

Efficiency and Total Factor Productivity of Public Hospitals in Gezira State, Sudan (2011-2016)

Lena Bedawi Elfadli Elmonshied* and A.Osman Elnoor Mosa Fadlalla**

**Associate Professor, Department of Economics*

Faculty of Business and Administration, University of Prince Nourah Bint Abdulrahman, Riyadh- Saudi Arabia

LBELmonshid@pnu.edu.sa

***Faculty of Economics and Rural Development University of Gezira*

Abstract: OBJECTIVE: To examined from an empirical point of view, the efficiency of public hospitals in Sudan-Gezira state using the most recent advances in the empirical literature on the measurement of efficiency. A sample consists of 10 Gezira state public hospitals for which relevant data is available over the period 2011-2016 were selected.

METHODS: The technique employed in the analysis, is the non-parametric Data Envelopment Analysis (DEA) method, which utilizes the idea of the distance functions to handle the case where a production unit produces more than one output with a vector of inputs. This technique was applied DEA-type Malmquist efficiency for estimating public hospitals efficiency, we have also estimated the contributions of technological, technical and scale changes to productivity growth, and identified the major sources of productivity gains or losses For the DEA technique, economic efficiency is decomposed into allocative efficiency and technical efficiency, while the latter is further decomposed into pure and scale efficiencies. Furthermore, we have calculated the economies of size and investigated whether public hospitals are operating along their long-run cost curves.

RESULTS: The most important results concerning economic (cost) efficiency are summarized as follows the overall average cost efficiency is estimated at 24 percent, implying an average cost inefficiency of 76 percent ,results on productivity growth are public hospitals haven't been able to achieve productivity improvement for becoming more technologically advanced (average techch is -17 percent. These results suggest that the total factor productivity change (tfpch) refers to the technological backwardness and technical inefficiency change (teffch). Such decline in technology may reflect to the use of ancient equipment and shortage of trained human resources for health sector. Finally, the results concerning scale economy, based on the parametric method of the DEA, suggest that the most public hospitals in Sudan- Gezira state (60 percent) are in conditions of constant returns to scale thus, have the required optimal size. Furthermore 40 percent of public hospitals in the sample are having size problems.

CONCLUSIONS: In particular, these hospitals stretch or expand their activities to the extent that they become subject to decreasing returns to scale. Hospitals could reduce inefficiency by human capital development through training and qualifying health manpower and supporting staff internally and externally and also by decreasing administrative expenses. In addition to that, efficiency savings could augment the gains from user fees in terms of mobilizing additional resources, and increase cost-recovery ratios.

Keywords: Public hospitals efficiency, Data envelopment analysis, Malmquist productivity

LIST OF ABBREVIATIONS

Wad Madeni Teaching hospital	WMTH
Wad Madeni Maternity hospital	WMMH
Wad Madeni Children hospital	WMCH
Elmanagil hospital	EMEH
24 Elqurshi hospital	GURH
ELhush hospital	EHUH
Elgeneed hospital	EGNH
Tumpul hospital	TAMH
Elmature hospital	EMTH
Elrpei Rural hospital	ERRH
Allocative efficiency	AE
Scale efficiency	SE
Pure technical efficiency	PTF
Technical efficiency	TE
Technical efficiency change	Techch
Total factor productivity	Tfpch
Decision Making Units	DMU
Efficiency change	Effch
Scale efficiency change	Seffch
Pure efficiency change	Pech

1. INTRODUCTION

Considerable efforts have been made over the past decade to improve the understanding of available techniques for the measurement of efficiency and to gain empirical knowledge about the efficiency in the production of health services. Higher efficiency can allow greater production and better quality of services without committing further financial or real resources. It is important to note that better health is essential to improve quality of the labor force leading to efficiency of financial and physical investment as well.

In general, the economic terminology “efficiency” means absence of waste or using the resource as affectively as possible to satisfy people needs and desires. The concept of efficiency encompasses at least two components, namely a locative efficiency and technical efficiency, allocative (or Pareto) efficiency is the benefit attributable to the re-organization of the inputs (Samuelson and Nordhaus, 1992).

Health sector reforms aim at adapting to new change and challenges facing health systems in the political, economic, cultural and social areas at global, regional and national levels. The main determinants of these reforms are the consequences of macroeconomic reforms in developing economies, the move towards privatization and market economy, escalating cost of health care and changing role of government.

1.1 Problem of Study

The infrastructure of the health system in Sudan is often weak with limited access for rural and deprived population. The public network is affected by an insufficient budget, shortage in essential drugs and equipment.

Inspired by an empirical literature, which has investigated the efficiency of public hospitals particularly Gezira state faces weak efficiency of hospitals. Therefore, the research attempts to give an answer for the question: have the regulatory changes in their financial and managerial structure improved the efficiency and productivity of public hospitals in Gezira State over the period (2011-2016).

1.2 The Objectives of the Research

The main objective of this research is to analyze the Malmquist efficiency of Gezira State hospitals.

The specific objectives are:

To analyze the availability of various inputs and performance of outputs of each hospital in the sample.

2- To have efficiency analysis across the hospitals to identify the hospitals providing best services compared to others in the sample and to identify the over or under utilization of resources in these hospitals.

1.3 The Hypotheses

Due to the recent experience of public hospitals in Sudan, as in other developing countries it is hypothesized that:

1. The efficiency scores of the main players (public hospitals) in this sector are very low.
2. The eldest hospitals are relatively more efficient (relatively closer to the frontier) than the new hospitals.
3. The Sudanese public hospitals operate under non-increasing returns to scales and the hospitals witness decreasing average total factor productivity.

1.4 Research Methodology

The research carried out at Gezira state, the data covered the period from 2011 to 2016. This period together with the chosen hospitals, the sample consist of 10 public hospitals in Gezira state, which is collected from Ministry of Health in Gezira and hospital – level data set for these institutions over that period. To estimate the data is applied Data envelopment Analysis (DEA) Malmquist index uses the linear programming technique to compute the efficiency scores of each hospital.

2. LITERATURE REVIEW

Previous studies on the assessment of hospitals used various and different concepts of efficiency and productivity. Examples of these include total factor productivity, allocative efficiency, and technical efficiency. It is therefore essential to fully understand what these concepts mean before attempting to draw conclusions from previous literature. Total factor productivity is defined as the ratio of all outputs of a Decision Making Unit (DMU) divided by all production inputs. The value indicates how much output vectors can be produced by a unit vector of inputs (Coelli et al, 1998). Allocative efficiency deals with the minimization of the cost of producing a given level of output with proper choice of inputs and a given set of input prices, assuming that the organization being examined is already fully technically efficient (Avkiran, 1999). Finally, technical efficiency measures the ability of a DMU to obtain maximum outputs from a given set of inputs while assuming full allocative efficiency. Technical efficiency itself may be confounded by scale effects. Thus, it can be decomposed into pure technical efficiency and scale efficiency. Pure technical efficiency gauges the management performance in maximizing output. Scale efficiency indicates whether a DMU is operating at the optimal scale size. There would be scale inefficiencies if the DMU is operating at any other scale size (Avkiran, 1999).

Friesner et.al (2005) argued that efficiency measurement has been one of the most extensively explored areas of health services research over more recent times. Despite this attention, few studies have examined whether a provider's efficiency varies on a monthly, quarterly or other sub-annual basis. The authors examined the empirical evidence of seasonal inefficiency using a quarterly panel of general, acute-care hospitals from Washington State. It is observed that hospital efficiency does vary over time; however, the nature of this dynamic inefficiency depends on the type of efficiency being measured. The results suggest that technical and cost efficiency vary by quarter. Allocative and scale efficiency also vary on a quarterly basis, but only if the data are jointly disaggregated by quarter and another firm-specific factor such as size or operating status. Thus, corporate decisions and government policies designed to improve the efficiency of hospital care need to account for seasonal trends in hospital efficiency.

Chowdhury et al (2010) reported results on the Malmquist Productivity index obtained through the application of Data Envelopment Analysis (DEA) for hospital services using panel data for Ontario hospitals between 2003 and 2006. Efficiency is also decomposed into efficiency change that represents movement towards the best practice frontier, and technological change to represent movement of the frontier itself. The study also uses kernel density estimation techniques for analyzing efficiency distributions of the productivity scores and their components across different types of hospitals (e.g. small /large and rural /urban) and over time. The results suggest that in addition to average productivity, it is important to examine distributions of productivity and of its components which are found to differ by hospital type and over time. Their results suggest that productivity growth occurred mostly through improvement in technology and in spite of declining efficiency. The results provide useful insight into the underlying mechanisms of observed changes in overall productivity, in technological change and in technical efficiency change in this vital sector of the health care market.

According to Zere, E et. al (2006), Used Hospital capacity utilization ratios and data envelopment analysis (DEA) technique to assess technical efficiency of all 30 public sector hospitals in Namibia over four financial years (1997/98 to 2000/2001). The DEA model is based on data for three inputs (total recurrent expenditure, beds and nursing staff) and two outputs (total outpatient visits and inpatient days). To test for the robustness of the DEA technical efficiency scores, (Jackknife analysis) was used. The findings suggest the presence of substantial degree of pure technical and scale inefficiencies. Average technical efficiency during the given period was less than 75 percent. Less than half of the hospitals were located on the technically efficient frontier. Increasing returns to scale is observed to be the predominant form of scale inefficiency. It is concluded that the existing level of pure technical and scale inefficiencies of district hospitals is considerably high and may negatively affect the government's initiatives to improve access to quality health care and scaling up of interventions that are necessary to achieve health-related MDGs. To improve the overall performance of the health system, it is necessary that inefficient hospitals learn from their efficient peers identified by the DEA model.

According to Yusefzadeh et.al (2013), since hospitals are the most costly and important components of any health care system, it is important to know their economic values, pay attention to their efficiency and consider factors affecting them. The authors assessed technical scale and economic efficiency of hospitals in the West Azerbaijan province of Iran using Data Envelopment Analysis (DEA), and data on three inputs and two outputs. Slack and radial movements and surplus of inputs were calculated for selected hospitals. Finally, a model was proposed for performance-based budgeting of hospitals and health sectors using the DEA technique. Average scores of technical efficiency, pure technical efficiency (managerial efficiency) and scale efficiency of hospitals were 0.584, 0.782 and 0.771, respectively. The capacity of efficiency promotion in hospitals without any increase in costs and with the same amount of inputs was about 41.5 percent. Only four hospitals among all hospitals (23) scored the maximum level of technical efficiency. Hospitals with a technical efficiency score of less than one have original and projected amounts of inputs. Hence, these hospitals should reduce their amounts of inputs to achieve maximum efficiency and optimal performance. The results of this method were applied in benchmarking hospitals for making decisions about resource allocation, linking budgets to performance results, and controlling and improving hospitals performance

3. THE ECONOMY AND HEALTH SECTOR OF SUDAN

3.1 A Brief Overview of Sudan's Economy

Sudan was the largest country in Africa and the Arab world until 2011, when South Sudan separated as an independent country, following an independence referendum. Sudan is now the third-largest country in Africa (after Algeria and the Democratic Republic of Congo) and also the third largest country in the Arab world (after Algeria and Saudi Arabia). According to the World Bank classification, Sudan is classified amongst the lower-medium-income economies. According to the UNDP-HDI classification the average GDP per capita for Sudan is among the world's low-income and low human development group.

Data from Sudan's Central Bureau of Statistics and Central Bank of Sudan (2013) about the structure of Sudan's economy indicates the dominance of the services (49 %, 46.7 %) and agricultural (30.6 %, 30.6 %) sectors and low share of the

industrial sector (20.4 %, 21.1 %) in GDP in 2012 and 2013 respectively (See Central Bank of Sudan, 2013, p. 120). The structure of the Sudanese economy shows the importance of both the agricultural (71 %, 39 %) and services (21 %, 43%) sectors compared to the industrial sector (9 %, 18 %) in terms of both the share in total employment (1990) and value added as a percentage of GDP (2002) respectively (cf. World Development Indicator (WDI) database 2005). The structure of Sudan economy is characterized by rent-seeking, shifting from agricultural based economy to oil-based (or oil-dependent) economy that appears from high dependency on oil for exports and revenues, with oil contributing over 95 % of exports and about 50 % of government revenues. The heavy reliance on oil implies that Sudan's economy turned from low to lower- medium-income economy but suffers from uncertainty and high fluctuation in economic growth.

For some times, Sudan's economy has been characterized by low GDP per capita income, the presence of high rates of poverty, unemployment and inequalities in resources sharing. According to the World Bank's classification, Sudan was listed amongst the least developed poor and highly indebted economies but following the exploitation of oil and improvement in its economic performance, the country has turned from a low income economy into a lower medium income economy according to the World Bank classification. The increasing dependence on oil has led to sound economic growth. Consequently, Sudan's real economic growth averaged about 9 % during 2005–2007, putting Sudan among the fastest growing economies in Africa (The World Bank WB-DTS 2008). In 2010, Sudan was considered as the 17th fastest growing economy in the world given the rapid development of the country -largely from oil profits, despite international sanctions (UNDP, 2014).

However, the secession of the South in 2011, had gravely affected the economy as more than 80 % of Sudan's oil fields existed in the southern part of the country. This decline in oil revenues caused a major adjustment to the Sudan's fiscal situation and prompting financial austerity measures. The situation was further exacerbated by the continuing tensions between Sudan and South Sudan and their inability to reach an agreement over transit fees for oil from South Sudan (UNDP, 2014).

3.2 The Healthcare System in Sudan

This section briefly outlines the health system in Sudan. In addition to health institutions, we focus on the main characteristics of Sudan's healthcare system, with emphasis on the institutional, organizational and administrative structure of the system, together with the financial and human resources devoted to health.

3.2.1 Health Institutions

The history of comprehensive and organized medical services in Sudan dates back to 1899 with the inauguration of the Anglo Egyptian condominium rule, which showed some concern for the health of the indigenous population. At the time, health services followed, in the main, an officiated pattern with a combination of governmental control and governmental provision. Few military hospitals were built and scattered over the country in six big towns. The ministry of Health (MOH) was established in 1949, representing a significant development in history of health administration in Sudan. In 1954 Sudan was admitted as an associate member of the World Health Organization (WHO). This marked the beginning of WHO-assisted projects to help the country face its major public health problems.

Health services are provided by both the public and private sectors. The main provider director and agency responsible for health services is the Federal Ministry of Health besides the military and the police hospitals and the increasing number of private hospitals and clinics. The Federal policy necessitated a new structure and organization of the health sector. Accordingly, in 2011 the structure of the health sector consisted of the Federal Ministry of Health (FMOH) and 15 state ministries of Health (SMOH). Federal constitutional decrees have shifted almost complete execution and implementation of promotive, preventative, and curative health activities to state authorities. The environmental health service became the direct responsibility of the municipalities. Each state Ministries of Health (SMOH) has its own minister, a general director of health and provincial directors according to the number of provinces in the state. There are a number of department in the SMOH, each has its own duties and responsibilities (e.g. primary health care, curative medicine, epidemiology and environmental health, pharmacy and drug control, statistical and health information, financial administrative and personal

department). In each state there are a number of state hospitals, rural hospitals, health centers, dispensaries and primary health care units.

Information about Health Care Facilities in Sudan during the period 2008-2015 illustrated in table (1) clearly reflects the low level of primary health care facilities that constitute the base of the health care delivery pyramid. The table indicates the insignificant changes in dressing station number. While primary health cares units has increasing number from 2005 in 2008 to 3440 in 2013. The Hospitals has a significant growth until 2013-2014 the number of the hospitals steady in 428, then increased to 433 hospitals in 2015, as well the health centers and Dispensaries has a significant growth during all the period. Two points can be taken into consideration when reviewing table (1) first the health care pyramid has been shrinking at the bottom, while expanding at the top in contra-direction to policy recipes. Second, the rate of growth is not adjusted with population growth.

Table (1) Some Health Care Facilities in Sudan, 2008-2015

Year	Hospitals	Health Centers	Basic Units		
			Radiation-Units	Dressing Station	Primary Health Centers Units
2008	395	1398	165	542	2005
2009	407	1479	155	467	2067
2010	426	1603	195	359	1869
2011	419	1900	178	359	3726
2012	425	2020	196	365	3755
2013	428	2183	160	365	3440
2014	428	715	160	365	2906
2015	433	715	161	365	2837

Source: Federal Ministry of Health

3.2.2 Health Policies and Strategic Plans

Public health spending is low in Sudan relative to advanced economies, and health outputs and outcomes need to be substantially improved. Simply increasing public expenditure in the health sector, however, may not significantly affect health outcomes if the efficiency of this spending is low. Thus, to improve the performance of the health sector in Sudan, a number of measures have been taken in the context of national planning for the recovery and development of the health system. This section briefly outlines the health policies and strategic plans.

The national health policy reiterates the principles and directions laid down in the Constitution and vows to achieving the Millennium Development Goals (MDGs), maintaining and securing human rights and dignity, and fighting disease and ignorance. Specifically, since communicable diseases constitute a major cause of morbidity and mortality, the hitherto promulgated policies endorse their control and eradication. In this vein, the policies focus on reforms to strengthen the health system at the local and national levels based on the principles of primary health care. Further, the policies aim at building capacity in local health management and planning at federal, state and local levels for creating an enabling environment for the decentralized units within the health system

To achieve these long-term objectives, the Federal Ministry of Health (FMoH) has produced a 25-year strategic plan for the health sector (2003-2027) in response to the national government initiative for all sectors. The Strategy has eight goals, with sub-objectives, targets and indicators. The major priorities were to embark on an effective health system reform based on fair financing options, reduce the burden of diseases, promote healthy life styles, develop and retain human resources and introduce advanced technology while assuring equity, quality and accessibility. The strategic directions for improved health indicators for all citizens will be achieved through a broadened primary health care concept. Attention

will be given to human resource development through well planned and managed programs. Emphasis will be on health financing and pro-poor system reforms aiming to increase allocations and investing on health and especially targeting the poor and the disadvantaged groups. Public health services will be the responsibility of the government.

Goals of the strategy include combating HIV/AIDs, malaria T.B. and other communicable diseases, promoting healthy life style and reducing the burden of non-communicable diseases. Reducing child and maternal mortality, developing, managing and organizing health human resources, developing an integrated model of health care provision that delivers high quality and accessible services, building the capacity of federal and state ministries of health to be able to implement the strategy, developing sound systems to improve and optimize the allocation and use of health resources and to create an environment conducive to partnership building and promote the role of the private sector in health.

In line with the 25-year long term strategic plan and National Health Policy, a five-year medium-term Plan (2007-2011) envisaged the provision of health care to the citizens of Sudan, with special emphasis on the health needs of the poor, the underserved, and the disadvantaged that can lead all vulnerable groups to a socially and economically productive life. It sets objectives in terms of achieving MDGs, addressing all aspects of the health system, and promoting health as central to sustainable development and peace, supporting health interventions, reducing the burden of prevalent disease and strengthening emergency and humanitarian action for health. Following the Global Immunization Vision and Strategy (2006-2015) adopted by the World Health Assembly May 2005, the comprehensive multi-year national immunization plan (2006-2010) aimed at achieving eight objectives through four strategic directions: (i) service delivery and program management; (ii) advocacy and communications; (iii) surveillance and data for decision-making; and (iv) vaccine supply, quality and logistics.

3.3. Health Sector in the Gezira State

Gezira state lies mainly between the Blue Nile and the White Nile, in the central part of Sudan, south of Khartoum. It has a population of about 3.7 million, relying mostly on agriculture and grazing; people reside mainly in about three thousand scattered small rural villages. Tropical diseases like malaria and bilharzias are endemic.

The health system is composed of “healthcare centers” as the first line of primary care. Health centers that differ in size and function are mainly served by nurses, “medical assistants,” and doctors (medical officers). “Rural hospitals,” the referral point from health centers, are led by medical officers. Many such hospitals have operating theatres and wards for inpatient care. Secondary care hospitals are found in cities and are served by specialist doctors. Tertiary care hospitals in Medani (state capital) represent the end referral point for the entire state and sometimes from neighboring states. The secondary and tertiary hospitals are overburdened with patients who could have been managed at the primary care level, reflecting the need for qualified trained family physicians capable of providing higher-quality services with higher accessibility to the population.

3.3.1 Financing of the Health sector in Gezira State

The delivery of health services and the health of the population depend, amongst other, on the resources available for the health sector and how those resources are used. The allocation of funds by function has implications for the equity and efficiency of the health service delivery system. Over-funding of large central hospitals and under-funding of the primary health care network of peripheral health services is inequitable and inefficient as many diseases can be treated in primary health care and at less cost to both patient and health system.

Likewise, to be efficient, special disease control programs should target key health problems for which there are cost-effective interventions. Many types of financing of health care in Sudan do exist. These include government raised (general and earmarked taxation); social insurance contribution and this is levied through payroll and direct payment premiums, out-of-pocket payments and recently private insurance. Gezira state public health spending increased from 220.4

million SDG in 2015 to 250.9 in 2017. Table 2 shows the distribution of health manpower by sector and category in Gezira State during 2016. Professional health manpower engaged in the public sector in Gezira State during 2016 included 278 specialists, 653 MOs, and 17 dentists.

Table (2) Distribution of Health Manpower by Sector, Gezira State 2016

Jobs	Great Med-ani	South of Ge-zira	East Gezi-ra	Elhasahisa	Elkamleen	Elmanagil	Elqurash	Om-Elgora	Sum
Specialists	139	15	18	33	35	25	8	5	278
Medical Officer	325	25	61	114	57	43	10	18	653
Medical Assistant	218	120	107	103	68	43	24	44	727
Nurse	718	217	225	382	178	181	129	53	2083
Technicians	985	249	151	304	152	102	27	46	2016
Pharmacist	130	3	13	20	10	14	-	3	193
Registrar	123	43	17	79	19	9	7	4	301
Dentist	10	3	1	2	1	-	-	-	17
Public Health Officer	81	25	23	37	23	33	-	8	230
Health Visitor	11	10	2	7	6	5	1	3	45
Midwife	198	354	457	308	188	280	249	169	2203

Source: Ministry of Health in Gezira State

Table 3 shows the distribution of health facilities by sector and type in Gezira State during 2016. During that year the public sector in Gezira State ran runs 8 hospitals. These were served by 4461 beds, outpatient and inpatient was (1142304) and (165316), respectively.

Table (3) Distribution of Health Facilities by Sector, Gezira State, 2016

No	States	No of beds	Outpatient	Inpatient
1	Great Medani	1494	286768	66314
2	South of Gezira	244	100013	4189
3	Elmanagil	264	47932	13658
4	Elqurash	303	14979	6298
5	East Gezira	700	204572	1603
6	Elhasahisa	943	305297	39431
7	Elkamleen	333	99861	11498
8	Om- Elgora	180	55882	7915
	Total	4461	1142304	165316

Source: Ministry of Health in Gezira State

4. METHODOLOGY AND EMPIRICAL RESULTS

4.1 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a non-parametric mathematical programming approach to frontier estimation which uses linear programming to sketch a boundary function (efficient frontier) to observed data for relatively homogenous firms. It evaluates the efficiency of an individual hospital in comparison to other hospitals in the same hospital industry. The hospitals on the frontier have an efficiency score of one and are considered to be technically efficient relative to their peers. The efficiencies of the hospitals below the efficiency frontier are measured by their distance to the frontier Coelli (1994).

4.2 Malmquist Productivity Growth Index

This measure is concerned with how performance changes over time, where performance is measured in terms of total factor productivity (TFP) which is calculated as an index of output divided by an index of all inputs used. The purpose of measuring productivity is that it explicitly accounts for inefficiency. Moreover, comparisons of efficiency scores over time could be captured by examining changes in TFP over time. These changes may be attributed to changes in the values of distance functions from one year to another. In turn, these changes could be either due to (i) movement of institutions within the input-output space or (ii) to technical change captured by the shift of the production frontier over time (Gilbert and Wilson 1998; Wheelock and Wilson 2000).

As Berger and Humphrey (1997) pointed out, a long period is needed to uncover the underlying sources behind the efficiency and productivity developments. And since productivity growth (or change) is defined as the net change in output due to efficiency change and technical change, the study of total factor productivity change could be used to decompose the sources of efficiency into technical progress, pure technical efficiency change, and scale change. According to Berg et al. (1992) and Wheelock and Wilson (1999), the trend in annual efficiency scores may not accurately reflect the true impact of the operating environment when the benchmark frontier, against which efficiency scores are computed subject to change. Though closely related, efficiency and productivity concepts refer to different aspects of institutions' performance. Indeed, in a situation where change in efficiency is associated with technological progress, we can observe a joint decrease in institution efficiency and an increase in its productivity.

In practice, researchers employ different performance indices, such as the stochastic Tornqvist (1936) index or the non-stochastic Malmquist (1953) index, to measure productivity change in economic units. Stochastic approaches attribute deviations from the frontier to both purely random shocks and inefficiency, whereas non-stochastic approaches attribute all deviations from the frontier to inefficiency.

As mentioned in the previous section, distance functions can be used to define a variety of index numbers, which will be adopted in the present study as they are the most commonly used instruments to measure changes in levels of various economic variables and productivity. This measure of productivity will allow an examination of how performance of hospitals changes over time. Thus, total factor productivity is a generalization of single-factor productivity measure, such as labor productivity, which is the ratio (an index) of output to a single input, labor. Total factor productivity growth refers to the change in productivity over time and gives the relationship between productivity and efficiency.

Our first task in this section is to outline a more sophisticated method to measure changes in the levels of variable outputs and the associated change in the inputs used in the production process over time or across hospitals. Using a suitable formula, we can then compute input and output quantity index numbers. In turn, that will eventually lead to a measure of an index of total factor productivity (TFP). The second task is to examine the relationship between TFP indices and measures of efficiency and technical change.

The TFP index provides a measure of output change over a given period net of input quantity used over the same period. This index is preferred to partial productivity measures (such as output per unit of labor) since partial measures can

provide a misleading picture of performance. In what follows we briefly describe the computational method used here in deriving an index of TFP, either over time or across institutions.

The Malmquist index is defined using distance functions. As we noted earlier, distance functions allow one to describe a multi-input, multi-output technology without the need to specify a behavioral objective, such as cost minimization or profit maximization. We may define input distance functions as a function characterizing the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function, on the other hand, considers a maximal proportional expansion of output vector, given an input vector.

To understand the measurement of the Malmquist index as well as its decomposition, consider a production technology defined over the input set, $p(x)$, which represents the set of all output vectors y that can be produced using the input vector, x ; that is:

$$p(x) = \{y : x \text{ can produce } y\} \quad (1)$$

The output distance function is defined on the output set, $p(x)$ as:

$$d_0^t(x_t, y_t) = \min \{\delta : (y_t / \delta) \in p(x_t)\} \quad (2)$$

This gives a normalized measure of the distance from the location of a hospital in the input-output space to the production frontier at time t in the hyper-plane, where inputs are held fixed. The distance function, $d_0^t(x_t, y_t)$, will take a value less than or equal to one if the output vector, y^t , is an element of the feasible production set, $p(x)$ at time t . Furthermore, the distance function will take a value of unity if y^t is located on the outer boundary of the feasible production set, and will take a value greater than one if measured relative to the technology in another period, that is $\{0 \leq d_0^t(x_t, y_t)\}$ being less than, equal to, or greater than 1.

The Malmquist total factor productivity index measures the TFP change between two data points by calculating the ratio of the distance of each data point relative to a common technology. Following Färe et. al (1994), Ray (1999), Wheelock and Wilson (1999), and Mukherjee et al (2001), we calculate the Malmquist index m_0 , as the geometric mean of two Malmquist productivity indexes between the base period s , and period t , given by:

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)} \right]^{1/2} \quad (3)$$

Where $d_0^s(x_t, y_t)$ represents the distance from period t to the period s technology. A value of $m_0 > 1$ will indicate positive TFP growth from period s to period t while a value less than unity indicates a TFP decline.

Caves, Christensen and Diewert (1982) assumed that there is no technical inefficiency so that $d_0^s(x_s, y_s) = d_0^t(x_t, y_t) = 1$. However, since it is common to observe some degree of inefficiency in the activities of most hospitals, the assumption that $d_0^s(x_s, y_s) \leq 1$ and $d_0^t(x_t, y_t) \leq 1$ is likely to be more realistic. Where technical inefficiency is present, the output-oriented Malmquist productivity index defined in equation (5.8) can be rewritten as:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)} \right]^{1/2} \quad (4)$$

where the ratio outside the square bracket measures the change in the input oriented technical efficiency between years s and t , and the geometric mean of the two ratios inside the bracket captures the shift in technology between the two periods, evaluated at y_s, x_s and y_t, x_t . Figure (1) illustrates the decomposition of productivity components, where we have depicted constant returns to scale technology involving a single input and a single output. The institution produces at the points S and T in period s and t , respectively. In each period the hospital is operating below the technology corresponding to the period in question. Hence there is technical inefficiency in both periods.

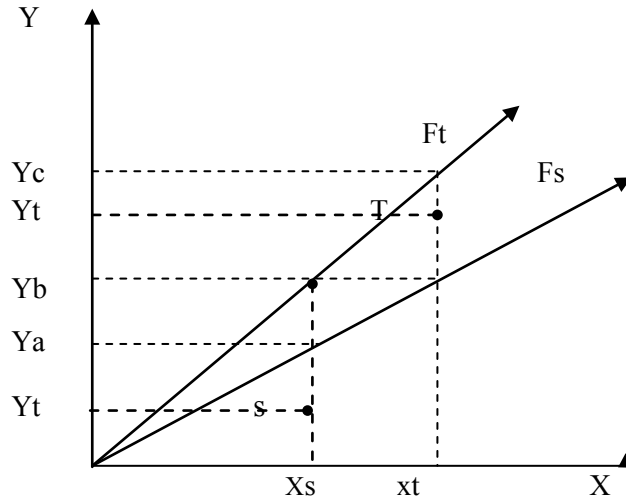


Figure (1) Productivity Change Source: Coelli et.al (1996)

In view of equation (4):

$$\text{Efficiency Change} = \frac{y_t/y_c}{y_s/y_a} \quad (5)$$

$$\text{Technical Change} = \left[\frac{y_t/y_b}{y_t/y_c} \times \frac{y_s/y_a}{y_s/y_b} \right]^1 \quad (6)$$

In empirical applications, and given that suitable panel data are available, the CCD method calculates the four distance measures that appear in equation (3), for each firm in each pair of adjacent time periods using DEA-like linear programming method suggested by Färe et al (1994). Thus, for the i th hospital, we calculate four distance functions to measure the TFP change between two periods. This requires solving four linear programming problems, given by:

$$\begin{aligned} [d_0^t(y_t, x_t)]^{-1} &= \max_{\phi, \lambda} \Phi, \\ \text{subject to } & -\phi y_t + Y_t \lambda \geq 0 \\ & x_t - X_t \lambda \geq 0 \\ & \lambda \geq 0, \end{aligned} \quad (7)$$

where $d_0^t(x_t, y_t)$ denotes the distance from period t observation to period t technology.

$$\begin{aligned} [d_0^s(y_s, x_s)]^{-1} &= \max_{\phi, \lambda} \Phi, \\ \text{subject to } & -\phi y_s + Y_s \lambda \geq 0 \\ & x_s - X_s \lambda \geq 0 \\ & \lambda \geq 0, \end{aligned} \quad (8)$$

where $d^s(x_s, y_s)$ denotes the distance from period s observation to period s technology.

$$\begin{aligned} [d_0^t(y_s, x_s)]^{-1} &= \max_{\phi, \lambda} \Phi, \\ \text{subject to } & -\phi y_s + Y_t \lambda \geq 0 \\ & x_s - X_s \lambda \geq 0 \\ & \lambda \geq 0, \end{aligned} \quad (9)$$

where $d^t(x_s, y_s)$ denotes the distance from period s observation to period t technology.

$$\begin{aligned} [d_0^s(y_t, x_t)]^{-1} &= \max_{\Phi, \lambda} \Phi, \\ \text{subject to } & -\phi y_t + Y_s \lambda \geq 0 \\ & x_t - X_s \lambda \geq 0 \\ & \lambda \geq 0, \end{aligned} \quad (10)$$

where $d^t(x^t, y^t)$ denotes the distance from period t observation to period s technology. In all these problems, Φ is a scalar indicating efficiency change for the i -th hospitals and λ is a $(N \times 1)$ vector of constants. It should be noted that in the linear programming problems (9) and (10), where production points are compared to technologies for different time periods, the Φ parameter need not be greater than or equal to one, because the data points could lie above the feasible production set. This will most likely occur in problem (10) where a production point from period t is compared to technology in an earlier period, s .

4.3 Study Sample

the percent study focuses on the public hospital for number of reasons. First, the public sector provides health services to the majority of the population. Second, such services consume a considerable proportion of expenditure on the health; however, if public health expenditure lead to the improvement of population wellbeing and increase the quality of life, they can hardly be regarded as an unmitigated burden on society. The study sample has been withdrawn from Gezira State, by far the second populated state in Sudan. The data cover the period from 2011-2016. This period, together with the chosen hospitals was dictated by the availability of a complete and consistent hospital level data set for these institutions over that period. The sample consist of 10 hospitals in Gezira state

4.4 Specification of Inputs and Outputs

Hollingsworth & Parkin (1995) discuss the fact that the use of too many inputs and outputs will lessen the ability to identify inefficient units. The fact that DEA operates more powerfully when the number of DMUs exceeds the number of the combined total of inputs and outputs by at least twice (Drake & Howcroft, 1994) restricted the input and output measures choice for this study. Being faced with different challenges, but with the support of the literature review, 5 inputs and 2 outputs were selected to measure efficiency in Gezira State.

Table (4) gives a list of the input and output variable, as well as the input price variable, their code, unit measurement, and source date.

Table (4) Variable Codes and Data Sources

Variable Category	Code	Variable	Unit of Measurement	Source of Data
Output	OUPD	Outpatients Department visits	Number	AHSR
	INPD	Inpatients days		
Input	EXP	Total current expenditure	SDG	FMOH, MOFGS, GSMOH
	NOD	Number of Doctors per hospital	Number	AHSR
	NON	Number of Nurses	Number	
	NOB	Number of Beds	Number	
	NOMT	Number of Administrative staff and labour staff	Number	
	NOAV	Number of medical assistant and technicians	Number	

input price	CEXP	Units current expenditure	Murabaha margin	Bank of Sudan
	CNOB	Units cost of Beds per hospital	SDG	GMEC HCC
	WNOD	Average cost of Doctors	SDG	Computed from FFAOGS
	WNOAV	A Average cost of Administrative staff and labour staff	SDG	
	WNOMT	Average cost of medical assistant and technicians	SDG	
	WNON	Average cost of Nurses	SDG	

Source: compiled from different sources: AHSR: Annual health statistical report, MOFGS: Ministry of Finance, FMOH: federal ministry of health, FFOGS financial accounting administration of Gezira state, GSMOH: Gezira state ministry of health, GMEC: GIAD Medical equipment corporation, SDG: Sudanese pounds.

4.5 Cost Efficiency of Individual Hospital in Gezira State

Table (5) reports average output of outpatient cases for different input. We observe that, among all ratios for all hospitals, the ratio of OUP to NOD is the highest (EMTH) and (EGNH) hospitals registered the highest average outpatient visits for both doctors (NOD) and medical assistants and technicians staff (NOMT) during the sample period, suggesting that on average a sampled hospital serves about 100-150 outpatient each day. The lowest output of OUP for NOD and NOMT inputs are registered for WMMH hospital, these low ratios means that these hospitals have better opportunity to provide quality medical services to their outpatients. The highest ratios of OUP to the number of nurses (NON) are registered for EGNH and TAMH hospitals, while these ratios are lowest for WMMH and WMTH hospitals. ERRH hospital registered the lowest unit cost, WMMH registered the highest cost (EXP) per (OUP).

Table (5) Average Ration Outpatient Days to Input, and Current Expenditure (SDG) Per Outpatient Days in Gezira State Hospital (2011-2016)

Hospital	EXP/OUTP	OUTP/NOD	OUTP/NOMT	OUTP/NOAV	OUTP/NON	OUTP/NOB
WMTH	188.3	369.2	269.8	200.3	302.5	150.7
WMCH	71.7	1654.5	940.5	501.9	457.7	269.1
WMMH	470.3	359.5	269.4	171.3	188.8	73.0
EMEH	148.7	965.6	564.0	566.2	608.9	224.0
GURH	44.4	2256.7	706.6	613.7	619.1	159.4
EHUH	66.9	1662.5	712.5	662.4	601.3	239.5
EGNH	43.8	5359.8	1745.1	1429.3	1271.8	471.9
TAMH	105.7	3618.2	1578.1	1158.9	1545.3	326.8
EMTH	98.0	4415.9	1387.9	467.1	578.3	138.0
ERRH	5.3	6449.8	1215.2	590.5	704.6	236.2

Source: Author calculations based on data

Table (6) reports average of inpatient days to different input. We observe that, among all ratios for all hospitals, the ratio of INPD to NOD is the highest (EMTH) and (ERRH) hospitals registered the highest average outpatient visits for both doctors (NOD) and medical assistants and technicians staff (NOMT). the ratios of INPD to NOD and NOMT are lowest for WMTH hospital (91 and 67, respectively), EHUH hospital (120 and 51, respectively), and EMEH hospital (150 and 88, respectively) these low ratios, however, may suggest that these hospital have better opportunity to provide quality medical services to their patient would have reasonable time to devote to each patient.

The ratio of INPD to the number of nurses (NON) and to the number of beds (NOB) is the highest for WMCH and WMMH hospital. While these ratios were the lowest for EGNH and EHUH hospitals. EGNH hospital registered the highest cost (EXP) per INP, ERRH hospital registered the lowest unit cost (EXP) these result provide early indication of quantitative efficiency with other costs constant.

Table (6) Average Ration Inpatient Days to Input, And Expenditure (Sdg) to Inpatient Days in Gezira State Hospital (2011-2016)

Hospital	EXP/ INPD	INPD/ NOD	INPD/ NOMT	INPD/ NOAV	INPD/ NON	INPD/NOB
WMTH	759.7	91.5	66.9	49.6	75.0	37.4
WMCH	295.7	401.3	228.1	121.8	111.0	65.3
WMMH	660.8	255.9	191.8	121.9	134.4	51.9
EMEH	954.4	150.5	87.9	88.2	94.9	34.9
GURH	376.4	266.3	83.4	72.4	73.1	18.8
EHUH	926.0	120.2	51.5	47.9	43.5	17.3
EGNH	1410.9	166.4	54.2	44.4	39.5	14.7
TAMH	911.1	419.8	183.1	134.5	179.3	37.9
EMTH	542.6	797.8	250.7	84.4	104.5	24.9
ERRH	46.4	741.5	139.7	67.9	81.0	27.2

Source: Author calculations based on data

The result of cost efficiency for individual hospital are reported in table (7) We observe that the overall average cost efficiency(CE) score is estimate at 0.24 implying that the hospital under study could have saved about 0.76 percent of the cost they have incurred in producing the same levels of output. Since cost efficiency is composed of technical efficiency and allocative efficiency, more insight on the source of cost inefficiency can be gained by evaluating the relative sizes of these measures. From table (7) it is observe that the average hospital is 0.80 technically efficient compared to best practice hospital (implying an average technical inefficiency of 0.20) and 0.27 allocative efficient (implying an average allocative inefficiency of 0.73) according, although technical inefficiency contribution to high in cost efficiency of Hospital in Gezira State.

Table (7) Average Efficiency of Individual Public Hospitals in Gezira State (2011-2016)

Hospital	TE	AE	CE
WMTH	0.47	0.16	0.09
WMCH	0.89	0.09	0.08
WMMH	0.38	0.07	0.03
EMEH	0.64	0.22	0.14
GURH	0.90	0.21	0.19
EHUH	0.76	0.28	0.22
EGNH	1.00	1.00	1.00
TAMH	1.00	0.15	0.15
EMTH	1.00	0.29	0.29
ERRH	1.00	0.20	0.20
Mean	0.80	0.27	0.24

Source: Author calculations based on data

Table (7) illustrate Cost efficiency score for individual hospitals ranged between the lowest score 0.30 for (WMMH) hospital and the highest score for (EGNH) hospitals, indicating that it is the most cost efficiency of all hospitals forming the best cost efficiency (CE) frontier, followed by (EMTH) with a cost efficiency score 0.24 (implying an inefficiency score 0.76). These results emphasize findings in table (7) it also worth full to note that EMTH has the first average ratio of the inpatient to the doctor, estimated with 797 inpatient per doctor in the sample. WMTH registered the lowest average ratio of inpatient days to number of doctor, estimate at 91 per doctor. The hospital average is 0.80 technically efficient compared to the best practice hospital (implying an average technical inefficiency of 0.20). WMMH hospital turned out as the most technical inefficient among the hospitals, from table (7) that WMMH has the secondary lowest ratios inpatient to each input moreover EHUH hospital characterized by secondary highest expenditure per outpatient. The allocative efficiency score 0.27(implying an inefficient score of 0.73) .The ranking on the hospital basis of allocative efficiency suggest that EGNH represents the best practice frontier in the industry, with score one, followed by TAMH, while the EMEH hospital have score 0.29(implying an inefficient score of 0.71), WMMH ranked as the last of allocative efficiency score 0.07 (implying an inefficient score of 0.93).

4.6 DECOMPOSITION OF TECHNICAL EFFICIENCY OF INDIVIDUAL HOSPITAL GEZIRA STATE:

In this section we reports of component of technical efficiency (TE) namely pure technical efficiency(PTE), and scale efficiency(SE) including returns to scale. We begin with result on the decomposition of technical efficiency for individual hospital in Gezira State.

Table (8) bellow report the result of the decomposition of technical efficiency for each hospital in the sample the first column reproduce the result of technical efficiency(TE) the average technical efficiency(0.80 implying an average technical inefficiency of hospital of 0.20) the observed technical inefficiency can be attributed to the lack of managerial, underutilization of capital, besides same factor which could influence the efficiency of hospital such factor are not traditional input assumed to be outside the control of the manager, like the characteristics and structure under which hospital operate and environmental variable which include location difference, type specialization, and nature of activities, size and government regulation and the distance of the hospital from the centers. The decomposition of technical efficiency suggest that on average hospital are 0.91 purely technically efficiency implying pure inefficiency 0.09 and 0.90 scale efficient implying scale inefficiency 0.10.

The level of the individual hospital the researchers observe form table (8) that the ranking of hospital based on pure technical efficiency has changed significantly compared to the ranking technical efficiency. In particular, WMCH, WMTH, EMEH, ERRH, EGNH, TAMH, and EMTH are the most purely technical efficiency hospital forming the pest practice frontier with score of unity. WMMH is the last purely technical efficient hospital with score of 0.38 (implying inefficiency with score of 0.62)

Table (8) Decomposition of Technical Efficiency in Same Individual Hospital Gezira State (2011-2016)

Hospital	TE	PTE	SE	Return to scale
WMTH	0.47	1.00	0.47	DRS
WMCH	0.89	1.00	0.89	DRS
WMMH	0.38	0.38	0.97	DRS
EMEH	0.64	1.00	0.64	DRS
GURH	0.90	0.90	1.00	–
EHUH	0.76	0.76	1.00	–
EGNH	1.00	1.00	1.00	–
TAMH	1.00	1.00	1.00	–
EMTH	1.00	1.00	1.00	–
ERRH	1.00	1.00	1.00	–
Mean	0.80	0.91	0.90	

Source: Author calculations based on data

4.7 Economies of Scale in Hospital Gezira State

Scale efficiency measures the extent to which individual public hospitals can take advantage of returns to scale by altering its size towards the optimal scale. Hospitals operating with (non-increasing, increasing or constant) returns to scale are likely to be viewed as attractive institutions either because they are currently operating in the optimal size range (in the case of constant returns to scale), or have the opportunity to become more efficient through growth (in case of increasing returns to scale). In contrast, hospitals operating with decreasing returns to scale are likely to be viewed as unattractive institutions because they are already too large in terms of scale economies and would have to be reduced in size to achieve optimum scale.

Given availability of data, the DEA software used for the empirical study of efficiency automatically gives results pertaining to the nature of returns to scale under which each hospital is operating. Table (8) and (9) summarizes these qualitative results in terms of frequency distributions of hospitals over the three types of economies of scale, namely increasing returns to scale (IRS), constant returns to scale (CRS) and decreasing returns to scale (DRS).

Table (9) Distribution of Gezira public hospital According Economies to Scale (2011-2016)

Return to Scale	Number of Hospital	Percentage
IRS	0	—
CRS	6	%60
DRS	4	%40
Total	10	%100

Source: Author calculations based on data

From table (9) illustrate that more of individual public hospital in the sample operates under constant returns to scale, 60% of the hospital they are current constant return to scale. Hospital operating under constant return to scale (6 out of 10 hospitals in the sample) thus has the required optimal size. While those operating under decreasing returns to scale represent are 40% these results suggest that they are not operating under most productive scale size that they are already too large (stretched) in term of scale economies and would have to be reduced in size to achieve optimal scale hospital. They need adjust their capacity in order to their efficiency. Such a reading suggest the present of technical and pure technical efficiency problems.

4.8 CHANGE IN PRODUCTIVITY OF INDIVIDUAL PUBLIC HOSPITAL:

The efficiency results reported in the previous sections are period averages, where annual efficiency measures were calculated for each individual hospital before taking the period average. This indicates that, given the data, an analysis of changes in efficiency over time can also be handled it can be captured through the concept of total factor productivity defined as an index of outputs divided by an index of inputs. To appreciate the relationship between productivity and efficiency in the context of distance functions recall that changes in the value of the distance function from one year to another could be either due to a movement within the input-output space or, alternatively, due to technical change corresponding to the shift of the production frontier over time. The change in total factor productivity (denoted tfpch), as measured by the input-oriented Malmquist index, is positive if the ratio is less than unity (reflecting an improvement in productivity) while if the ratio is greater than one, it reflects a deterioration in productivity (Fare et.al, 1989). All indices are calculated relative to the previous year and reported for each hospital in each year. In addition to the change in total factor productivity, the software used in the analysis enables the calculation of technical efficiency change (teffch), technological change (techch), pure technical efficiency change (pech), and scale efficiency change (sech). To obtain the annual rate of growth we simply subtract one from the reported results. Table (10) reports the results of the Malmquist performance index for the average hospital over the period 2011-2016. All indices are calculated relative to the previous year. With 2011 taken as the base year, we obtain indices for the period 2012-2016. In what follows we discuss these results.

Table (10) Malmquist Efficiency and Total Factor Productivity Change in Hospital of Gezira State (2011-2016)

Year	teffch	techch	Pech	Sech	tfpch
2012	0.94	1.23	0.96	0.98	1.16
2013	0.94	1.22	1.01	0.94	1.15
2014	0.94	1.05	0.87	1.08	0.99
2015	1.00	1.14	0.96	1.04	1.14
2016	1.00	1.19	0.94	1.07	1.20
Mean	0.96	1.17	0.95	1.02	1.12

Source: Author calculations based on data

Table (10) report the results on the productivity change. From the results reported on total factor productivity change (tfpch), the researcher observe that over the period under consideration average total factor productivity decreased at an annual average rate 12 percent, further productivity public hospital in Gezira State has decline by 16 percent in 2012, 15 percent in 2013, 14 percent 2015, and 20 percent in 2016. Productivity changes reflect the product of changes in technical efficiency and technology (Coelli et al., 1998). According to our findings, it seems that public hospitals in technological change have not been able to achieve productivity improvements through becoming more technologically advanced. This is attributed more to the decline in technical change (at an average rate of 17 percent). In other words, these results suggest that total factor productivity change (tfpch) was attributable to technological backwardness (techch). It is observed that techch decreasing during the study period, such decline in technology may reflect both use of ancient equipment, the lack of financial resources and shortage of trained human resources in the health sector.

Table (10) report the results on the two component of efficiency change, namely the change pure technical efficiency (pech) which due to managerial activity only, and the change in scale efficiency (sech). According to these results, public hospital recorded an average increased in pure technical efficiency change over the study period, except for 2013 the pure technical efficiency decreased 1 percent, the pure technical efficiency increased at an annual average rate 5 percent over the period, from the low rate of -1 percent in 2013, the result suggest that the observed growth in technical efficiency may attributed to growth in managerial efficiency more than to growth in scale efficiency (sech).

Table (11) Malmquist Efficiency and Total Factor Change Productivity For Individual Gezira State Hospital (2011-2016)

Hospital	teffch	techch	pech	sech	tfpch
WMTH	0.87	1.03	0.75	1.16	0.90
WMCH	0.95	1.00	1.00	0.95	0.96
WMMH	0.86	1.19	0.86	1.01	1.02
EMEH	0.92	1.04	0.85	1.09	0.96
GURH	1.02	1.45	1.02	1.00	1.48
EHUH	1.03	1.22	1.03	1.00	1.26
EGNH	1.00	1.10	1.00	1.00	1.10
TAMH	1.00	1.25	1.00	1.00	1.25
EMTH	1.00	1.31	1.00	1.00	1.31
ERRH	1.00	1.15	1.00	1.00	1.15
Mean	0.96	1.17	0.95	1.02	1.12

Source: Author calculations based on data

Table (11) presents the changes in productivity for each hospital in the sample over the period 2011-2016. From the results under the (tfpch) column in table (11), we observe that total factor productivity increased for only 3 hospitals namely WMTH, WMCH and EMEH. While it decreased for 7 hospitals, EMEH, WMMH, ERRH, GURH, EHUH, EGNH, and TAMH, the total factor productivity varied from the low rate of -48 percent (for GURH), -31 percent (for EMTH), -26 percent (EHUH), -25 percent (for TAMH) and -15 percent (for ERRH), to high rate of 10 percent (for WMTH). For the two components of productivity growth, the results suggest that technical efficiency (teffch) increased for 4 hospitals namely WMTH, WMCH, WMMH, and EMEH. It remained constant for TAMH, EGNH, ERRH. Technical change (techch), on the other hand, declined for all hospitals, varying between a lower rate of -45 percent for GURH and -3 percent for WMTH, the technical efficiency change of hospitals WMTH, EHUH, EGNH, WMMH, EAMH, ERRH, EMEH, EMEH, GURH, and TAMH decreased, constant for one hospital (WMCH).

For the two components the technical efficiency changes the results suggest that pure of technical efficiency change (pech) remain constant for 5 hospitals WMCH, TAMH, ERRH, EGNH, and EMTH, But increased for 2 hospitals ERRH and GURH, decreased for 3 hospitals WMTH, WMMH and EMEH. The scale efficiency sech decreased for 3 hospitals namely WMMH, WMTH and EMEH, and remained constant for 6 hospitals. WMTH represent the lowest scale efficiency change (-16 percent). The reduction in productivity for both types of hospitals may be attributed more to the lack of technological changes and innovations in hospitals than to technical efficiency change.

5. CONCLUSION

Productivity and efficiency of public hospitals have more recently become topical issues worldwide, receiving considerable attention in policy circles and within academic arena. As enrollments in public hospitals expanded, public funding is becoming increasingly scarce, particularly as competition increases from other recipients of public funds. The DEA results indicate that over the study period Sudanese public hospitals case study of Gezira state have been inefficient, and indeed are more cost inefficient. It is observed that total factor productivity in public hospitals declined over the study period, and that almost of them (6 hospitals representing 60 percent of the 10 hospitals in the sample) operates under constant returns to scale, while 40 percent operate under decreasing returns to scale. These results suggest that the most public hospitals in Sudan have the required optimal size, and the rest of public hospitals in the sample are having size problems. In particular, these hospitals (stretch) or expand their activities to the extent that they become subject to decreasing returns to scale. The very low estimates of overall average cost efficiency means that hospitals managerial behavior constitutes a serious problem in the smooth functioning of the health sector and may in the medium and long term jeopardize the continuity of these hospitals in providing health services. Indeed, these findings also suggest that Gezira state hospitals are not yet ready to compete globally in the field of health provision. Under conditions of globalization, a mean efficiency score that is lower than that for developed countries indicate the need for Sudanese hospitals to further improve efficiency. This is one of the vital areas for policy intervention, where the government could play the positive role of creating the appropriate environment for hospitals to promote efficiency. Hospitals could also reduce inefficiency through human and material capital development and better management and allocation of inputs and resources. While hospitals managements should be chosen on the basis of competence and expertise, they also need autonomy which describes management arrangements where managers have a greater degree of authority than in a traditional, directly managed public service. Autonomy can include financial management, e.g. freedom to spend within an overall budget, setting pay levels, transferring money between budget heads and selling off assets and responsibility of personnel management, e.g. hiring and firing staff, setting terms and conditions of employment, reward and discipline; and service development, including offering new services.

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