TECHNICAL EFFICIENCY OF PUBLIC INSURANCE HEALTH CENTERS IN GEZIRA STATE OF SUDAN

Mr. Almoghirah. A. G. Abdellah

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Health Economics and Health Care Management
Faculty of Economics
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ประสิทธิภาพเชิงเทคนิคของศูนย์สุขภาพภายใต้การประกันภาครัฐในรัฐกาซีร่า ประเทศซูดาน

นายอัลโมกีร่าห์ เอ. จี. อับเดลลา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาเศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ
คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
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By	Mr. Almoghirah A.G Abdellah
Field of Study	Health Economics and Health Care Management
Thesis Advisor	Associate Professor Sothitorn Mallikamas, Ph.D.

Accepted by the Faculty of Economics, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

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อัลโมกีร่าห์ อับเดลลา: ประสิทธิภาพเชิงเทคนิคของศูนย์สุขภาพภายใต้การประกันภาครัฐในรัฐกาซีร่า ประเทศซูดาน. (TECHNICAL EFFICIENCY OF PUBLIC INSURANCE HEALTH CENTERS IN GEZIRA STATE OF SUDAN) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. โสตถิธร มัลลิกะมาส, 67 หน้า.

การศึกษานี้มีจุดประสงค์ในการวัดประสิทธิภาพทางเทคนิค (การได้ผลผลิตที่มากที่สุดจากทรัพยากรที่มีอยู่) ของศูนย์สุขภาพระดับปฐมภูมิภายใต้ระบบประกันภัยทางตรงจำนวน 31 แห่ง และระบบประกันทางอ้อมจำนวน 57 แห่ง ใน รัฐกีซิร่าประเทศซูดาน และศึกษาปัจจัยกำหนดประสิทธิภาพทางเทคนิคของทั้ง 2 แบบ ในขั้นแรกอาศัยแบบจำลอง Input Orientated Data Envelopment Analysis ในการวิเคราะห์ของประสิทธิภาพทางเทคนิคของทั้งสองระบบสุขภาพ ในขั้นที่สองอาศัยแบบจำลองโทบิทในการประมาณการปัจจัยกำหนดประสิทธิภาพทางเทคนิคของศูนย์สุขภาพ

จากผลการศึกษาพบว่าค่าประสิทธิภาพทางเทคนิคเฉลี่ยของศูนย์สุขภาพทั้งทางตรงและทางอ้อมมีค่าเท่ากับ 77% 45.4% ของศูนย์สุขภาพทางตรงและ 43.9 % ของศูนย์สุขภาพทางอ้อมดำเนินการอย่างไม่มีประสิทธิภาพ จากผลของการวิเคราะห์แบบจำลองโทบิต พบว่าขนาดของศูนย์สุขภาพขนาดใหญ่ การเป็นศูนย์ขนาดใหญ่ และอยู่ในเมือง มีผลลบต่อการไม่มีประสิทธิภาพเทคนิคอย่างมีนัยสำคัญ การอยู่ในเมืองส่วนสัดส่วนของบุคคลากรทางการแพทย์ต่อบุคลลการอื่นๆในระดับสูง ขนาดกำลังสองและปี 2012 เป็นตัวแปรที่มีผลต่อการเพิ่มขึ้นของการไม่มีประสิทธิภาพทางเทคนิคอย่างมีนัยสำคัญ

สาขาวิชา เศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ ลายมือชื่อนิสิต ....

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##5585703429: MAJOR HEALTH ECONOMICS AND HEALTH CARE MANAGEMENT
KEYWORDS: TECHNICAL EFFICIENCY / DIRECT / INDIRECT PRIMARY HEALTH CENTERS / VARIABLE RETURNS TO SCALE / DATA ENVELOPMENT ANALYSIS

ALMOGHIRAH ABDELLAH: TECHNICAL EFFICIENCY OF PUBLIC INSURANCE HEALTH CENTERS IN GEZIRA STATE OF SUDAN
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This study aimed to measure the technical efficiency of 31 direct and 57 indirect insurance public primary health centers in Gezira State of Sudan and to identify the possible factors affecting their technical inefficiency. In the first stage, an input orientated data envelopment analysis was adopted to compute the technical efficiency scores for both types of health centers. In the second stage Tobit model was used to determine the factors that affect technical inefficiency of the health centers.

The study revealed that the average technical efficiency score of both direct and indirect health centers was 77%. The results also showed that 45.4% of direct and 43.9% of indirect health centers were run inefficiently. From the results of Tobit regression, being direct health center, large size and large center in urban were found to be significant and negatively affecting the technical inefficiency. Being in urban, high ratio of medical to non-medical staff, the size in form of square and the time dummy variable for year 2012 significantly increased the technical inefficiency of the health center.

Field of Study: Health Economics and Health Care Management. Student's Signature ………………..
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LIST OF ABBREVIATIONS

CRS	Constant returns to scale
TECRS	Technical Efficiency Constant returns to scale
DEA	Data envelopment analysis
DMU	Decision making unit
EMRO	East Mediterranean Regional Office
FMOH	Federal Ministry of Health
MSB	Marginal social benefit
MSC	Marginal social cost
NHIF	National Health Insurance Fund
PPS	Production Possibility Set
SMOH	State Ministry of Health
TE	Technical Efficiency
TI	Technical Inefficiency
VRS	Variable returns to scale
TEVRS	Technical Efficiency Variable returns to scale
WHO	World Health Organization

CHAPTER I
INTRODUCTION

1.1. Efficiency in health sector:

Policy makers now have become concerning on more efficient ways to deliver health services .Efficiency improvements in the health sector, even in small amounts, can produce considerable savings of resources or expansion of services for the community.(Peacock, Chan, Mangolini, & Johansen, 2001)

This is very essential for a developing country like Sudan which is suffering from scarcity of resources in different economic fields specially the health sector. In addition to that lack of coordination among different health care providers may lead to more inefficient use of resources.

1.2. Primary Health Care:

As its name suggests, primary care represents the "gateway" through which most people gain access to health care. Indeed, many aspects of health care - including preventative medicine, routine prescribing, and even minor surgery - are dealt with in their entirety in the primary health care sector.

The performance of primary care should ultimately be judged on its effect on the health outcome of individual patients.(Javier & Peter, 1996)

1.3. Main health care providers in Sudan:

Health care services in Sudan are delivered through primary, secondary and tertiary levels. The primary health level constitutes the bulk of the health service delivery and represents the base of the system pyramid. Health services are provided through different partners including in addition to Federal and State Ministries of Health, national health insurance, armed Forces, police, universities, private sector (both for profit and philanthropic). However, before the establishment of the Health Coordination Council at the federal level , those partners used to perform in insolation due to ill-defined managerial systems for coordination and guidance.(EMRO, 2004)

1.4. Direct provision of health services by NHIF:

Since 2002 the National Health Insurance Fund (NHIF) in Sudan has been affiliated to the Ministry of Welfare and Social Security after being under direct supervision of Ministry of health (MOH) for 7 years. Thence it has started to provide health services by direct provision method beside the indirect one. So there are two types of health centers through which NHIF avails medical services to its clients:

1.4.1. Direct health centers:

These are the centers that owned and/or directly administered by NHIF. The staff in these centers is paid by fixed salaries and bonus regardless of the number of patients seen. The total number of direct health centers is 294 in 2010.(NHIF, 2010)

1.4.2. Indirect health centers:

These are the health centers that NHIF purchases medical services from, and that is on contract basis. In contrast to direct centers the payment mechanism here is fee for service. The total number of indirect health centers is 289 in 2010.(NHIF, 2010)

From NHIF's perspective, direct provision method helps providing services where there is no service provided by MOH or other providers, or there is but, not within the quality standard setting of NHIF. It is also regarded as a cost containment mechanism that maintains continuity of NHIF services under scarcity of resources.

This policy is faced by great opposition from many stakeholders, especially MOH. Those against this policy argue that the main mandate of NHIF is the population coverage affairs and not the provision of health services. Health service providers including MOH also argue that if NHIF continues to produce services directly this will ultimately lead to disfiguring of the health system by creating unnecessary competition among public providers as well as wasting of resources.

Client's representatives, on the other hand, argue that they seek client's satisfaction regardless of who the provider is. From their perspective, quality is a target but direct provision shouldn’t be at the expense of their contribution and the sustainability of the services.

The policy makers at the highest level of the executive authority, the Federal Council of Ministers intervenes by directing NHIF to discontinue expanding in direct provision of services. Moreover, the council encourages NHIF to concentrate on purchasing the services and providing the services in a joint manner with other providers especially the ministries of health at the state level. But no decision was made towards the current situation with regard to acting current direct health centers.

1.5. Overview of health system in Sudan:

1.5.1. Ministry of Health Administrative structure:

The introduction of federalism in Sudan fostered a three-layered health system structure. These are Federal Ministry of Health (FMOH), State Ministries of Health (SMOH) and Local Health System. The FMOH became the main layer for policymaking, strategic planning, co-ordination, regulation, international relations and central source of technical support and guidance for the states. These roles are reflected in the organizational structure for the FMOH.

The FMOH is linked to 17 State Ministries of Health. Within each State there are a number of localities. The 2nd layer composed of 17 State Ministries of Health, that share the responsibility of planning, legislation and financing with the Federal MOH. However, it takes the direct responsibility for the organization of health in the state and support of the local health system. Nevertheless, due to their weak capacities there are notable gaps. The exceptions are Khartoum and Gezira SMOH, which have relatively better performing health systems. The third layer in the federal setup is the locality level. It emphasizes the principles of primary health care represented in decentralization, community participation, intersectoral co-ordination and integration of services. The locality health system has been established to strengthen the health management capacity in the administrative boundaries of the localities. This is to overcome the problems of supervision, leadership, curative-preventive dichotomy and to support the referral system. This supports the process of bottom-up planning.(EMRO, 2004)

1.5.2. Health insurance:

The national health insurance scheme plays a significant role in health spending, covering about 46.9 % of the target population in 2010. The institution of the present Health Insurance Fund has been commenced by passing legislation in 1994 to establish the General (National) health insurance corporation. The first activities were started in Sinnar State in1995.The unit of enrolment is the household which is composed of the household head and his/her dependents (parents, wife, sons up to 18 years and daughters till marriage). According to the NHIF statistical report 2010 36% per cent of the covered populations are government employees, 25.2% are poor families, 1.5% is families of martyrs, 3.2% are students and 20.5% are members of the informal sector. The health insurance is financed by a premium of 10% from employees' salary, of which 60% is the employer's contribution while 40% is equivalent to employee's share. Clients in the informal sector pay flat rate contributions on contract basis. Various government programs and charities cover the premiums for the poor and the other categories. Since 2005 NHIF has adopted the insurance card nationalization policy which allows clients to be treated in any insurance health facility all over the country regardless of the State the client registered in. While consultation, laboratory investigations and surgical procedures are free, yet insured persons should purchase medicines at government pharmacies paying 25% of the cost. NHIF avails medical services to its clients through 1110 facilities all over Sudan, comprising 294 direct health centers, 289 indirect health centers, 21 direct hospitals and 506 indirect hospitals.(NHIF, 2010)

Table I-1 The distribution of NHIF health facilities

State	Health Centers		Hospitals		Total
	Direct	Indirect	Direct	Indirect	
Khartoum	0	28	0	213	**241**
Sinnar	30	12	2	21	**65**
Gezira	30	95	0	64	**189**
Jadarif	18	24	1	21	**64**
Red sea	16	7	0	11	**34**
River nile	20	35	0	29	**84**
White nile	22	16	2	20	**60**
North darfour	16	1	1	14	**32**
Blue nile	9	6	0	13	**28**
West darfour	16	2	0	9	**27**
North kordofan	47	14	7	23	**91**
Northern	19	28	0	29	**76**
Kassala	13	13	0	10	**36**
South kordofan	11	5	2	11	**29**
South darfour	16	3	1	14	**34**
West kordofan	11	0	5	4	**20**
total	**294**	**289**	**21**	**506**	**1110**

Source: NHIF statistical report 2010

1.6. The thesis questions

This study aims to answer the following questions:

1-Are the health centers that provide health services under the direct method technically efficient compared with indirect ones?

2-what are the factors that affect the technical inefficiency of direct and indirect health centers?

1.7. Objectives:

1.7.1. General Objective:

To assess the technical efficiency of direct and indirect health centers that provide medical insurance services to NHIF's clients at Gezira State and to determine the factors that affect their inefficiency.

1.7.2. Specific Objectives:

1-To calculate the technical efficiency scores of direct and indirect health centers of NHIF at Gezira State during the period 2009 to 2012.

2-To identify the factors affecting technical inefficiency of direct and indirect health centers.

1.8. Hypotheses:

This study assumes the following relationships between the technical inefficiency score of the health center as the dependent variable and the type of the health center whether direct or indirect, location, size and ratio of medical staff to non-medical staff and time trend over the period (2009-2012) as independent variables:

-Hypothesis1: The type of the health center according to provision of health services is expected to have negative relationship with the technical inefficiency if it is direct center.

-Hypothesis 2: Location of the health center is expected to have negative relationship with the technical inefficiency if it is in an urban area.

-Hypothesis 3: Ratio of number of medical staff/number of non-medical staff is expected to have negative relationship with the technical inefficiency.

-Hypothesis 4: The size of the center (number of departments or divisions) is expected to have negative relationship with the technical inefficiency.

-Hypothesis 5: The squared size of the health center is expected to have positive effect on technical inefficiency of the health center.

-Hypothesis 6: The time trend over the period 2009 to 2012 is expected to have negative relationship with technical inefficiency scores of the direct centers.

-Hypothesis 7: The effect of size of the health center on technical inefficiency is expected to vary with location and to be lower with urban than rural.

1.9. The Scope:

This study was confined to public health centers that provided medical services to NIHIF's clients in primary health care level in Gezira State. So, it included all the 31 direct health insurance centers and 57 indirect public health centers. The secondary data required were collected in the period from 2009 to 2012 for the direct centers, and for the indirect public health centers for the year 2012. So the total number of observations was176.

1.10. Background of Gezira State:

1.10.1. Geographic and Socio-demographic characteristics

Gezira State is located central in Sudan spanning about 25,549.2 km2. Its population is about 3,900,440 as 2012 projection on 2008 census. (Sudan, 2010). The State is divided administratively into 7 localities. The main economic activity of people is agriculture and that is due to the presence of Gezira Scheme. The main city in the State is Wad Medani which is the capital and the second biggest city in Sudan after Khartoum. Other towns include Hasahisa, Almanagil, Rofaa, Alkamlin, Um Algora and Alhoush.(Cabinet Affairs, 2008)

1.10.2. Health system in Gezira State:

The health system is governed by the State Ministry of Health (SMoH) which represents the main provider of curative, preventive and promotive health services in the State. Other main providers include NHIF, Military, Police, universities and private sectors.

Gezira is the 3rd state to implement the health insurance system after Sinnar and Khartoum and that was in 1997. The health insurance coverage is 43% of the target (which is 80% of total population). The institutes that provide medical health services to NHIF clients amount to 190, in the 1st quarter 2011, including 64 teaching general and special hospitals as well as a rural under direct administration of SMOH and other providers, 126 primary health centres of which 31 are under direct NHIF administration (direct centers), as well as 95 indirect health centres of which 68 are under localities (SMOH).(Directorate, 2011)

Table I-2 The distribution of health facilities in Gezira State

Locality	Health centers			Hospitals			Total
	Direct	Indirect	Total	Direct	Indirect	Total	
Wad Medani	9	34	**43**	0	15	**15**	**58**
Kamlin	7	19	**26**	0	6	**6**	**32**
Hasahisa	3	6	**9**	0	15	**15**	**34**
East Gezira	2	4	**6**	0	8	**8**	**14**
South Gezira	4	13	**17**	0	8	**8**	**25**
Managil	3	13	**16**	0	8	**8**	**24**
Um Algura	3	6	**9**	0	4	**4**	**13**
Total	31	95	**126**	0	64	**64**	**190**

Source: Statistical report NHIF-Gezira State 1st quarter 2011.

CHAPTER II
LITERATURE REVIEW

2.1. Definition of Efficiency:

Measurement of efficiency begins with Farrell (1957) who drew upon the work of Debren (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. He proposed that the 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. These two measures are then combined to provide measure of total economic efficiency. (Coelli, 1996)

2.1.1. Technical efficiency:

It is defined as production of maximum quantity of output for a given value of a set of inputs or the production of a given quantity of output produced with the least cost set of inputs. Sometimes called cost efficiency or operational efficiency.

A decision making unit (DMU) is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.(Cooper, Seiford, & Zhu, 2011)

2.1.2. Productive efficiency:

This refers to producing the maximum quantity of output with a given quantity of inputs, or equivalently, producing a given quantity of output with minimum quantity of inputs. Sometimes this is called technical efficiency. Productive efficiency is concerned with producing goods and services with the optimal combination of inputs to produce maximum output for the minimum cost.

To be productively efficient means the economy must be producing on its production possibility frontier i.e. it is impossible to produce more of one good without producing less of another. Productive efficiency is closely related to the concept of Technical Efficiency. A firm is technically efficient when it combines the optimal combination of labor and capital to produce a good i.e. cannot produce more of a good, without more inputs.

Productivity is simply defined as the ratio of output to input of a production unit, while its efficiency is a comparison between observed and optimal values of its output and input.(Hal, K., & S., 1992)

2.1.3. Social efficiency:

Social efficiency is the change in allocation of resources. This is the optimal distribution of resources in society, taking into account all external costs and benefits as well as internal costs and benefits. Social Efficiency occurs at an output where Marginal Social Benefit (MSB) = Marginal Social Cost (MSC).

Social efficiency is closely related to the concept of Pareto efficiency – A point where it is impossible to make anyone better off without making someone worse off

- Social benefit = private benefit + external benefit
- Social Cost = private cost + external cost

Efficiency is also defined as the ratio of the observed level of attainment of a goal to the maximum that could have been achieved with the observed resources. Normally outputs are zero when inputs are zero. In health, however health level would not be zero if there were no health expenditures, that is no health system. So to measure the contribution of the health system we have to determine what it achieves in excess of what would be achieved in its absence (the minimum). Accordingly, we define performance as the current level population health, in excess of the estimated minimum compared with the maximum achievable level of health given the inputs. Because of the similarity between performance and efficiency, the term is used interchangeably.

Neither the maximum (frontier) nor the minimum levels of health are observable so they have to be estimated. Two strategies could be used for estimating the maximum; one involves defining feasible interventions, identifying their costs and outcomes, and choosing those that maximize health for the available resources.(Gantugs, 2006)

Measuring efficiency in producing health services is a particularly challenging exercise because a variety of factors - quality of care, case mix, input price, scale of operation - vary among providers. All these factors affect the relation between required resources and health service outcome. Thus, comparisons of efficiency of different providers must be careful to include only the most similar providers in the group to be compared. They must also have data on these other factors for appropriate interpretation of the measures of efficiency.(Ricardo, 1995)

2.2. Some previous studies on efficiency of different levels of health care:

In reviewing published applications of efficiency measurement in health care up to 2003 it was found that two thirds of studies made use of data envelopment analysis (DEA) alone. A fifth of studies used two- stage analysis (DEA followed by some form of regression) to attempt to identify further determinants of efficiency.(Bruce, 2003)

Ismail (2010) conducted a study aiming at measuring the technical efficiency of the Sudan's health institutions at state level and drawing policy implications for the health sector. To apply DEA as a tool for measuring the technical efficiency scores the study considered each state ministry of health as a Decision Making Unit (a total of 15 observations). Thereafter, an output oriented DEA model was used to estimate the efficiency scores of states' health institutions for the year 2007. The results of that study showed 6 states out of 15 were technically inefficient under constant return to scale (CRS), while 5 states were technically inefficient under variable return to scale (VRS).(Mohamed, 2010)

Kirigia et al (2004) measured the technical efficiency of public health centers in Kenya using the DEA approach. The objectives of that study were: to determine the degree of technical efficiency of individual primary health care facilities in Kenya, to recommend the performance targets for inefficient facilities, to estimate the magnitudes of excess inputs, and to recommend what should be undertaken in the other countries in the World Health Organization (WHO) African Region with a view to empowering Ministries of Health to play their stewardship role more effectively. The study was carried out in a selection of 32 public health centers out of a total number of 350. The inputs used in that study were the resources used to produce outputs including: clinical officers, nurses, physiotherapists, laboratory technicians, occupational therapists, laboratory technologists, public health officers, beds and nonwage recurrent expenditures. The study used 10 intermediate inputs including different common diseases' visits as well as antenatal care, immunization and family planning visits. Later on some inputs and outputs were grouped together to avoid redundancy. The study found that 44% of the health centers in Kenyan sample were technically inefficient. Furthermore they recommended corrective actions to improve the efficiency of public health centers in Kenya. (Joses, Ali, Luis, Nzoya, & Wilson, 2004)

Kirigia et al (1996) conducted a study aiming at investigating the technical efficiency of public clinics in Kwazulu- Natal province in South Africa and to draw policy implications. That cross-sectional study was based on 155 public clinics and used DEA as a method to measure the technical efficiency. The main outcome measures were technical and scale efficiency scores. The results obtained by the study revealed that 30% of public clinics were found to be technically efficient. The presence of inefficiencies indicated that a clinic has excess inputs or insufficient outputs compared to those clinics on the efficient frontier. The study recommended that Kwazulu- Natal provincial public clinics would in total have to decrease inputs by 417 nurses and 457 general staff. Alternatively, outputs would have to be increased by 115534 antenatal visits, 1010 deliveries, 179075 child care visits, 121658 family planning visits, 36032 psychiatric visits, 56068 sexually transmitted disease visits and 34270 tuberculosis visits.(Joses, Luis, & H., 2001)

Osei et al (2005) conducted a pilot study on technical efficiency of public district hospitals and health centers in Ghana 2005. The objectives were to estimate the relative technical efficiency and scale efficiency of a sample of public district hospitals and health centers in Ghana and to demonstrate policy implications for health sector policy-makers. The method used by the study was the DEA approach to estimate the efficiency of 17 district hospitals and 17 health centers. The study revealed that 47% of hospitals were technically inefficient with an average T.E score of 61% and standard deviation of 12%. 59% of hospitals were scale inefficient manifesting an average SE of 81% with standard deviation of 27%. 47% of health centers were scale inefficient with an average SE scores of 84% with standard deviation of 16%. The authors recommended continuous monitoring of productivity growth, allocative efficiency and technical efficiency of all health facilities in Ghana (hospitals and health centers) in the course of the implementation of health sector reforms.(Osei et al., 2005)

Annemarie (1997) examined some aspects of both technical and economic efficiency in a sample of 68 health facilities representing public and private sectors in Ogun State in Nigeria. The ultimate goal of the study was to assess the cost structure of health care services. Facilities which appeared to be technically efficient were used to estimate a production function which represents the maximum levels of health services which can be produced with given combinations of personnel and non-personnel inputs. From these estimates reflecting technical efficiency, measures of the marginal physical productivity of high- and low-level health workers were then compared with their relative wages to determine whether cost-minimizing staffing patterns were being used. Differences between public and private facilities were briefly explored. By estimating a short-run cost function, marginal costs, average costs, short-run economies of scale and economies of scope were calculated.(Annemarie 1993)

Wichian & Pongsa (2009) used an input-oriented DEA in a study that conducted to measure the technical efficiency of 7 university hospitals, 24 regional hospitals and 43 general hospitals. Then they identified the determinants of hospital efficiency with regression analysis using ordinary least square (OLS). The study used different aggregate inputs including numbers of different staff categories such as: physicians, nurses and other personnel, in addition to capital and material costs. The aggregate outputs included in-patient visits, out-patient visits, number of graduated or trained residents, number of graduated medical students, median adjusted relative weight of DGRs, number of publicized researches and hospital standardized mortality ratio. The explanatory variables which are used included: bed-physician ratio, squared number of physicians, nurse-physician ratio and other personnel-physician ratio.(Wichian & Pongsa, 2009)

Hsi-Hui (1998) combined data envelopment analysis (DEA) with regression analysis to evaluate the efficiency of central government-owned hospitals in Taiwan over the years between 1990 and1994. Efficiency was estimated using DEA with the choice of inputs and outputs of hospital operations. A multiple regression model (OLS) was then employed in which the efficiency score obtained from the DEA computations was used as the dependent variable, and a number of hospital operating characteristics are chosen as the independent variables. The results indicated that the scope of services and proportion of retired veteran patients were negatively and significantly associated with efficiency, whereas occupancy was positively and significantly associated with efficiency. The results also showed that hospital efficiency had improved over time during the periods studied.(Hsi-Hui, 1998)

In health care system, researchers measure outputs in terms of number of treatments provided or number of inpatient day. However, these are only intermediate outputs. Effectiveness is concerned with the degree to which outputs (treatment) produces improved outcomes for patients. In health care the issue of effectiveness is of crucial importance when considering efficiency.

2.3. Concept of technical efficiency measurement:

1- Output-orientated measurement (maximal possible output from a given set of inputs): which assumes that the firm can manipulate the quantities of outputs while quantities of inputs are given, to achieve the most efficient point.

2- Input-orientated measurement (minimal possible input from a given set of outputs): which assumes that quantities of inputs can be changed to reach the most efficiency point while quantities of outputs are given.

2.4. Data Envelopment Analysis (DEA):

Data Envelopment Analysis (DEA) is a non-parametric method used in operation research and econometrics for multivariate frontier estimation and ranking. DEA is a linear programming method to measure the efficiency of multiple decision making units (DMUs) when the production process presents a structure of multiple inputs and outputs.

2.4.1. Advantages of usage of DEA:

1-There is no need to explicitly specify a mathematical form for the production function.

2-It has proven to be useful in uncovering relationships that remain hidden for other methodologies.

3-It is capable of handling multiple inputs and outputs.

4-It can be used with any input-output measurement.

5-The source of inefficiency can be analyzed and quantified for every evaluated unit.

In DEA methodology, formerly developed by Charnes, Cooper and Rhodes (1978), efficiency is defined as a weighted sum of outputs to a weighted sum of inputs, where the weighted structure is calculated by means of mathematical programming and constant return to scale are assumed. In 1984 Banker, Charnes and Cooper developed a model with variable return to scale.

Data Envelopment Analysis (DEA) has been recognized as a valuable analytical research instrument and a practical decision support tool. DEA requires general production and distribution assumption only. However, if those assumptions are too weak, inefficiency levels may be systematically underestimated in small samples. In addition, erroneous assumptions may cause inconsistency with bias over the frontier. Therefore, the ability to alter, test and select production assumptions is essential in conducting DEA-based research. However, the DEA models currently available offer a limited variety of alternative production assumptions only.

2.4.2. The traditional DEA framework:

In DEA, the performance of decision making units (DMUs) is evaluated against an empirical approximation for the production possibility set (PPS). The (PPS) is defined as the set of all combinations of inputs and outputs that are attainable given the current production technology. P = y can be produced from x. That set is approximated using a set of observations on inputs and outputs for n DMUs (j=1,….,n). The standard Charnes, Cooper and Rhodes (1978) model is based on the assumption that the true production technology is characterized by constant return to scale (CRS). For each evaluated DMU, a reference unit is selected from the approximating set. These reference units can be used for efficiency estimation and performance benchmarking purposes. The input-output combination of the evaluated unit relative to that of the reference unit can be used for evaluating the efficiency of past operations and for assessing potential improvements for future operations. The units that constitute the reference unit are potential benchmark partners. In addition, comparing the production process of the evaluated unit with that of the benchmark partners can reveal causes for past inefficiencies and remedies for future improvements. Whereas the structure of approximating set depends on the assumptions imposed on the production technology and the distribution of observations, the selection of a particular reference unit from that set depends on the preference of the evaluating manager. It is generally difficult to reliably elicit managerial preferences and moreover properly incorporate preferences in an optimization problem. However, using certain assumptions about the general characteristics of the preference structure, the decision problem can be simplified. An assumption that is implicit in most DEA models is that the evaluator prefers more over less for the referencing outputs and less over more for inputs. That is considered as a valid assumption, because the purpose of the reference units is to assess inefficiency and potential performance improvements relative to production possibilities if its outputs are higher and its inputs are lower. If the above assumption holds, all composite units that are dominated by other units, i.e. units that produce more output with equal or less input, or alternatively, consume less input for equal or more output, can be discarded as decision alternatives. Only non-dominated units have to be considered as potential reference units. (Gantugs, 2006)

DEA constructs a piece-wise linear-segmented efficiency frontier based on best practice, with no assumption about the underlying technology but no scope for random error, making it more vulnerable to data errors. DEA has the advantages that it is able to manage complex production environments with multiple input and output technologies like hospitals, but being a non-statistical method it does not produce the usual diagnostic tools with which to judge the goodness of fit of the model specifications produced.

2.4.3. Theoretical Data Envelopment Analysis:

Data Envelopment Analysis (DEA) has been one of the most popular techniques to evaluate efficiency of production firms. DEA uses the concept of linear programming to construct a non-parametric piecewise efficient surface, or frontier, from the observed production input-output data and to calculate efficiency score distance relative to this efficient surface. DEA is very ideal for measuring efficiency of hospitals with multiple inputs and outputs(Wichian & Pongsa, 2009).(Wichian & Pongsa, 2009)

DEA models may be more useful in smaller-scale studies designed to judge specific efficiency improving interventions in given hospital markets in contrast to stochastic frontier regression (SFR) models may be better suited to industry-wide investigations of efficiency determinants and policy effectiveness.(Thomas & Alan, 2000)

2.5. Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS):

The assumption of constant returns to scale (CRS) is only appropriate when all DMUs are acting at their optimal scale. Some factors may render a DMU not acting at optimal scale like imperfect competition and financial constraints.

The variable returns to scale specification has become popular and it permits the calculation of TE devoid of the effects of scale efficiency.(Coelli, 1996)

2.6. Tobit analysis:

The use of econometric models with truncated or censored error terms is increasing. One of the models that are seeing increasing use is Tobit analysis. It is a model devised by Tobin (1958) in which it is assumed that the dependent variable has a number of its values clustered at a limiting value usually zero. The Tobit models uses all observations both those at the limit and those above it, to estimate a regression line. It is to be preferred, in general, over alternative techniques that estimate a line only with the observations above the limit.(McDonald & Moffitt, 1980)

CHAPTER III
RESEARCH METHODOLOGY

3.1. Study design:

This is an analytical study using econometric and mathematical techniques.

3.2. Study population:

The study population constituted the public primary health care centers in Gezira State that provide health care services to NHIF clients.

3.3. Study sample:

All direct health centers in Gezira State, which are 31 in number and, 57 indirect public centers, constituted the study sample.

3.4. Data required:

Secondary data for specific inputs and outputs of the health centers were collected retrospectively. Form the period 2009 to 2012 (4 years) for the direct centers and for the year 2012 for indirect ones. So the total number of observations was 176.

The specific inputs and outputs variables that contributed to the production function of these centers were defined as follows:

3.4.1. Inputs variables:

Number of physicians: including general and specialists physicians and medical assistants.

Number of laboratory technicians: including all technical personnel working in the laboratory department such as laboratory technicians, laboratory assistants, malaria technicians and laboratory attendants.

Operational expenditure: including all non-wage recurrent expenses such as, water, electricity and telephone bills, maintenances for buildings and equipment and stationaries.

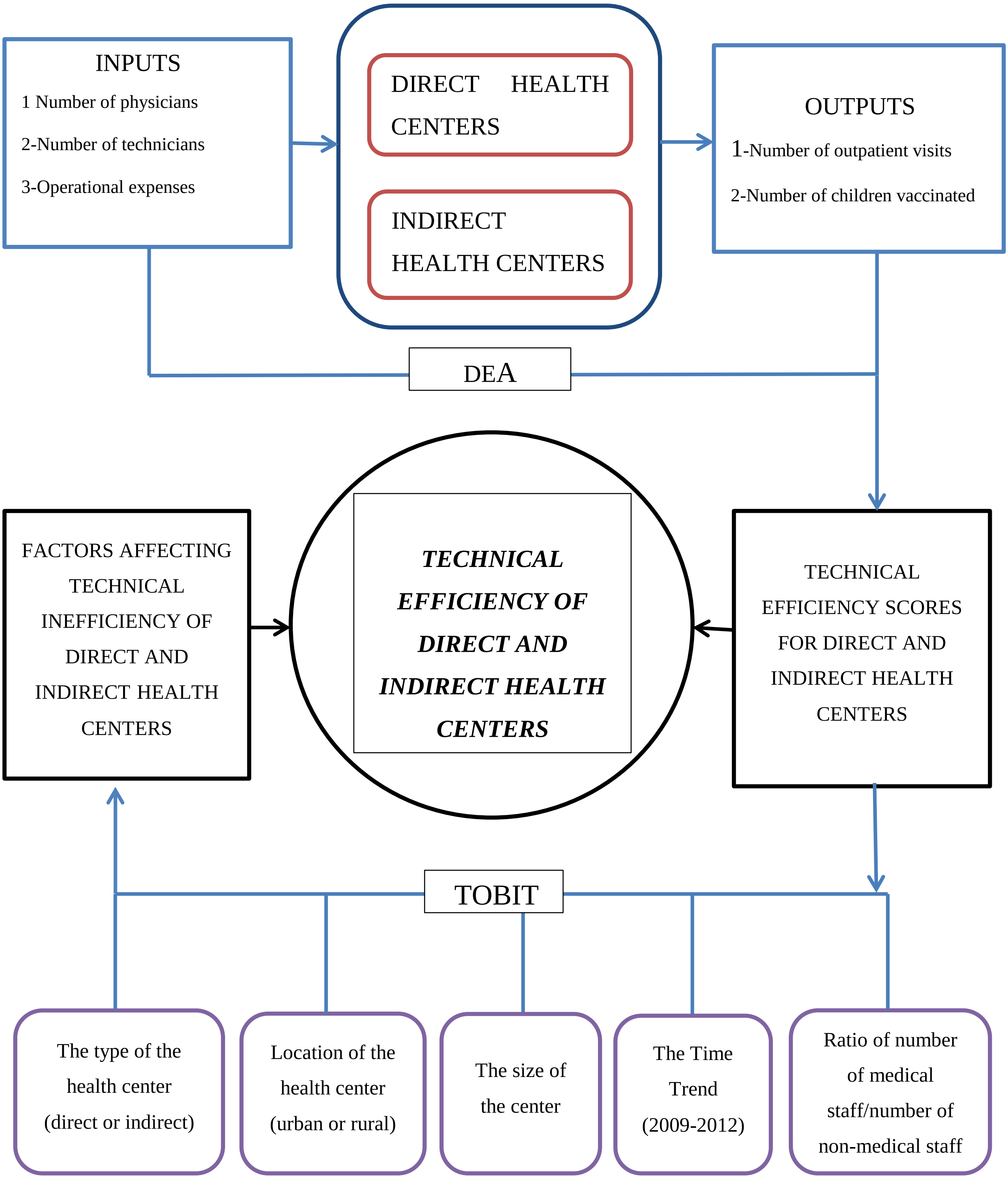
3.4.2. Output variables:

Number of outpatient visits: Since the scope of this study is the primary health centers in which there is no inpatient services so, main output of these centers was the total number of outpatient visits per year. These included mainly the common acute diseases visits, chronic diseases follow up visits, minor surgical procedures like cut wound repairs, dressing and drainage of small abscesses.

Number of children vaccinated: vaccination of children against the seven vaccine-preventable diseases is one of the service package that is delivered through the primary care. So the total number of children vaccinated against these diseases per year according to Expanding Program of Immunization (EPI) in Gezira State was considered as another output in this study.

3.5. Conceptual Framework

Figure III-1 Conceptual Framework



3.6. Data analysis:

Two techniques were used as analytical tools into two stages in this study:

3.6.1. Data Envelopment Analysis (DEA):

In the 1st stage –the stage of measuring the technical efficiencies of the health centers in the sample- Data Envelopment Analysis (DEA) was used as a tool to calculate the technical efficiency scores of the chosen health centers. Data were analyzed using DAE computer program (DEAP version 2.1).

DEA Model:

Input-orientated DEA model was used in this study with two assumptions constant return to scale (TECRS) and variable return to scale (TEVRT).

i. -DEA weights model, input-oriented constant return to scale (CRS):

$$Eff = \underset{\mu r,\ vi}{Max} \sum r\ \mu r\ yrj0$$

Subject to:

$$\sum r\ \mu r\ yrj - \sum i\ vixij \leq 0 \quad ; \forall j$$

$$\sum i\ vixij0 = 1$$

$$\mu r,\ vi \geq 0 \quad ; \forall r,\ ; \forall i$$

ii. 2-DEA weights model, input-oriented variable return to scale (VRS):

$$Eff = \underset{\mu r,\ vi}{Max} \sum r\ \mu r\ yrj0 + \mu 0$$

Subject to:

$$\sum r\ \mu r\ yrj - \sum i\ vixij + \mu 0 \leq 0 \quad ; \forall j$$

$$\sum i\ vixij0 = 1$$

$$\mu r,\ vi \geq 0 \quad ; \forall r,\ ; \forall i$$

Where:

yrj: is the amount of output r produced by health center j,

xij : is the amount of input i produced by health center j,

μr: is the weight given to output r (r = 1,…,t and t is the number of outputs),

vi: is the weight given to input i (i = 1,…,m and m is the number of inputs),

n: is the number of health centers,

j0: is the health center under assessment.

3.6.2. Regression Analysis:

In the 2nd stage, the stage of identifying the factors affecting the technical inefficiencies of the health centers in the sample in terms of direction (positive or negative effect) and magnitude, regression analysis using Tobit model was used.

The technical inefficiency scores were generated by subtracting each technical efficiency score from 1. This score of technical inefficiency was regressed as dependent variable against independent variables which included:

- The type of provision of health services whether direct or indirect,
- Geographical location of the health center whether urban or rural,
- Ratio of number of medical staff/number of non-medical staff,
- The size of the center (number of departments or divisions) ,
- The size inform of square,
- The time trend and
- . The interaction term of location and size.

The regression model:

The regression model was formulated as follows:

$$T.I_i = \beta_0 + \beta_1 TYPE_i + \beta_2 LOC_i + \beta_3 SIZE_i + \beta_4 RMD_i + B_5 SIZE_i^{\,2} + \beta_6 TYPE*YR10_i + \beta_7 TYPE*YR11_i + \beta_8 TYPE*YR12_i + B_9 LOC_i*SIZE_i + \varepsilon_i$$

Where:

- $T.I_i$: is the technical inefficiency score (VRS) for the ith health center, generated from the obtained technical efficiency (T.E) score of the ith center (VRS) as follows: $T.I_i = 1 - T.E_i$
- β_0: is the constant term.
- $\beta_1 - \beta_9$: are the coefficients of the explanatory variables.
- $TYPE_i$: is dummy variable =1 if direct center, = 0 if indirect center
- LOC_i: is a dummy variable = 1 if the center is located in an urban area and = 0 if in a rural area.
- RMD_i: is the ratio of number of medical staff/number of non-medical staff.
- $SIZE_i$: is number of departments or divisions of the health center.

- $SIZE_i^2$: is the square of number of departments or divisions of the health center.
- $LOCi*SIZE_i$: is a cross term between the size and the location of the center
- $TYPE*YR10_i$: is a time dummy for efficiency scores in the year 2010 for direct centers.
- $TYPE*YR11_i$: is a time dummy for efficiency scores in the year 2011 for direct centers.
- $TYPE*YR12_i$: is a time dummy for efficiency scores in the year 2012 for direct centers.
- ε_i: is the error term.

Table III-1 Types of explanatory variables and expected signs of coefficients

Coefficient	Explanatory variable	Type of variable	Expected sign of coefficient
β_1	TYPE	Dummy	(-) if direct center
β_2	LOC	Dummy	(-) if in urban area
β_3	SIZE	Continuous	(-)
β_4	RMD	Continuous	(-)
β_5	SIZE2	Continuous	(+)
β_6	TYPE*YR10	Time Dummy	(-)
β_7	TYPE*YR11	Time Dummy	(-)
β_8	TYPE*YR12	Time Dummy	(-)
β_9	LOC*SIZE	Cross term	(-)

-The type of the health center according to provision of health services was expected to have negative relationship with the technical inefficiency if it is direct center.

-Location of the health center was expected to have negative relationship with the technical inefficiency if it is in an urban area.

-Ratio of number of medical staff/number of non-medical staff was expected to have negative relationship with the technical inefficiency.

-The size of the center (number of departments or divisions) was expected to have negative relationship with the technical inefficiency.

-The squared size of the health center was expected to have negative relationship with technical inefficiency up to a certain level after which the relationship was expected to change to positive.

-The time trend (moving from 2009 towards 2012) was expected to have negative relationship with technical inefficiency scores of the direct health centers.

- The relationship between the size of the center and technical inefficiency was expected to vary with location. The slope was expected to be lower for urban because the urban centers had more departments than rural ones.

CHAPTER IV
RESULT AND DISCUSSION

4.1. Descriptive analysis of data used for DEA:

Data was collected from 31 direct primary health centers for 4 years 2009, 2010, 2011 and 2012. There were 3 centers that started to work in 2010 and one center in 2011, hence the total number of observations for direct centers were 119. With regard to the indirect centers, data was available for the year 2012 from 57 primary health centers .So finally the total number of observations for direct and indirect primary health centers in Gezira State was 176.

The variables for DEA model include two outputs: the total number of outpatients per year and the total number of children vaccinated against the scheduled childhood illnesses according to Extending Program of Immunization (EPI) in Sudan. The input variables include 3 outputs: the total number of physicians, the total number of laboratory technicians and the total operational expenses per year.

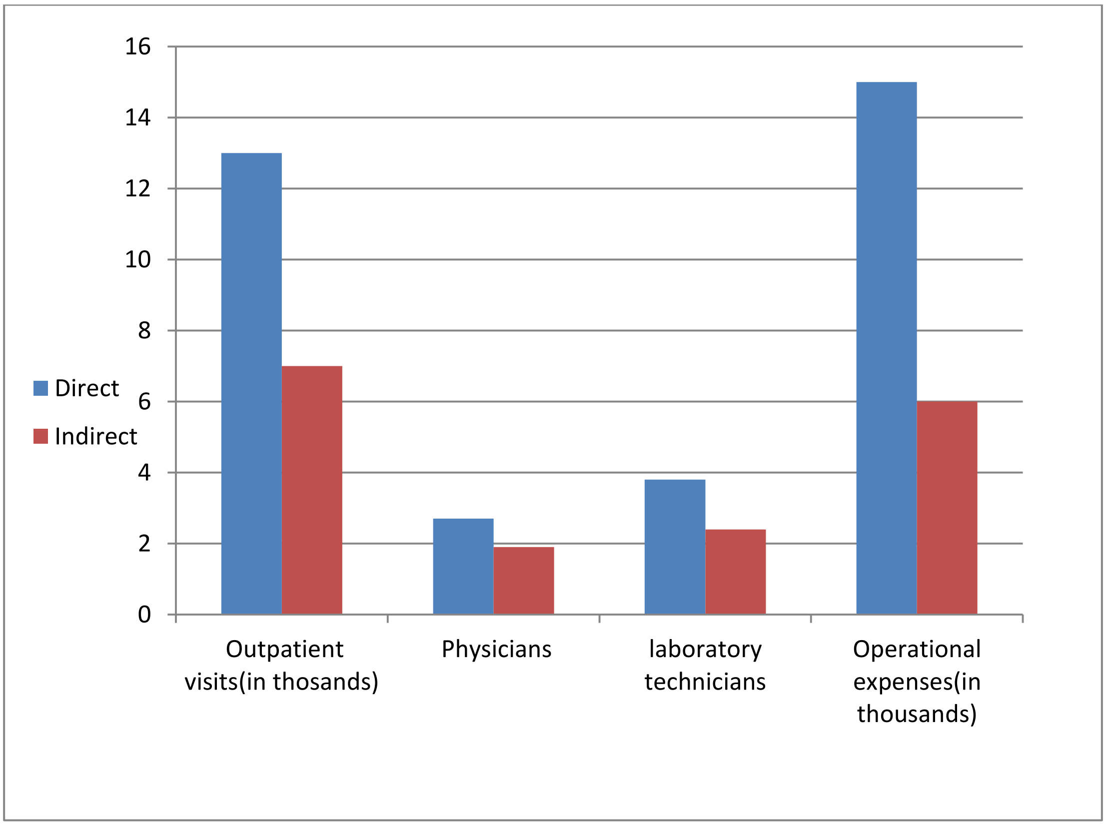
The mean for the number of outpatients per year was found to be 11430 while the mean for number of children vaccinated was 461. The means for the input variables: the number of physicians, the number of laboratory technicians and the operational expenses per year figured to 2.4, 3.3 and 12100 respectively as shown in table (IV-1)

Table IV-1 Descriptive statistics of output and input variables for DEA

	No of outpatient visits	No of vaccinated Children	No of Physicians	No of laboratory technicians	Operational Expenses
Mean	11431	461	2.4	3.3	12100
Median	5344	268.5	2	2.5	5913
Maximum	109992	3695	15	26	87875
Minimum	345	1	1	1	300
Std. Dev.	15974	547	2.4	3.4	16036
Observations	176	176	176	176	176

Interestingly, the comparison between direct and indirect public health centers revealed that the mean of the outpatient visits for direct centers was nearly as twice as that of the indirect ones 13343 and 7437 respectively. This indicates that these direct centers, collectively, are attracting clients. So it is not surprising to find that the means of number of physicians and the number of laboratory technicians are higher than those of the indirect centers 2.7 and 3.8 compared with 1.9 and 2.4 respectively. The result also showed a great difference between direct and indirect health centers in the total amount of money spent as operational expenses. The mean for the direct centers was 15008 more than double the amount spent in the indirect centers the mean of which was found to be 6027 (Figure IV-1).

Figure IV-1 Some input and output variables of direct and indirect health centers



More interesting was the comparison between both types of centers in the number of children vaccinated. Although there was no marked different between the means of both direct and indirect health centers but there were 6 direct centers

(19%) with very negligible numbers of vaccinated children. This could reflect that these direct centers were cure oriented, meaning that their directorate did not pay this greatly important aspect in the primary heath package a considerable attention the thing that reflected negatively on their performance.

4.2. Results of input-orientated DEA:

The relative technical efficiency scores of direct and indirect primary health centers were obtained using DEA as a tool. The analysis was done under two assumptions; constant return to scale (CRS) and variable return to scale (VRS).

4.2.1. Results of input-orientated DEA under (CRS) assumption:

The mean of technical efficiency for all centers direct and indirect was found to be 0.32 (Table IV-2).

The analysis showed that only 4 centers out of 88 are technically efficient; each having a technical efficiency score of 1.This represented about 4.5%. Of these centers the analysis revealed that only one direct center among 31 has a score technical efficiency figured to 1, while 3 centers out of 57 indirect category has technical efficiency score of 1.These represented 3.2% and 5.3% respectively.

The technical efficiency scores of the direct centers ranged from minimum of 0.065 and a maximum of 1, with a mean of 0.3 while those of indirect centers ranged from minimum of 0.046 and a maximum of 1 with a mean of 0.4.

Table IV-2 Summary statistics for TECRS and TE VRS scores for all centers

	CRSTE	VRSTE
Mean	0.32	0.77
Maximum	1	1
Minimum	0.046	0.184
Std. Dev.	0.227	0.264

In ranking of the technical efficiency scores, the results showed that 90.8% of the direct centers had technical efficiency scores below the score of 50%, 2.5% of them had score of 100%, 1.7% ranging between 90 to 99.9% and 0.8% ranged between 80 to 89% . In contrast to indirect centers 75.4% of them had technical efficiency score below 50%, 14.0% had scores ranging between 50 to 79.9%, 1.8% had scores ranging between 80 to 89.9% and 5.3% had scores of 100% technical efficiency (Table IV-3).

Table IV-3 Ranking of TECRS for direct and indirect health centers

TECRS	DIRECT CENTERS	%	INDIRECT CENTERS	%
100%	3	2.5%	3	5.3%
90-99.9%	2	1.7%	2	3.5%
80-89.9%	1	0.8%	1	1.8%
50-79.9%	5	4.2%	8	14.0%
<50%	108	90.8%	43	75.4%
TOTAL	119		57	

Regarding the time trend of technical efficiency scores of the direct centers over the period between 2009 and 2012 the results revealed that there were fluctuations of the mean technical efficiency scores. It was 0.31 in 2009 then decreased to 0.29 in 2010 after that increased to 0.32 in 2011 and finally decreased to a figure of 0.27 in 2012. This fluctuation can be explained by the changes that occurred in the inputs and outputs of the production function of the direct centers. The means of the number of physicians, number of laboratory technicians increased steadily over these years 2.1 to 3.3 and from 3.3 to 4.2 respectively , while the mean of operational expenses fluctuated between 12003 and 18035. On the other hand the mean of the outpatient visits fluctuated between 11830 and 15295 while the mean of the number of children vaccinated remained quiet steady.

4.2.2. Results of input-orientated DEA under (VRS) assumption:

When the DEA was run under the assumption of variable return to scale the mean technical efficiency score of all centers was found to be 0.774. The score for each center is shown in tables (IV-5) for direct centers and (IV-6) for indirect centers.

It was revealed that 55% of the centers were technically efficient, 32% of the remaining inefficient ones had technical efficiency scores ranging between 50 and 74.9% and 12% of them having scores below 50% (Table IV-4).

Table IV-4 Ranking of TEVRS scores for direct and indirect health centers

TEVRS	DIRECT CENTERS	%	INDIRECT CENTERS	%	ALL CENTERS	%
100%	65	54.6	32	56.1	97	55.1
75-99.9%	2	1.7	0	0	2	1.1
50-74.9%	38	31.9	18	31.6	58	31.9
<50%	14	11.8	7	12.3	21	11.9
	119		57		176	

Comparing the two categories of health centers the study found that 65 observations (54.6%) of the direct centers are technically efficient; having a score of pure technical efficiency of 1 (100%), while 32 (56%) of the indirect centers are technically efficient (Table IV-4). The percentage of centers that had score between 0.75 and 0.99 is 1.7% and 0% for the direct and indirect centers respectively while the percentage of centers that had score between 0.50 and 0.74.9 is 31.9% and 31.6 for the direct and indirect centers respectively. The remaining centers which had technical efficiency scores below 0.50 represented 11.8 % and 12.3 for direct and indirect centers respectively (Figures IV-2 and IV-3).

Figure IV-2 Ranking of TEVRS scores for direct centers

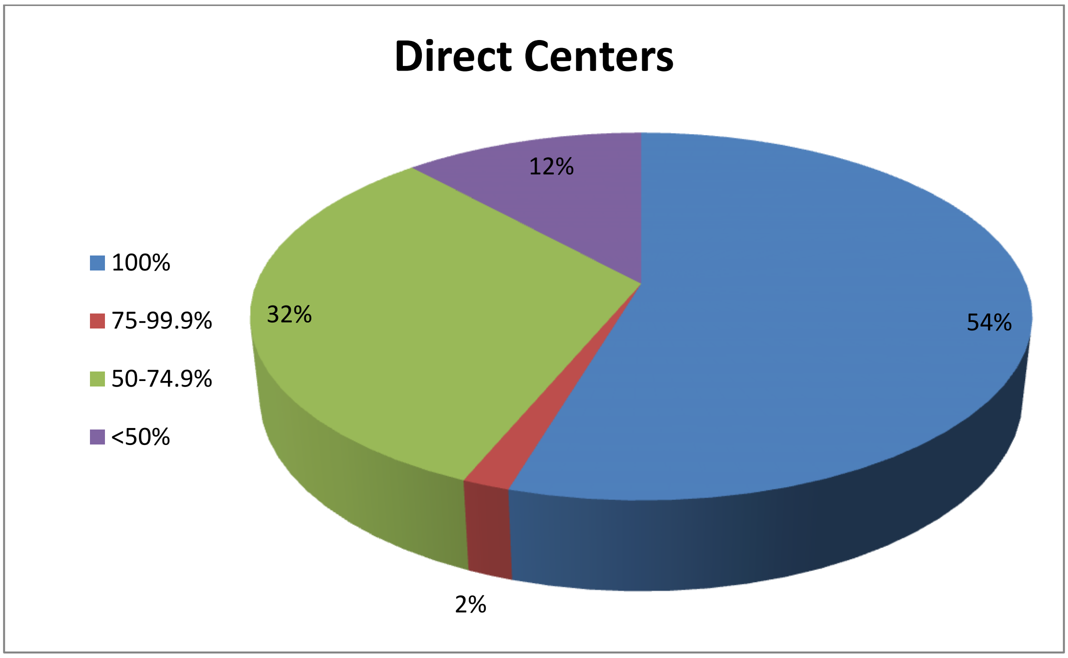


Figure IV-3 Ranking of TEVRS scores for indirect centers

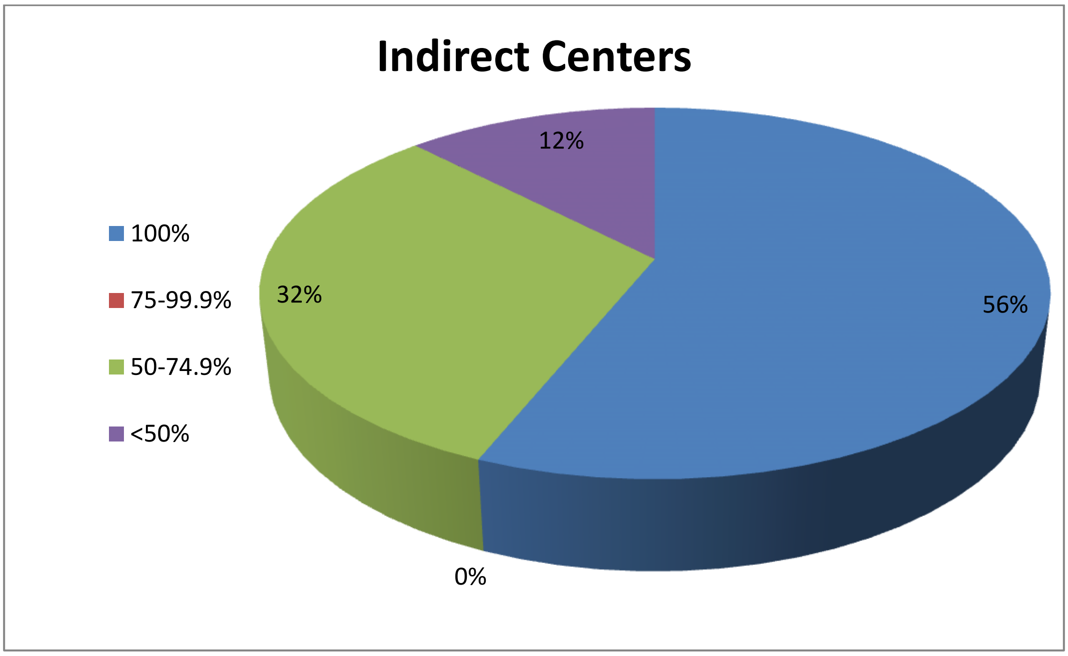


Table IV-5 Technical efficiency scores (CRS) and (VRS) for direct centers

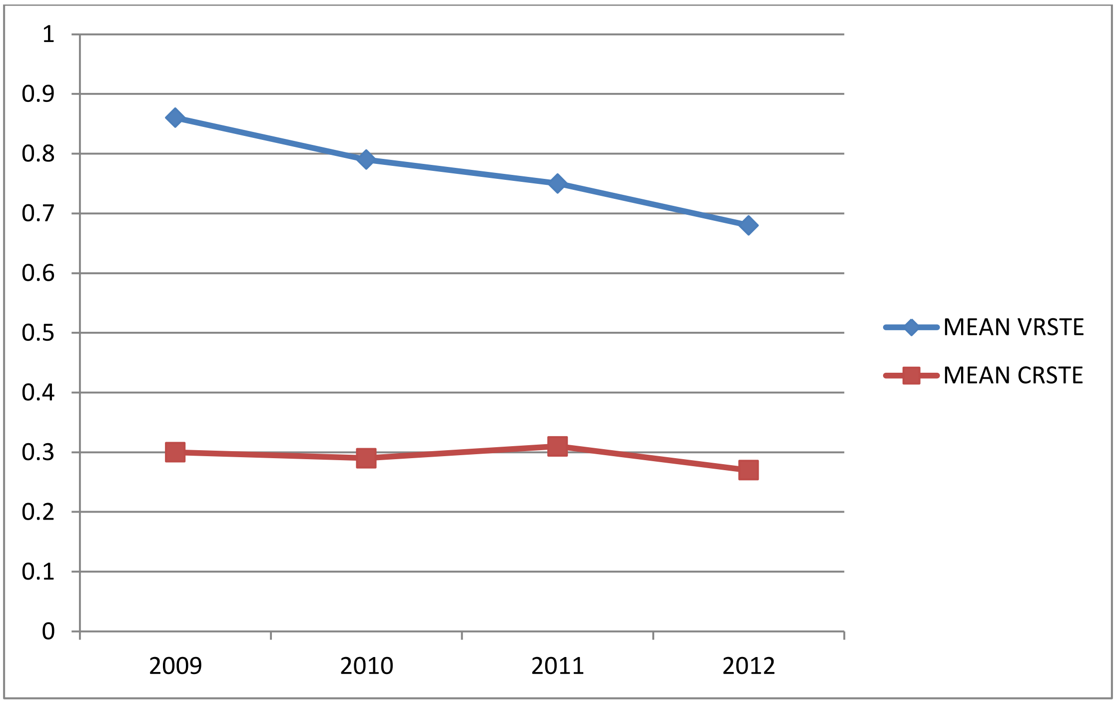
Center	TECRS	TEVRS	Center	TECRS	TEVRS	Center	TECRS	TEVRS
1	0.403	1	41	0.203	1	81	0.205	1
2	0.222	0.58	42	0.126	0.5	82	0.376	1
3	0.324	1	43	0.268	1	83	0.427	1
4	0.274	1	44	0.27	1	84	0.332	1
5	0.336	0.36	45	0.411	0.698	85	0.207	0.5
6	0.391	0.391	46	0.465	0.783	86	0.158	1
7	0.389	0.456	47	0.54	0.791	87	0.167	1
8	0.183	0.184	48	0.957	1	88	0.262	1
9	0.416	0.419	49	1	1	89	0.13	1
10	0.366	0.729	50	1	1	90	0.103	0.5
11	0.663	1	51	0.875	1	91	0.072	0.5
12	0.274	0.662	52	1	1	92	0.508	0.682
13	0.224	1	53	0.351	1	93	0.333	0.5
14	0.377	1	54	0.144	1	94	0.33	0.333
15	0.332	0.576	55	0.142	1	95	0.176	0.197
16	0.265	0.5	56	0.127	1	96	0.426	1
17	0.169	1	57	0.224	0.333	97	0.424	1
18	0.124	1	58	0.187	0.25	98	0.901	1
19	0.352	1	59	0.255	0.278	99	0.304	0.357
20	0.141	0.5	60	0.337	1	100	0.286	1
21	0.227	1	61	0.317	1	101	0.213	0.5
22	0.197	1	62	0.359	1	102	0.264	0.5
23	0.252	1	63	0.464	0.593	103	0.215	0.5
24	0.362	1	64	0.39	0.417	104	0.1	1
25	0.305	0.5	65	0.454	0.456	105	0.109	1
26	0.622	1	66	0.551	0.705	106	0.082	0.5
27	0.338	0.5	67	0.065	0.5	107	0.186	1
28	0.351	0.504	68	0.114	0.5	108	0.189	1
29	0.181	1	69	0.089	0.5	109	0.184	1
30	0.234	1	70	0.075	1	110	0.184	1
31	0.383	1	71	0.135	1	111	0.173	1
32	0.128	0.5	72	0.111	1	112	0.126	0.5
33	0.186	1	73	0.085	1	113	0.13	0.5
34	0.229	1	74	0.102	1	114	0.137	0.5
35	0.218	0.514	75	0.094	1	115	0.078	0.5
36	0.155	0.5	76	0.103	1	116	0.378	1
37	0.45	0.559	77	0.085	1	117	0.294	0.5
38	0.458	0.653	78	0.261	1	118	0.276	0.5
39	0.417	0.56	79	0.212	1	119	0.341	0.5
40	0.322	0.402	80	0.213				

Table IV-6 Technical efficiency sores (CRS) and (VRS) for indirect centers

Center	TECRS	TEVRS	Center	TECRS	TEVRS
1	0.287	1	30	0.591	1
2	1	1	31	0.089	1
3	1	1	32	0.636	0.656
4	0.405	0.454	33	0.798	1
5	0.265	0.339	34	0.32	1
6	0.221	0.333	35	0.377	1
7	0.484	0.488	36	0.974	1
8	0.763	1	37	0.454	1
9	0.25	0.545	38	0.875	1
10	0.386	0.56	39	0.565	1
11	0.329	1	40	0.422	1
12	0.318	0.5	41	0.107	1
13	0.608	0.714	42	0.058	1
14	0.13	1	43	0.18	0.5
15	0.293	1	44	0.162	0.5
16	0.248	0.536	45	0.088	1
17	0.121	1	46	0.11	0.5
18	0.315	1	47	0.272	1
19	0.264	0.333	48	0.204	1
20	0.207	1	49	0.046	0.5
21	0.103	0.5	50	0.531	1
22	0.148	0.5	51	0.128	0.5
23	0.269	1	52	0.107	1
24	0.078	0.25	53	0.216	0.531
25	0.254	1	54	0.266	0.389
26	0.492	0.508	55	0.333	0.591
27	1	1	56	0.146	0.5
28	0.573	1	57	0.19	0.5
29	0.974	1			

The time trend for technical efficiency (VRS) of the direct centers over the period between the year 2009 and 2012 showed a declining pattern. The mean technical efficiency score was 0.86 in 2009, 0.80 in 2010, 0.77 in2011 and reached 0.69 in 2012 (Figure IV-4).

Figure IV-4 Time trend for (TECRS) and (TEVRS) for direct centers



4.3. Input savings:

One of the valuable advantages of DEA is the measurements of the levels of inputs and outputs that are needed for an inefficient DMU in order to be efficient. Including in the result of DEA are the calculated input slacks for each individual health center in this study (input-orientated DEA). The following table (IV-7) shows the summary of the amounts needed from each input for both direct and indirect health centers to reach the level of 100% technical efficiency under variable return to scale. The comparison between the two types is shown in Figure (IV-7).

Table IV-7 Summary of input savings for direct and indirect health centers

Variables	Direct		Indirect	
	Actual	Excess	Actual	Excess
Physicians	80	3	109	5
Lab Technicians	113	20	134	31
Operational Expenses	446506	103796	343579	137822

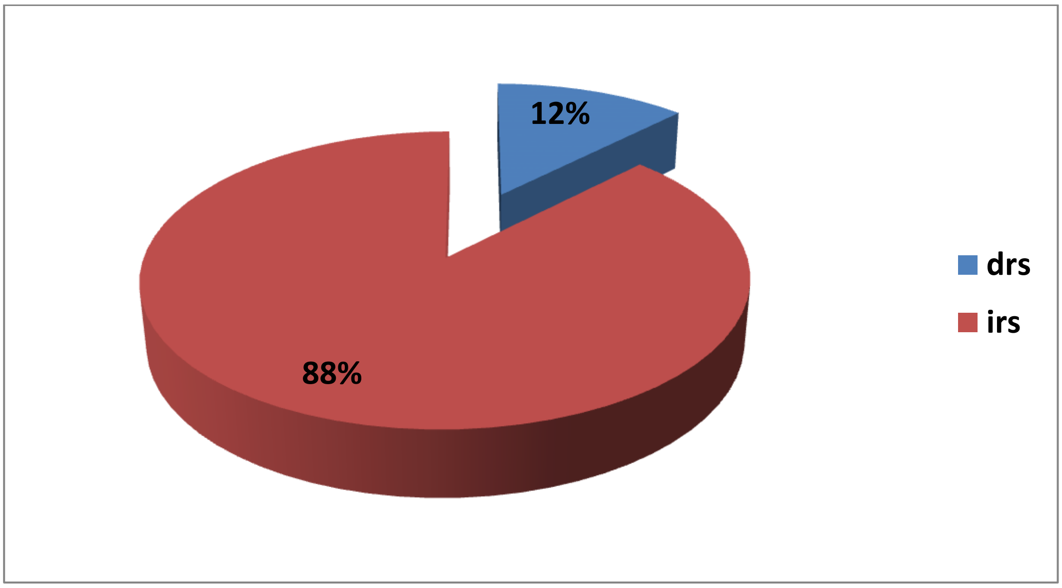
4.4. Pattern of scale inefficiency for direct and indirect centers:

Although the scale efficiency is out of the scope of this study, it is inevitable to mention some findings related to pattern of scale inefficiency as they were an essential part of the result of DEA.

It was found that scale inefficient centers of both direct and indirect reached a total of 169 constituting 96% of all observations, only 7 centers were found to be scale efficient. From the inefficient centers 88% showed a pattern of increasing return to scale meaning that these centers were too small for the volume of outputs they produced. On the other hand 12% of the inefficient centers showed decreasing return to scale, meaning that they were too large relative to their outputs.

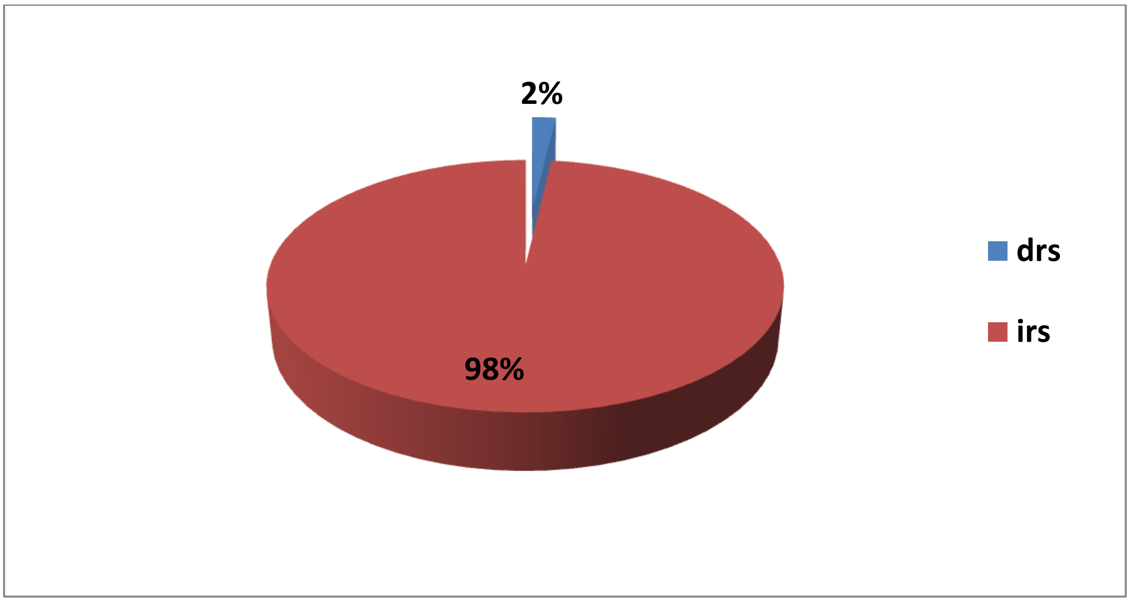
Comparing the two types of health centers the results showed that 83% and 98% of direct and indirect centers respectively showed increasing return to scale pattern as shown in (Figure IV-5) and (Figure IV-6).

Figure IV-5 Pattern of scale inefficiency of direct health centers



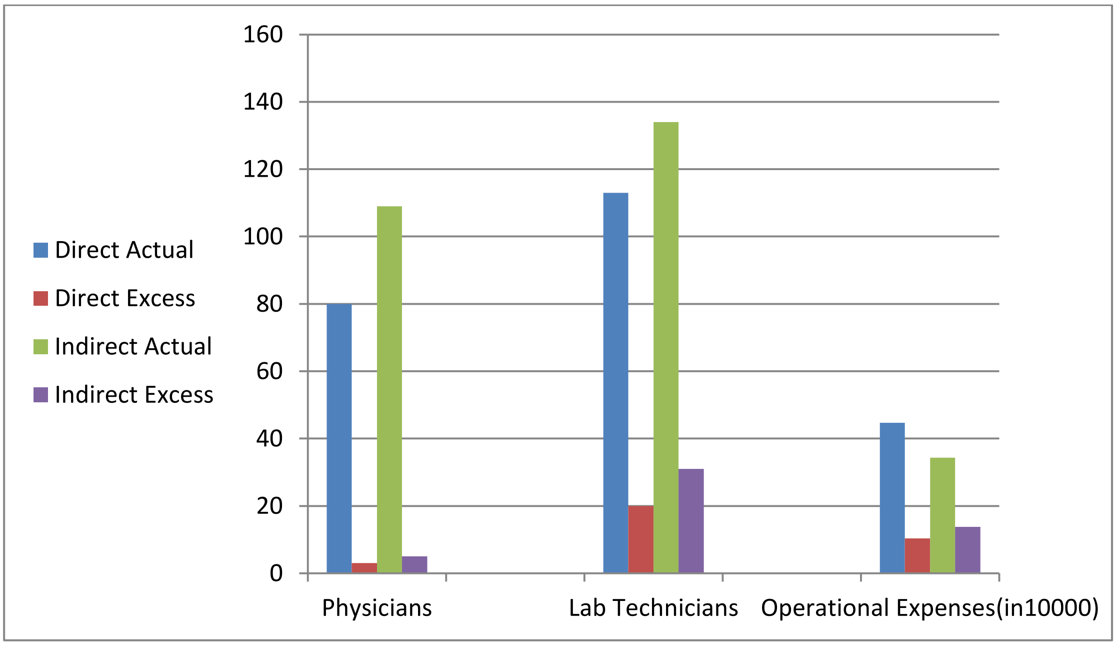
drs: decreasing return to scale, irs: increasing return to scale

Figure IV-6 Pattern of scale inefficiency of indirect health centers



drs: decreasing return to scale , irs: increasing return to scale

Figure IV-7 Input savings for direct and indirect health centers



4.5. Descriptive analysis of data used for regression model:

The second stage of data analysis used in this study is the regression analysis of the hypothesized model in order to identify factors that affect technical inefficiency of public insurance health centers in Gezira State.

The DMUs used in first stage, DEA, represented by 176 direct and indirect health centers. The technical inefficiency score of the i^{th} center was regressed as a dependent variable against 9 independent variables including: type of the center whether direct or indirect, location of the center whether in urban or rural area, the size of the center with regard to its number of departments, size squared, the ratio of medical staff to non-medical staff, time dummy variables as well as some interaction term between size and location. It is worth noting that time dummy variables used here were multiplied with type dummy variable because the data available for 4 years are confined only to direct centers.

The technical inefficiency scores used in this regression were generated from technical efficiency scores obtained from DEA under the assumption of variable return to scale .This assumption (VRS) is appropriate for DMUs used in this study which were working under many constrains including competition and insufficient budgets that impeding them from acting to optimal scales.

Descriptive analysis of the variables showed that total number of observations for each variable was 176. The technical efficiency scores were ranging from a minimum value of 0.184 to a maximum of 1 with a mean value of 0.77. RMD ranged between 0.29 and 8 with a mean of 1.9, while SIZE and SIZE ^{2} ranging between a minimum values of 3 and 9 and a maximum values of 12 and 144 with means of 7.6 and 60.9 respectively (Table IV-8).

Table IV-8 Summary statistics for some continuous variables used in regression

	RMD	SIZE	SIZE_2	T_E
Mean	1.9	7.6	61	0.77
Median	1.7	7	49	1
Maximum	8	12	144	1
Minimum	0.29	3	9	0.18
Std. Dev.	1.3	1.9	28.6	0.26
Observations	176	176	176	176

4.6. Results of regression analysis:

The result of the regression analysis was obtained using STATA computer program. The result showed that form 9 variables 6 were significantly affecting the technical inefficiency of the health centers at 95% confidence interval and 1 variable was significant at 90% confidence interval while 2variables were insignificant (Table IV-9).

This study used the type of health center (TYPE) as an indicator for the effect of ownership or administration on the technical inefficiency. The result of regression analysis confirmed that the type of the health center whether direct or indirect was significantly affecting the technical inefficiency of the center. The negative sign of the coefficient indicates that if the center is direct; administered by NHIF the technical inefficiency will be lower by 0.44 times compare with indirect center, holding other variables constant (Table IV-9).

The location of the health center is proved by the result of the regression analysis in this study to have a significant effect on the technical inefficiency. The positive sign indicates that being in an urban area the health center will have increased technical inefficiency score by a magnitude of 1.7 when compared to rural health centers holding other variables constant and considering this as a base line effect (without the effect of size). The effect of location on technical inefficiency could be explained by that the urban health centers use more inputs in order to keep an accepted level of quality as well as the uses of sophisticated equipment which consume more expenses and use more personnel. The mean for operational expenses per year was found to be 22303 SDG for urban centers compared with 6954 SDG for rural centers (Figure IV-8). Another explanation is that in the rural centers there was less number of labors, due to the less preference of medical personnel to work in rural areas. The mean for labor in urban centers was found to be 19 compared with 13 for rural centers (Figure IV-9).

Figure IV-8 Comparing operational expenses means of rural and urban centers

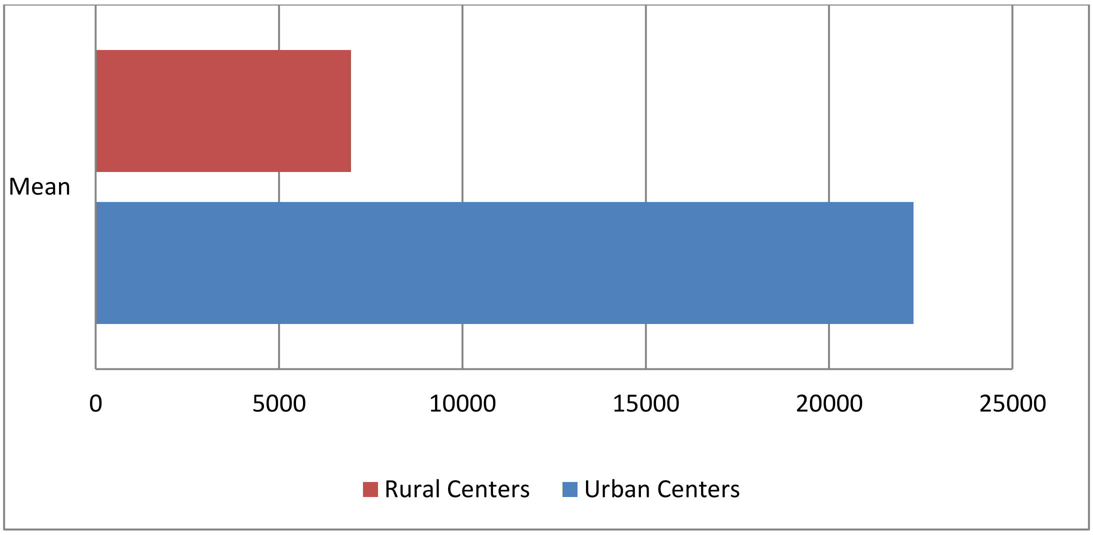
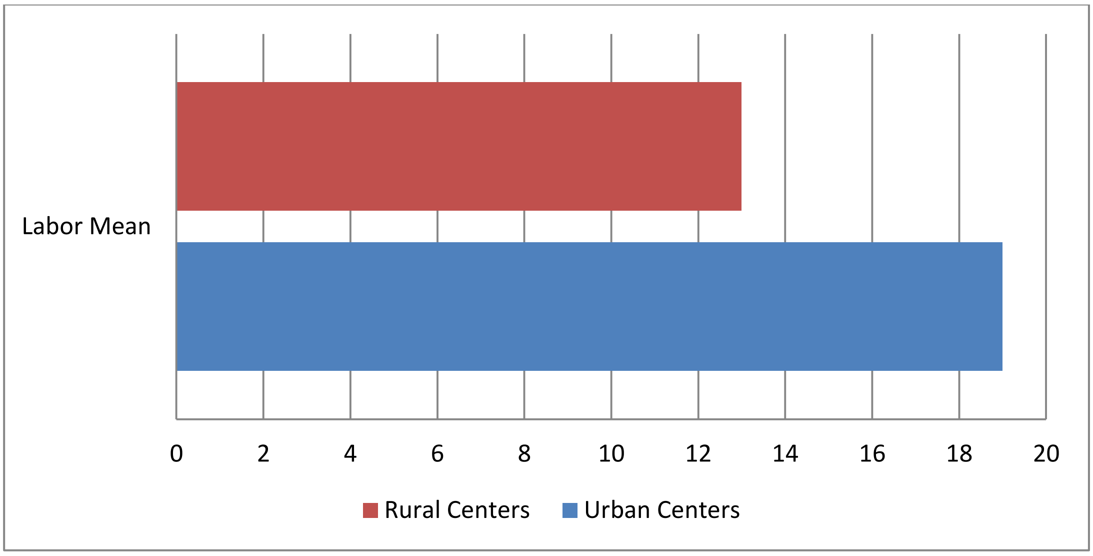


Figure IV-9 Comparison between means of labor in urban and rural centers



The size of the health center (SIZE) was found to have a significant effect on its technical inefficiency score at 90% confidence interval in this study. Bigger health centers were 0.2 times less technically inefficient than smaller ones, holding other variables constant and considering this as a base line effect (without the effect of location in the interaction term discussed below). The sign of the coefficient was shown to be negative and this was expected since the bigger the health center (having more departments) the more attractive it would be for clients and consequently more output it produced, hence less technically inefficient.

Table IV-9 Result of Tobit regression

Tobit regression				Number of obs	=	176	
				LR chi2(9)	=	59.79	
				Prob > chi2	=	0	
Log likelihood =	-97.4611			Pseudo R2	=	0.2347	

TI	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
TYPE	-0.43588	0.133568	-3.26	0.001	-0.69958	-0.17218
LOC	1.706059	0.385478	4.43	0	0.945022	2.467096
SIZE	-0.20942	0.125528	-1.67	0.097*	-0.45725	0.038406
RMD	0.081998	0.037303	2.2	0.029	0.008351	0.155644
$SIZE^2$	0.026036	0.009008	2.89	0.004	0.008251	0.043821
TYPE*YR10	0.138572	0.138907	1	0.32	-0.13567	0.412811
TYPE*YR 11	0.167488	0.140785	1.19	0.236	-0.11046	0.445436
TYPE*YR 12	0.34764	0.134733	2.58	0.011	0.08164	0.61364
LOC*SIZE	-0.19436	0.049737	-3.91	0	-0.29256	-0.09617
_cons	-0.01434	0.450519	-0.03	0.975	-0.90379	0.875103
/sigma	0.419076	0.038176			0.343707	0.494445
Obs.	summary:					
		97 left-censored observations at ti<=0				
		79 uncensored observations				
		0 right-censored observations				

* = Significant at 90% confidence interval

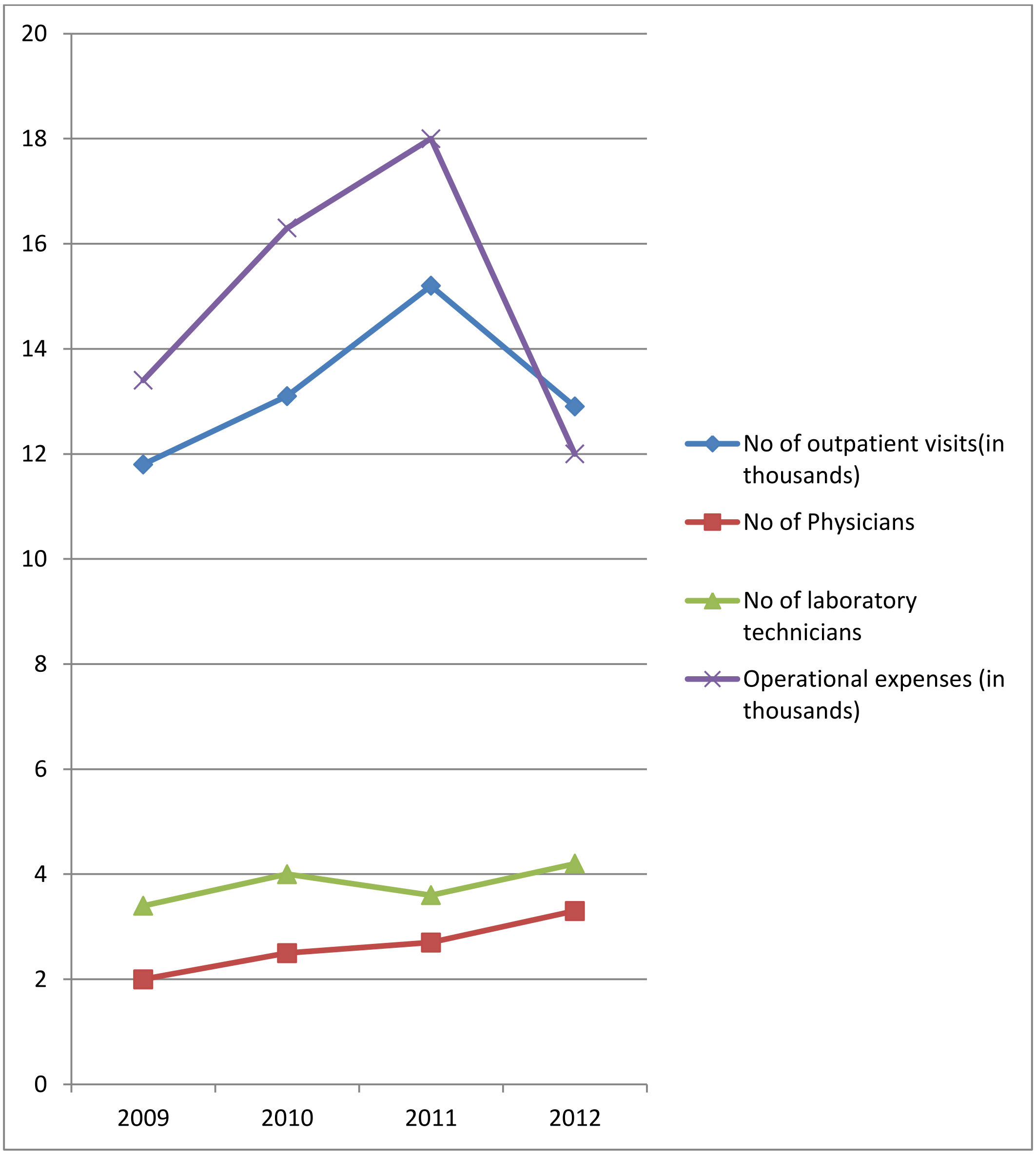
The size square ($SIZE^2$) was also significantly influencing the technical inefficiency of the center. The positive sign of its coefficient meant that as the squared size of the center increased by one unit its technical inefficiency increased by 0.03 holding other variables constant. The study used this variable because the technical inefficiency is bound while the size is not. It was found that as the size increased the technical inefficiency decreased up to a certain level after which the technical inefficiency increased with increasing size.

The ratio of medical staff to non-medical staff (RMD) was used in this study as a proxy for the redundancy in employment. It was confirmed by the result of the regression analysis that the effect of (RMD) on technical inefficiency was significant, and it contributed positively to it. This implied that as the (RMD) increased the technical inefficiency of the center increased by 0.08 holding other variables constant.

This was true since the mean of (RMD) in this study was greater than one (>1) as shown by descriptive analysis having a figure of 1.9 (Table IV-8).

Three time dummy variables were used by this study to assess the time trend of technical inefficiency over the period from 2009 to 2012 and that was confined to the direct centers only due to availability of data over the above mentioned period of time. To obtain this the time dummies were multiplied by (TYPE). The result of regression revealed that the technical inefficiency of the direct centers was increasing over the period from 2009 to 2012 indicated by the positive signs of all time dummy variables meaning that the technical inefficiency scores of the centers in year 2010 and the year 2011 increased with reference to year 2009 but this increasing in technical inefficiency was insignificant statistically as shown by p values of 0.32 and 0.236 respectively (Table IV-9). The same as with the year 2012 the technical inefficiency scores increased by 0.35 with reference to year 2009 and that was statistically significant ($p<0.05$). This could be explained by the increase in inputs of the direct centers over these years. By comparing the means of each input and output between the year 2009 and year 2012 it was found that the number of physicians increased by 60% and the number of laboratory technicians increased by 23% while the operational expenses decreased only by 10%. On the side of outputs, there was 9% increase in the number of outpatient visits on average while the number of vaccinated children increased by 21% (Figure IV-10).

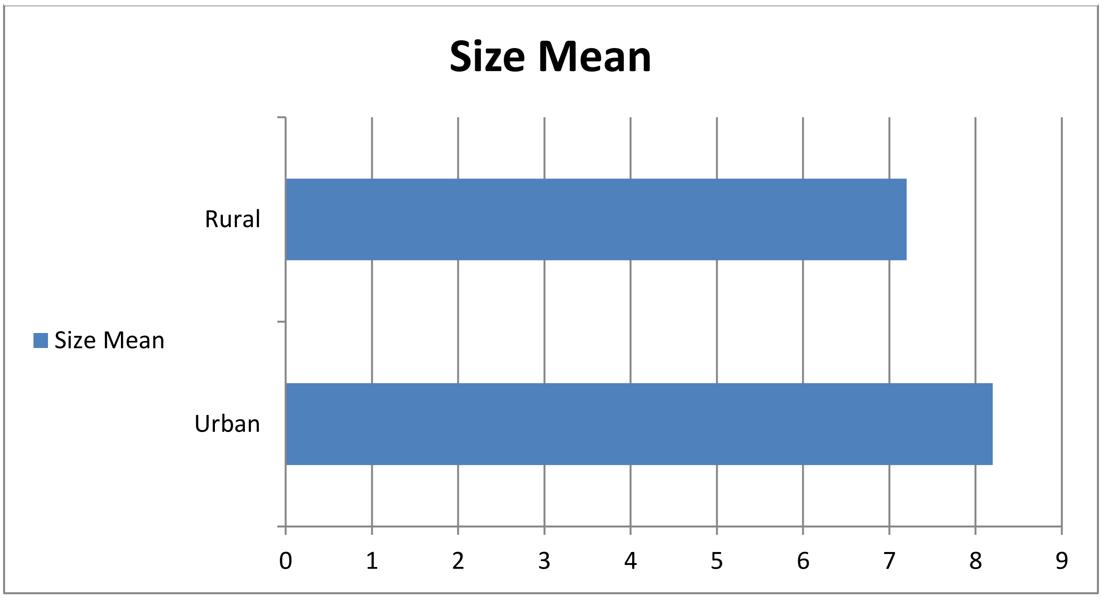
Figure IV-10 Pattern of some inputs and outputs of direct centers over time



The variable LOC-SIZE was used in this study as an interaction term to assess the relationship between this complex and the technical inefficiency testing the hypothesis that the effect of the size of the health center varied with location. The result showed that the effect of size on technical inefficiency significantly varied with location as denoted by $p<0.05$ (Table IV-9). The negative sign of the coefficient indicated that the slope (that reflected the relationship between the size and technical inefficiency of the health center) was lower for urban center compared with rural one.

The magnitude of the coefficient (0.19) indicated the difference between the effect of urban and rural location on the technical inefficiency of the health center. From the descriptive statistics it was found that the mean of the center size was 8.2 for urban centers compared with 7.2 for the rural (FigerIV-11).

Figure IV-11 Comparison between the size means of urban and rural centers



CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1. Conclusion:

From the available information this is the first study in assessing the technical efficiency in the primary level of health service delivery in Sudan. This study used data from 31 direct public insurance health centers covering 4 years period extending from 2009 to 2012 as well as data from 57 indirect ones in the year2012 in Gezira State. The data was collected from two sources; the State Ministry of Health and Executive Directorate of NHIF in Gezira State.

The variables used in this study included; the number of physicians, number of laboratory technicians and operational expenses as input mix in addition to number of outpatient visits and number of vaccinated children as output mix. These input and output mixes were used in the first stage of analysis to obtain the technical efficiency scores of these centers under two assumptions CRS and VRS using DEA as an analytical tool. Then the technical inefficiency scores were generated from TEVRS scores and used as an independent variable to identify the factors that affect the technical inefficiency of these centers using Tobit model as a method for regression. The independent variables included the type of the health center, the location, the size, the ratio of medical to non- medical staff ,the size^2, the location*size and 3 time dummies.

The results of the study showed that the means of technical efficiency were found to be 32% for CRSTE and 77% for VRSTE. It is also revealed that there were 54.6 % of the direct health centers working efficiently relative to their peers, and 56.1 % of the indirect health centers found to be relatively efficient (TEVRS).

Among the factors which were examined for their effects on technical inefficiency the study showed that the type, the size and the location*size were found to be significant and negatively affecting the VRS technical inefficiency score of the health center. On the other hand the location, the ratio of medical to non- medical staff, the size^2 and the time dummy variables 2012 were significantly affecting the VRS technical inefficiency score of the health center but in the positive direction.

Other factors were found to have insignificant effects included the time dummies for years 2010 and year2011.

The results of this study are not far from what were obtained by previous studies in the region. Kirigia et al (2004) measured the technical efficiency of public health centers in Kenya using the DEA approach. The study found that 44% of the health centers in Kenyan sample were technically inefficient. Osei et al (2005) conducted a pilot study on technical efficiency of public district hospitals and health centers in Ghana 2005. The study revealed that 47% of health centers were scale inefficient.

5.2. Policy implications:

From the results revealed by this study valuable policy implications could be derived in order to improve the performance of the public health centers in the primary level:

There were many public health centers in Gezira State (45.4 % of direct and 43.9 of indirect health centers) which run inefficiently, meaning that they used excess inputs or produced less out-puts. Each individual center in this study was provided by details of its status of technical efficiency relative to best practice of others. The target inputs that are needed for the center in order to be efficient were availed by this study. So for policy makers it is of value to know these details so as to take appropriate corrective actions to improve performance of these centers.

Direct provision of services by NHIF would be confined only for efficient or potentially efficient health centers for better usage of resources (45.4 % of direct centers were found to be inefficient).

The size of the health center should be adjusted to the optimum level that positioned the center in technically efficient status. Furthermore any plan of expansion of a health center or any department should be based on efficiency improving background.

5.3. Recommendations:

Excess physicians or laboratory technicians as well as monetary resources can be reallocated to the most needing facilities.

It is important for the NHIF to consider the comprehensive package of primary health care with special attention to the vaccination of children in its all health centers (20% of direct centers were found to have the minimum number of vaccinated children) for further improvement of their performance.

It is essential to exert more efforts for monitoring the trend of technical efficiency of primary health centers over time continuously through meticulous reporting of special targeted information in order to take appropriate protective and corrective actions as early as possible.

5.4. Limitation of this study:

Quality of services is of great important dimension as far as technical efficiency of health facilities is concerned. The study was limited by usage of quality indicators which could generate considerable variations in the performance health facilities. So the assumption that all health facilities included in this study were acting with the same quality is unlikely the case in reality.

The performance of primary care should ultimately be judged on its effect on the health outcome of individual patients. Efficiency measurements in this study used intermediate outputs such as number of outpatient visits and number of children vaccinated. Although these are not the ultimate outputs of the primary health care services but just proxies to the aggregate change in health status of citizens which is measured by indices like quality adjusted life years (QALY) and disability adjusted life years (DALY). Lack of such indices again was a limitation of this study.

Availability of data from primary health centers especially indirect ones was challenging. It was proposed to include more indirect centers and to expand the time scope of data to be 4 years, but that was limited due to lack of some important data. Operational expenses per year were typical example of a variable that necessitated tremendous efforts in order to get accurate values.

5.5. Recommendations for further studies:

Inclusion of qualitative analysis is of great value in order to make further extension of this study. This is important in digging deeply for factors influencing technical efficiency in the field of health.

Technical efficiency does not mean overall economic efficiency, so other types of efficiency are essential to be assessed. These may include allocative efficiency and total economic efficiency to have comprehensive measurements of overall efficiency.

Other factors which can affect the technical efficiency can be included in the model of regression to examine its significance magnitude and direction of effect. Such factors may include the population density around the center and the population coverage by health insurance in the catchment area, in addition to the level of health education, health awareness and their level of satisfaction about the services provided by the health facility.

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APPENDICES

APPENDIX A: raw data of inputs and outputs for DEA

Center	Outpatient Visits	Children Vaccinated	physicians	lab Techs	Operational Expenses
1	65341	1	6	16	48885.2
2	66019	1	11	26	74745
3	109992	1	13	25	77664
4	85510	1	12	23	27774.09
5	23212	450	3	5	6675
6	25827	590	6	4	29543.04
7	31572	193	7	5	30591
8	25906	660	8	11	10747
9	27476	206	6	4	29275
10	58203	473	9	11	80674
11	57704	483	5	6	87875
12	48648	512	15	11	26858
13	6042	160	1	2	8550
14	6797	192	2	1	7125
15	8364	159	2	2	1886
16	5258	173	2	3	1205
17	2875	260	1	2	1995
18	2521	246	1	3	2696
19	5128	248	1	1	2865
20	1667	279	2	2	2244
21	2788	574	1	2	3435
22	2271	513	1	2	4415
23	4406	523	1	2	3897
24	3822	512	1	1	3880.65
25	6665	997	2	3	4336
26	8330	915	2	1	5327
27	9193	965	4	2	13979
28	6733	995	3	2	4794
29	4724	243	1	3	5675
30	6305	193	1	3	7128
31	10354	270	1	2	7094
32	5778	447	2	5	6577
33	4712	267	1	3	4935
34	6192	193	1	3	6197
35	6287	319	2	2	5945

Center	Outpatient Visits	Children Vaccinated	physicians	lab Techs	Operational Expenses
36	4535	214	2	2	5099
37	36497	194	7	5	47909
38	39895	188	5	6	45608
39	37593	172	6	6	46335.95
40	32906	218	6	7	34253
41	1799	350	1	2	1852
42	1953	420	2	2	5503
43	2887	506	2	1	4806
44	1621	600	1	1	6753
45	41995	1	6	7	29888
46	48839	543	7	7	60300
47	42157	521	6	5	44184
48	37445	583	5	2	41600
49	2721	2800	1	1	4680
50	7880	2955	1	2	10080
51	6873	2980	1	3	6984
52	5274	3695	1	3	3600
53	5272	153	1	1	12680
54	3889	179	1	4	10080
55	3824	151	1	3	4320
56	3227	179	1	3	3000
57	15455	1	3	5	33198
58	17917	1	4	7	37999
59	18416	1	8	4	31010
60	2368	689	1	1	10996
61	4800	731	1	2	12807
62	3696	981	1	2	8735
63	31642	1	4	5	5563
64	22253	1	3	4	9438
65	27252	1	4	4	17553
66	33062	1	4	4	16900
67	2734	1	2	3	28183
68	4780	1	2	3	11855.99
69	3752	1	2	3	11396.91
70	1778	116	1	2	12372

Center	Outpatient Visits	Children Vaccinated	physicians	lab Techs	Operational Expenses
71	1688	104	1	2	1078.5
72	2987	76	1	2	22129
73	1939	130	1	2	2307
74	1110	110	1	2	1308
75	924	95	1	2	1208.5
76	593	120	1	1	1468
77	345	115	1	1	1709.5
78	6129	428	1	3	56397
79	5713	233	1	4	5568
80	5755	263	1	4	5880
81	5534	250	1	3	4520
82	10142	223	1	2	48950
83	11526	219	1	3	7080
84	8952	228	1	2	7080
85	8682	244	2	3	7000
86	4007	226	1	3	4962
87	4468	212	1	2	9845
88	7085	223	1	2	8042
89	2839	222	1	2	6527
90	4344	1	2	3	7500
91	2170	1	2	2	6853
92	15258	1	2	2	3900
93	17981	1	2	4	5950
94	24746	1	5	5	41651
95	19037	1	8	7	30000
96	2834	725	1	1	2700
97	7599	864	1	2	3500
98	11256	968	1	1	11400
99	15976	996	3	4	12000
100	3762	801	1	3	3360
101	4236	791	2	3	5100
102	4067	939	2	2	5950
103	3272	943	2	3	6100
104	1238	287	1	4	3100
105	1840	261	1	3	4800

Center	Outpatient Visits	Children Vaccinated	physicians	lab Techs	Operational Expenses
106	1920	301	2	3	5400
107	4288	312	1	3	5700
108	2541	497	1	3	2900
109	2846	414	1	2	4500
110	2734	423	1	2	3900
111	2701	438	1	3	14950.99
112	2644	274	2	2	3500
113	3385	254	2	2	6000
114	3749	237	2	2	9840
115	2789	323	2	4	12900
116	4215	1147	1	3	3400
117	4410	1254	2	3	5800
118	4886	1410	2	3	10200
119	3117	2000	2	3	15100
120	7740	335	1	3	6490
121	24096	683	4	1	6212
122	36451	1339	4	4	2124
123	15544	1168	4	3	6241
124	13354	783	4	4	4867
125	7200	671	3	4	3850
126	25512	754	6	3	9108
127	14628	762	3	1	7801
128	7504	301	2	2	4361
129	11140	582	3	2	3998
130	2870	531	2	1	2753
131	2170	769	4	2	2639
132	8500	101	2	2	814
133	2090	98	2	1	2736
134	3900	272	1	1	29560
135	7452	166	2	2	5560
136	1560	123	1	1	4800
137	8500	192	1	2	16189
138	7248	1925	3	4	20400
139	2700	195	1	1	2115
140	1452	242	2	2	3224

Center	Outpatient Visits	Children Vaccinated	physicians	lab Techs	Operational Expenses
141	3288	381	2	2	5167
142	5912	485	1	3	8500
143	4008	212	4	4	4500
144	5580	461	1	4	8228
145	11200	1130	2	7	2800
146	27000	1241	1	2	2100
147	9000	437	1	3	1200
148	3600	220	2	1	300
149	2600	1065	1	5	1800
150	1800	1	1	3	1500
151	9000	720	2	4	1400
152	2720	950	1	3	1200
153	2750	1	1	1	500
154	6250	393	1	3	1500
155	3600	220	1	1	300
156	9204	836	1	2	21060
157	13132	416	1	1	14560
158	8476	270	1	1	18050
159	10720	584	1	2	25200
160	2456	171	1	2	3600
161	650	128	1	2	2616
162	4346	413	2	2	5784
163	6000	445	2	3	6132
164	720	151	1	1	2868
165	4000	131	2	3	2652
166	5414	510	1	2	6852
167	5500	176	1	2	3144
168	640	81	2	2	2088
169	4800	916	1	2	1860
170	3500	194	2	2	3348
171	2900	123	1	2	2556
172	5998	139	2	2	2488
173	12000	161	3	3	14976
174	10000	237	2	2	3828
175	700	820	2	2	10296
176	2880	400	2	2	2784

APPENDIX B: Input slacks (input savings) for each center in the sample

Center	**Physicians**	**Lab Technicians**	**Operational Expenses**
1	0	0	0
2	0	0.64	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	7296.921
7	0	0	0
8	0.333	0	0
9	0	0	3478.087
10	0.763	0	0
11	0	0	0
12	4.518	0	0
13	0	1	4709.483
14	0.881	0	3137.172
15	0	0	0
16	0	0.429	172.405
17	0	1	1627.093
18	0	2	2351.86
19	0	0	349.639
20	0	0	721.837
21	0	1	2534.023

22	0	1	3617.581
23	0	1	1952.779
24	0	0	2685.448
25	0	0.36	520.929
26	0.475	0	1266.4
27	0.484	0	1691.654
28	0.044	0	0
29	0	1.999	3781.223
30	0	1.947	4624.887
31	0	0.817	2896.207
32	0	1.429	1880.192
33	0	1.992	3276.983
34	0	1.942	4010.969
35	0	0	0
36	0	0	893.897
37	0	0	0
38	0	0	0
39	0	0	0
40	0	0	0
41	0	1	1331.302
42	0	0	2111.965
43	1	0	4020.465
44	0	0	5807.884
45	0	0	0
46	0.773	0	0

47	0.216	0	0
48	0	0	0
49	0	0	0
50	0	0	0
51	0	1.039	2417.792
52	0	0	0
53	0	0	9955.862
54	0	3	9360.995
55	0	2	3695.235
56	0	2	2700
57	0	0.387	2568.369
58	0	0.333	1808.837
59	0	0	0
60	0	0	9899.791
61	0	1	9932.014
62	0	1	6701.604
63	0	0	0
64	0	0	0
65	0	0	2280.274
66	0	0	0
67	0	0.5	13791.5
68	0	0.5	3917.18
69	0	0.5	5178.079
70	0	1	12072
71	0	1	778.5

72	0	1	21829
73	0	1	2007
74	0	1	1008
75	0	1	908.5
76	0	0	1168
77	0	0	1409.5
78	0	2	52430.35
79	0	2.941	4094.124
80	0	2.942	4324.485
81	0	1.953	2941.777
82	0	1	39165.13
83	0	1.727	4074.578
84	0	0.873	3091.419
85	0	0.345	805.439
86	0	2	4071.914
87	0	1	8286.536
88	0	0.963	3872.862
89	0	1	6223.605
90	0	0.5	2371.317
91	0	0	3126.5
92	0	0	0
93	0	0.415	617.374
94	0	0	9394.264
95	0	0	0
96	0	0	1542.674

97	0	0.843	1475.929
98	0	0	0
99	0	0	0
100	0	1.925	2155.846
101	0	0.481	817.171
102	0	0	569.677
103	0	0.5	1522.581
104	0	3	2686.256
105	0	2	4430.395
106	0	0.5	2262.488
107	0	2	4349.945
108	0	2	2129.744
109	0	1	3870.651
110	0	1	3255.372
111	0	2	14280.9
112	0	0	1358.326
113	0	0	2642.279
114	0	0	4398.793
115	0	1	5975.14
116	0	1.684	1908.124
117	0	0.442	854.168
118	0	0.469	1594.196
119	0	0.5	4074.749
120	0	1.879	4065.536
121	0	0	0

122	0	0	0
123	0.29	0	0
124	0.139	0	0
125	0	0.177	169.915
126	0.164	0	0
127	0.671	0	1745.278
128	0	0	0
129	0	0	0
130	1	0	1925.023
131	1	0	87.477
132	0.018	0	0
133	1	0	2436
134	0	0	28776.92
135	0	0	0
136	0	0	4500
137	0	1	8784.768
138	0	0.236	1205.482
139	0	0	1815
140	0	0	1274.651
141	0	0	2010.174
142	0	1.972	5587.514
143	0	0	233.464
144	0	2.961	6091.688
145	0	1.892	0
146	0	0	0

147	0	1.769	484.615
148	1	0	0
149	0	3.514	697.554
150	0	2	1200
151	0	1.06	0
152	0	1.58	206.763
153	0	0	200
154	0	1.862	931.236
155	0	0	0
156	0	1	12489.82
157	0	0	0
158	0	0	10680.56
159	0	1	14577.12
160	0	1	3300
161	0	1	2316
162	0	0	1255.649
163	0	0.446	910.636
164	0	0	2568
165	0	0.5	446.063
166	0	1	3682.795
167	0	0.956	1502.833
168	0	0	744
169	0	0.724	673.313
170	0	0	1374
171	0	1	2256

172	0	0	0
173	0	0	0
174	0	0	0
175	0	0	3829.395
176	0	0	786.419
mean	0.084	0.621	3142.08

APPENDIX C: Technical inefficiency scores for each center in the sample

Center	TI score	Center	TI score
1	0	31	0
2	0.42	32	0.5
3	0	33	0
4	0	34	0
5	0.64	35	0.486
6	0.609	36	0.5
7	0.544	37	0.441
8	0.816	38	0.347
9	0.581	39	0.44
10	0.271	40	0.598
11	0	41	0
12	0.338	42	0.5
13	0	43	0
14	0	44	0
15	0.424	45	0.302
16	0.5	46	0.217
17	0	47	0.209
18	0	48	0
19	0	49	0
20	0.5	50	0
21	0	51	0
22	0	52	0
23	0	53	0
24	0	54	0
25	0.5	55	0
26	0	56	0
27	0.5	57	0.667
28	0.496	58	0.75
29	0	59	0.722
30	0	60	0

Center	TI score	Center	TI score
61	0	91	0.5
62	0	92	0.318
63	0.407	93	0.5
64	0.583	94	0.667
65	0.544	95	0.803
66	0.295	96	0
67	0.5	97	0
68	0.5	98	0
69	0.5	99	0.643
70	0	100	0
71	0	101	0.5
72	0	102	0.5
73	0	103	0.5
74	0	104	0
75	0	105	0
76	0	106	0.5
77	0	107	0
78	0	108	0
79	0	109	0
80	0	110	0
81	0	111	0
82	0	112	0.5
83	0	113	0.5
84	0	114	0.5
85	0.5	115	0.5
86	0	116	0
87	0	117	0.5
88	0	118	0.5
89	0	119	0.5
90	0.5	120	0

Center	TI score	Center	TI score
121	0	151	0.344
122	0	152	0
123	0.546	153	0
124	0.661	154	0
125	0.667	155	0
126	0.512	156	0
127	0	157	0
128	0.455	158	0
129	0.44	159	0
130	0	160	0
131	0.5	161	0
132	0.286	162	0.5
133	0	163	0.5
134	0	164	0
135	0.464	165	0.5
136	0	166	0
137	0	167	0
138	0.667	168	0.5
139	0	169	0
140	0.5	170	0.5
141	0.5	171	0
142	0	172	0.469
143	0.75	173	0.611
144	0	174	0.409
145	0.492	175	0.5
146	0	176	0.5
147	0		

148	0		
149	0		
150	0		

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