efficiency of government hospitals.

5.5.3 Nurses

Number of nurses was significant at 5% and its coefficient had positive sign, which shows that number of nurse can influence the efficiency score positively. Ceteris peribus, the higher number of nurses the higher the efficiency score. Thus an increase in a number of Nurses by 1% will result to increase in efficiency score by 0.26% if CRSTE and by 0.173% if VRSTE. This finding is comparable to the findings of Hamidi, (2016) who supported that nurses are important factor in the production of hospitals output and have high influence in efficiency of the hospital.

5.5.4 Clinical officers

Number of clinical officer was significant at 1% and its coefficient had a negative sign, meaning that holding other things constant number of clinical officers is negatively related to the efficiency score. Holding other thing constant increase in 1% of clinical officers will result to decrease by 0.776% if CRSTE and by 0.568% if VRSTE. Besides that, clinical officers have negative relation to efficiency scores they are important factor in hospital production.

5.5.5 Medical Attendant

Number of medical attendant had coefficient with negative sign and it was significant at 1% level. The negative sign show negative relation to the efficiency score. Holding other factors constant 1% increase in medical attendant will result to increase in CRSTE score by 0.346% and increase in VRSTE score by 0.264%. However medical attendant are crucial in hospital production.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Tanzania has made a great step and improvement in provision of health services since independence. Various policies have been formulated and implemented for the aim of attaining efficiency in provision of health service and that every person in every place of Tanzania gets access to health services. All these are proved from the increased health budget, improved access to Primary Health Care, availability of health financing mechanism, and the attained some of Millennium Development Goals. Despite achievements on the Millenium Development Goals, in order to achieve Tanzania vision of 2015, the government and other stakeholders needs to play effective role in achieving Sustainable Development Goals (SDG) of 2030. Thus estimation of efficiency in public hospitals is crucial so as to enable evaluation of the implemented policies in the provision of health service.

The general objective of the study was to determine the level of efficiency in public hospitals in Tanzania. The study estimated efficiency of 16 regional referral hospitals and 114 district hospitals as public hospitals in Tanzania. Data for the study were from the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC). The study determined the level of technical and scale efficiency as an answer to the level of efficiency in public hospitals in Tanzania. Moreover the study revealed adjustment that can be done on the inputs and outputs variable for the inefficient hospital to attain efficiency. In addition the study determined influence of efficiency and inefficiency in public hospitals in Tanzania. Thus the study bridged literature gap of efficiency studies in Tanzania by employing both Parametric and Non parametric approach in estimation of efficiency, also by stating the adjustment that can be done for inefficient hospitals to attain efficiency.

In descriptive analysis the study revealed that district hospitals offers health services to a large number of Tanzanian than Regional referral hospitals. The findings of the study also show that Regional referral hospitals attained high efficiency level compared to District hospitals. Since 62.5% of Regional referral hospitals are operating efficiently and only 30.7% of the District hospitals are efficient. Where the average technical efficiency from DEA were 69.3% and 90.7% for district and Regional referral hospitals, and from SFA average results are 58% for Regional referral hospitals and 55% for district hospitals. In scale efficiency, 78.95% of district hospitals were depicted to be scale inefficient and only 21.05% of district hospitals were scale efficient while for Regional referral hospitals 43.75% were scale efficient and 56.25% of Regional referral hospitals were scale inefficient. Tobit regression results revealed that nurse, medical doctors, clinical officers and medical attendant are important factors in hospital production process, and they have influence on efficiency of public. Beds, clinical officers and medical attendant were revealed to influence efficiency negatively, that their increase in the production process holding other factors constant reduces level of efficiency while nurses and medical doctors influence efficiency positively, that increase in nurses and medical doctors holding other factors constant result to increase in efficiency of public hospitals.

6.2 Conclusion

This study concludes that the efficiency level both technical and scale efficiency attained in public hospitals (Regional referral hospitals and District hospitals) for the year 2016 needed adjustments so as to attain efficiency in all public hospitals. However the study revealed inefficiency both scale and technical efficiency, despite that, regional referral hospitals are efficient compared to District hospitals. Likewise both Regional and District hospitals needs adjustment of resources to attain the Most Productive Scale Size, as seen in presentation of findings in chapter four, this conclusion is based on the first and second objective of the study.

Furthermore the study concludes that some hospitals have high access to resources such as medical staff (Medical doctors, Nurses, Medical attendant, Clinical Officers) other hospitals are in shortage. Also the inputs used in production process of health services are crucial and have got great influence on the efficiency of public hospitals. As presented chapter four this concludes is in accordance with the third objective of the study.

The study also concludes that SFA and DEA give different results for Regional referral hospitals and District hospitals, where the result from DEA are higher compared to the result from SFA. Beside the differences both DEA and SFA shows the efficiency hospitals since Regional referral Hospitals in both methodology attained higher score compared to the District hospitals which were proved to be less efficient compared to Regional referral hospitals.

6.3 Policy Implications

The government of Tanzania especially The Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), Ministry of Finance and Planning and other concerned ministry needs to keep more efforts on reducing inefficiency in public hospitals and improve the level of efficiency in provision of health services consistently. Basing on the findings that there is high level of inefficiency in district hospitals hospital and some regional referral hospitals were inefficient in 2016.

Also there is a need of efficiency estimation to be done regularly in each year to have the clear trend of efficiency both technical and scale efficiency in public hospitals. Since, findings revealed that for scale efficiency 56.25% and 78.95% of regional and referral hospitals respectively were scale inefficient. Regular estimation of efficiency creates easiness in the monitoring and evaluation of the performance of public health facility. Moreover Improving or increasing level of efficiency in public hospitals depict improvement in provision of health service, availability of better health services and attaining operation at Most Productive scale size.

Basing on the findings that public hospitals (Regional and District hospitals) require adjustments on the inputs and outputs, Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), and President's Office- Regional Administration and Local Government needs to reallocate the inputs resources such as medical doctor doctors, nurses, medical attendant, clinical officers and beds. Since study revealed that to attain efficiency some hospitals needs to reduce the inputs allocated as there are excess of inputs which is not equivalent to the output produced hence inefficiency. Hospitals with shortage resources needs to be provided with sufficient resources to attain efficiency, and hospitals with excess needs to be considered in reallocation of the inputs

The government and other concerned ministries or stakeholders needs to take measures on making sure that every public hospital or health facility in Tanzania is provided with sufficient medical doctors and nurses basing on the findings that these inputs are important in hospital production and efficiency in general. If hospital is provided with enough or sufficient number of nurses and doctors are likely to operate efficiently holding other factors constant.

Furthermore, the MoHCDGEC needs to maintain a data base on the outputs, inputs and their prices for each public hospital or health facility. Availability of complete information on the outputs, inputs used and their prices enables computation and easiness the estimation of efficiency and easy monitoring of the public hospitals in Tanzania.

6.4 Recommendations

Based on the findings and conclusion made by the study, the following recommendations have been made by the researcher so as to improve efficiency of public hospitals in Tanzania

The government of Tanzania especially the concerning ministry of the health sector, Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) needs to improve on the allocation of resources especially the medical staff since some hospitals were observed to have fewer (no sufficient) medical staff and results in inefficiency of public hospitals, also provision of poor health services in public hospitals. Hospitals with excess resources need to be considered where the resources can be used in hospitals with shortage of these resources.

District hospitals needs to be highly considered with enough and sufficient resources, improvement on the offered services, and also several monitoring needs to be done in these hospitals as they are the ones serving majority of Tanzania. Thus the researcher recommends them to be given the superiority to cover and offer improved quality health services.

Also, the researcher recommends that estimation of efficiency to be done in every year or regularly, hence be able to monitor performance of these public hospitals. The estimations can be done using both methods of estimating efficiency. Furthermore the researcher recommends that information that are necessary for estimation of efficiency to be readily available in every health facilities to support scholars or other stakeholders perform the estimation of efficiency.

In addition the researcher recommends that emphasis should be made on the use of various systems that are designed to be used in Public health facilities to keep and record information. With the technological changes that keeps on occurring, public hospitals needs to acquire the use of technology in keeping records and running their operations. Much emphasise must be keep on the usage of available health systems such as DHIS 2 etc. This can enable each health facility to have records and information which can be necessary in the evaluation and monitoring of the facility performance.

6.5 Limitations of the Study

Unavailability of time series data on both inputs and output variables is first limitation the researcher faced since the researcher intended to estimate efficiency for 4 years from 2013 to 2016 but ended up estimating efficiency for the year 2016 only. Hence this limitation was solved by choosing a year that had information on both input and output variables.

Unavailability of data on input prices is the second limitation. This limited the researcher on the estimation of cost efficiency and be unable to use SFA on the estimation of allocative efficiency of public hospital. This limitation was solved by estimating technical efficiency using SFA production function without involvement of cost or prices.

Unavailability of some variables in hospitals or incomplete data, this limitation resulted to not have all public hospitals. Thus the researcher used only District hospitals and Regional referral hospitals where those with incomplete information were omitted.

6.6 Area for Further Research

Another research needs to be done involving time series data to estimate efficiency of all public hospitals and measure productivity of these hospitals in Tanzania using both DEA and SFA. Also one can conduct a research estimating cost efficiency, scale efficiency and technical efficiency of public hospitals or private hospitals or faith based hospitals in Tanzania, and comparison can be done between efficiency of public, private and faith based hospitals. Furthermore the qualitative and quantitative research on the factors that influence efficiency in public hospitals in Tanzania can be done.

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APPEN ICES

APPENDIX 1

Data obtained for district hospitals

Hospitals	OPD	IPD	BEDS	MD	NURSE	CLIN OFFCR	MD attend
Karatu Lutheran Designated District Hospital	66,215	3,002	100	11	43	41	145
Nkoaranga Other Hospital	18,162	1,558	150	21	36	20	82
Monduli District Hospital	26,554	3,310	100	9	71	53	171
Wasso Designated District Hospital	17,297	2,862	205	13	105	56	224
Mvumi Mission Designated District Hospital	28,321	7,568	280	3	37	8	127
Kondoa District Hospital	53,640	3,857	216	5	0	6	96
Kongwa District Hospital	39,772	5,180	155	7	37	8	116
Mpwapwa District Hospital	10,816	4,867	260	5	39	12	134
Bukombe District Hospital	47,443	4,895	763	7	35	4	68
Chato District Hospital	14,204	5,404	647	12	38	8	106
ILULA HOSPT	37,303	2,203	100	46	146	28	400
Mafinga Hospital	37,303	7,564	220	5	57	12	150
Biharamulo Hospital	303,571	11,457	200	5	37	10	86
Nyakahanga Hospital - Designated District Hospital	48,152	11,324	181	19	69	6	142
St. Mary's Isingiro Hospital	16,611	3,412	100	11	36	6	90
Kagera Sugar Hospital	11,830	2,571	63	6	67	2	127
Rubya Designated District Hospital	34,015	11,178	536	29	104	10	198
Mpanda Hospital - District Hospital	16,976	10,082	165	6	40	13	45
MAWENI HOSP	34,657	8,202	159	4	80	8	63
Heri Mission Hospital	67,992	1,393	142	12	37	8	95
Kasulu District Hospital	8,787	11,896	188	34	109	20	278
Kibondo Hospital	33,457	7,684	174	5	4	6	30
MAWENZI	21,673	11,496	200	94	404	17	634
HAI HOSPITAL	129,253	7,596	150	28	72	12	175
Kibosho Hospital	59,617	6,348	200	23	73	14	205
USANGI DISTRICT HOSPT	56,859	1,559	100	13	47	12	156
HURUMA HOSPT	15,146	4,817	122	21	71	10	155

SAME DISTRICT HOSPT	49,972	3,144	145	24	74	16	193
KINYONGA DIST HOSPT	23,827	2,710	120	10	70	8	157
Liwale DH Hospital	27,654	1,633	328	8	34	2	110
Nachingwea District Hospital	16,940	7,549	300	26	101	4	175
Ruangwa District Hospital	25,839	5,163	430	11	36	6	87
BABATI TOWN HOSPITAL	32,009	5320	380	28	57	8	98
Dareda Hospital	12,510	4,755	200	3	76	4	58
Tumaini Hospital	24,997	7,167	181	3	36	6	30
Kibaya District Hospital	51760	4358	100	7	35	4	82
Hydom Lutheran Hospital	141,423	12,805	480	22	69	6	141
Orkesumet Lutheran Hospital	6,123	1,503	150	9	4	8	59
Kibara Hospital	8970	2817	450	24	74	16	172
Bunda DDH Hospital	54095	6784	305	6	52	2	65
Butiama Hospital	9525	3714	300	6	34	2	85
Kowak Hospital	12660	5202	388	47	147	30	340
Nyerere DD Hospital	18334	7122	758	7	64	4	43
Tarime Hospital	35978	7053	857	25	75	18	172
Igawilo City District Hospital	34098	1009	837	89	337	14	527
Itete Hospital	48034	2695	409	9	34	2	69
Chunya District Hospital	20680	3210	388	18	68	4	136
Kyela District Hospital	43819	7208	200	18	67	2	133
Chimala Mission Hospital	29860	5456	200	23	73	12	167
Tukuyu Hospital	64952	9302	104	20	70	8	149
Mazimbu Hospital	20149	855	321	33	32	10	147
Illovo Hospital - Other Hospital	583	1306	297	21	71	14	172
Kilosa Hospital	19170	10328	246	32	107	6	234
Lugala Hospital	23235	2622	289	5	36	2	103
Mahenge Hospital	24576	3484	267	19	69	6	140
Ndanda Hospital	42232	8078	473	20	70	8	161
Mkomaindo Hospital	68516	11984	654	7	4	6	0
Newala District Hospital	61963	7478	271	12	37	8	101
Tandahimba District Hospital	49942	8208	129	11	36	6	93

Mwanza Military Hospital	2556	606	346	17	42	6	126
Ngudu District Hospital	6061	1842	239	12	71	18	166
Magu District Hospital	17283	9843	298	14	42	9	126
BUKUMBI HOSPT	18729	2838	176	15	34	6	130
Misungwi District Hospital	4516	4503	182	22	78	9	166
Sengerema D.D Hospital	127394	13492	493	17	42	10	163
Nansio District Hospital	4420	9100	163	11	36	6	95
MAKAMBAKO	37810	3300	182	5	76	12	0
Lugarawa Other Hospital	11215	3243	390	46	171	10	320
Ikonda Hospital	14519	7572	582	29	104	6	193
Njombe District Hospital	26430	4613	299	31	117	15	267
Ilembula Lutheran Hospital	35254	6823	819	13	36	6	99
TUMBI	142360	10628	628	34	83	13	194
Bagamoyo District Hospital	47683	7741	325	22	38	12	144
Kisarawe District Hospital	28515	2920	271	29	36	10	89
Mafia District Hospital	25006	4002	120	6	33	6	61
Mkuranga Hospital	38754	7813	467	24	38	6	109
Utete District Hospital	15312	1585	75	22	72	6	180
Namanyere DD Hospital	38534	3881	182	15	40	14	128
Ruanda Hospital	5143	965	400	32	107	16	241
Mbinga Town Council Hospital District Hospital	17258	7063	680	3	39	10	0
LITUHI HOSPT	3871	1322	290	19	69	6	130
Kiuma Hospital	23758	2642	345	45	145	26	329
Kolandonto Hospital	28961	4375	499	0	4	4	0
Kahama District Hospital	107948	6381	300	15	12	6	0
Mwadui Williamson Hospital	8087	7352	488	12	37	2	122
Bariadi District Hospital	59647	10192	380	12	37	8	109
Mkula Hospital	11240	4363	300	4	1	2	32
Maswa District Hospital	21837	11045	245	11	36	6	101
Makiungu Hospital	52348	7280	340	19	69	6	137
St. Gaspar Hospital	48798	6609	330	1	8	2	0
Kilimatinde Hospital	9469	2905	400	27	102	6	197

Iambi ELCT Hospital	10684	2382	200	12	37	8	97
st Carolus Designated District Hospital	24929	4093	190	10	35	4	84
Mwambani Hospital	11377	5801	300	2	78	4	0
Isoko Hospital	8602	2512	250	8	38	6	0
Mbozi Mission Hospital	33138	3920	400	3	8	2	**0**
Igunga Hospital	21298	7654	205	21	71	10	169
Nzega Hospital	68938	11152	378	23	73	14	178
Sikonge Designated District Hospital	32993	4958	400	11	36	6	92
Milambo Baracks Hospital	5135	591	390	17	80	6	152
Urambo Hospital	12352	4072	300	9	34	2	72
Bumbuli Mission Designated District Hospital	6844	2674	540	11	36	6	79
St. Francis Kwamkono Other Hospital	26792	3004	200	19	52	6	144
Handeni District Hospital	25147	13119	300	0	69	6	0
Kilindi CDH Hospital	13217	3936	420	12	37	8	98
Korogwe District Hospital	14266	5582	250	29	104	10	228
Lushoto District Hospital	34996	3957	400	13	38	10	110
VIJIBWENI HOSPITAL	46786	1701	500	69	14	0	0
MWANANYAMALA HOSPITAL	834639	1811	1219	865	79	518	24
TEMEKE HOSPITAL	339577	12949	1578	618	90	323	23

APPENDIX 2

Data obtained for Regional Refferal hospitals

	OPD	IPD	BEDS	BED OCCUPANCY	MEDICAL DOCTOR	CLINICAL OFFICER	MEDICAL ATTENDANT
Mt. Meru Regional Referral Hospital	123,608	15,205	318	61069	83	32	345
DODOMA REGIONAL HOSPITAL	284,041	34,346	400	73,467	76	30	482
Geita Regional Referral Hospital	49,887	12,614	256	25,649	37	18	250
IRINGA REGIONAL HOSPITAL	47,443	5991	377	28934	35	20	188
BUKOBA REGIONAL REFFERAL HOSPT	16,820	12,805	308	55,267	12	12	144
SOKOINE REFFERAL HOSPITAL	20,787	5,798	450	7,903	17	2	120
Nyangao Referral Hospital	31,290	8,322	178	7,463	14	12	118
Manyara Regional HOSPITAL	11,932	820	490	2471	28	24	73
MUSOMA REGIONAL HOSPITAL	4878	4964	500	83674	25	10	148
Morogoro Regional Referral Hospital	169544	26618	546	638	38	26	307
LIGULA REFFERAL HOSPT	0	5637	609	73822	22	8	133
BUGANDO REFFERAL HOSPT	0	0	984	5271	119	30	709
Sumbawanga Reginal Hospital	24849	6927	727	2462	23	6	194
ST,JOSEPH Referral Hospital	46884	14885	400	7190	6	4	93

Ruvuma Regional Hospital	1300	27918	465	1029	15	8	145
Shinyanga Regional Regional Referral Hospital	93731	1896	400	3,865	26	8	176
Singida Regional Hospital	49284	10536	500	638	18	2	118
AMANA REGIONAL REFERRAL HOSPITAL	167838	13601	1952	96468	1329	731	53

APPENDIX 3

Result from DEA – District hospitals

Results from DEAP Version 2.1

Input orientated DEA
Scale assumption: VRS

Two-stage DEA method

EFFICIENCY SUMMARY: District hospitals

No	Crste	Vrste	Scale	Sc.Type	No	Crste	Vrste	Scale	Sc.Type
1	0.35	0.481	0.729	Irs	42	0.1	0.226	0.44	Irs
2	0.475	0.487	0.974	Irs	43	1	1	1	Crs
3	0.715	0.726	0.985	Drs	44	1	1	1	Crs
4	1	1	1	Crs	45	0.552	0.72	0.766	Irs
5	0.44	0.483	0.911	Irs	46	0.336	0.425	0.791	Irs
6	0.307	0.737	0.416	Irs	47	0.178	0.221	0.804	Irs
7	0.182	0.45	0.404	Irs	48	1	1	1	Crs
8	1	1	1	Crs	49	0.103	0.527	0.195	Irs
9	0.546	0.946	0.577	Irs	50	0.442	0.918	0.481	Irs
10	0.298	0.369	0.809	Irs	51	0.427	0.96	0.445	Irs
11	0.388	0.479	0.81	Irs	52	0.154	0.287	0.537	Irs
12	0.274	0.503	0.545	Irs	53	1	1	1	Crs
13	0.538	0.934	0.576	Irs	54	0.25	0.435	0.574	Irs
14	0.652	0.677	0.963	Irs	55	0.552	0.961	0.574	Irs
15	1	1	1	Crs	56	0.613	0.691	0.888	Irs
16	0.308	0.747	0.412	Irs	57	0.689	0.691	0.998	Drs
17	0.456	0.592	0.77	Irs	58	0.288	0.528	0.546	Irs
18	0.9	1	0.9	Drs	59	0.815	1	0.815	Irs
19	0.216	0.628	0.343	Irs	60	0.559	0.594	0.94	Irs
20	0.071	0.169	0.422	Irs	61	1	1	1	Crs
21	0.558	0.581	0.961	Irs	62	0.906	0.98	0.925	Irs
22	0.425	0.427	0.995	Irs	63	0.614	0.891	0.69	Drs
23	0.375	0.379	0.99	Irs	64	0.074	0.488	0.151	Irs
24	0.073	0.377	0.193	Irs	65	0.434	0.467	0.929	Irs
25	0.157	0.257	0.612	Irs	66	0.678	1	0.678	Irs
26	0.289	1	0.289	Irs	67	0.043	0.44	0.097	Irs
27	0.755	0.896	0.842	Irs	68	0.355	0.508	0.698	Irs
28	1	1	1	Crs	69	1	1	1	Crs
29	0.678	1	0.678	Irs	70	1	1	1	Crs

30	1	1	1	Crs	71	0.566	0.577	0.98	Irs
31	0.383	0.668	0.572	Irs	72	0.409	0.499	0.82	Irs
no	Crste	vrste	scale	Sc.type	No	Crste	vrste	scale	Sc.type
32	0.658	1	0.658	Drs	73	1	1	1	Crs
33	0.121	0.314	0.386	irs	74	0.376	0.609	0.618	Irs
34	0.725	1	0.725	irs	75	0.657	0.784	0.838	Irs
35	1	1	1	crs	76	1	1	1	Crs
36	0.426	0.473	0.902	irs	77	0.597	0.999	0.598	Irs
37	0.187	0.396	0.472	irs	78	1	1	1	Crs
38	0.261	0.465	0.561	Irs	79	0.049	0.522	0.093	Irs
39	0.799	0.808	0.989	Drs	80	0.64	0.657	0.973	Irs
40	0.319	0.588	0.543	Irs	81	0.316	0.505	0.627	Irs
41	0.214	0.54	0.397	Irs	82	1	1	1	Crs
42	0.1	0.226	0.44	Irs	83	0.471	0.485	0.971	Irs
84	0.598	0.649	0.922	Irs	99	0.52	0.819	0.634	Irs
85	0.116	0.373	0.311	Irs	100	0.29	0.615	0.472	Irs
86	0.227	0.312	0.725	Irs	101	1	1	1	Crs
87	0.159	0.66	0.24	Irs	102	0.478	0.873	0.548	Irs
88	1	1	1	Crs	103	1	1	1	Crs
89	0.527	0.556	0.948	drs	104	0.223	0.24	0.931	Irs
90	0.545	0.559	0.976	drs	105	0.466	1	0.466	Drs
91	0.224	1	0.224	irs	106	0.946	1	0.946	Irs
92	0.041	0.288	0.141	irs	107	1	1	1	Crs
93	0.391	0.505	0.774	Irs	108	0.81	1	0.81	Irs
94	0.514	0.514	1	crs	109	0.468	0.479	0.978	Drs
95	0.236	0.419	0.563	Irs	110	0.588	0.913	0.643	Irs
96	1	1	1	Crs	111	0.303	0.617	0.492	Irs
97	0.782	1	0.782	Drs	112	0.243	0.709	0.343	Irs
98	0.394	0.519	0.758	Irs	113	1	1	1	Crs
99	0.52	0.819	0.634	irs	114	0.196	0.307	0.638	Irs

Mean crste = 0.535, vrste = 0.703, scale = 0.729

Note: crste = technical efficiency from CRS DEA

vrste = technical efficiency from VRS DEA

scale = scale efficiency = crste/vrste

APPENDIX 4

Summary of inputs and outputs – District hospitals

Hospital	BED	MD DCT	NURSE	CLNOFF	MEDATT	IPD	OPD
1	0.0	8.6	6.8	0.0	0.0	400.4	14993.5
2	0.0	3.4	0.0	0.0	13.2	0.0	0.0
3	0.0	0.7	0.0	0.0	8.2	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	32.2	0.0	8.7	0.0	32.8	1542.4	1284.7
6	0.0	4.7	0.0	0.0	30.2	2397.8	26120.5
7	0.0	1.2	0.0	0.0	0.0	2680.2	35235.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	11.7	0.0	54.2	1797.2	31523.4
10	0.0	0.4	0.0	0.0	2.8	0.0	24021.2
11	0.0	2.6	4.7	0.0	0.0	0.0	12808.6
12	0.0	4.9	0.0	0.0	0.0	916.4	1253.8
13	0.0	0.0	37.4	0.0	3.2	0.0	25964.2
14	0.0	8.8	0.0	0.0	6.4	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	3.4	0.0	0.0	1.0	3670.8	0.0
17	0.0	3.1	6.0	0.0	0.0	0.0	28028.5
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	1.5	0.8	0.0	0.0	3171.7	33365.2
20	0.0	10.4	8.5	0.0	0.0	3052.0	0.0
21	0.0	1.3	1.5	0.0	0.0	0.0	24975.5
22	0.0	1.2	0.0	0.0	0.0	0.0	28043.5
23	0.0	2.0	0.0	0.0	22.2	0.0	11764.3
24	0.0	2.0	2.1	0.0	0.0	3714.5	44287.1
25	0.0	4.7	0.0	0.0	2.1	0.0	6388.3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	18.8	0.0	21.8	0.0	61.8	3404.1	555.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	2.4	0.0	19.5	20.7	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	1.6	4.7	0.0	0.0	3300.3	33215.5
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	1.2	0.0	0.0	6.6	0.0	0.0

37	0.0	6.0	0.0	0.0	0.0	1192.0	19369.1
38	0.0	0.7	0.0	0.0	0.0	1634.7	27596.0
39	0.0	9.1	18.1	0.0	64.5	0.0	25339.3
40	0.0	0.0	0.0	0.0	1.0	296.5	18432.8
41	0.0	10.0	4.7	0.0	0.0	3540.9	11170.1
42	0.0	4.7	2.6	0.0	0.0	1062.7	23170.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	17.0	0.0	2413.0
46	0.0	4.7	0.0	0.0	0.0	0.0	20250.7
47	0.0	2.5	5.6	0.0	0.0	0.0	25699.2
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	4.7	3.0	0.0	0.0	3317.0	40554.3
50	0.0	0.0	13.3	0.0	80.7	3930.7	15076.5
51	0.0	0.0	13.3	0.0	70.8	2897.5	17289.1
52	0.0	7.4	3.2	0.0	0.0	601.3	22519.0
53	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	0.0	0.4	0.0	0.0	0.0	1929.8	5092.3
55	0.0	0.3	10.8	0.0	0.0	1228.4	17347.3
56	0.0	0.0	0.0	0.7	47.3	0.0	63639.8
57	0.0	0.0	0.0	0.0	7.4	0.0	28492.0
58	0.0	4.5	0.6	0.0	0.0	982.8	18372.9
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.7	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	28.8	0.0	0.0	0.0	67901.3
63	0.0	55.0	265.1	0.0	335.0	0.0	2929.4
64	0.0	10.4	0.0	0.0	21.6	5262.0	18372.7
65	0.0	0.0	0.0	1.6	0.0	0.0	29637.8
66	70.0	2.0	0.0	0.0	0.0	2689.0	15660.0
67	0.0	2.9	0.0	0.0	0.0	3987.7	32358.7
68	0.0	3.5	4.6	0.0	0.0	0.0	44565.3
69	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	0.0	7.6	0.0	0.0	17.5	0.0	1211.2
72	0.0	0.0	0.0	18.2	1.0	0.0	63179.1
73	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	0.0	1.7	38.1	0.0	33050.5
75	0.0	0.0	0.0	1.0	75.0	0.0	10014.5
76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	0.0	0.0	56.2	0.0	0.0	45.1	33904.7

78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79	0.0	3.1	0.0	0.0	3.1	3708.9	31659.1
80	0.0	2.6	0.0	0.0	0.0	0.0	21754.5
81	0.0	2.8	0.0	0.0	4.8	170.1	58.5
82	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	0.0	0.0	0.0	0.0	9.1	0.0	0.0
84	0.0	0.0	0.0	0.0	3.4	0.0	0.0
85	0.0	0.0	3.0	0.0	0.0	2157.1	36718.5
86	0.0	2.0	2.3	0.0	0.0	0.0	21941.0
87	0.0	9.3	0.0	6.0	0.0	2845.7	22188.5
88	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	62.5	0.8	18.5	0.0	0.0	0.0	211455.6
90	0.0	3.5	0.0	0.0	1.1	0.0	85894.8
91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	0.0	2.8	3.3	0.0	0.0	4105.3	42023.3
93	0.0	1.1	0.0	0.0	0.0	19.7	15614.9
94	0.0	9.6	0.0	0.0	61.8	0.0	0.0
95	0.0	5.1	0.0	0.0	4.6	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.0	1.0	0.0	0.0	0.0	80.8	7054.7
99	0.0	2.4	0.0	0.0	0.0	318.6	15534.4
100	0.0	5.1	0.0	0.0	11.1	1293.5	18692.0
101	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102	0.0	3.6	0.0	0.0	2.2	585.7	31753.6
103	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104	0.0	0.6	0.0	0.0	0.0	0.0	84.4
105	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109	0.0	11.5	0.0	0.0	46.0	0.0	0.0
110	0.0	0.0	6.9	0.0	32.1	1041.6	26476.5
111	0.0	3.6	0.0	0.0	23.4	1778.5	0.0
112	0.0	10.0	0.0	0.0	22.4	878.6	16983.2
113	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	0.0	0.0	0.0	9.9	0.0	245.4	24626.4
Average	1.610	2.526	5.075	0.514	11.118	735.750	15517.108

APPENDIX 5

Result from DEA – Regional referral hospitals

Results from DEAP Version 2.1

Input orientated DEA
Scale assumption: VRS

Two-stage DEA method

EFFICIENCY SUMMARY: Regional referral hospitals

hospital	Crste	Vrste	Scale	Sc. Type
1	1	1	1	Crs
2	0.732	0.937	0.781	Irs
3	1	1	1	Crs
4	0.648	0.838	0.774	Irs
5	0.428	0.676	0.633	Irs
6	0.267	1	0.267	Irs
7	1	1	1	Crs
8	0.699	0.815	0.858	Irs
9	0.189	0.675	0.28	Irs
10	0.882	1	0.882	Irs
11	1	1	1	Crs
12	1	1	1	Crs
13	1	1	1	Crs
14	0.576	1	0.576	Irs
15	1	1	1	Crs
16	0.3	0.568	0.527	Irs
mean	0.733	0.907	0.786	

Note: crste = technical Efficiency from CRS DEA
vrste = technical Efficiency from VRS DEA
scale = scale Efficiency = crste/vrste

APPENDIX 6

Summary of inputs slacks – Regional referral hospitals

Hospital	Bed	Meddct	Nurse	Clinoffc	Mdattend	Inpatient	Outpatient
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	34.711	2.545	22.969	0.000	16779.768
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	6.793	24.643	0.121	31.551	0.000	23087.879
5	0.000	6.793	24.643	0.121	0.000	5482.162	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	30.977	10.553	7.497	30.132	2622.338	0.000
9	0.000	8.078	15.252	0.000	0.000	7716.948	36736.866
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.192	4.236	0.000	0.000	2277.168	5947.797
Average	0.000	3.302	7.127	0.643	5.291	1131.164	5159.519

APPENDIX 7

TEST FOR FUNCTIONAL FORM

LR Test of functional form

```
frontier lnopd lnbeds lnmedclinoff lnnursemedatt, distribution(exponential)

Iteration 0:   log likelihood = -241.20432  (not concave)
Iteration 1:   log likelihood = -190.15572
Iteration 2:   log likelihood = -181.91824
Iteration 3:   log likelihood = -180.75101
Iteration 4:   log likelihood = -180.72675
Iteration 5:   log likelihood = -180.72675

Stoc. frontier normal/exponential model           Number of obs   =
128
                                                  Wald chi2(3)    =
33.76
Log likelihood = -180.72675                       Prob > chi2     =
0.0000

----------------------------------------------------------------------------
---
        lnopd |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
--------------+-------------------------------------------------------------
---
       lnbeds |   .0235655   .1400898     0.17   0.866    -.2510054
.2981364
 lnmedclinoff |   .5330811   .1035454     5.15   0.000      .330136
.7360263
lnnursemedatt |  -.2872117   .1077637    -2.67   0.008    -.4984246   -
.0759987
        _cons |   10.55234   .9248429    11.41   0.000     8.739678
12.365
--------------+-------------------------------------------------------------
---
     /lnsig2v |  -.8525943    .245344    -3.48   0.001     -1.33346   -
.3717288
     /lnsig2u |  -.3938794   .3166908    -1.24   0.214    -1.014582
.2268232
--------------+-------------------------------------------------------------
---
      sigma_v |   .6529223   .0800953                      .5133847
.8303862
      sigma_u |   .8212401   .1300396                      .6021245
1.120093
       sigma2 |   1.100743   .1881478                        .73198
1.469506
       lambda |   1.257792   .1821838                      .9007178
1.614865
----------------------------------------------------------------------------
---
Likelihood-ratio test of sigma_u=0: chibar2(01) = 32.63  Prob>=chibar2 =
0.000



frontier lnopd lnbeds lnmedclinoff lnnursemedatt ln2beds ln2medclioff
ln2nursemedatt lnbedslnmedclinoff lnbedslnnursemedatt lnmedclinofflnnu
> rsemedatt , distribution(exponential)
```

```
Iteration 0:   log likelihood = -197.37945
Iteration 1:   log likelihood = -193.94469
Iteration 2:   log likelihood = -185.30809
Iteration 3:   log likelihood = -183.62932
Iteration 4:   log likelihood = -179.47096
Iteration 5:   log likelihood = -179.27867
Iteration 6:   log likelihood = -179.27803
Iteration 7:   log likelihood = -179.27803

Stoc. frontier normal/exponential model           Number of obs   =        128
                                                  Wald chi2(9)    =      32.67
Log likelihood = -179.27803                       Prob > chi2     =     0.0002

------------------------------------------------------------------------------------
------
                    lnopd |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
--------------------------+---------------------------------------------------------
------
                   lnbeds |  -1.727214   2.913798    -0.59   0.553    -7.438152
3.983724
             lnmedclinoff |   1.256982   1.697434     0.74   0.459    -2.069927
4.583891
            lnnursemedatt |  -2.204454   2.221504    -0.99   0.321    -6.558521
2.149613
                  ln2beds |   .0784653   .2198955     0.36   0.721    -.3525219
.5094526
             ln2medclioff |   .1540094   .1281061     1.20   0.229    -.0970739
.4050927
           ln2nursemedatt |   .1274497   .1302014     0.98   0.328    -.1277404
.3826397
       lnbedslnmedclinoff |  -.1710995   .2911081    -0.59   0.557    -.7416608
.3994619
      lnbedslnnursemedatt |   .2642691     .32132     0.82   0.411    -.3655065
.8940447
lnmedclinofflnnursemedatt |  -.1975449   .2064045    -0.96   0.339    -.6020903
.2070006
                    _cons |   19.06554   10.94273     1.74   0.081    -2.381816
40.51289
--------------------------+---------------------------------------------------------
------
                 /lnsig2v |  -.8304895   .2512209    -3.31   0.001    -1.322873   -
.3381055
                 /lnsig2u |  -.4645165   .3350578    -1.39   0.166    -1.121218
.1921848
--------------------------+---------------------------------------------------------
------
                  sigma_v |   .6601787   .0829254                      .5161093
.8444644
                  sigma_u |   .7927414   .1328071                      .5708613
1.100861
                   sigma2 |   1.064275   .1805005                      .7105002
1.418049
                   lambda |   1.200798   .1893595                      .8296604
1.571936
------------------------------------------------------------------------------------
------
Likelihood-ratio test of sigma_u=0: chibar2(01) = 29.07  Prob>=chibar2 = 0.000

estimate store tlo


. lrtest (cdo) (tlo), stats


Likelihood-ratio test                                 LR chi2(6)  =
2.90
(Assumption: cdo nested in tlo)                       Prob > chi2 =
0.8216
```

```
Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
-
       Model |    Obs    ll(null)   ll(model)     df          AIC
BIC
-------------+---------------------------------------------------------------
-
         cdo |    128           .   -180.7267      6     373.4535
390.5657
         tlo |    128           .    -179.278     12     382.5561
416.7804
-----------------------------------------------------------------------------
-
               Note:  N=Obs used in calculating BIC; see [R] BIC note

lrtest (cdi) (tli), stats

Likelihood-ratio test                                 LR chi2(6)  =
8.88
(Assumption: cdi nested in tli)                       Prob > chi2 =
0.1806

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
-
       Model |    Obs    ll(null)   ll(model)     df          AIC
BIC
-------------+---------------------------------------------------------------
-
         cdi |    128           .    -143.803      6     299.6061
316.7182
         tli |    128           .    -139.364     12      302.728
336.9524
-----------------------------------------------------------------------------
-
               Note:  N=Obs used in calculating BIC; see [R] BIC note
```

APPENDIX 8

Results from SFA

```
frontier lnipd lnbeds lnmedclinoff lnnursemedatt, distribution(exponential)

Iteration 0:   log likelihood = -144.73684
Iteration 1:   log likelihood = -143.97533
Iteration 2:   log likelihood = -143.80363
Iteration 3:   log likelihood = -143.80303
Iteration 4:   log likelihood = -143.80303

Stoc. frontier normal/exponential model           Number of obs   =
128
                                                  Wald chi2(3)    =
12.77
Log likelihood = -143.80303                       Prob > chi2     =
0.0052

------------------------------------------------------------------------------
---
        lnipd |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
--------------+---------------------------------------------------------------
---
       lnbeds |   .3460625   .1131993     3.06   0.002     .1241959
.5679291
 lnmedclinoff |  -.0353433   .0938951    -0.38   0.707    -.2193744
.1486878
lnnursemedatt |   .1344441   .0844357     1.59   0.111    -.0310469
.299935
        _cons |   6.558634   .7325341     8.95   0.000     5.122894
7.994375
--------------+---------------------------------------------------------------
---
     /lnsig2v |  -1.387296   .3041729    -4.56   0.000    -1.983463   -
.7911277
     /lnsig2u |  -1.002122   .3801858    -2.64   0.008    -1.747272   -
.2569716
--------------+---------------------------------------------------------------
---
      sigma_v |   .4997498   .0760052                      .3709338
.6733003
      sigma_u |   .6058875   .1151749                      .4174309
.8794261
       sigma2 |   .6168495   .1076718                      .4058166
.8278823
       lambda |   1.212382   .1741192                      .8711144
1.553649
------------------------------------------------------------------------------
---
Likelihood-ratio test of sigma_u=0: chibar2(01) = 8.27   Prob>=chibar2 =
0.002



frontier lnopd lnbeds lnmedclinoff lnnursemedatt, distribution(exponential)

Iteration 0:   log likelihood = -241.20432  (not concave)
Iteration 1:   log likelihood = -190.15572
Iteration 2:   log likelihood = -181.91824
Iteration 3:   log likelihood = -180.75101
```

```
Iteration 4:   log likelihood = -180.72675
Iteration 5:   log likelihood = -180.72675

Stoc. frontier normal/exponential model          Number of obs   =
128
                                                 Wald chi2(3)    =
33.76
Log likelihood = -180.72675                      Prob > chi2     =
0.0000

----------------------------------------------------------------------------
---
        lnopd |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
--------------+-------------------------------------------------------------
---
       lnbeds |   .0235655   .1400898     0.17   0.866    -.2510054
.2981364
 lnmedclinoff |   .5330811   .1035454     5.15   0.000      .330136
.7360263
lnnursemedatt |  -.2872117   .1077637    -2.67   0.008    -.4984246   -
.0759987
        _cons |   10.55234   .9248429    11.41   0.000     8.739678
12.365
--------------+-------------------------------------------------------------
---
     /lnsig2v |  -.8525943    .245344    -3.48   0.001     -1.33346   -
.3717288
     /lnsig2u |  -.3938794   .3166908    -1.24   0.214    -1.014582
.2268232
--------------+-------------------------------------------------------------
---
      sigma_v |   .6529223   .0800953                      .5133847
.8303862
      sigma_u |   .8212401   .1300396                      .6021245
1.120093
       sigma2 |   1.100743   .1881478                        .73198
1.469506
       lambda |   1.257792   .1821838                      .9007178
1.614865
----------------------------------------------------------------------------
---
Likelihood-ratio test of sigma_u=0: chibar2(01) = 32.63  Prob>=chibar2 =
0.000
```