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TECHNICAL EFFICIENCY OF PUBLIC HEALTH CENTERS: THE CASE OF ADDIS ABABA AND SELECTED HEALTH CENTERS OF OROMIA

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BY

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Abstract

This paper combines Data Envelopment Analysis (DEA) with regression analysis to evaluate the technical efficiency of public health centers in Addis Ababa and selected health centers of Oromia Region. Efficiency is first estimated using DEA with the inputs and outputs Specific to the health centers operations. An OLS and Logit models are then employed in which the efficiency scores obtained from the DEA Computations is used as the dependent variable, and a number of health center operating characteristics are chosen as the independent variables. The DEA results indicate that 60 % of health centers in data set have some degree of technical inefficiency and about 60% were scale inefficient. In the analysis, the input reduction required to make the inefficient health centers technically efficient is also identified. From the OLS and Logit results, location and availability of public health care providing unit (hospital) in the area are significantly associated with efficiency. In conclusion, the DEA results constitute a strong guide to health care decision-making, especially with regard to rational use of health care resources.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The health status of the population in a particular country is one of the important indicators of human welfare and national development. Good health, as people know from their experience, is a crucial part of well-being. However, as pointed out in the World Development Report (WDR) (1993), spending on health can also be justified on purely economic grounds. Improved health contributes to economic growth in many ways: It reduces production losses caused by worker illness; it permits the use of natural resource that had been totally or nearly inaccessible because of disease; it frees for alternative uses resources that would otherwise have to be spent on treating illness.

Health has an important impact on Development. A healthy population is one of the major end goals of development. For this reason, therefore, adequate health care must also be seen as one of the important starting points of the development process. Most of the time, progress in development is measured in purely economic terms but certainly its ultimate goal should be to improve the quality of life and provide the best possible satisfaction of human needs and aspirations. Healthy people are an essential element of economic and social progress since, throughout history; the primary driving force of development has been human energy (Lambo, 1993).

Health problems are usually related with the level of socio-economic development attained by a given country. In Ethiopia, like most developing countries, the health status of the population is the reflection of the low level of the economic development. Under financing of the health system and a low capacity for management contribute to poor access to basic health services, and ultimately, poor health status.

The health status of Ethiopians is among the lowest even by African standards. For instance, in 1998 infant mortality was estimated at 105 per 1000 live births, and life expectancy at birth was 44 years. In the same year, the average infant mortality for Africa was 81 per 1000 live births while life expectancy at birth was 52 years (African Development Report, 2000).

Based on the Ethiopian Demographic and Health Survey, one of every 6 Ethiopian children will die before the fifth birthday, with 58 % of these deaths occurring during the first year of life. The infant mortality in the country is often due to diarrhea, measles, respiratory infections and other preventable diseases (CSA, 2001).

In addition to the above health problems, Ethiopia is one of the hardest hit by HIV\AIDS pandemic. According to the Ministry of Health Report, there were 83,487 cases of AIDS reported to the ministry since the beginning of the AIDS epidemic up to June 2000. By this time the estimated population infected with HIV were about 2.6 million. By now most of them are expected to develop AIDS and the number of infected with HIV could be much larger than the above figure. This fast spreading disease coupled with rapid population growth made the health care provision in the country to be very difficult (MoH, 2000).

The health service facilities are inadequate both in scope and as well as in access and limited health care in the country is provided through hospital based curative system. Until very recently the government was the sole provider of the service and the private health care system is not well developed. Even the available health care facilities are concentrated in urban areas.

According to the Ministry of Health's annual report (2001), the health care facilities in the country consists of 2,293 health stations, 1,023 health posts, 1170 private clinics, 382 health centers, 110 hospital, 311 pharmacies, 249 drug shops, 1,917 rural drug vendors. The total number of hospital beds is 10,736. The ratio of the health facilities to the population is that, about one hospital bed for more than 6,086 people, one Doctor (physician) for 47,836 people and one Nurse for over 8461 people. However, WHO recommends one Doctor to serve not more than 10,000 people and one nurse for not more than 5,000 people.

These figures show that there is a big gap between the available health care facilities and the population. The gap might continue until the economy will be able to provide the services to the required level. However, given the limited health care services of the country, there is a need to utilize efficiently the available resources in the sector.

In recent years, the Ethiopian government took some measures to improve the health care delivery system, from curative to preventive and designed a strategy whose aim is to make the health care system more cost effective and efficient (Transitional Government of Ethiopia, 1993). The government planned the realization of the health development objectives through a twenty-year health development strategy, with a series of five-year investment programs. Accordingly, remarkable improvements have been made in increasing the size and mix of health workers through the establishment of numerous health-training institutions as well as in increasing population coverage and access to modern health services, through construction of primary health facilities in both rural and urban areas. In spite of government's efforts geared at improving the health status of the population, the health status indicators are still at poor conduction relative to other African Countries.

Within the context of the on going health sector reforms, one of the major concerns is the improvement of the efficiency in the allocation and utilization of the limited public health facilities. In order to improve the efficiency in the allocation and utilization of the public health resources, it is important to have empirical evidences and knowledge of the degree of (in) efficiencies that currently exist in the provision of primary health care services as well as factors responsible for the existing level(s) of (in) efficiencies. Thus, the purpose of this study is to identify the determinants and extent of inefficiencies in the health centers under considerations.

1.2 Statement of the Problem

As indicated above, the health status of the population in Ethiopia is among the lowest in Sub-Saharan Africa, and health care facilities are limited in number and distribution.

In view of the limited public resources for health care system and the increasing demands, there is an urgent need to look into how to improve the efficiencies (both allocative and technical) in the use of available public health resources.

Understanding the causes of inefficiencies in the health care delivery system enables to reduce excessive health care expenses and assist health care units to search for better resource allocations. As Kirigia et al. put it:

" Inefficiency signifies the denial of additional citizens of opportunities to realize health improvements at zero extra cost. This is what makes inefficiency both immoral and unethical." Kirigia et al. *(2000: 2).*

This study therefore attempts to provide some evidence on the extent and causes of technical (in) efficiency that may exist in public health facilities (especially health centers). The study also tries to identify those factors responsible for the differences in efficiency observed in selected health centers. Specifically, the study attempts to provide answers to the following questions:

1. To what extent are public health facilities (health centers) technically efficient?
2. What are the factors responsible for variations in the observed level of technical efficiency in public health centers?
3. To what extent will the elimination of the inefficiencies improve service coverage?

1.3 Objectives of the study

The overall objective of this study is to investigate the possible determinants and extents of inefficiencies in the health centers in Addis Ababa City Administration as well as health centers in selected zones of Oromia Regional State.

The specific objectives of the study are:

- To determine the extent and level of technical efficiency in public health centers.
- To identify the major determinants of the observed level of technical inefficiency in the selected public health centers.
- And to draw appropriate policy implication and recommendations.

1.4 Significance of the study

Since an improved health is a curtail part of people's well-being that contributes to the economic growth of a country, the achievements of any other activity depend on health. Thus understanding of the level of inefficiencies and factors that affect the efficiency of the health care provision in the country would enable policy makers to design an effective strategies of health care resource utilization so as to improve the health status of the people. Therefore, this study will provide a base for further empirical research on the subject, particularly on primary health care. Finally, the out come of this study is intended to provide relevant evidence for policy makers in Addis Ababa City Administration and Oromia Region in planning and implementing primary health care programs.

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1.5 Scope and limitations of the study

- This is a micro level study limited to Addis Ababa City Administration and health centers from selected Zones of Oromia Regional State. Comparing to the large area of the country, it is difficult to make generalization from the study made in such limited area. Moreover, the data used in the study is a secondary data collected from Zonal Health Departments and Health Centers' Record Offices, using monthly, quarterly, or annual reports. Thus, it will be very difficult to be sure whether every activity of each health center under consideration is properly registered timely and reported to respective offices without any subjective influence.

- There may be variation in quality of care from one health center to another (e.g. those facilities offering higher quality may require more personnel time and other inputs than those offering low quality of care). Given that this study was based on secondary data, it was not possible to determine whether there was any variance in quality of care across the facilities.

- Health care providing units could be argued to produce deaths through negligence, human errors, etc. In this study we did not include the number of health center deaths

- Drug supplied to patients at the health centers is one of the inputs in health crare services. But, for some of the health centers considered in this study this data was not available and due to this DEA was computed excluding this data. However, to see the impact of this input on technical efficiency, a separate DEA was computed only for those health centers for which the data was available

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1.6 Organization of the study

The remaining part of the paper is organized as follows: Chapter two presents background information on health care provision in the country. Chapter three reviews the theoretical and empirical evidences of previous studies on the efficiency of health care provision. Chapter four presents the methodology employed in the study. Chapter five deals with data analysis and discussion and finally, Chapter six presents the conclusion and recommendation of the study.

CHAPTER TWO

BACKGROUND OF THE HEALTH SECTOR

2.1 REVIEW OF THE HEALTH CARE SYSTEM IN ETHIOPIA

Ethiopia has currently an estimated population of 65.3 million, of which more than 55.5 million (85.0 percent) are living in rural areas. It has an estimated population growth rate of about 2.9 percent in spite of the high mortality in the country (MoH, 2001).

The health care services in the country are provided by the Ministry of Health (MoH), Humanitarian Organizations, and the private sector, of which the former is the dominant one. The health care facilities in the country are mainly concentrated in urban areas and hence the urban population uses the services better than the rural population. According to the data of Demography and Health Survey of Ethiopia (DHS), the service utilization for urban households was 53.8 percent compared to 42.6 percent for rural households (CSA, 2001).

With regard to health problems, the majority of ill health in Ethiopia is related to potentially preventable, communicable diseases and nutritional problems (MoH, 2001). These health problems are mainly associated with low socio-economic status of the population, poor environmental conditions and poor coverage of health and other social services in the country.

The low health status of the people is reflected in high infant and maternal mortality rates. Infant mortality rate was 97 per 1000 Live Births and children under 5 mortality rates per 1000 were 140 and life expectancy at birth was 51.0 years (MoH, 2001).

Poverty level has aggravated the health status of the population. The higher the country's average income percapita the more likely its people are to live long and healthy lives. As income increases the access to basic needs such as food, shelter and proper health care facilities are also expected to be improved. However, income alone will not guarantee good health. Equally important is the distribution of income among the people. With improvement in income and its distribution the health status of the population is expected to improve (WDR, 1993).

However, percapita income in Ethiopian is very low and large portion of its population live in absolute poverty. According to the Ministry of Economic Development and Cooperation (MEDaC), about 45 percent of the population in Ethiopian live in absolute poverty, meaning they are unable to lead life fulfilling the minimum requirement for their livelihood. The report also indicates significant difference in poverty levels between urban and rural areas. Accordingly, 47 percent of the rural population live in absolute poverty while 33 percent of the urban population were found in absolute poverty (MEDaC, 1999).

Other factors, which contribute to ill health, are factors like high level of illiteracy rate and low level of status of women in the society. Women's economic status and education level contributes to both maternal and child health. Households with more education are expected to enjoy better health. Education will improve the access of an individual to better income and better health care. As it was indicated in World Development Report (WDR), Education greatly strengthens women's ability to perform their vital role in creating healthy households. It increases their ability to benefit from health information and to make good use of health services. Mother's schooling delays early marriage, which could improve risks, associated with early age pregnancies. Educated women also have better access to family planning services and are better aware of hygiene, nutrition and importance of immunization of their children (WDR, 1993).

In this regard, the adult literacy rate in the country is very low. The overall literacy rate in 1996 was about 23 percent. Levels of literacy rates also varied by sex; 29.5 percent of the total male population were literate while only 15.3 percent of the female population were literate implying a big gender bias in favor of the male population (MEDaC, 1999).

To mitigate the problem, the then Transitional Government of Ethiopia launched a new Health policy in 1993 with the following main objectives:

- Democratization and decentralization of health services system.
- Developments of the preventive and promotive components of health care.
- Development of an equitable and acceptable standard of health service system that will reach all segment of the population.
- Promotion of the participation of the private sector and non-governmental organizations in health cares.
- Development of appropriate capacity building based on assessed needs.

- Provision of health care for the population on a scheme of payment according to ability with special assistance mechanisms for those who cannot afford to pay.

The new health policy restructured the health care system from the former six-tiered system to four-tiered system. The six tiered system consisted the Health Posts (HP), Health Stations, Health Centers, Rural Hospitals, Regional and Referral Hospitals while the four tiered system constitutes of Primary Health Care Units (PHCU), including Health posts; district hospitals, Zonal hospitals and specialized hospitals. The health care management was also decentralized and come under Regional Health Bureaus.

Although the government took various encouraging measures to improve the health status of the population, the health indicators remain at a low level relative to other African Countries.

2.2 Health profile

There is general consensus that health indicators in developing countries have shown improvement in the past years. Life expectancy is improved, and many serious diseases have been controlled, and some eliminated; (though new once are presently emerged). But the health status of individuals in these countries remains well below health promoting service. Life expectancy at birth in sub-Saharan African is still only two third of the average level in developed countries, and the average child mortality rate is more than fifteen times that of developed economies (Jack, 1999).

The majority of the Ethiopian population does not have access to modern medicine and relies heavily on the relatively accessible and inexpensive traditional remedies (Tadele and Mohammed, 1996).

Fewer than 20 percent of Ethiopians live within a two-hour walk of a modern health care facility. Lack of access to appropriate health care, poor nutritional status, together with high fertility contributed to one of the highest maternal mortality rates and low level of life expectancy (USAID, 2000).

Table-2.1 presents the severity of the health status of the population compared to other neighboring African Countries.

2.1 Comparative health indicators for East African Region

Country	**Infant Mortality rate per 1000 Live Births**			**Life expectancy at Birth (in years)**					
				1980		**1990**		**1998**	
	1980	**1990**	**1998**	**M**	**F**	**M**	**F**	**M**	**F**
Ethiopia	**148**	**123**	**108**	**40**	**44**	**44**	**47**	**43**	**45**
Djibouti	132	116	101	43	47	47	50	50	53
Kenya	81	67	64	54	58	55	58	49	51
Sudan	92	85	67	48	51	50	52	55	58
Africa	**112**	**97**	**81**	**48**	**51**	**50**	**53**	**51**	**53**

Source: African Development Report, 2000

As indicated in table 2.1, the health status of the population is the poorest even by African standard. According to MoH (2001), the top 10 leading causes of hospital deaths in the country in the year 2001 were: Tuberculosis of respiratory system (10.1 Percent), pneumonia (7.3 percent), all types of malaria (4.6 percent), Bacillary dysentery (2.2 present), accidents (1.6 percent), meningitis (1.5 percent), Hypertension (1.4 percent) Gustro-ententis and colitis (0.8 percent), AIDS (0.8 percent) and Leishmaniasis (0.5 percent).

Malnutrition is one of the causes of ill health mostly affecting child health. Children suffering from malnutrition are usually shorter to their age. Malnutrition is mainly due to low income, lack of food security and in some cases, due to poor knowledge about nutritional requirements and dietary habits.

One out of two Ethiopian child under five years of age were stunted (short for their age), 11 percent wasted (thin for their age), and 47 percent were under weight (CSA, 2001).

Sanitation and lack of safe water have contributed to poor health status of the population. Available data indicates that River /Lake is the most important source of water for the population in the country (MEDaC, 1999). According to this report, 54 percent of the population in the rural areas and 18.50 percent of urban were dependent on river or Lake as a source of water. Thus, people-having access to safe water in the country is not more than 25 percent. The report also pointed out the problem related to sanitation in the country. Thus, Sanitation as measured by type of toilet facility in use is at a very poor state all over the country in general and in rural areas in particular. Of the total population in the country 84 percent used field /forest as toilet and only 12.6 percent used pit latrines. In urban areas, 56.4 percent of the population used pit latrines while 40.9 percent used field or forest for toilet sanitation. Only about 2.70 percent used standardized flush toilet. In the majority of the rural areas 95.8 percent used field / forest and only 3.5 percent used pit latrines as toilets. Thus, majority of the population in rural areas and quite large number of the urban population in the country are exposed to diseases caused because of poor sanitation and water born diseases.

2.3 Health Coverage

The health care infrastructure of the country is underdeveloped. Both the number and distribution of health care facilities are sub standard. Based on Ministry of Health Report, (MoH, 2001), the total health services coverage in the country was only about 51.2 percent. This figure is quite low and there are no equitable health services between the urban and the rural areas. More health services are concentrated in urban areas than in rural areas and are generally delivering poor quality of health care (Tadelle and Mohammed, 1996). The health care delivery system gives emphasis to curative hospital based services than preventive and community based health care services; though the Health Policy of 1993 advocates the later one.

As indicated in the Table 2.2, population to health center ratio was 171,058, while one health center was supposed to give services to population of not more than 10,000. Population per primary health care (health centers and health stations together) in the same year was 24,428. Furthermore, the ratio of health personnel to the population is also below standard. One Physician (Medical Doctor) is expected to serve about 47,836 people, and one Nurse for about 8,461. However, according to World Health Organization (WHO) standard, one Doctor is supposed to give service for not more than 10,000 and one Nurse for the population about 5,000.

Table 2.2: Ratio of medical personnel and health facilities to population in the country

Medical personnel or health facilities	Number of medical personnel Or health facilities	Ratio per population
Doctors	1366	47836
Health Officers	296	220757
Nurses	7723	8461
Health assistants	7386	8847
Hospitals	110	594036
Beds	10736	6086
Health centers	382	171058
Health stations	2293	28497
Health posts	1023	63875
Pharmacies	311	210109
Drug shops	249	262426
Rural drug vendors	1917	34087
Private Clinics	1170	

Source: MoH Report, 2001.

Thus, from above figures it can be seen that there is a big gap between the health care facilities and the population.

One of the inputs into production of health care services is the medical personnel, which include physicians, nurses, health assistants and the like. These health care providers are mainly concentrated in urban areas and rural population has limited access to trained and experienced physicians.

2.4 Health Care spending

Differences in health spending could be one of the causes for differences in health status of the population across countries. For instance, in 1990 total annual health spending ranged from less than $ 10 per person in several African and Asian Countries were it was more than $2, 700 in the United States of America (WDR, 1993).

According to MOH annual report, the government health budget (Percent of Governments total) was only 7.3 % and Government health expenditure percapita (ETB) was 11.5; which was about 1.3 US dollars (MOH, 2001). Three major sources finance the expansion and maintance of health care in the country; Government, donors and the private sector. Among these, the government share is the highest one. Government expenditure on health care services is from internal source and from external assistance. The internal is very weak because of weak tax bases and competition between sectors for limited resources. Concerning the external source, this source is also weak and not to the required level. As it was pointed out by Development Studies Associates (DSA), relative to other African Countries Ethiopia had low level of official development assistants (DSA, 1998). Thus, though the health expenditure of the country has shown an increment over past years, the expenditure is still far low relative to the need of the population for adequate health care.

As it has been discussed above, the health care services are poor both qualitatively and quantitatively, mainly due to under financing of the health care system, poor infrastructure, low level of the income of the population, an uneven distribution of health care facilities etc. Thus, much has to be done to improve the health status of the population, through better resource mobilization and improving the efficiencies of the health sector resources available at hand.

CHAPTER THREE

REVIEW OF THEORETICAL AND EMPERICAL LITERATURE

3.1 THEORETICAL LITERATURE ON EFFICIENCY

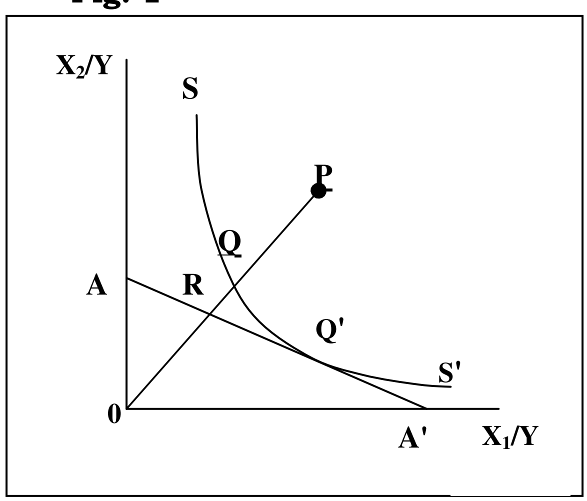
By efficiency of a production unit we mean a comparision between observed and optimal values of its outputs and inputs. The comparision can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output, or some combination of the two. In these two comparisions the optimum is defined interms of production possibilities. It is also possible to define the optimum interms of behavioral goal of the production unit. In this event efficiency is economic and is measured by comparing observed and optimum cost, revenue, profit, or whatever the production unit is assumed to persue, subject to the appropriate constraints on quantities and prices (Lovell,1993).

To measure the level of efficiency of a firm or a plant, the maximum possible output is relevant, and more often attempt is made to estimate it as a function of input quantities. Such function is often called a frontier production function, with the word "frontier" emphasizing the idea of maximality which it embodies. Similarly, a frontier cost function would give the minimum possible cost as a function of output quantity and input prices (Schmidt,1986).

In his seminal work, Farrell (1957) proposed that the efficiency of a firm consisting of two components: technical efficiency which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. Price information is necessary for any discussion of allocative efficiency. The overall efficiency is the product of pure technical, allocative and scale efficiency measures.

Farrell's idea can be illustrated using simple example involving firms that use two inputs to produce a single output. Consider a firm using two inputs X_1 and X_2 producing output Y, and assume that the firm's production function (frontier) is Y= f (X_1, X_2). Assume that it is characterized by constant returns to scale, so that it may be written: $1= f\left(\frac{X_1}{Y},\frac{X_2}{Y}\right)$. That is, frontier technology can be characterized by the unit isoquant. This is shown by SS′ in figure 1 below.

Fig. 1



Sorce : Coelli (1996 :p.5)

Suppose a firm uses quanties of inputs, defined by the point P, to produce a unit of output. The technical inefficiency of that firm could be represented by the distance QP, which is the proportional reduction in all inputs that could theortically be achieved without any reduction in output. This is usually expressed in percentage terms by the ratio QP/OP. The technical efficiency (TE) of a firm is then defined as :

$$TE = \frac{OQ}{OP}$$

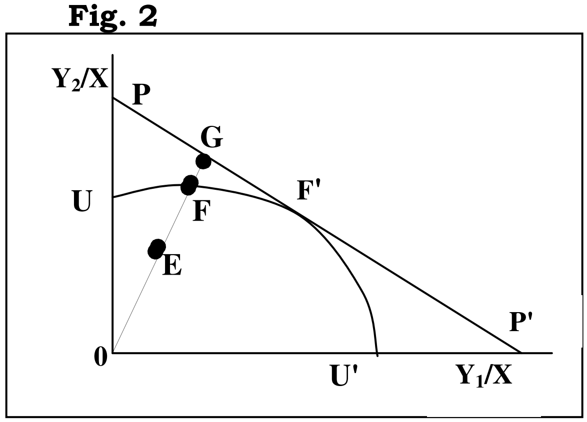
$$= 1 - \frac{QP}{OP}$$

If the input price ratio, represented by the line AA' in the figure above, is also known, allocative efficiency may also be calculated. The allocated efficiency of the firm operating at P is defined to be the ratio $\frac{OR}{OQ}$ since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point Q', instead of at the technically efficient, but allocatively inefficient, point Q. The total economic efficiency is defined to be the ratio $\frac{OR}{OP}$, which is the product of technical and allocative efficiency,i.e., $\left(\frac{OR}{OP}\right) = \left(\frac{OQ}{OP}\right)\left(\frac{OR}{OQ}\right)$

Technical inefficiency is measured either as a proportional reduction in input usage or as proportional increase in output production. The former is known as Input-orientated, while the latter is Output-orientated approach. The two measures provides the same result when constant returns to scale exists in production, but will be unequal when increasing returns to scale are present (Coelli, 1996).

In the above simple model used to illustrate efficiency measurement, input-orientated production is assumed. One can also consider output-orientated efficiency measures. Following Coill's (1996) formulation, consider the case where production involves two outputs (Y_1 and Y_2) and a single input (X). Again, assuming constant returns to scale, the technology can be represented by a unit production possibility curve in two dimension as follows, in Figure-2. In the figure, curve UU' is the unit production possibility curve and the point E corrosponds to an inefficient firm. Unlike in the case of input- orientated, in this case the inefficient firm lies below the curve because UU' represent the upper bound of the production possibilities.

Fig. 2



Source : Coelli (1996 : p.8)

In the above Figure EF represents technical inefficiency. That is, the amount by which output could be increased without requiring extra inputs. Therefore, a measure of output- orientated technical efficiency is the ratio :

$$TE_O = \frac{OE}{OF}$$

Similar to the input-orintated model one can measure allocative efficiency, if price information is available. Assuming PP` to be isorevenue, allocative efficiency is given as:

$AE_o = OF/OG$

This has revenue increasing interpretion, while in the input-orientated case it has cost reducing concept.

In many studies researchrs have tended to selected input-orientated models because, in many cases, for firms or decision making units, input quantities apper to be the decision variables. But, in cases where a firm is given a fixed quantity of resources to produce as much out put as possible, output-orientate approach could be more appropriate (Coelli,1996).

Note that, since efficient unit isoquant discussed above is not observable, it is estimated from a sample of observations. Farrell (1957) suggested the use of either a non parametric piecewise-linear convex isoquant or a parametric function, such as the Cobb-Douglas form (Forsund et al.,1980).

As it was pointed out by Lovell (1993), Farrell`s approach has been extended and applied by numerous studies such as that of Farrell and Field house (1962), Seitz (1970, 1971), Afriat (1972), Dugger (1974), and Meller (1976).
Farrell also suggested a second approach to efficiency measures, which involve a parametric function. He proposed computing a parametric convex hull of the observed input-output ratios (Foursund et.al., 1980).

Aigner and Chu (1968) considered the estimation of a parametric frontier production in input/output space. They specified a Cobb-Douglas production (in log form) for a sample of N firms as follows:

$$\ln(y_i) = F(x_i;\beta) - u_i \qquad i = 1,2,\ldots,N \qquad (1)$$

Where y_i is the output of the i-th firm; x_i is the vector of input quantities used by the i-th firm; β is a vector of unknown parameter to be estimated; F (.) denotes an appropriate functional form (in this case the Cobb-Douglas); and u_i is a non-negative variable representing inefficiency in production. The parameters of the model were estimated using linear programming, in such a way that

$\sum Ui$ is minimized,

Subject to constraints that: $Ui \geq 0$, i=1,2,…,N.

The ratio of observed output of the i-th firm, relative to the potential output defined by the estimated frontier, given the input vector x_i, was suggested as an estimate of the technical efficiency of the i-th firm; that is,

$$TEi = \frac{Yi}{\exp(F(X_i;\beta))} = \exp(-U_i) \qquad (2)$$

This indicates the magnitude of the output of the i-th firm relative to the output that could be produced by the fully efficient firm using the same input vector.

Afriat (1972) specified a model similar to (1), except that the u_i were assumed to have a gamma distribution and the parameters of the model were estimated using the maximum likelihood (ML) method.

One of the criticisms of the above deterministic frontier estimators is that no account is taken for the possible influence of measurement errors and other noise upon the shape of the estimated frontier, since all observed deviations from the estimated frontier are assumed to be the result of technical inefficiency.

In light of this criticism, Aigner, Lovell and Schmidt (1977) proposed the estimation of a stochastic frontier production, where noise is accounted for by adding a symmetric error term (v_i) to the non-negative error term in (1) above to provide:

$$\ln (y_i)= F(x_i;\beta)+v_i-u_i , \qquad i= 1,2,\ldots,N. \qquad (3)$$

The important idea behind the stochastic frontier model is that the error term is composed of two parts. A symmetric component which permits random variation of the frontier across firms, and captures the effects of measurement error, other statistical noise, and random shocks outside the firms control (Forsund et.al., 1998).

The parameters of this model are estimated by ML, given suitable distributional assumptions for the error terms. Aigner, Lovell and Schmidt (1977) assumed that v_i has normal distribution and u_i has either the half normal or the exponential distribution. This stochastic model specification not only addressed the noise problem associated with earlier (deterministic) frontiers, but also permitted the estimation of standard errors and tests of hypothesis, which were not possible with the earlier deterministic models. The stochastic frontier is not, however, without problems. The main criticism is that there is no a priori justification for the selection of any particular distribution form for the u_i (Coelli, 1995).

In addition to the stochastic frontier methods discussed above, non-parametric mathematical programming approach to frontier estimation, known as data envelopment analysis (DEA), has also been developed. DEA was initially coined by Charnes, Cooper, and Rhodes (1978) and since then different people have further extended and applied the methodology (Lovell, 1993).

The purpose of DEA is to construct a non- parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. It is a linear programming technique, which identifies best practice within a sample, and measures efficiency based on differences between observed and best practice units.

DEA provides a comprehensive analysis of relative efficiency for multiple input-output situations by evaluating each decision-making unit (DMU) and measuring its performance relative to an envelopment surface composed of other DMUs. Firms (Units) that lie on the surface are considered to be efficient. Units that do not lie on the surface are termed inefficient and the analysis provides a measure of their relative efficiency (Seiford et.al., 1993).

There are two basic types of envelopment surfaces in DEA, referred to as constant returns- to- scale (CRS) and variable returns-to-scale (VRS) surfaces. In their work, Charnes, Cooper, and Rhodes (1978) proposed a model, which had an input orientation and assumed constant returns to scale (CRS) production.

The Constant Returns to Scale (CRS) DEA model

The constant returns to scale DEA model can be illustrated using a simple model as it was formulated by Battese et. al. (1998) as follows. Suppose there is data on K inputs and M outputs on each N firms. For the i-th firm these are represented by the vector x_i and y_i, respectively. The KX×N input matrix, X, and the MX×N output matrix, Y, represent the data of all N firms. Using ratio form, for each firm, the ratio of all outputs over all inputs could be represented as $u'y_i/v'x_i$, where u' is an M×1 vector of output weights and v' is a K×1 vector of input weights. To select optimal weights the mathematical programming problem could be specified as:

$$Max_{U,V} \frac{U'Y_i}{V'X_i}$$

$$\text{S.t} \quad \frac{U'Y_j}{V'X_i} \leq 1 \qquad j = 1,2,\ldots,N, \qquad (1)$$

$$U,V \geq 0$$

The model involves finding values for U and V, in such a way that efficiency measure of the i-th firm is maximized, subject to the constraint that all efficiency measure must be less than or equal to one. One problem with the above formulation is that it has an infinite number of solutions (Coelli, 1996). To avoid this, Colli suggested another constraint, $v'x_i$ to be equal to one. Thus, the above problem could be written as:

$$Max_{\mu,v}(\mu' Y_i),$$
$$\text{S.t} \quad V' X_i = 1,$$
$$\mu' Y_j - V' X_j \leq 0,$$
$$\mu, V \geq 0 \qquad j=1,2,\ldots,N, \qquad (2)$$

The notation is changed from U and V to μ and V to show the transformation. This formulation is known as the " multiplier form" of the linear programming model (ibid).

The linear programming equation (2) can also be formulated in its dual form as:

$$Min_{\theta,\lambda}\theta,$$
$$\text{S.t} \quad -Y_i + Y\lambda \geq 0,$$
$$\theta X_i - X\lambda \geq 0, \qquad (3)$$
$$\lambda \geq 0.$$

Where, θ is a scalar and λ is a N×1 vector of constants.

In most DEA analysis the dual form is preferred to the primal model, because it involves fewer constrains than the primal form (K+M<N+1). The value of θ obtained is the efficiency score in the dual model.

The CRS assumption is only appropriate when all decision-making units (DMU) are operating in an optimal scale (i.e., one corresponding to the flat portion of the Long Run Average Cost Curve, (LRAC). However, Imperfect competition, constraints of finance, etc., may result in non-optimal operation of firms (Battese, 1998).

In DEA analysis output and input slacks (i.e., excess outputs and inputs) are considered to provide an accurate indication of technical efficiency of a firm (Coelli, 1995). Slacks are the extra amount by which an input (output) can be reduced (increased) in equal proportion to reach the production frontier. From the relationship given in equation 3, the output slacks will be equal to zero only if $Y\lambda - y_i = 0$, while the input slacks will be equal to zero only if $\theta x_i - X\lambda = 0$ (ibid).

Variable Returns to Scale (VRS) and Scale Efficiency

Following the CRS model by Charnes et al. (1978), subsequent papers have considered alternative set of assumptions and later on Banker, Charnes, and Cooper (1984) proposed the variable returns to scale (VRS) model. The VRS model, though similar to the CRS, model, measures pure technical efficiency and returns to scale for each of the sample firms. Scale efficiency can be measured by dividing the CRS efficiency scores by the VRS efficiency scores. The CRS linear programming problem given above can be modified to drive the VRS by adding the convexity constraint, N1=1 to equation (3). Thus, the VRS model in its dual form will be:

$$Min_{\theta,\lambda}\theta,$$

S.t $\quad -Y_i + Y\lambda \geq 0,$

$$\theta X_i - X\lambda \geq 0, \quad (4)$$

$$N1'\lambda = 1,$$

$$\lambda \geq 0$$

Where, N1 is an N×1 vector of ones.

Many studies have decomposed the technical efficiency scores obtained from a CRS DEA into two components one due to scale inefficiency and the other due to "pure" technical inefficiency. Pure technical efficiency is a measure of the distance a firm is off the production function under the variable returns to scale. Conducting both a CRS and VRS DEA models upon the same data can do this. Thus, with the VRS DEA model, one can analyze the existence of economies of scale and confirm productive scale size (minimum efficient scale) of a decision-making unit and estimate the number of DMUs operating at the efficient scale (T.Coelli, 1996). If there is difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency, and that the scale inefficiency can be calculated from the difference between the VRS scores and CRS scores.

One problem of the measurement of scale efficiency is that the value obtained from the ratio of CRS to VRS value does not indicate whether the firm is operating in increasing returns to scale or decreasing returns to scale. This problem demands to run another DEA problem known as non- increasing returns to scale (NIRS) model (Lovell, 1993). This is done by changing the constraint in the model (4), $N1'\lambda=1$ to $N1'\lambda\leq1$. Thus, the model is formulated as:

$$Min_{\theta,\lambda}\theta,$$

S.t $-Y_i + Y\lambda \geq 0,$ (5)

$N1'\lambda \leq 1,$

$\lambda \geq 0$

Whether the firm is operating in increasing returns to scale or decreasing returns to scale can be determined based on comparison of the VRS technical efficiency score with that of NIRS score. If they are equal, decreasing returns to scale exists and if they are different, increasing returns to scale exists (Battese et. al., 1998).

A number of extensions to the basic DEA models have appeared in the literature. Many of these enhancements were originally proposed either as to take into account managerial or organizational factors or stipulations; proposed as a solution to overcome inconsistencies in or incompleteness of the data; and/or developed as refinements to a particular model (Seiford, 1993). Regardless of their origin, these extensions are now accepted as valuable additions to the methodology of data envelopment analysis. Among the extensions made to DEA model were consideration of a stochastic element into the model (Sengupta 1990), inclusion of categorical and environmental variables; and use of panel data and the Malmquist index (Farel et al., 1994), were the common ones (Seiford, 1993).

Among different techniques used for measuring efficiency, the stochastic (Econometric) and the Mathematical Programming approach (DEA) are widely used. The two approaches differ in many ways, but the essential differences, and the source of advantages of the one approach or the other, as Lovell (1993) has explained in his article, boil down to two points:

- *"The Econometric approach is parametric and confounds the effects of mis-specification of functional form (of both technology and inefficiency) with inefficiency. The Programming approach is non-parametric and less prone to this type of specification error.*
- *The Econometric approach is stochastic and so attempts to distinguish the effects of noise from the effects of inefficiency. The Programming approach is non-stochastic, and lumps noise and inefficiency together and calls the combination inefficiency", (Lovell, 1993:19).*

However, DEA has wide application especially in service industries where there are multiple inputs and outputs, such as Banking, Health, Telecommunication and Electricity distribution. With DEA, one can explicitly consider the multiple outputs and inputs of a health care providing unit, specifically, the multiple outputs reflected the case mix and the multiple resources used to produce these services are simultaneously considered to gain an overall evaluation of technical efficiency. In addition, one can incorporate other health care providing unit's outputs, such as teaching, research and community education programs.

DEA was developed in a public sector, not-for profit environment, in which prices are not reliable at most and missing at worst. Consequently the vast majorities of DEA use quantity data and calculate Technical efficiency, despite the fact that the procedure is easily adapted to the calculation of Economic efficiency in a situation where price data are available and reliable (Lovell, 1993).

Attributes and Limitation of the Model

The major attributes/advantages of DEA versus other techniques for evaluating health facilities efficiency (e.g. ratio analysis and econometric techniques) as it as explained by Sherman (1984: 931), in his paper " *Hospital efficiency Measurement and Evaluation: Empirical test of new technique*", are that*:*

- DEA is particularly useful because it can simultaneously accommodate multiple outputs and inputs and does not require specific knowledge of the efficient absolute or relative amounts of inputs required for each health facility output.
- Health facilities located as inefficient are strictly inefficient, and there is no problem of false identification of efficient health care facilities as inefficient provided that all relevant outputs and inputs are included in the set.
- DEA indicates the general magnitude of inefficiencies present in the health facilities.
- DEA objectively locates inefficient health facilities without the need for an arbitrary cut off point to separate potentially inefficient and efficient health facilities as is needed for ratio analysis.
- DEA locates technical or pareto inefficiencies in a manner more consistent with economic theory than econometric regression techniques i.e. DEA measures efficiency compared with the best health facilities

rather than based on mean or central tendency relationship that reflects a mixture of efficient and inefficient behavior.

On the other hand, the limitations of DEA include the following:

- Being a deterministic rather than a stochastic technique, DEA provides results that are particularly sensitive to measurement errors. If one organization's inputs are understated or its outputs overstated, then the organization can become an outlier that significantly distorts the shape of the frontier and reduces the efficiency scores of nearby organizations. In regression-based studies, the presence of error terms in the estimation tends to discount the impact of the outliers.
- DEA only measures efficiency relative to best practice within the particular example. Thus, it is not meaningful to compare the scores between two different studies because differences in best practice between the samples are unknown. Similarly, a DEA study that only includes observations from within the state or nation cannot tell us how these observations compare with national or international best practices.
- DEA scores are sensitive to input and output specification and the size of the sample. Increasing the sample size will tend to reduce the average efficiency score, because including more organizations provides greater scope for DEA to find similar comparison partners. Conversely, including too few organizations relative to the number of outputs and inputs included without increasing the number of organizations will tend to increase efficiency scores on average. This is because the number of dimensions in which a particular organization can be relatively unique (and, thus, in which it will not have similar comparison partners) is increased. DEA gives the benefits of the doubt

to organizations that do not have similar comparison organization, so they are considered efficient by default. There are different rules as to the minimum number of organizations in the sample should be. One rule is that the number of organizations in the sample should be at least three times greater than the sum of the number of outputs and inputs included in the specification.

3.2 Emperical Evidence

There are relatively few studies on efficiency of health care provision, at least compared to the number of studies on health care production and health care demand. More over, most of the studies on efficiency of health care provision used stochastic frontier approach rather than the non-stochastic DEA technique (Sherman,1984). However, the following are among the DEA techniques employed in evaluating efficiency of health care provision.

In the literature on health care managment, DEA has been used to analyze efficiency of public health facilities, espically hospitals. Patrica Brynes et. al. (1990) studied the performance of US hospitals using DEA methodolgy. The study examined Technical and Allocative efficiency of 123 community, non-profit hospitals operating in California. They considered six inputs and three outputs. The three outputs were, medical-surgical acute discharges ,medical surgical intensive care discharges , and maternity discharges. The inputs include five labour inputs, namely, registered Nurses , Management and Administrative personnel, Technical services personnel, Aides and orderlies, and liciensed practical Nurses. All labour inputs were measured in full-time equivalence hours. Number of Beds were used as proxy for capital input. To gauge the cost performance of hospitals, they computed four DEA- type linear programming problems for each hospital. The solution was used to determine the amount by which observed inputs can be proportionally reduced, while still producing the given output level. They were able to evaluate Technical and Allocative efficiency of the hospitals in their studies. Their result show that there was allocative inefficiency to a greater extent than technical inefficiency. They estimated the costs that would be saved if inefficiencies were reduced to be 32% to 40% of operating costs.

Burgess et al. (1993) carried out efficiency study on Veterans Hospital in the US. Their study analysed annual data collected by the U.S. Depertment of Veterans Affairs (VA) on Veteran hospitals basd on the data from 1985 to 1987. The data contain information on inputs used by VA hospitals ; including various measures of capital (infrastructure, labour, and supplies) as well as information on outputs, including surgical procedures, patient days, discharges, research and teaching activity, etc. A determinstic, non- parametric production frontier was constructed in order to measure the technical efficiency of each VA hospital relative to the performance of other hospitals in the VA system. Their result indicated that there were relatively inefficient hospitals which deserve closer examination so as to improve their efficiencies.

Sherman (1984) employed DEA technique to a set of teaching hospitals in Massachusetts in the US. As it was indicated in his study, he identified as well as measured the magnitude of inefficiency present and the amount of potential resource reducation possible if the inefficient hospitals were turned to operate as efficient as those hospitals which were relatively more efficient.

Chang (1998) used the DEA technique followed by regression analysis to evaluate the efficiency of Centeral Government-owned Hospitals in Taiwan using pannel data for the years 1990 to 1994. Efficiency was first estimated with DEA using approprate inputs and outputs being specific to the hospitals' operations. A multiple regression model was then used in which the efficiency scores obtained from the DEA computations was used as the dependent variable and a number of hospital operating characteristics were chosen as the explanatory variables. He considered service complexity, occupance rate, proportion of retired veterans and anticpatory impact of National Health Insurance Program (NHI) as explainatory variables. He also included a time trend as one explanatory variable in the model. The result indicated that while the scope of services and proportion of retired veteran patients were negatively and signficantely associated with efficiency, the occupancy rate has a positive and significant impact on efficiency; that is, a high occupancy rate results in a high efficiency. Furthermore, the time cofficient was positive and significant, suggesting that the efficiency performance has improved for the hospitals over time. The study also found a positive relationship between efficiency and anticipated implementation of the National Health Insurance Programme.

In his study on Korean Hospitals, Ehearth(1997) selected 62 hospitals out of 102 general hospitals (which included both private and public) based on a stratified random sampling. The hospitals were rendering about 15 different specialities and all have more than 300 beds. The outputs were divided into 15 kinds of services for 15 specialities. The output for each speciality was measured by an adjusted number of patients, which was defined as a weighted sum of outpatients and inpatients. In the study, one inpatient was considered as equivalent to 2.5 outpatients. The weight, 2.5, was estimated from production cost of the hospital industry, basd on privious studies undrtaken in the country.

He carried out two DEA models assuming (CRS and VRS) followed by regression analysis.

The explanatory variables used to explain the inefficiency in the regression analysis include number of beds and its square, ratio of labor to bed, utilization of expensive technology, ratio of insured patients to total patients, length of stay, ownership and location.

He noted that concerning overall efficiency, 16 hospitals (25.8%) were efficient. Regarding pure technical efficiency, the VRS model indicated 23 hospitals (37.1%) to be efficient. Concerning scale efficiency, 19 hospitals (30.6%) were fond to be scale efficient.

Relative to private hospitals, public hospitals were found to have lower levels of both technical and scale efficiencies.

The result of regeression analysis has shown that lobour intensity, location and the proportion of insured patients were significant factors in determining hospitals' efficiency, while high-tech indicators, ownership, and the proportion of insured patients were more significant variables in explaining the degree of inefficiency among the selected hospitals. The proportion of insured patients was significant variable in both models.

Chilingeria (1995), in a study "Taking DEA inside the Hospital", used DEA methology to evaluate the efficiency of Physicans in a single hospital in the US. Chilngeria first used ratio analysis and then the DEA methodology. In the analysis, he compared the two techniques and found that the DEA analysis were able to identify six best practices and fourteen inefficient physicians that were not detected by the ratio analysis. On the other hand, he found in no cases where DEA evaluated a physician as an inefficient when the ratio analysis identfied to be efficient. He used the Tobit model to evaluate the impact of other catagorical variables on efficiency. He used the DEA scores as the dependent variables and physicians age, physician's sub-speciality institutional affilation[1], and effictiveness scores as explanatory varibles. These variables were coded as dummy varibles (0=30-40 years old, 1= 41+years ; 1= Board Certified subspecialist, 0= internest or general surgeon ; 1= affiliated with HMO, 0=fee-for-service). An effictiveness score was calculated for each physcian by subtracting the number of cases of morbidity and mortality from the total number of cases and dividing by the total number of cases. The DEA scores were transformed into a binary variables, were a DEA score of 100%=1 was coded as « efficient » and a DEA score of less than 100%=0 was coded as « inefficient ». The result showed that the affilation with the HMO was the only significant variable.

Avila (1996) employed Ratio Analysis to evlaluate the performance and efficiency of public hospitals in Mexico. He collected data from 277 public hospitals (PH), which were financed by government, and 260 hospitals owened and operated by the Social Security system (SSH). Input-to-output ratios were computed by combining informations on budget, staffing, hospital activity, capacity, and utilization. Several hospital services were transformed into relative value units of output or "adjusted discharges" to create composite measurements of productivity and efficiency. The analysis found significant difference between Public Hospitals and Social Security Hospitals in operting expenses per bed per day. According to the study, social security hospitals had almost four times higher expense per adjusted discharge than public hospitals. The hospital activity analysis showed lower bed ocupancy in Public Hospitals as

[1]. ***Every physician was either an employee of a local prepaid group practice HMO, or they belong to amore***

compared to Social Security Hospitals as well as lower annual discharges per bed. This study, while it is a simple approach, could be critcized from methodological point of view. The study used Ratio Analysis which considers only single input and single out put or weighted average of inputs and outputs. But, health care production incorporates multiple inputs and outputs. Thus, considering the ratio of single input and output limits the contribution and/or impact of other inputs on the health care out comes.

While numerous studies on health care efficiency has been undertaken in developed countries, the situation in developing counteries particularely in Africa, is different; only very limited number of studies have been under taken. Kirigia et. al. (2000), undertook DEA study on efficiency of public hospitals in Kwazulu-Natal province of South Africa. In this study, hospitals were assumed to produce four types of outputs: inpatient days, outpatient department visits, surgical operations and live births. Nine inputs were included in the computation of efficiency scores: number of medical doctors, number of nurses, number of paramedics, number of technicians, number of adminsterative staff, number of general staff, number of labour provisioning staff, other types of staff, and number of beds. In their study, they run Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) DEA models to evaluate technical and scale efficiency. Their result have shown that 40% of the hospitals had some degree of technical inefficiency and 58% were scale inefficient.They were also able to identify slakes of inputs in the hospitals of Kwazulu-Natal State.
Kirigia et.al., (2000) conducted efficiency analysis in Kenya using DEA methodology on 54 public hospitals. They computed technical efficiency of Hospitals by solving two fractional programming models, under the assumption of constant returns to scale (CRS) and variable returns to scale (VRS).

traditional practice fee-for service.

Out of 54 District Hospitals included in the analysis, 39 (72%) were technically efficient whilst the remaining 15 (28%) were technically inefficient. They pointed out that the technically inefficient hospitals had an average technical efficiency scores of 84% and a standard devation of 15.5%. This implies that on average, they could reduce their utilistion of all inputs by 16% without reducing output. On the other hand, out of the 54 hospitals, 17 (31.5%) of the hospitals were scale inefficient. Their finding suggested that there was room to increase total output by 10.1%.

However, the above two studies did not try to look at other factors which are out of the control of the decision making unit and which could influence efficiency of the health care providing units. These are factors like location of the health care providing unit (urban or rural), size, case complexity (number of service type), etc. Thus, the effects of these variables would have been tested to see their impacts on efficiency using appropriate models.

In the case of Ethiopia, Tadelle and Mohammed (1996) carried out Cost effectiveness and Program evaluation analysis in the health sector of the country. In their study, they identified major program/ interventions practiced in the country, and analysed the factors which influence the sustainable performance of the selected interventions. Furthermore, their study has estimated the cost-effectiveness of most of the interventions.

Their study has shown that the skill of health personnel to be the most important factor, especially in case management of diseases. In their study, they were able to estimate the costs per case i.e, the total amount of money required for a full course treatment of a patient either as an outpatient or as an inpatient. However, their study was mainly based on experties' openion and there could be subjectivity influnce in their results. Moreover, the study only considered Accounting costs without including opportunity costs such as travel and waiting time costs.

Development Studies Associates, (DSA), (1998) conducted cost-efficiency analysis in Ethiopia with the objective of evaluating the actual and normative costs of providing curative and preventive health care services in the country. In their study they considered samples from four regions, which include, Southern Nations, Nationalities and People's Region (SNNPR), Benishangul and Gumuz, Addis Ababa City Administration and Oromia. There were 7 hospitals, 13 health centers and 14 health stations in the study. They further categorized the health centers and health stations as urban and rural.

The costs considered in the study were costs related to health care services, such as outpatient visit, Maternal and Child health (MCH) services, inpatient stay and delivery services. The cost breakdown was further classified as building, equipment and furniture, salaries and benefits and other operational costs. Adjustments have been made for new and repeated patients as well as for outpatients and inpatients. Accordingly, two repeat outpatients were considered as one new outpatient equivalent and four new outpatients were considered as one inpatient equivalent. New patient equivalent (NPE) was used as a basis for calculating per patient costs. In the study, they were able to calculate the average costs for each health services and the maximum and minimum costs required in providing these services across each level of health care units.

Concerning health centers, their study singled out that the operational costs to be the important one and health centers to have higher average costs than the health stations.

The study pointed out that evaluating unit cost of health service in the country appears to be very difficult mainly because of poor health management information system and problems associated with data on health care costs. Nevertheless the study laid ground for cost efficiency study of the health care provision in the country.

CHAPTER FOUR
METHODOLGY

In the preceding chapter, we presented the theoretical and emperical literature on the evaluation of Technical Efficiency, this chapter will present the model on which this study is based, and the type of data used, method of data collection and the variables which are used in this study for estimation purposes discussed.

Comparative performance evaluation is an essential element of the managerial control function. The performance of an organization is usually evaluated with itself over time, or by comparision with other organizations in the same industry. However, performance measurement presents a special challenge to many non-profit organizations because the objectives of such organizations are often less clear-cut than those of profit seeking. Accordingly, the accomplishment of non-profit organizations may be difficult to specify precisely and even more difficult to measure in terms of traditional aggregative performance indicators such as return on investment, residual income, profitability, etc. On the other hand, all health care organizations, just like other commercial or non-profit orgnizations, use resources to provide many types of services. Comparative efficiency assessment of how well inputs are used to produce these services, then, becomes an important issue.

Such efficiency assessment is also important for another two reasons. First, in many countries the state owned sector is the major provider of both commercial and social services, and the issue of whether health care organizations are reasonably efficient is also one of contemporary concern.The state owned sector accounts for substantial employment and investment in many developed as well as developing countries. Therefore, understanding the determinants of efficiency performance of state owned organizations becomes relevant in shedding light on wheather national progress is being sustained or not. Second, the efficiency of health care delivery has become a major concern of policy makers in many countries. One of the main purposes of such reform is to control excessive health care expenses and force health care organizations to search for better utilization of resources (Chang, 1998).

To over come the above mentioned limitations arising from the application of traditional financial performance measures to public health centers, this paper combines Data Envelopment Analysis (DEA), followed by a regression analysis to investigate the main factors that determine the technical efficiency of the health centers. That is, in the first stage efficiency scores are estimated using DEA with appropriate health center-specfic inputs and outputs. Since health care efficiency performance may also be associated with other organizational environmental factors, it is worth while to identify and evaluate factors that are associated with (in)efficiency. Thus, in the second stage, regression models are specified in which the efficiency score obtained from a DEA procedure is the dependent variable and a number of health center operating characteristics included as independent variables. In this case the variable returns to scale DEA result is used as dependent variable.

4.1 The specification of DEA Model

4.1.1 The Constant Returns to Scale (CRS)

The CRS DEA model is used to measures overall efficiency for each of the sample health centers. The objective function is to maximize the efficiency of a health center subject to the constrains that no health center will be more than 100% efficient. Further more, the coefficient values are assumed to be positive and non- zero, when the same set of coefficients (weights) are applied to all other health centers being compared. To define the DEA model,

Let :

h_i : be technical efficiency for health center i.

Y_{ri} : the amount of output r producd by health center i.

X_{ji} : the amount of input j used by health center i.

U_r : the weight given to output r.

V_j : the weight given to input j.

i : indicates n different health centers.

r : indicates the s different outputs.

j : indicates the m different inputs.

U_r and v_j are variables to be estimated.

Under the restriction that each health center's efficiency is judged against its individual weight system, efficiency of a health center can be obtained as a solution to the following problem :

Maximize the efficiency of health center i under the restriction that the efficiency of all units ≤ 1. The algebric model is (for health center k as an example) :

$$Max_{U,V}\, h_k = \frac{\sum_{i=1}^{s} Ur_k Yr_k}{\sum_{j=1}^{m} Vj_k Xj_k} \qquad (1)$$

S.t $\frac{\sum_{r=1}^{s} Ur_i Yr_i}{\sum_{j=1}^{m} Vj_i Xj_i} \leq 1,$ For each unit i

Ur,Vj ≥ o.

Equation 1 is a fractional programming model, and to solve, it needs to convert into linear form. Thus, following Charnes and Cooper's transformation of fractional programming into linear programming the following constraint is introduced. That is,

$$\sum Vj_k Xj_k = 1$$

Thus, the multiplier form of the linear programming problem for health center k become :

$$Maxh_k = \sum_{r=1}^{s} Ur_k Yr_k$$

S.t $\sum_{r=1}^{s} Ur_i Yr_i - \sum_{j=1}^{m} Vj_i Xj_i \leq 0,$ Fro each unit i.

$$\sum_{j=1}^{m} Vj_k Xj_k = 1, \qquad (2)$$

$$Ur, Vj \geq 0$$

4.1.2 The Variable Returns to Scale (VRS) Model

The VRS model, measures pure techchnical efficiency and returns to scale for each of the health centers. A simple relaxation of the assumption of the CRS model enables us to change the CRS model into VRS model. This is done by adding another constraint, convexity constraint, to equation (2) of the CRS model. This convexity constrain is not imposed in the CRS case. Hence, in a CRS-DEA, a firm or a health centr may be « benchmarked »[2] against firms, which are larger (smaller) than it. Thus, the convexity constraint enables a health center to be benchmarked or compared with health center of a similar size. Therefore, the VRS model is:

$$Max \quad h_k = \sum UrYr_h + W_k$$

$$\text{S.t} \quad \sum Ur_i Yr_i - \sum Vj_i Xj_i + W_k \leq 0$$

$$\sum Vj_k Xj_k = 1, \qquad (3)$$

$$Ur, Vj \geq 0$$

$$\sum W_i = 1$$

Where : w_k is the convexity constraint.

Scale efficiency is measured by dividing the CRS efficiency score by the efficiency score of the VRS.

This study uses the "DEAP Version 2.1 Computer program" developed by Coelli (1996) to estimate the DEA equations 2 and 3 in the Model given in this part.

4.2 The Regression Model

The efficiency estimates calculated by DEA are made with the assumption of homogenous operating characterstics. But, each of these may vary from one health center to another and efficiency may be affected by factors represting

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[2] ***Benchmarking is the process of comparing the performance of an individual organization against a benchmark, or ideal, level of performance.***

health center operating characteristics. In order to identify and evaluate the impact of health center-specific factors on efficiency, the efficiency score for each health center, calculated using DEA, is used as the dependent variable in a regression model. This helps to analyze factors, which might be beyond the control of the decision-making unit, and which can possibly give some health centers an advantage or disadvantage compared to other health centers.

Different researchers used different models in the regression part after they run DEA. For example, Chang (1990) used absolute error regression in addition to OLS, in his study of hospital efficiency in Taiwan. Eherth (1997) used Logit and truncated linear regression model, while Chilingerian (1995) employed Tobit model in his study of efficiency of Physicians in Hospital.

The Regression models used in this study are the linear regression (OLS) and Logit models. Since efficiency scores obtained from DEA model are continues between zero and one, OLS regression could be employed. However, efficiency scores are bounded from above at one and OLS regression might produce biased parameter estimates (McCarty et. al., 1993). Thus, to over come the limitation of OLS, Logit model is also used in the analysis.

In the regression model that we estimate, we included four independent variables representing the factors likely to have impact on efficiency performance of health center in the sample. A brief description of the variables and expected relationships is as follows.

Definition of Variables and expected relationships

POP: population of the Presumed catchment area of the health center.

It is expected that as population increases the demand for health care services increases and the health care services are used optimally, which imply that there will be a positive relation ship between technical efficiency and population.

PTPH: Proportion of outpatient treated per medical staff.

As the proportion of outpatient treated per health professional is increasing there is more health care out come with less of labor input and hence technical efficiency is expected to have positive relationship with proportion of patient treated.

AVHU: this is a dummy variable representing availability of public health care unit in the area of the health center. If there is any other health care providing unit in the area, particularly public hospital, it is possible that patients undermine the services given at health center level and less of the services are consumed from the given level of health care inputs.

LOC: is a dummy variable representing the location of the health center, rural or urban.

It is hypothesized that health centers located in small towns or countryside are less sensitive to productivity and people in countryside are expected to demand less of the services relative to those in big towns or cities.

There fore the Linear regression Model, is of the form:

$$E_i = \beta_0 + \beta_1 POP + \beta_2 PTPH + \beta_3 AVHU + \beta_4 LOC + \varepsilon_i \qquad (4)$$

ε_i: is the disturbance term, which is distributed with mean zero and variance δ^2.

Where, E_i is the efficiency score of health center i.

POP = Population of the presumed catchment area of the health Center.

PTPH = Patients treated (new patient equivalent) per health workers Perday[3].

AVHU = Represents the availability of health care unit in the area.

= 1, if Public hospital is available in the area

= 0, otherwise.

LOC = Represent location of the health center.

= 1, if the health center is in urban or big town

= 0, otherwise.

Alternatively, the Logit model is used in order to analyze the effects of the explanatory variables on the probability that a health center is efficient or inefficient. Accordingly, Logit model is derived as follows.

Let Z_i be efficiency score for health center i.

Z_i = 1, if efficiency score = 1

= 0, if efficiency score < 1.

The observed values of Z_i are realizations of a binomial process with Probability:

P_i= Prob (Z_i=1) and 1-Pi= Prob (Z_i=0)

Thus, the likeli hood function is:

$$L = \prod_{i=1}^{n} (1 - Pi)^{1-Zi} Pi^{Zi} \qquad (5)$$

[3] ***In the year under consideration, there were 252 working days.***

Under the assumption that commulative distribution of random error of equation of the type:

$Z_i = \beta' X_i + \gamma_i$, is the Logistic, the model is formulated as:

$$P_i = 1 - F(-\beta' X_i) = \frac{\exp(\beta' X_i)}{1 + \exp(\beta' X_i)} \quad (6)$$

(See Maddala, 1983:22-25)

Where: $Z_i = \alpha_0 + \alpha_1 POP + \alpha_2 PTPH + \alpha_3 AVHU + \alpha_4 LOC + \gamma_i$

F= is function of commutative distribution.

P_i= probability that a health center is efficient.

4.3 The Data

To apply DEA, it is necessary to identify and obtain the data for sets of outputs and inputs relevant to the health care facilities for a common time period of operation. The outputs and inputs are measured in their physical units.

Input and output data were obtained from Addis Ababa City Addminstration and selected Zones of Oromia Regional State Zonal health department offices and in most cases from the health centers record offices. From Oromia, the Health Centers included in the study are from East Shoa, West Shoa, North Shoa and Arsi Zones. The data is for the period between July 2000 to June 2001, (Hamle 1992 to Sene 1993 E.C). There were 14 health centers from Addis Ababa City Adminstration and 26 health centers from selected Zones of Oromia Regional State. Out of these health centers from Oromia, 6 are from East-Shoa Zone, 8 from West-Shoa, 4 from North-Shoa and 8 health centers from Arsi Zone. Overall, there are 40 health centers in the study.

Availability of data and easy assessibility of the areas are the main reason to select these health centers.

In this study, health centers are assumed to produce mainly three outputs: (1) Outpatient casual visits (OPD), (2) MCH visits, and (3) Delivery services. Five inputs were included in the computation of efficiency scores: (1) Doctors and or Health officers, (2) Nurses of all catagories, (3) Health Assistants, (4) Other Technical Staff and (5) Adminstrative staff. In addition to these inputs, Drug supplied to the patients is also used as an input for those health centers were this data was available.

In this study outputs are converted into new patient equivalents (NPE) adopting results from previous study done on unit costs of preventive and cureative health services by Development Studies Associates (1998). Accordingly, two reapted outpatients are considered as one outpatient and one Delivery is considered as equivalent to four New Patient Equivalent.

Detail description of input and output variables is given in Table 4.1.

Table 4.1 Definitions and Description of Variables

Variables	Description
Outputs	
1.Outpatient Department visits(OPD)	New patient Equivalent of outpatients treated in the year.
2.Maternal and Child health services (MCH)	This include New patient equivalent of: Antnatal care, family planing and Immunization services in the year.
3. Delivery Services	Adjusted number of live births in the year.
Inputs	
1. Doctors/ Health officiers	Number of medical doctors and or health officiers
2.Nurses of all category	This include: Staff Nurses, Clinical Nurses, Public Health Nurses, Junior nurses, etc.,
3. Health Assistants	Number of health assistants.
4. Other Technical Staffs	This include: Pharmacists or Druggists, Lab Technicians, Saniterians, etc.,
5. Adminstrative Staff	Subordinate staff which give supportive services.
6. Drug Supplied	Value of Drug supplied in Birr at the Health Centers in the year.

- **Data on the drug supplied is available only for 29 Health Centers.**

The summary of sample statistics is shown in Table 4.2 . The average adjusted number of patients treated per year consists of 22,722 outpatients, 18,964 MCH services and 1780.2 (NPE) Live Births.

The average medical staff include 2 physicians, 11.53 Nurses, 7.75 Health Assistants and 5.6 Other Technical staff. The average number of Adminsterative staff for the sample is 17.18. The average value of Drug supplied is 101,382.90. Out of the health centers in the sample about 50% are located in urban areas (in large towns or cities), and 50% are located in rurals or small towns.

Table 4.2: Summary statistics of inputs and outputs

Category of Variable	Mean	Standard Deviation	Minimum	Maximum
Inputs				
Doctors/Health Officers	2.0	1.198	1	7
Nurses	11.53	4.777	3	25
Health Assistants	7.75	3.848	1	16
Other Technical Staff	5.6	2.351	1	11
Drug Supplied in Birr	101382.9	51776.25	17729.85	224370.22
Administrative Staff	17.175	6.097	7	30
Outputs				
OPD casual visits (NPE)	22722.1	14,174.10	3848	61,476
MCH visits (NPE)	18,964.2	11,486.66	3,177	49,836
Delivery services	1780.2	1485.07	196	5780

- **Output values are in New Patient Equivalent (NPE).**

CHAPTER-5

EMPERICAL RESULTS

In this section results on technical and scale efficiency of the health centers obtained from the two DEA models is presented. Furthermore, factors affecting the level of technical efficiency are discussed based on the results from the regression analysis.

5.1 DEA RESULTS

Technical and Scale efficiency scores for each health centers is given in Table 5.1. It is important to recall that efficiency scores range between 1 (efficient) and 0 (totally inefficient).

With respect to overall efficiency, the CRS model showed that 16 health centers (40%) were efficient and 24 (60%) were inefficient. This result indicates that there is severe technical inefficiency in the health centers under consideration. Regarding pure technical efficiency, the VRS model found 27 health centers (67.5%) efficient and the remaining 13 health centers (32.5%) inefficient. The scale efficiency scores indicate that 16 health centers (40%) are scale efficient, which means that 24 health centers (60%) are scale inefficient.

Table- 5.1: Technical and Scale efficiency Scores

Region/ Zone	Health center	Constant Returns to Scale	Variable Returns to Scale	Scale Efficiency	Scale♦
Oromia					
East Shoa Zone	Adaa	1.000	1.000	1.000	CRS
	Adama	0.807	0.828	0.975	DRS
	Meki	0.780	1.000	0.780	IRS
	Mojo	0.818	0.930	0.879	IRS
	Siraro	0.693	1.000	0.693	IRS
	Zeway	1.000	1.000	1.000	CRS
West Shoa Zone	Gindo	0.490	1.000	0.490	IRS
	Holota	1.000	1.000	1.000	CRS
	Ijaji	0.682	0.899	0.758	IRS
	Jaldu	0.446	1.000	0.446	IRS
	Leman	0.312	0.750	0.416	IRS
	Shanan	0.976	1.000	0.976	CRS
	Tulubolo	0.419	0.822	0.510	IRS
	Walliso	1.000	1.000	1.000	CRS
North Shoa Zone	Chancho	0.568	1.000	0.568	IRS
	Gabraguracha	1.000	1.000	1.000	CRS
	Gundomeskel	1.000	1.000	1.000	CRS
	Gohatsion	0.872	1.000	0.872	IRS
Arsi Zone	Addis Hiwot	1.000	1.000	1.000	CRS
	Abomssa	1.000	1.000	1.000	CRS
	Asella	0.525	0.570	0.922	IRS
	Bokoji	0.615	1.000	0.615	IRS
	Dera	0.806	1.000	0.806	IRS
	Gobessa	0.799	1.000	0.799	IRS
	Robe	0.567	1.000	0.567	IRS
	Sagure	0.602	0.749	0.804	IRS
Addis Ababa					
Zone-1	Addisketema	1.000	1.000	1.000	CRS
	Tekelehamant	0.950	0.959	0.990	DRS
Zone-2	Woreda-22	0.923	0.952	0.969	IRS
	Wored-23	1.000	1.000	1.000	CRS
Zone-3	Woreda-17	0.912	0.929	0.981	DRS
	Woreda-18	0.655	0.685	0.957	IRS
	Woreda-19	1.000	1.000	1.000	CRS
Zone-4	Entoto	0.447	0.548	0.815	IRS
	Gullale	1.000	1.000	1.000	CRS
	Shiromeda	1.000	1.000	1.000	CRS
	Woreda-13	0.776	0.814	0.953	IRS
	Yeka	1.000	1.000	1.000	CRS
Zone-5	Woreda-25	1.000	1.000	1.000	CRS
Zone-6	Woreda-26	1.000	1.000	1.000	CRS
Mean		0.811	0.936	0.864	

♦
CRS = Constant returns to scale:
IRS = Increasing returns to scale
DRS = Decreasoing returns to scale

Among the inefficient health centers 1 (4.2%) has a technical efficiency between 31-40 %, 4 (16.7%) between 41-50 %, 3 (12.5%) between 51-60%, 5 (20.8%) between 61-70%, 3 (12.5%) between 71-80%, 4 (16.7%) between 81-90%, and 4 (16.7%) between 91-99%. The inefficient health centers have an average technical efficiency score of 68.5%. This implies that on average they could reduce their utilization of all inputs by 31.5% without reducing outputs. The meaning of the inefficient rating derived from DEA can be understood by examining the result of specific health center. For instance, consider Leman health center with pure technical efficiency score of 0.750, this health center is technically inefficient. This means that Leman health center should be able to produce its actual outputs level using 25% ((1.00-0.750)×100) less of each input. The same holds for other inefficient health centers depending on their efficiency scores.

Table-5.2: Summary of Efficiency score

	Overall Technical Efficiency (CRS)	**Pure Technical Efficiency (VRS)**	**Scale Efficiency (CRS/VRS)**
Mean	0811	0.936	0.864
S.D	0.212	0.121	0.184
Minimum	0.312	0.548	0.416
Maximum	1.000	1.000	1.000
Health Centers On frontier	40%	67.5%	40%

The average overall technical efficiency score for the entire sample is 0.811, for pure technical efficiency is 0.936 and for scale efficiency is 0.864 (Tab 5.2). The minimum score for overall technical efficiency in the sample is 0.312 this means this health center could reduce all its inputs by about 68.8% without reducing existing level of outputs.

Of the 40 health centers in the data set, 16 exhibit constant returns to scale (CRS); which means they are operating at their most productive scales. Of the remaining health centers, 21 exhibit increasing returns to scale (IRS) and 3 operating under decreasing returns to scale (DRS). Thus, in total twenty-four health centers have some degree of scale inefficiency.

Out of the 40 health centers considered, 3 (7.5%) have a scale efficiency score 41-50%, 3 (7.5%) between 51-60%, 2 (5%) between 61-70%, 3 (7.5%) between 71-80%, 5 (12.5%) between 81-90%, 8 (20%) between 91-99%, and 16 (40%) about 100%. 24 (60) of the health centers were scale inefficient, meaning their scale efficiency score was less than unity. This implies that these health centers are not operating at most productive scale size for their observed input mix. In order to operate at most productive scale size, a health center exhibiting decreasing returns to scale should scale down both outputs and inputs. Similarly, those health centers showing increasing returns to scale should expand both outputs and inputs so as to be efficient.

The average scale efficiency score in the whole sample was 86.4% (with standard deviation of 0.203); implying that there is a potential to increase total output by 13.6%.

Table-5.3 Returns to Scale

	Increasing Returns to Scale	**Constant Returns to Scale**	**Decreasing Returns to Scale**
No of Health Centers	21	16	3
(%)	52.5%	40%	7.5%

From the efficiency scores, we find that scale inefficiency is also one of the main factors, which reduces overall efficiency of the health centers. For instance, Gindo health center has an overall technical efficiency score of 0.490 (Table 5.1), which is quite low, while its pure technical efficiency score from VRS DEA result is 1.000. That is, the health center is technically efficient but scale inefficient. Thus, for most health centers, their scale inefficiency has contributed to the overall technical inefficiency.

Comparing the health centers of the two regions, on average the health centers from Addis Ababa City Administration are relatively efficient, both in scale and technically.

Among the health centers considered from Oromia Zones, only 30.8% are technically efficient, and 30.8% are scale efficient. This means, about 69.2% of the health centers included from this Region in the sample are both technically and scale inefficient. While, among health centers from Addis Ababa City Administration, about 57.1% are technically efficient and 57.1% are scale efficient (Table 5.4). The average technical and scale efficiency scores for health centers from Addis Ababa are 0.905 (90.5%), 0.976 (97.6%), respectively. On average they are close to being efficient. But, in case of health centers from Oromia Zones, the technical efficiency score is 0.761 (76.1%) and scale efficiency score is 0.803 (80.3%). That is, on average these health centers could reduce their inputs by 23.9% without affecting their level of outputs and improve their scale of operation by 19.7%, respectively. The minimum technical efficiency score in the entire sample is also observed in one of the health centers from Oromia Zones, which is 0.312.

Table- 5.4 Efficiency Score of Health Centers in Addis Ababa and selected Zones of Oromia

Health Centers in Oromia (n=26)	**Overall Technical Efficiency (CRS)**	**Pure Technical Efficiency (VRS)**	**Scale Efficiency**
Mean	0.761	0.944	0.803
S.D	0.219	0.111	0.201
Minimum	0.312	0.570	0.416
Maximum	1.000	1.000	1.000
Health Centers on frontier	30.8%	73.1%	30.8%
Health Centers in Addis Ababa (n=14)	**Overall Technical Efficiency (CRS)**	**Pure Technical Efficiency (VRS)**	**Scale Efficiency**
Mean	0.905	0.921	0.976
S.D	0.167	0.141	0.049
Minimum	0.447	0.548	0.815
Maximum	1.000	1.000	1.000
Health Centers on frontier	57.1%	57.1%	57.1%

Comparing health centers from urban areas with those in rural areas, those health centers in urban areas are relatively efficient both in scale and technically (Table-5.5). From 40 health centers in the data set, 20 (50%) are located in urban areas and the rest 20 (50%) in the rural areas. Thus, in the urban areas, 12 (60%) of them are technically efficient and 12 (60%) are scale efficient. While, among the health centers in the rural areas, only about 4 (20%) are technically efficient and 4 (20%) are scale efficient.

Therefore, from DEA results we can observe that there is big difference in technical efficiency between health centers in urban and rural areas.

Table-5.5: Efficiency Scores of health centers in Urban and Rural areas

Health Centers in Urban areas (n=20)	**Overall Technical Efficiency**	**Pure Technical Efficiency**	**Scale Efficiency**
Mean	0.900	0.914	0.978
S.D	0.170	0.147	0.044
Minimum	0.447	0.548	0.815
Maximum	1.000	1.000	1.000
Health Centers on Frontier	60%	60%	60%
Health Centers in Rural areas (n=20)	**Overall Technical Efficiency**	**Pure Technical Efficiency**	**Scale Efficiency**
Mean	0.722	0.958	0.749
S.D	0.216	0.085	0.196
Minimum	0.282	0.629	0.200
Maximum	1.000	1.000	1.000
Health centers on the Frontier	20%	75%	20%

DEA result has demonstrated that 60% of the health centers were run inefficiently; and they need to either reduce their inputs or increase their output in order to become efficient (table-5.6). The presence of inefficiency indicates that a health center has excess inputs or insufficient outputs compared to those health centers on the frontier. The specific amount of input reduction required to make inefficient health centers technically efficient is listed in Appendex-2.

Table- 5.6: Input reduction and/ or Output increases needed to make inefficient Public Health Centers under consideration efficient.

Type of variable	Category of variable	Number
Inputs	Doctors/Health officers	6
	Nurses	29
	Health Assistants	30
	Other Technical Staffs	27
	Administrative staff	48
Outputs	OPD (NPE) causal visits	40840
	MCH (NPE) visits	91607
	Delivery (NPE) services	5947

Based on the DEA results, overall, the following inputs are currently wasted and not utilized in the production of health centers outputs in the public health centers considered. These include 6 Doctors/Health officers (7.5%); 29 Nurses (6.29%); 30 Health Assistants (9.68%); 27 Other Technical staff (11.49%) and 48 Administrative staffs (6.94%). These are the specific input reductions required as a whole to make inefficient health centers become technically efficient.

One of the inputs in health care services is the Drug supplied to the patients. This input could be considered as proxy for capital input in the case of health care services at health center level. Computing DEA models using the Drug supplied as one of the inputs for those health centers, for which this data was available, gives the following results (Table-5.7).

Table-5.7: Technical and Scale Efficiency Scores when data on Drug Supplied is included

REGION/ZONE	Health Center	Constant Returns to Scale	Variable Returns to scale	Scale Efficiency	Scale
Oromia					
EastShoa Zone	Adaa	1.000	1.000	1.000	CRS
	Adama	0.807	0.828	0.975	DRS
	Meki	0.781	1.000	0.781	IRS
	Mojo	0.974	1.000	0.974	IRS
	Siraro	0.745	1.000	0.745	IRS
	Zeway	1.00	1.000	1.000	CRS
North Shoa	Chancho	0.568	1.000	0.568	IRS
	Gebraguracha	1.000	1.000	1.000	CRS
	Gundomeskel	1.000	1.000	1.000	CRS
	Gohatsion	0.872	1.000	0.872	IRS
Arsi Zone	Addis Hiwot	1.000	1.000	1.000	CRS
	Abomssa	1.000	1.000	1.000	CRS
	Asella	0.528	0.570	0.927	IRS
	Bekoji	0.615	1.000	0.615	IRS
	Dera	0.806	1.000	0.806	IRS
	Gobessa	0.805	1.000	0.805	IRS
	Robe	0.567	1.000	0.567	IRS
	Sagure	0.620	0.749	0.828	IRS
AddisAbaba City Administration					
Zone-1	Addis Ketema	1.000	1.000	1.000	CRS
	Teklehamanot	1.000	1.000	1.000	CRS
Zone-2	Woreda-22	1.000	1.000	1.000	CRS
Zone-3	Woreda-17	1.000	1.000	1.000	CRS
	Woreda-18	0.760	0.866	0.878	IRS
	Woreda-19	1.000	1.000	1.000	CRS
Zone-4	Entoto	0.454	0.558	0.813	IRS
	Gullale	1.000	1.000	1.000	CRS
	Shiromeda	1.000	1.000	1.000	CRS
	Woreda-13	0.782	0.824	0.949	IRS
	Yeka	1.000	1.000	1.000	CRS
Mean		0.851	0.945	0.900	

Out of 29 health centers in the data set, 14 (48.3%) are technically efficient and 14 (48.3%) are scale efficient. This means 51.7% of the health centers are both technically and scale inefficient.

The mean technical efficiency is 0.851, which means that these health centers could produce the same level of outputs using 14.9% less of each input.

Comparing the technical efficiency results of the health centers before including the value of Drug supplied, as input with the results after this input is included; those health centers which were efficient before are still efficient, while the efficiency of some health centers have been improved after including the Drug supplied as an input. For instance, health centers like Gebraguracha, Abomssa from Oromia and Tekelehamanot, Woreda-22, and Woreda-17 from Addis Ababa become efficient after including this input. Thus, had this data been available for all health centers under consideration the efficiency of the health centers would have been improved.

TABLE-5.8: SUMMARY OF EFFICIENCY SCORE FOR HEALTH CENTERS WITH DATA ON DRUG SUPPLIED

n=29	Overall Technical Efficiency (CRS)	Pure Technical Efficiency	Scale Efficiency
Mean	0.851	0.945	0.900
S.D	0.179	0.124	0.137
Minimum	0.454	0.558	0.567
Maximum	1.000	1.000	1.000
Health Centers on frontier	48.3%	79.3%	48.3%

5.2 Factors affecting health center efficiency

The empirical results from linear regression (OLS) and Logit using the efficiency scores from DEA model as the dependent variable is presented in Table 5.9. Except, the variable for population (POP), the signs of other variables are consistent with what is anticipated. Among the variables, proportion of patients treated per health professionals (PTPH) is significant in both models. This could be used as proxy for labor intensity in the health centers. That is, as more of patients are treated with a given level of health professionals or labor input technical efficiency also increases or vice versa.

Similarly, location of health centers is significant in both models. With regared to the Logit model, this indicates the probability that health centers in the cities (large towns) are efficient than the probability in rural areas or small towns by 18.89%. This result is in agreement with the results obtained from DEA models. That is, among inefficient health centers from the DEA results, most of them are from rural areas. That is, out of 24 technically inefficient health centers, 16 (66.7%) are located in rural areas (small towns).

Table 5.9 Estimation results for linear regression and Logit models

Variables	Coefficient estimates	
	OLS	**Logit**
Constant	0.8417 (15.258)♦	-5.0370 (-2.164)♦♦♦
POP	-6.46×10^{-7} (-2.626)	-0.0002 (-1.550)
PTPH	0.02745 (3.987)♦	1.3359 (2.814)♦
AVHU	-0.1060 (-1.868)♦♦♦	-20.1374 (-2.132)♦♦
LOC	0.0705 (2.245)♦♦	18.8913 (5.347)♦
χ^2 (4)		30.01
R^2	0.49	

Numbers in parentheses are t and z values
♦: Significant at the 1% level.
♦♦: Significant at the 5% level.
♦♦♦: Significant at the 10% level
n=40

The negative coefficient for availability of health care providing unit (Hospital) in the area of the health center supports the hypothesis that availability of Public hospital in the area reduces technical efficiency of the health centers. This variable is highly significant in the Logit model. It is also significant in OLS at 10% significant level.

In such cases, enforcing Referral system could improve the efficiency of primary health care units.

In both models, population has negative relationship with technical efficiency, though it is insignificant. However, the insignificance of this variable does not necessarily mean that it has no effect on technical efficiency. It may simply mean that this variable is poor proxy for technical efficiency.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study was conducted with the prime objective of investigating the level of technical inefficiencies in Public health centers, particularly in Addis Ababa City Administration and health centers from selected Zones of Oromia Region. The study used non- parametric DEA technique followed by linear regression and Logit analysis to examine the factors that influence the efficiency of the sampled health centers.

Technical and scale efficiencies for each 40 health centers are examined.
In the analysis, the Constant returns to scale DEA model has demonstrated that 60% of the health centers considered are technically inefficient; and they need either reduce inputs or increase their outputs in order to become efficient. The presence of inefficiencies indicates that a health center has excess inputs or insufficient outputs compared to those health centers on the efficient frontier.

Furthermore, results from variable returns to scale DEA model has shown that, out of 40 health centers, 24 (60%) are scale inefficient. This implies that either they have to scale up or down their operation depending whether they are operating in increasing returns to scale or decreasing returns to scale, respectively, so as to operate at optimum scale. Based on scale efficiency score, out of 24 scale inefficient health centers, 21 are operating in increasing returns to scale and hence have to increase their scale of operation and the remaining 3 health centers are operating at decreasing returns to scale.

The results from the DEA models have also shown the total amount of specific inputs that are currently wasted and not utilized in the production of health care outputs in the health centers. Thus, overall about 6 physicians, 29 nurses, 30 health assistants, 27 technical staff, and 48 administrative staff are the specific inputs required to make inefficient health centers efficient.

Results from the OLS and Logit analysis indicated that location of the health centers have important impact on level of technical efficiency. Based on the regression result, health centers located in urban areas (big towns or cities) perform better than those in rural (or small towns). This is also reflected in the DEA results as well. That is; at most those health centers in rural areas have found to have efficiency scores less than unity. The other important variable affecting technical efficiency of the health center found from the result is availability of public hospital in the area. The results indicated that the availability of hospital in the area negatively affects the technical efficiency of health centers. This could be because of the preference of the people for treatment at higher level than at primary health care.

6.2 Recommendations

Given the limited health care resources in the country, it is important to understand the level and causes of inefficiencies in the health care system. This enables to improve the utilization of health care services and appropriate health care resource allocation. To this end, the above results will be useful in providing relevant evidences for health care managers in the regions where the health centers are located. Nevertheless, under the given limitation of the study, which was explained in the previous part, it would not be worthwhile to provide conclusive policy recommendations. However, some general policy options could be forwarded. Thus, depending on the results from DEA and regression analysis, the following are possible policy options available to the Regional health system managers:

1. Excess health professionals may be used in other primary health care units such as health posts or may be transferred to peripheral areas.
2. Excess Administrative staff could also be used in other alternative areas.
3. Health centers located in rural areas are found to be less efficient than those in the urban areas. In line with this, the existing Government policies, which give more attention to rural areas, need to be strengthening in order to improve the efficiencies of the health centers. This could be through proper allocation of health care personnel, giving incentives for health workers in remote areas etc.

4. The health care provision in the Country is organized based on referral system. But, the referral system is poorly implemented and this causes resource losses at primary health care level. Thus, to improve technical efficiency of primary health care units (health centers), it is important that the referral system is enforced.

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Appendex-1

Data on Health Centers outputs and Inputs

Data on Health Centers outputs

OROMIA REGION

No.	Health Center	OPD			MCH				
		New	Repeat	NPE	Antenatal				
					New	Repeat	NPE	New	Re
1	Adaa (Bishoftu)	17037	9072	21573	5024	10660	10354	4452	24
2	Adama (Naz.)	15666	19439	25386	1291	3861	3222	2403	2
3	Meki	7391	11743	13263	1586	1296	2234	1408	2
4	Mojo	10880	11147	16454	2840	5535	5608	2687	2.
5	Siraro (Aje)	8816	10598	14115	1556	675	2585	153	1
6	Zeway	20495	21506	31248	4583	5859	7513	1266	9
	West Shoa								
7	Gindo	2427	2842	3848	710	850	1135	397	4
8	Holota	12521	11730	18386	2174	3570	3959	1168	5
9	Ijaji	6620	7741	10491	1475	2689	2820	699	1
10	Jaldu	5461	10860	10891	820	1014	1327	1215	7
11	Leman	3635	4090	5680	240	412	446	993	8
12	Shanan	3717	3882	5658	831	1036	1349	311	1
13	Tulubolo	4913	6695	8261	856	1475	1594	1155	6
14	Woliso	109159	19697	20764	2224	4623	4536	1346	3
	North Shoa								
15	Chancho	5526	11424	11238	941	1146	1514	1753	2
16	Gebragunacha	6514	24137	18583	1256	1496	2004	1152	1
17	Gundomeskel (Derra)	5078	11722	10969	375	232	491	7185	9
18	**GOHATSION**	4333	11335	10001	874	1083	1416	663	1
	Arsi Zone								
19	Addis Hiwot	12732	11496	18480	646	643	968	584	1
20	Abomssa	18844	23078	30381	964	813	1371	780	3
21	Asella	13212	13985	20205	2397	3065	3930	889	9
22	Bekoji	6546	13819	13456	1055	888	1499	919	2
23	Dera	10875	14608	18179	1534	3331	3200	1140	3
24	Gobessa	7693	10718	13052	1424	1331	2090	1024	1
25	Robe	8717	9104	13269	1630	1482	2371	2103	5
26	Sagure	10877	8522	15135	890	792	1286	829	4

Health Centers outputs
Addis Ababa City Administration

	Health Center	OPD			ANTENATAL			F/P	
		New	Repeat	NPE	New	Repeat	NPE	New	Repeat
27	Addis Ketema	30062	52608	56366	4055	7094	7602	10273	17976
28	Teklehamanot	19447	34034	36464	2726	4772	5112	4296	7518
29	Worda-22 (Lideta)	5170	9046	9693	1034	1873	1971	304	1984
30	Woredsa-23 (Mekanessa)	24055	18635	33373	2555	9424	7267	4389	14217
31	Woreda-17	25616	21973	36603	2817	8874	7254	3580	8474
32	Woreda-18	13623	23842	25544	2512	4398	4711	2982	5220
33	Worda-19	26069	22589	37364	1693	8152	5769	1638	14742
34	Entoto	11404	19958	21383	1640	2870	3075	1526	2670
35	Gullale	25360	44378	47549	3398	5946	6371	5184	9074
36	Shiromeda	32787	57378	61476	2512	4396	4710	5054	8844
37	Woreda-13	22040	29386	36733	1858	3250	3483	1282	2242
38	Yeka	24005	42010	45010	2512	4396	4710	5270	9224
39	Woreda-25	24108	35949	42083	2357	10410	7562	1415	14903
40	Woreda-26	12267	16160	20347	1384	4497	2633	1835	15707

Data on Health Centers Inputs

Health Center	Doctors/ Health officers	Nurses	Health Assistants	Other Technical staff	Administrative staff	Value of Drug supplied in Birr
Oromia						
East-Shoa						
Adaa	***1***	***12***	***10***	***6***	***13***	***27,680.35***
Adama	***2***	***17***	***14***	***8***	***15***	***60,862.95***
Meki	***1***	***11***	***6***	***5***	***7***	***29,565.30***
Mojo	***3***	***14***	***12***	***5***	***10***	***17,729.85***
Siraro	***1***	***11***	***3***	***5***	***12***	***39,897.66***
Zeway	***2***	***11***	***8***	***8***	***10***	***50,062.65***
West-Shoa						
Gindo	***1***	***8***	***2***	***3***	***13***	***……***
Holota	***3***	***9***	***6***	***4***	***21***	***…..***
Ijaji	***2***	***7***	***5***	***4***	***13***	***…..***
Jaldu	***1***	***10***	***10***	***5***	***13***	***…..***
Leman	***2***	***6***	***3***	***3***	***21***	***…..***
Shanan	***1***	***7***	***1***	***1***	***13***	***……***
Tulubolo	***3***	***7***	***6***	***4***	***13***	***…..***
Waliso	***7***	***6***	***6***	***7***	***13***	***…….***
North-Shoa						
Chancho	***1***	***10***	***8***	***4***	***13***	***89,434.86***
Gabraguracha	***2***	***10***	***3***	***6***	***11***	***74,952.92***
Gundomeskel	***1***	***7***	***5***	***3***	***10***	***80,963.26***
Gohatsion	***1***	***12***	***3***	***5***	***12***	***45,457.30***
Arsi-zone						
Addis Hiwot	***1***	***3***	***3***	***2***	***13***	***110,983.71***
Abomsa	***1***	***11***	***7***	***8***	***16***	***131,918.19***
Asella	***3***	***10***	***11***	***6***	***21***	***224,370.22***
Bokoji	***1***	***7***	***5***	***6***	***16***	***153,949.73***
Dera	***1***	***8***	***4***	***10***	***15***	***130,430.48***
Gobesa	***1***	***4***	***6***	***4***	***11***	***152,287.89***
Robe	***1***	***10***	***9***	***7***	***16***	***182,279.79***
Sagure	***2***	***6***	***7***	***9***	***15***	***206,147.20***
Addis Ababa						
Zone-1						
Addis Ketema	***3***	***17***	***16***	***4***	***24***	***93,882.10***
Tekelehamanot	***2***	***13***	***9***	***5***	***27***	***103,212.55***
Zone-2						
Woreda-22	***2***	***17***	***8***	***3***	***26***	***91,603.50***
Woreda-23	***3***	***14***	***11***	***8***	***29***	***……***
Zone-3						
Woreda-17	***3***	***25***	***12***	***4***	***24***	***146,783.35***

Woreda-18	***2***	***20***	***14***	***4***	***27***	***88,486.60***
Woreda-19	***3***	***15***	***14***	***5***	***21***	***83,947.80***
Zone-4						
Entoto	***3***	***13***	***10***	***8***	***21***	***124,893.70***
Gulalle	***2***	***16***	***7***	***11***	***24***	***115,375.18***
Shiromeda	***3***	***14***	***10***	***8***	***22***	***121,436.89***
Woreda-13	***3***	***13***	***10***	***8***	***21***	***96,165.50***
Yeka	***2***	***14***	***10***	***10***	***23***	***65,343.55***
Zone-5						
Woreda-25	***3***	***14***	***13***	***5***	***30***	***……***
Zone-6						
Woreda-26	***1***	***22***	***4***	***3***	***12***	***……***

……= Data is not avilable

Appendex-2: Summary of Input and Output Slacks

Summary of output slacks

Health Center	OPD	MCH	DELIVERY
ADAA	0.000	0.000	0.000
ADAMA	0.000	0.000	1764.814
Meki	0.000	0.000	0.000
Mojo	0.000	0.000	0.000
Siraro	0.000	4003.593	525.898
Zeway	0.000	0.000	0.000
Gindo	3366.240	0.000	451.721
Holeta	0.000	0.000	0.000
Ijaji	7018.640	0.000	0.000
Jaldu	1003.420	25338.868	490.244
Leman	7991.750	2547.375	440.000
Shanan	0.000	0.000	0.000
Tulubolo	6664.401	4942.056	0.000
Waliso	0.000	0.000	0.000
Chancho	0.000	23960.831	56.470
Garbaguracha	0.000	0.000	0.000
Gundomeskel	0.000	0.000	0.000
Gohatsion	0.000	0.000	735.085
Addishiwot	0.000	0.000	0.000
Abomsa	0.000	0.000	0.000
Asella	0.000	0.000	426.437
Bokoji	2987.852	0.000	330.154
Dera	0.000	0.000	528.813
Gobessa	0.000	0.000	0.000
Robe	0.000	0.000	112.961
Sagure	0.000	0.000	84.360
Addis Ketema	0.000	0.000	0.000
Tekelehamonot	0.000	4314.153	0.000
Wored-22	7452.347	7235.632	0.000
Woreda-23	0.000	0.000	0.000
Woreda-17	4355.588	0.000	0.000
Woreda-18	0.000	1250.529	0.000
Woreda-19	0.000	0.000	0.000
Entoto	0.000	5438.911	0.000
Gulalle	0.000	0.000	0.000
Shiromeda	0.000	0.000	0.000
Woreda-13	0.000	12575.070	0.000
Yeka	0.000	0.000	0.000
Woreda-25	0.000	0.000	0.000
Woreda-26	0.000	0.000	0.000
mean	1021.006	2290.175	148.674

Summary of input slacks

Health Center	Doctors / Health Officers	Nurses	Health Assistants	Other Technical Staff	Administrative Staff
ADAA	0.000	0.000	0.000	0.000	0.000
ADAMA	0.321	2.293	2.145	0.008	0.000
Meki	0.000	0.000	0.000	0.000	0.000
Mojo	1.676	1.381	5.124	0.000	0.000
Siraro	0.000	5.522	0.000	2.744	0.051
Zeway	0.000	0.000	0.000	0.000	0.000
Gindo	0.000	0.561	0.140	1.364	0.912
Holeta	0.000	0.000	0.000	0.000	0.000
Ijaji	0.000	0.000	0.000	0.080	0.000
Jaldu	0.000	2.683	4.571	1.341	3.488
Leman	0.500	0.000	0.000	0.625	2.750
Shanan	0.000	0.000	0.000	0.000	0.000
Tulubolo	1.465	0.000	0.280	0.000	0.000
Waliso	0.000	0.000	0.000	0.000	0.000
Chancho	0.000	2.931	3.009	0.939	3.052
Garbaguracha	0.000	0.000	0.000	0.000	0.000
Gundomeskel	0.000	0.000	0.000	0.000	0.000
Gohatsion	0.000	2.351	0.083	2.892	0.332
Addishiwot	0.000	0.000	0.000	0.000	0.000
Abomsa	0.000	0.000	0.000	0.000	0.000
Asella	0.486	0.000	1.656	0.000	0.000
Bokoji	0.000	1.928	1.377	3.365	4.406
Dera	0.000	0.892	0.446	7.517	2.478
Gobessa	0.000	0.000	0.000	0.000	0.000
Robe	0.000	3.777	3.405	3.051	6.043
Sagure	0.460	0.000	0.000	3.097	0.000
Addis Ketema	0.000	0.000	0.000	0.000	0.000
Tekelehamonot	0.000	0.000	0.000	0.000	6.650
Wored-22	0.442	0.000	3.717	0.000	10.493
Woreda-23	0.000	0.000	0.000	0.000	0.000
Woreda-17	0.645	4.632	0.000	0.000	3.408
Woreda-18	0.000	0.000	3.890	0.000	3.882
Woreda-19	0.000	0.000	0.000	0.000	0.000
Entoto	0.000	0.000	0.350	0.000	0.000
Gulalle	0.000	0.000	0.000	0.000	0.000
Shiromeda	0.000	0.000	0.000	0.000	0.000
Woreda-13	0.000	0.000	0.000	0.000	0.000
Yeka	0.000	0.000	0.000	0.000	0.000
Woreda-25	0.000	0.000	0.000	0.000	0.000
Woreda-26	0.000	0.000	0.000	0.000	0.000
mean	0.150	0.724	0.755	0.676	1.199

Appendex-3: Population of the Presumed Catchment Area of the Health Centers
Oromia Region

No	Health Center	Population
	East Shoa	
1	Adaa (Bishoftu)	262,960
2	Adama (Naz.)	306,110
3	Meki	152,263
4	Mojo	106,385
5	Siraro (Aje)	203,139
6	Zeway	128,102
	West Shoa	
7	Gindo	98,102
8	Holota	124,215
9	Ijaji	191,646
10	Jaldu	165,092
11	Leman	103,344
12	Shanan	104,420
13	Tulubolo	59,355
14	Woliso	206,621
	North Shoa	
15	Chancho	154,213
16	Geberaguracha	114,195
17	Gundomeskel (Derra)	159,844
18	Gohatsion	131,252
	Arsi Zone	
19	Addis Hiwot	105,061
20	Abomssa	111,050
21	Asella	241,136
22	Bekoji	196,077
23	Dera	127,077
24	Gobessa	137,255
25	Robe	268,673
26	Sagure	123,110

Addis Ababa City Administration

	Health Center	Population
	Zone-1	
27	Addis Ketema	94,755
28	Tekelhamanot	107,008
	Zone-2	
29	Woreda-22	47,619
30	Woreda-23	136,768
	Zone-3	
31	Woreda-17	168,745
32	Woreda-18	80,425
33	Woreda-19	155,424
	Zone-4	
34	Entoto	120,781
35	Gullale	136,843
36	Shiromeda	112,272
37	Woreda-13	77,087
38	Yeka	86,650
	Zone-5	
39	Woreda-25	105,021
	Zone-6	
40	Woreda-26	57,111