*Sumerianz Journal of Medical and Healthcare, 2019, Vol. 2, No. 2, pp. 9-25*
*ISSN(e): 2663-421X, ISSN(p): 2706-8404*
*Website: https://www.sumerianz.com*



Original Article Open Access

# The Efficiency of the Health System in Chad

**Charfadine M. Hassan***
Adam Barka's university of Abeche, Chad

**Djimoudjiel Djekonbe**
Dschang School of Economics and Management, Cameroon

**Dany R. Dombou T.**
Dschang School of Economics and Management, Cameroon

## Abstract

This paper measures and investigates the determinants of Chadian health system efficiency. The method used through the analysis is a non-parametric approach on panel data. By orienting the analytical framework from the global level (of the country) to the local level, the study will consider the following questions: Is Chadian Health System Efficient? What are the determinants Chadian Health System efficiency? To answer those questions, a DEA approach is used and a Tobit model is estimated. The results suggest that Chadian health system as a hole is not efficient. Indeed, the region of Ndjamena despite his high concentration of medical staff and material resources have the lowest efficiency score (0.20); it's followed by the regions of Ouaddai and that of Occidental Logone whose efficiency scores are respectively 0.57 and 0.59. The results also show that the socio-environmental factors and health expenditures positively affect the health system. Moreover, some educational factors, like the gross literacy rate negatively affects the efficiency of the system.

**Keywords:** Efficiency; Health; Government spending; Non-parametric analysis.
**JEL Codes:** H75; I1.

## 1. Introduction

Improving the efficiency of the healthcare system is a key policy objective to reduce the growth in health spending [1]. The quest for efficiency in health systems has received particular attention in recent decades since the publication of the World Health Organization's World Health Report on this issue [2]. This report focuses on the need for each health system to analyse how its resources (inputs) are valued to deliver health services (outputs) in order to meet the expectations of the population and the needs of society.

To achieve the objective of the health system that aims to improve the overall health status of the population by providing health services to the majority at lower cost, the Chadian Government considers health sector (and Education) in its first priority. This is justified by the growing budget allocated these last years to the health sector. Indeed, the latter went from 6.7 % in 2008 to 9.46 % in 2013 [3].

Despite the fact that its share increases in public funding, the productivity of this sector is still low. That is why the health indicators measuring the health standing of the population are deteriorating. As an illustration, maternal mortality ratio (MMR) moves from 1099 in 2004 to 1200 per 100 000 living births in 2010/2012, whereas countries such as Cape Verde, Egypt, Libya and Tunisia have achieved MMR below 100 deaths per 100 0 00 births in 2010 [4]. Moreover, infant mortality remains high and has not significantly decreased over 10 years, that is 194 deaths for 1000 living births in 2013 [5].

Another important indicator is life expectancy. The life expectancy at birth for Chad was 46 in 2013 when it was 60.78 in Ghana and 59 years old in Benin [6]. In addition, malaria is a public health problem, as long as 40 % of patients suffer from it, and remains the leading cause of death with 29.3 % of adult deaths and 30 % for children under 5 years old deaths [5].

Moreover, with respect to the country's economic growth, statistics show that growth rate of real GDP is decreasing. It went from - 0.088 % in 2008 to – 3.9083 % in 2014 [6]. This assumes that health spending rises faster than GDP real. It's obviously raising the question of the economic viability of the health system, therefore the need to analyse the efficiency of this system. According to WHO [2] and Roberts, *et al.* [7], efficiency measures the relationship between the resources invested in the health system and the achievement of health goals.

The purpose of this paper is not to compare Chad's health system with other systems, but to study its own internal performances. By orienting the analytical framework from the global level (of the country) to the local level, the study will consider the following questions: Is Chadian Health System Efficient? What are the determinants Chadian Health System efficiency?

To provide answers, the study will first determine whether or not Chadian health system is efficient; and secondly, investigate the influence of public health spending, education and demography, as factors explaining the efficiency of the health system.

*Corresponding Author

## 2. Literature Review

Works around health issues in developing countries, such as Evans, *et al.* [8], have found a positive relationship between health system efficiency and per capita health expenditure. However, they show that there is a minimum level of per capita health expenditure below which a health system cannot perform, and therefore cannot be efficient. In the same line, Gupta and Verhoeven [9] underline a negative relationship between efficiency and health spending per capita.

According to WHO [2], a health system is defined as the whole set of organizations, institutions and resources devoted to the production of health services. In addition, it is considered as efficient, when it ensures his three-layered mission: *the improvement, the responsiveness and the fairness of people' health status*. The improvement of health level matches to the degree of the physical, mental and social well-being of the population. The responsiveness of the health system is the capacity for the system to meet the needs and expectations of the population.

By conducting a re-estimation of the efficiency of health systems through the use of the same data and sample that Evans, *et al.* [8], Grenne [10] has sought to explain the variations in efficiency scores. It has used a more flexible approach which allows considering the variation in time of the coefficients and the heterogeneity of countries in terms of their sensitivity to the explanatory variables. The author has estimated a production function of health by using the total expenditures on health and education as inputs and it shows that by introducing the variables capturing the heterogeneity, the results are significantly different for some countries such as Saudi Arabia and the United Arab Emirates.

The measurement of performance in the production is generally made by the calculation of effectiveness or efficiency. According to Dukhan [11], the effectiveness in the health sector which connects the inputs or outputs to the objectives sought by the health system is often confused with the concept of "efficiency" which extend the way in which the available resources of the health system are assigned to the delivery of health services. In this work, we will seek to measure efficiency rather than effectiveness

Debreu [12], Koopmans [13], and Farell [14], works focuses on efficiency. This concept is part of a context where its importance in the productive activity is unavoidable. The literature suggests an adequate approach to measure any type of efficiency. According to Koopmans [13], "a producer is technically efficient, if an increase of any output leads to a reduction of at least one other output or an increase of one or several inputs and if a reduction of any input is reflected by an increase of another input or a decrease of another output". In the health sector, the technical efficiency can refer to the relationship that exists between the resources used (labour, capital) and some outputs health. Therefore for Farell [14], the technical efficiency measures the way in which the health system chooses the quantities of inputs that come into the production process.

*The allocative efficiency* assesses the way in which a care facility chooses the proportions of the various inputs in relation to the price of the market. Theoretically, a production process is said allocatively efficient if the marginal rate of substitution between each pair of factors is equal to the proportion of the price of the latter.

*The economic efficiency* is determined by the combination of the technical efficiency and the allocative efficiency [14]. It refers to the concepts of productivity, quality and performance.

In fact, empirical studies, despite the various methods converge in terms of results. Alexander, *et al.* [15] analyse the efficiency of the health system in 51 developing countries in 1999 by dividing the country into two samples: those for which the income per head is less than $1,500 and those whose income per head is between $1500 to $4500. They highlight a positive relationship between efficiency and health expenditures per capita in purchasing power parity in countries with low income and a negative relationship in higher-income countries.

Mané [16] hasanalysed the technical efficiency in three types of care facilities in Senegal. The inputs used are the number of beds and the medical staff. The Outputs are the number of consultations, the days of hospitalization, the occupancy rate average, the average length of stay and the index of rotation of the beds. The score for the average efficiency was 68% for the whole of the hospitals during the period 2006-2010. Thus, the institutions mean that the number of beds is between 200 and 300 appear more efficient than large and smaller.

In the analysis of the efficiency for 28 public hospitals in Angola between 2000 and 2002, Kirigia, *et al.* [17] have used the method DEA with as outputs selected the consultation visits and the days of hospitalization. The inputs are the medical staff, the number of beds, pharmaceutical expenditure and non-pharmaceutical products. The results show a level of efficiency means of 68.5%. The index of productivity of Malmquist was 1.045 reflecting an increase of 4.5%. The authors show that this variation of total productivity is explained by an increase in the efficiency of 12.7% combined with a drop in the earnings due to the technical progress of 7.3%. The increase in efficiency is explained by an increase in the technical efficiency of 5% and an increase in the efficiency of 7.3%. Tlotlego, *et al.* [18], had also analysed the technical efficiency of 21 non-academics hospitals in Botswana on the period 2006-2008. The inputs considered are the number of staff and the number of beds. The outputs considered are the visits of consultations and the days of hospitalization. The results show a score of average efficiency of 70.4%. As for the analysis of the improvement of the total productivity factors, the authors have shown that efficiency has decreased by 1.5% during the period considered.

Zere, *et al.* [19], have applied the DEA method to analyse the efficiency of 30 Namibians hospitals. The [1]number of beds, the medical staff and the recurrent expenditures are used as inputs. The outputs considered are the number of consultations and the number of hospitalization days. Their results show an average score of efficiency between 62.7% and 74.3%.

[1]Large, Med[1]ium and Small

The efficiency scores tend to be high with a small sample size as the one that we have used. Indeed, it is generally accepted that with the growing number of units to analyse, there is more chance that the frontiers built by the DEA method approximate asymptotically of the true border. With a small sample, the border obtained has a tendency to be close to the unit analysed [20]. This proximity reduces the distance between each unit of the border efficiency, therefore tends to give the scores of high efficiencies unlike samples of large size [21].

However, previous studies have used aggregate data in considering all the care structures of a country in a single unit of production. This way of proceeding presents difficulties and has consequences, because, on the one hand, the aggregation of data is a complex procedure [22]. And on the other hand, measures of technical efficiency obtained from such data must be interpreted with caution, because they depend on the structural environment specific to each country.

## 3. Health System in Chad: Stylized Facts and Constraints

In Chad, the organization of the health system is based on a redistricting health plan, structured at three levels. The first level is constituted by the basic health units whose activities focus on prevention; the second level includes general hospitals, paediatrics and obstetrics services; and the third level includes the other sanitary structures.

In fact, Health Statistics DSIS [5] show that the problems of Chadian health system are at several levels: to the level of the supply of health care (1), to the level of development of health resources (2) and to the level of drugs supply (3).

### *3.1. The Supply and Constraintsof Healthcare*

The shortcomings related to the supply of health care are among others, access, availability and coverage of health care. The data reported by the DSIS [5], emphasize a low coverage in health care structures, inadequate technical trays in the health structures, a low operationality of the mechanism and of the reference system, a low quality in the delivery of care, a shortfall in the organization of services, an insufficiency in the management of generic essential drugs and vaccines.

### *3.2. Constraints at the Level of Development of Health Resources*

The workforce of health staff in 2013 is estimated to 8 176 agents, including denominational structures, those of the military, NGOs and other institutions not covered directly by the Department of Public Health. Among those, there are 573 doctors, 3 606 nurses, 451 midwives, 24 gynaecologists, 109 sanitation technicians, 72 pharmacists, 182 pharmacy technicians and 448 administrative agents [5]. Despite the efforts provided by the Government and its partners in the training and recruitment, the needs of health staff always remain high. The tables below show the evolution of medical service for the year 2013.

The table (1) presents the medical service that relates to both the situation of doctors and that of the pharmacists on the whole of the country in 2013. The ratio of population/doctor is 22 109. A substantial improvement is observed compared to the situation for the year 2012. This state requires a strengthening of the workforce by 694 additional physicians. This need has hardly changed in relation to the situation of 2012 due to the absence of a coherent plan and effective training of medical staff. In addition, with regard to the situation of pharmacists, Chad has a pharmacist for 175 951 inhabitants. The workforce of pharmacists present on the territory is 72, insufficient compared to the needs of 1267. According to the standards laid down by the WHO, Chad has need of 1195 pharmacists to fill the gap.

**Table-1**. Ratio: Inhabitants per doctor/pharmacist

| No. | DSR | POP | Doctors | Pharmacists | Hab/Med | Hab/Pharm | * WHO Standards Physicians/Pharmacist |
|---|---|---|---|---|---|---|---|
| 1 | Bahr el Gazal | 295 220 | 5 | 0 | 59 044 | - | 30 |
| 2 | Batha | 560 517 | 10 | 0 | 56 052 | - | 56 |
| 3 | Borkou | 107 389 | 8 | 0 | 13 424 | - | 11 |
| 4 | Chari-Baguirmi | 663 756 | 7 | 1 | 94 822 | - | 66 |
| 5 | Ennedi-Est | 69 559 | | 0 | | - | 7 |
| 6 | Ennedi-WEST | 123 132 | 9 | 0 | 13 681 | - | 12 |
| 7 | Gera | 617 780 | 7 | 0 | 88 254 | - | 62 |
| 8 | HadjerLamis | 650 482 | 13 | 0 | 50 037 | - | 65 |
| 9 | Kanem | 382 569 | 11 | 0 | 34 779 | - | 38 |
| 10 | Lake | 497 784 | 9 | 0 | 55 309 | - | 50 |
| 11 | Logone Occidental | 790 694 | 13 | 1 | 60 823 | - | 79 |
| 12 | Logone Oriental | 894 309 | 13 | 1 | 68 793 | 894 309 | 89 |
| 13 | Mandoul | 720 719 | 10 | 0 | 72 072 | - | 72 |
| 14 | Mayo-Kebbi is | 889 080 | 14 | 0 | 63 506 | - | 89 |
| 15 | West Mayo-Kebbi | 647 742 | 7 | 0 | 92 535 | - | 65 |
| 16 | Moyen-Chari | 674 753 | 16 | 1 | 42 172 | 674 753 | 67 |
| 17 | N'Djamena | 1091 774 | 254 | 51 | 4 298 | 21 407 | 109 |
| 18 | Ouaddai | 827 555 | 23 | 1 | 35 981 | 827 555 | 83 |
| 19 | Salamat | 346 897 | 8 | 0 | 43 362 | - | 35 |
| 20 | Sila | 444 620 | 13 | 0 | 34 202 | - | 44 |
| 21 | Tandjilé | 759 552 | 8 | 1 | 94 944 | 759 552 | 76 |
| 22 | **Tibesti** | 29 243 | 3 | 0 | 9 748 | - | 3 |
| 23 | Wadi Fira | 583 381 | 13 | 1 | 44 875 | - | 58 |
| | **Other*** | | 99 | 14 | - | - | - |
| **Total** | | **12668 507** | **573** | **72** | **22 109** | **175 951** | **1 267** |

**Source**: DSIS [5]

Due to the high level of maternal and infant mortality, the authorities in charge of the issue of maternal health and the technical and financial partners rely on midwives to reverse the trend. However, the table presented below reveals that the overall needs for midwives are not covered in full. It will, therefore, be necessary to strengthen the current workforce by 100 additional agents.

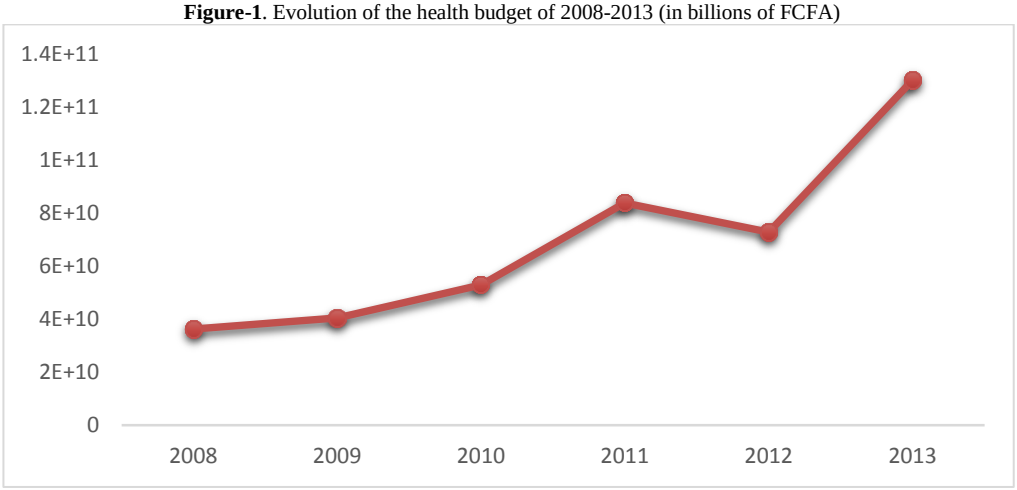
**Table-2.** Ratio of childbearing women per midwife

| No. | Delegation Regional Health | Women of childbearing age (FEAP) | Midwives | The ratios | The standards |
|---|---|---|---|---|---|
| 1 | Batha | 121 968 | 5 | 24 394 | 24 |
| 2 | Borkou | 23 368 | 4 | 5 842 | 5 |
| 3 | Chari-Baguir | 144 433 | 6 | 24 072 | 29 |
| 4 | Gera | 134 429 | 7 | 19 204 | 27 |
| 5 | HadjerLamis | 141 545 | 4 | 35 386 | 28 |
| 6 | Kanem | 83 247 | 5 | 32 098 | 17 |
| 7 | Lake | 108 318 | 2 | 54 159 | 22 |
| 8 | OccidentalLogone | 172 055 | 18 | 9 559 | 34 |
| 9 | OrientalLogone | 194 602 | 12 | 16 217 | 39 |
| 10 | Mandoul | 156 829 | 4 | 39 207 | 31 |
| 11 | Mayo-Kebbi | 193 464 | 14 | 13 819 | 39 |
| 12 | Mayo-Kebbi | 140 949 | 3 | 46 983 | 28 |
| 13 | Moyen-Chari | 146 826 | 21 | 6 992 | 29 |
| 14 | Ouaddai | 180 076 | 5 | 36 015 | 36 |
| 15 | Salamat | 75 485 | 4 | 18 871 | 15 |
| 16 | Tandjilé | 165 279 | 8 | 20 660 | 33 |
| 17 | Wadi Fira | 126 944 | 3 | 42 315 | 25 |
| 18 | N'Djamena | 237 570 | 244 | 974 | 48 |
| 19 | Barh el Gazal | 64 240 | 2 | 32 120 | 13 |
| 20 | East Ennedi | 15 136 | | | 3 |
| 21 | Ennedi West | 26 793 | 7 | 3 828 | 5 |
| 22 | Sila | 96 749 | 6 | 16 125 | 19 |
| 23 | Tibesti | 6 363 | 10 | 636 | 1 |
| | Other | | 57 | - | - |
| **Chad** | | **2 756 668** | **451** | **6 112** | **551** |

**Source**: DSIS [5]

The Government allocates each year a budget to the health sector. The figure below shows the evolution of the financing of the last five years. The effort of the State on the internal resources out of debt and external funding, traced by the indicator of the budget of the health/ the General Budget of the state, goes from 5.65 percent in 2012 to 9.8% in 2013. This is an important progress compared to the trend of the past several years where he was on average around 5%.

**Figure-1**. Evolution of the health budget of 2008-2013 (in billions of FCFA)




**Source**: authors from data of PNS-Chad (2008-2013)

## *3.3. Infrastructure and Sanitary Equipment*

The construction of infrastructures and the provision of equipment are the basis of health development. Since 2005, efforts have been made by the Chadian Government in this area. It is as well as from 2005 to 2013, the State has built 86 health centres, 19 Hospitals and 6 regional hospitals [5].

The table 3 below shows the situation of the logistics in the different health regional delegations in 2013. Biomedical Devices, the computer hardware, refrigeration, the means assemblies are of inputs necessary in the production of health. We note that the region of the Ennedi West and the region of the Salamat have no medical imaging equipment. The region of Sila has an ultrasound device but not of x-ray device. By against the region of the Barh El Gazel does not ultrasound device but has two devices of radiology. It would be desirable to remedy these problems in order to bring all regions at the same level.

**Table-3.** Situation of logistics in the DRS in 2013

| DSR | Ambulances | Computer Hardware | Generators | Refrigerators | Freezers | Ultrasound | Radiography |
|---|---|---|---|---|---|---|---|
| Barh El Gazel | 11 | 2 | 15 | 8 | 2 | 0 | 2 |
| Batha | 10 | 3 | 4 | 34 | 2 | 4 | 3 |
| Borkou | 8 | 3 | 5 | 5 | 1 | 1 | 1 |
| Chari-Baguirmi | 8 | 8 | 5 | 28 | 3 | 3 | 4 |
| Ennedi is | 6 | 8 | 7 | 7 | 1 | 1 | 1 |
| Ennedi West | 7 | 1 | 1 | 4 | 2 | 0 | 0 |
| Guera | 11 | 13 | 9 | 6 | 1 | 2 | 2 |
| HadjerLamis | 9 | 11 | 3 | 36 | 4 | 3 | 4 |
| Kanem | 6 | 4 | 8 | 47 | 11 | 2 | 2 |
| Lake | 6 | 8 | 7 | 31 | 8 | 2 | 3 |
| OccidentalLogone | 10 | 14 | 8 | 13 | 2 | 4 | 2 |
| Logone Oriental. | 14 | 6 | 10 | 52 | 8 | 2 | 3 |
| Mandoul | 11 | 24 | 7 | 35 | 6 | 6 | 4 |
| East Mayo Kebbi | 11 | 18 | 5 | 22 | 3 | 2 | 1 |
| West Mayo Kebbi | 8 | 12 | 4 | 41 | 3 | 2 | 1 |
| Means.Chari | 15 | 10 | 6 | 44 | 8 | 5 | 2 |
| N'Djamena | 10 | 7 | 4 | 56 | 10 | 2 | 1 |
| Ouaddai | 7 | 8 | 5 | 28 | 4 | 1 | 1 |
| Salamat | 7 | 8 | 4 | 28 | 2 | 0 | 0 |
| Sila | 7 | 5 | 3 | 22 | 8 | 1 | 0 |
| Tandjile | 9 | 2 | 4 | 56 | 4 | 1 | 1 |
| Wadi Fira | 10 | 3 | 4 | 42 | 3 | 3 | 2 |
| **TOTAL** | **201** | **178** | **128** | **645** | **96** | **47** | **40** |

**Source**: DSIS [5]

### *3.4. The Constraints at the Level of Drugs Availability*

The pharmaceutical sector has done over the past five years significant progress both on the institutional plan that in the field of supply. However, the consolidation and the sustainability of achievements are still fragile. A great effort remains to consent to ensure the population of quality medicines and accessible. The main shortcomings related to the pharmaceutical sector are at two levels.

The Act No. 24/PR/2000, relative to the Pharmacy suffers from a lack of application because of the weakness of the pharmaceutical inspections and veterinary products. The imports and the origin of the pharmaceutical products which fall in the country are sufficiently known;

The absence of a laboratory for quality control of pharmaceutical products. The procurement system of the public sector is faced with great difficulties of irregular supply and frequent stock-outs.

## 4. Measurement of the Health System's Efficiency

Several methods have been identified in the literature, either to explain the Efficiency [23] or to measure the efficiency of health systems [10, 24]. These empirical methods are among others: the parametric and nonparametric methods.

### *4.1. The Non-Parametric Method (DEA)*

The DEA (Data Envelopment Analysis) method has been developed by Charnes, *et al.* [25] to assess the efficiency of a U.S. federal program for the allocation of resources to schools. The use of this method is then generalized in other public organizations (hospitals, social services, offices of unemployment, electrical plants, police, etc.). In addition, the DEA is a non-parametric method and deterministic. Non-parametric, in the sense that it is not necessary to define a functional form for the border of production and deterministic since no hazard event is included in the specification of the model.Ozcan and Bannick [26] and Afonso and Aubyn [27] argue that the DEA approach is a useful method to assess the technical efficiency of the suppliers of health care service in the measure where you can use several inputs of different type and also several outputs during a single analysis.

### *4.2. The Parametric Method*

In 1957, Farrell initiates the parametric approach (SFA, Stochastic Frontier Analysis) by imposing the approximation of the production function effective by a functional form known a priori. As well, it employs the Cobb-Douglas function based on the constant returns to scale for estimating the productive performance of agricultural forty-eight American states [28]. The production function is called deterministic if the observed difference is due only to the inefficiency. In addition to the technical failure, if one takes into account the other errors of measurement, the omission of other explanatory variables, the incorrect specification of the model and the not taken into account the other events which can influence the production, the border, therefore, becomes stochastic. The method of stochastic borders was originally proposed by Meeusen and Broeck. [29] and Aigner and Schmidt [30]. The Stochastic model stipulates that the deviation of the technological frontier is composed of two terms, one representing the stochastic error and the other the inefficiency.

The stochastic error is generally assumed to follow a normal law and the inefficiency that can be either semi-normal, either normal, truncated exponential either. The level of production of a firm Y_i is the product of a deterministic component, inputs X_i whose form is given by a function of Cobb-Douglas type, the statistical noise 〖Ui and inefficiency. V *i*

$$Y_i = \exp(X_i\beta + V_i - U_i) \qquad (1)$$

.

$Y_i$ is the average health of the ith region (i=1,2,…,14); Is a vector Of inputs used by the ith region; β is a vector of unknown parameters; U_i is the error term normal (iid) N(0,σ_v^2) ;

And V_i is the term of technical inefficiency and follows a normal law-truncated.

This model can be estimated by the method of least squares corrected or by maximum likelihood.

# 5. Methodological Approach

## *5.1. THE Specification of the Estimation Method*

In this analysis, the choice will focus on the non-parametric approach DEA. The method adapts to the complexity of the technology multi-outputs/multi-inputs, the absence of true prices both for the inputs that for the outputs. In this way, the DEA is close to the theory of the X-efficiency of Leibenstein [31], and it is appropriate to the case of these complex organizations that are the heath institutions. In addition, the method allows to estimate of the scores of efficiency in a first time and in a second time, to explain the scores of efficiency in using the OLS or a Tobit model in panel to take into account the character truncated or censored of the endogenous variable between 0 and 1 [32]. Each score is, therefore, a relative measure between 0 and 1. For a given DRS, a score of 1 means that it is located on the border of efficiency; a score of efficiency in output orientation of 0.6 for example, indicates that it could improve its output of 0.4 without modifying its inputs.

## *5.2. The Mathematical Models of the DEA Method*

In this presentation, we will limit ourselves to describe the two models mostly used in the literature: the CCR model [25] and the BCC model [33]. These are two variants of the General Model, commonly called DEA. In both cases, we can distinguish: the models are known as "oriented inputs", if one examines the efficiency in terms of inputs, that is to say it is interested in the inefficiency in term of excess inputs; models called "oriented outputs" if we want to analyse the efficiency in terms of outputs, that is when it is needed to apprehend the inefficiency by the insufficiency of outputs.

## *5.3. Data*

The data used in the analysis of the efficiency of the health system come, for the majority from Chadian departments of health statistics. These departments not only describe the health data but conduct a more thorough analysis of the indicators in the National Plan for Health Development and the sheet of National Road to the reduction of maternal mortality, neonatal and infant mortality. They cover the period of 2004-2013 and relate to 14 regional delegations to health. The choice of these delegations Regional Health is guided by the availability of data on the period of the study. The variable literacy rate comes from the National Directorate of Literacy and the promotion of national languages. The variable access to the water comes from the Directorate of supply of drinking water and sanitation of the Ministry in charge of the water. In addition, to measure the efficiency of the health system, we must first specify the inputs and the outputs. In the area of health, the inputs and outputs used are very large. We have chosen those who meet the more, to the objective of our study.

### *5.3.1. The Choice of Inputs*

Tandon, *et al.* [34], distinguish two categories of inputs: direct inputs and indirect inputs. The direct inputs which are directly under the jurisdiction of the health care system used in the literature are: Hospital Finances [35], physicians and nurses number [36], health expenditures [15] and the number of beds [37]. The indirect inputs are the responsibility of individual behaviorsvis-a-vis the health (smoking, alcoholism). Here, we choose the labour factor and the capital. The work is measured by the number of medical staff (doctor, nurse and midwife). The capital stock is represented by the number of beds per 1000 inhabitants.

### *5.3.2. The Choice of Outputs*

According to Audibert, *et al.* [37], the outputs can be classified into two broad categories: simple measures and multidimensional measures. The simple measures include life expectancy at birth, the infant mortality rate, the rate of maternal mortality, the prevalence of HIV/AIDS, the crude mortality rate. Then we can consider as a multidimensional measure, the disability-adjusted of life expectancy and years of life corrected the inability (DALYS). LeLeu and Deveux [38], also add the days of length of stay, the number of patients cured. In the framework of this analysis, we have three outputs: The number of assisted delivery per qualified medical staff (1), the number of patients cured of malaria (2) and the number of malnourished cured (3).

**Table-4.** Presentation of the outputs, inputs and their descriptive statistics

| | Variable | Average | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| Outputs | | | | | |
| | The number of malnourished detected and cured in the regional hospitals | 2070,144 | 41,20439 | 0 | 25558 |
| | The number of assisted delivery by qualified personnel | 4025,34 | 2515,34 | 161 | 12828 |
| | The number of paludal treated in the healthcare institutions | 2513,171 | 3267,401 | 30 | 14694 |
| Inputs | | | | | |
| | Number of beds | 336,1286 | 287,389 | 0 | 2000 |
| | Number of physicians | 20,81429 | 50,80157 | 3 | 254 |
| | Number of nurses | *126,2571* | 180,9538 | 11 | 1289 |
| | Number of midwives | 16,13571 | 41,20439 | 0 | 244 |

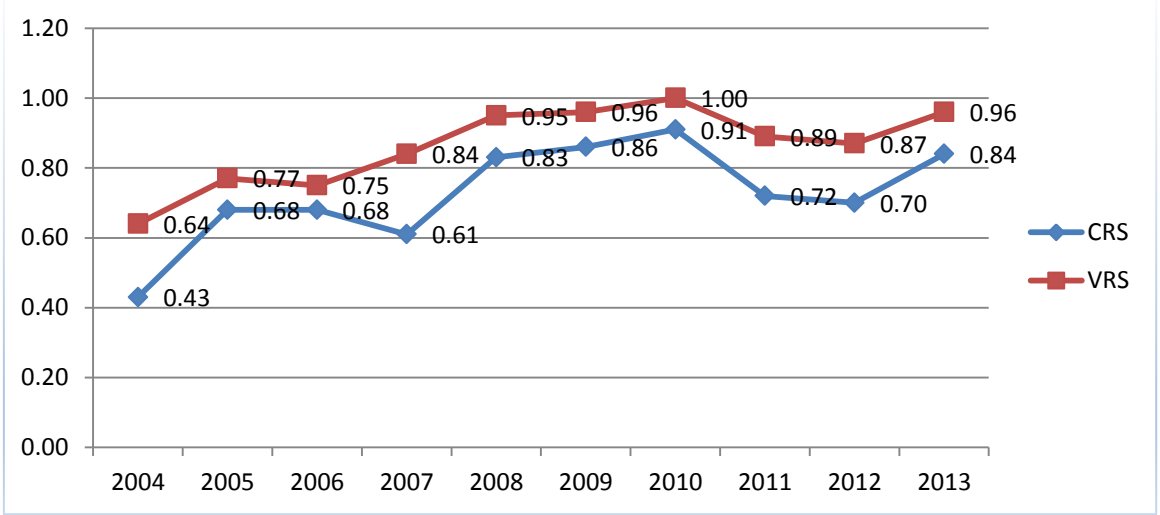
**Source:** Authors from the data of the study

The number of poorly-fed cured oscillates between 0 and 25558 per regional delegation of health (DRS). On average, each DRS track and heals 2070.14 underfed. The number of deliveries assisted by a qualified staff is on average 4025.34 in each DRS. The number of paludal treated in the DRS is 2513.17 on average. In addition, the number of paludal treated is very low for some DRS (30) and high for other (14694). With respect to the factors of productions, we find that on average each DRS offers 336 beds, 20.81 physicians, 126.25 nursing and 16.14 midwives.

## *5.4. Analysis of the Efficiency Scores*

Figure 4 shows the summary of efficiency scores [39] in 14 regional delegations of health (DRS). The adapted model is a model of returns to scale variables to output orientation (maximizing the output). The results show in 2004 a score of average efficiency of 0.43 under the assumption of constant returns to scale (CRS) to output orientation, and 0.64 under the assumption of the performance of variable Scale (VRS). The possibility of increasing the outputs while maintaining intact the level of inputs was respectively of 57% for the CRS and 36% for the VRS. We also note that the scores of effective means of all regions have evolved. They moved from 0.43 in 2004 to 0.68 in 2006 and then to 0.84 in 2013. In addition, the result highlights also that the efficiency scores vary when the technology is of type constant returns to scale (CRS) or variable return to scale (VRS). The gap of efficiency between the CRS technology and VRS one represents the efficiency of scale [20]. The production technology is CRS when the organizations have reached their optimal size and evolve in a situation of perfect competition. On the contrary, the technology is VRS when organizations do not operate to their optimal size and are evolve in a situation of imperfect competition or of regulated markets.

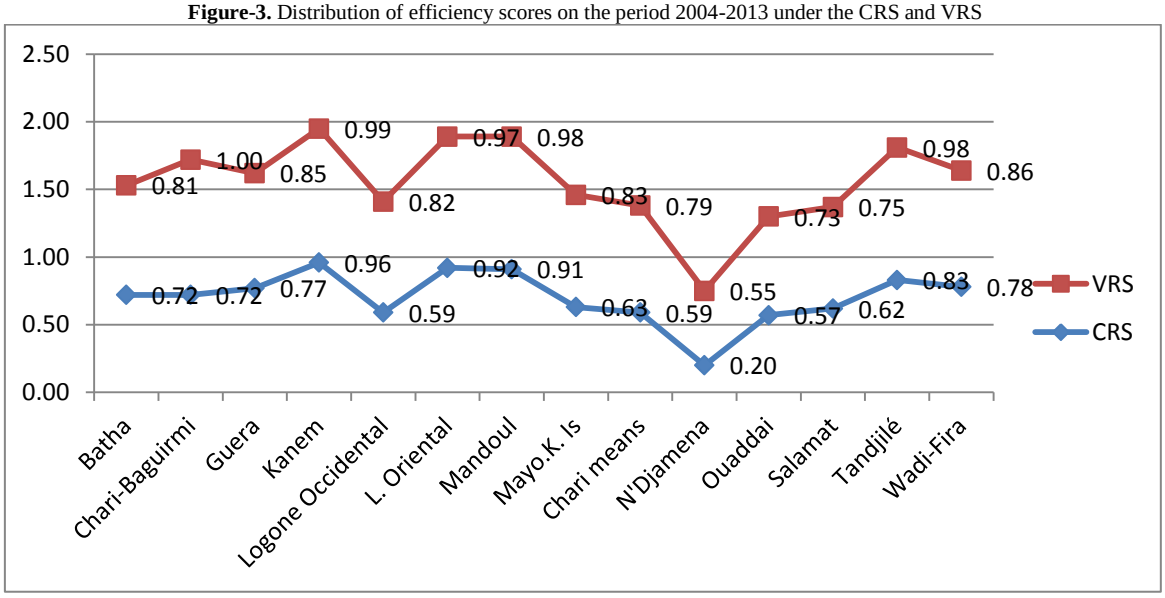
**Figure-2.** Distribution of efficiency scores means per year




**Source**: authors

Figure 5 shows that the region of the Kanem is the more efficient region, either a score of efficiency of 0.96 when the technology is of type CRS and 0.99 if the VRS Technology, followed by the Region of Logone Oriental (0.92), Mandoul (0.91) and the Tandjilé (0.83). Despite the concentration of human and material resources, the region of Ndjamena remains the least efficient, because the score of efficiency means between 2004-2013 is 0.20. There is a possibility to improve the performance of 80%. This weakness of the performance would be the result of the concentration of health staff in the capital. In 2012, 63% of physicians and midwives were engaged in Ndjamena, whose population represents only 9% of the total population. That is why the concentration of physicians in the city capital, in this city, quota is 1 doctor for 4 298 inhabitants [5].

**Figure-3.** Distribution of efficiency scores on the period 2004-2013 under the CRS and VRS




**Source**: authors extract of the estimate of the score of efficiency from the data of the study

Indeed, the determination of the efficiency scores has allowed us to situate the healthcare institutions in relation to each other. The estimation of the determinants of the technical efficiency will be made in the second step with a regression model where the efficiency scores will be regressed on variables likely to explain this efficiency as Djimasra [40], Dukhan [11] and Mané [16].

## *5.5. Econometric Model*

In order to determine the impact of these factors on the efficiency of the health system in Chad, we are regressing the technical efficiency scores on a set of variables. Greene [32] tells us that when a dependent variable has the peculiarity to be between 0 and 1, the ordinary least squares are not applicable, but rather a Tobit model. These models are particularly recommended when the values of the variable belong to a very specific interval. The Tobit model is used, when the dependent variable is continuous in an interval and the probability that this variable take null values, is positive.

The Tobit model can be presented as follows: a variable called is presumed to depend on a number of explanatory variables grouped in the vector The effects of which are grouped in the vector. It is assumed that the observed values of are the combination of the value predicted by the deterministic component of the model And of a residue whose value varies randomly for each individual. However, it is assumed that the variable is not directly observable, but that there is rather the variable. As well, the Tobit model may be presented as follows:

$$y_{it}^{*} = \alpha + X_{it}\beta + \varepsilon_i$$
$$y_{it} = 0 \text{ si } y_{it}^{*} \le 0 \qquad (2) \text{ with } . y_{it}^{*} \in [0 \;\; 1]$$
$$y_{it} = y_{it}^{*} \text{ si } 0 \le y_{it}^{*} \le 1$$

Where $y^{*}$ is the latent variable of the efficiency scores and $X_{it}$ is the vector of explanatory variables. The Tobit model with random effects connects the dependent variable , the independent variables $y^{*}$ which are added to the time a random effect and a residue:

$$y_{it}^{*} = \alpha + X_{it}\beta + \upsilon_i + \varepsilon_{it} \qquad (3)$$

Where $y_{it}^{*}$ represents the value that can take the latent continues variable for the observation of the region i at time t;

$\alpha$ represents the value of the ordered to the origin;

$X_{it}$ refers to the set of explanatory variables such as measured at time t for the region i;

$\beta$ is the vector of coefficients affecting these variables to estimate;

$\upsilon_i$ represents the value of the random effect associated with the region i and distributed according to ; $N(0, \sigma_v^2)$

And $\varepsilon_i$ is the error of the model that differs for each observation and follows a law $N(0,\sigma_\varepsilon^2)$ The estimation of the Tobit model censored passes by the maximization of the logarithm of the likelihood which is written as follows:

$$\ln L = \sum_{y_i>0}^{N} -\frac{1}{2}\left[\ln(2\pi)+\ln\sigma^2+\frac{(y_i-x_i'\beta)^2}{\sigma^2}\right]+\sum_{y_i>0}^{N}\ln\left[1-\Phi(\frac{x_i'\beta}{\sigma})\right] \quad (4)$$

Where N is the number of observations and is the standard deviation.

There are a multitude of factors returning in the determination of the efficiency in health, among which: the financing structure [11]; [41], the socio-sanitary environmental factors [22], the demographic factors [42], the educational factors [27] and the costs [2] recovery [43].

**Table-5**. Definition of explanatory variables of the Tobit model Double-censorship

| Description | Expected effects |
|---|---|
| Public health expenditure outside staff | - |
| The rate of gross literacy | + |
| The rate of access to drinking water | + |
| Population by delegations Regional Health | -/+ |
| External resources to the health | +/- |
| Recovery of Costs | + |

**Source**: Construction of authors from the review of the theoretical and empirical literature

## *5.6. Descriptive Statistics of the Determinants of Efficiency*

The descriptive statistics presented in Table 6 show that the variable health expenditures and outside staff are on average 153 million FCFA, the minimum is 1 403 304 FCFA, the maximum is 498 million FCA and the standard deviation is 87 million two hundred thousand FCFA. The table allows to generate the same statistics for the other variables in the model, but it should be noted that the rate of access to water, the literacy rate and the population are not expressed in monetary unit.

**Table-6.** Descriptive Statistics

| Variable | Average | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Health spending (FCFA) | 153 000 000 | 87 200 000 | 1 403 304 | 498 000 000 |
| The rate of access to water | 0,2692962 | 0,1159595 | 0.029 | 0,5398 |
| Population | 670 473,3 | 580 231 | 208 411 | 7 104 241 |
| Literacy rate | 0,508932 | 0,074333 | 0,3101 | 0,7936 |
| Health aid (FCFA) | 38 600 000 | 72 400 000 | 831 340 | 655 000 000 |
| Recovery of costs (FCFA) | 93 200 000 | 87 200 000 | 1 403 304 | 498 000 000 |

**Source**: authors

On the basis of the specification made by Djimasra [40], (DEA/Tobit) in cotton production, the Fouopi [44] in the field of banking and Audibert, *et al.* [37],Dukhan [11] and of Mané [16] in the field of health, the empirical model to estimate can be written in the form:

$$y_{it}^{*} = \beta_0+\beta_1\ln\left(\text{depst}_{i,t}\right)+\beta_2\text{Eau}_{i,t}+\beta_3\text{alpha}_{i,t}+\beta_4\ln\left(\text{pop}_{i,t}\right)+\beta_5\ln\left(\text{aide\_sant}_{i,t}\right)$$
$$+\beta_6\ln(\text{r\_cout}_{i,t})+\upsilon_i+\varepsilon_{i,t} \quad (5)$$

$y_{it}^{*}$ is the latent variable, $depst_{it}$ is the share of public health expenditures allocated to the regional delegations sanitary (DSR) , is the percentage of the population with access to a source of safe water, $aide\_sant_{it}$ represents the external resources in health, $alpha_{it}$ is the gross rate of literacy , $r\_cout_{it}$ is the recovery of cost; is the individual effect and is the random error term.

2Bamako Initiative (IB) is the name of the reform which aims to Pricing Health Care in the public sector. It builds on the fight against the disaffection of the structures of public health, the improvement of the efficiency of health spending and Equity

## 6. Results and Discussion

The following section present the main results of the study.

**Table-7.** Result of the estimate of the Tobit model to random effect double-censorship

| **Dependent Variable:** | **Scores of efficiency** | |
|---|---|---|
| **Explanatory variables** | Coefficient | T-statistics |
| Constant | -1,754 | -1,02 |
| Ln (health costs) | 0,1523*** | 2.88 |
| Rate of access to water | 0,1577* | 1.93 |
| Literacy rate | -0,7217*** | -2,61 |
| Ln (health aid) | 0,0791*** | 2.72 |
| Ln (r_COST) | -0,1286*** | -3,95 |
| Ln (population) | -0,0072 | -0.09 |
| $\sigma_{\varepsilon}$ | 0,2265*** | 4.28 |
| $\sigma_{\upsilon}$ | 0,2453*** | 14.54 |
| Observations not censored | 125 | |
| Censorship to the right | 15 | |
| Censorship to the left | 0 | |
| Wald Chi2(6) | 32,04 | |
| Prob>Chi2 | 0.000 | |
| Log-likelihood | -33,94 | |

*** Significant at 1%, **Significant at 5%,* significant at 10%.
**Source**: Authors

Table 7 shows the results of the estimation in which the dependent variable is the score of technical efficiency, the technology under VRS. The statistics of regression indicate that the Tobit method in the panel is adequate because the statistics $\sigma_{\varepsilon}$ et $\sigma_{\upsilon}$ are significant. In addition, the results suggest that *the health expenditures* (excluding medical staff) participate positively to the improvement of the performance of the health system. Because the coefficient associated with this variable is positive and significant at the threshold of 1%. This means that if health spending increases, the efficiency of the health system is improving. These results also suggest that the government must do more to increase spending on health. It's also important to note that this result is at the same order of magnitude as that obtained by Evans, *et al.* [8] on 191 countries which highlight a positive relationship between the efficiency of health systems and health expenditure per head. On the other hand, the result obtained observed by Dukhan [11] in a similar study is contradictory to our result, since health expenditures are negatively related to the efficiency of health systems.

The *environment variable: socio-sanitary* (accessto drinking water) confirm our hypothesis because the coefficient is positive and significant at the threshold of 10%. Indeed, when the population with access to a source of drinking water increases, the efficiency of the health system is improving. This can be explained by the decrease of the appearance of waterborne diseases such as cholera, fever and malaria.

The *external resources* contribute to improve the efficiency of the health system. The coefficient is positive and significant at the 1%. In the case of Chad, external resources had 4.2 percent of total public expenditure on health [45]. The country has a lot of bilateral and multilateral partners who are willing to invest in this sector. The support of partners is very often technique with a few financing of projects (PNS-Chad 2014). Chad has also acceded to the Paris Declaration on Aid Effectiveness; in this framework, we note also partners of the mechanism of Harmonization for Health in Africa including the World Bank, the African Development Bank (AfDB) and the Global Fund to fight HIV/AIDS, tuberculosis and malaria. According to the report (PNS-Chad 2014), their inputs have been determinants.

The *variable cost recovery* negatively influences the effectiveness of health system. The coefficient associated to this variable is significant at the threshold of 1%. The recovery of such costs that was adopted during the 37th committee of the WHO Regional Committee in Bamako in 1987 whose objective was to generate resources steadily to finance the operation of the health structure and activities of Health, has not had the expected effects (efficiency versus equity). Unfortunately, the obligation to pay for access to health care has had and continues to have a significant negative impact on the health status and the level of life of the people of Chad. This can simply mean that households do not have the necessary resources to be consulted by qualified medical staff, tending to guide their consumption of care toward traditional care which is not very effective in the reduction of mortality.

Lot of studies conducted throughout the 1990s have highlighted the fall of the rate of attendance of health structures as a result of the introduction of the recoveries of costs. For example, in Kenya, the implementation of pricing measures to users in 1989 resulted in an average decrease of the consultations of 45 percent in the district hospitals and 33% in the health centres. Similarly, a search conducted in Burkina Faso in the health district of Kongoussi has highlighted a decline of 15% of attendance of health centres as a result of the introduction of pricing to users [46].

The coefficient associated with the variable rate of literacy gross is negative and significant at the threshold of 1%, which is not consistent with the study first intuition. Two sources of explanation are possible: First, the empirical literature specifies that the educational variable influences the performance of the health system when the level of education beyond the secondary level. The lack of information on variable such as the level of secondary

education or the upper level, can explain such a result. The second explanation would be linked to the fact that individuals with a high level of education would have recourse to the private clinics.

Finally, with regard to the demographic variable, it is not significant, while the results obtained by Tlotlego, *et al.* [18] and of Mané [16] show that the size of the population negatively influence the efficiency of hospitals for the case of Botswana and Senegal.

## 7. Conclusion and Recommendations

The objective of this study was to measure the performance of the health system in Chad. More specifically, it is to evaluate the technical efficiency of health facilities in 14 regional health centre delegations and to determine the factors likely to influence the efficiency scores. Findings suggest that on average the efficiency scores moved from 0.43 in 2004 to 0.84 in 2013 for CRS technology; and the efficiency score moved from 0.64 in 2004 to 0.96 for VRS technology. As far as individual performance is concerned, the results show that the major regions have low efficiency scores. The region of Ndjamena despite his high concentration of medical staff and material resources have the lowest efficiency score (0.20); it's followed by the regions of Ouaddai and that of Occidental Logone whose efficiency scores are respectively 0.57 and 0.59.

Tobit model in a random effects panel is estimated to explain this efficiency. On the one hand, the socio-environmental factors and health expenditures positively affect the health system. On the other hand, the educational factors, the rate of gross literacy negatively affects the efficiency of the system. In addition, the demographic factor is not significant.

However, in view of the results obtained, the establishment of a policy of decentralization of the health infrastructure would bring health care to the population, especially in rural areas. The review of the mechanisms of recovery of costs by improving the procedures and the management of coordination and interventions policy. Finally, according to the descriptive statistics, the study shows that 70 percent of the Chadian people is excluded from the distribution of potable drinking water.

## References


[1] Boidin, B., 2014. *The health, global public good? Reflections from African experiences*. Villeneuve d'Ascq: University Press of the North.

[2] WHO, 2000. "Report on Health in the world for a system more efficient."

[3] MSP, 2013. "Ministry of public Health. Annual statistics."

[4] WHO, 2012. "World health statistics."

[5] DSIS, 2013. "Division of the health information system statistics Database."

[6] WDI, 2014. "World development indictors Database."

[7] Roberts, M., Hsiao, W., Berman, P., and Michael, R., 2004. *Greeting health reform right, A guide to improving performance and equity*. New York: Oxford University Press.

[8] Evans, D., Tandon, A., Murray, C., and Lauer, J. A., 2000. *The comparative efficiency of national health systems in producing health, Year analysis of 191 countries*. Geneva: World Health Organization.

[9] Gupta, S. and Verhoeven, M., 2001. "The efficiency of government expenditure, Experience from Arica." *Journal of Policy Modeling*, vol. 23, pp. 433-467.

[10] Grenne, W., 2004. *Distinguishing between heterogeneity and inefficiency: Stochastic frontier analysis of the world health organization's panel data on national health care systems. Stern school of business. New york university*. New York, USA: Department of Economics.

[11] Dukhan, Y., 2010. "Improve the efficiency of health systems and financial protection against the risk of disease in the developing countries." PhD thesis, University of Auvergne. Center for Study and Research on International Development CERDI.

[12] Debreu, G., 1951. "The coefficient of resource utilization." *Econometrica*, vol. 19, pp. 273-292.

[13] Koopmans, T., 1951. "Activity analysis of production and allowance." *Cowles Commission of Research in Economics, Monograph*,

[14] Farell, M., 1957. "The measurement of productive efficiency." *Journal of the Royal Statistical Society, Series has*, vol. 120, pp. 195-211.

[15] Alexander, C. A., Busch, G., and Stringer, K., 2003. "Implementing and interpreting a data envelopment analysis model to assess the efficiency of health systems in developing countries." *IMA Journal of Management Mathematics*, vol. 14, pp. 49-63.

[16] Mané, Y., 2013. "Efficiency and equity in the health system in Senegal." Univesrsité Claude Bernard-Lyon. Doctoral Thesis.

[17] Kirigia, I. M., Emrouznejad, A., Cassoma, B., ASBU, E. Z., and Barry, S., 2008. "A performance assessment method for hospitals: the case of municipal hospitals in Angola." *Journal of Medical Systems*, vol. 32, pp. 509-519.

[18] Tlotlego, N., J., N., and Sambo, G., 2010. "Assessment of productivity of hospitals in botswana, A dea application." *International Archives of Medicine*, vol. 3, p. 27.

[19] Zere, E., Oluwole, D., Kirigia, I. M., Mwkisia, C. N., and Mbelli, T., 2011. "Inequities in skilled attendance at birth in namibia, A decomposition analysis." *BMC Pregnancy and Childbirth*, vol. 2011, pp. 11-34.

[20] Coelli, T., Rao, D., Christopher, J., O'Donnel, and Goerge, E. B., 1998. *An introduction to efficiency year productivity analysis*. 2nd ed.

[21] Diewert, W., 1993. "Efficiency measures for diesel-electric power plants. A report prepared for world bank."
[22] Ambapour, S., 2004. "Technical effectiveness compared to health systems in sub-saharan africa, An application of the method dea, Office for the application of statistical methods and informatics, Working document."
[23] Rosko, M., 2001. "Cost efficiency of US hospital, A stochastic frontier approach." *Health Economics,* pp. 539-551.
[24] Evans, D., Tandon, A., Murray, C., and Lauer, J. A., 2001. "Comparative efficiency of national health systems, A cross-national econometric analysis." *British Medical Journal*, vol. 232, pp. 307-310.
[25] Charnes, Cooper, W., and Rhodes, E., 1978. "Measuring the efficiency of decision-making units`." *European Journal of Operational Research,* vol. 2, pp. 140-148.
[26] Ozcan, Y. and Bannick, R. R., 2001. "Comparative efficiency of national health systems: a cross-national econometric analysis." *British Medical Journal.*
[27] Afonso and Aubyn, 2004. "Non parametric approaches to education and health expenditure efficiency in oecd countries. Working paper n°1/2004/de/cisep,Uece."
[28] Amara, N. and Roman, R., 2000. *Measurement of the technical efficiency, Review of the literature. The series of research of cahiers du crea*. The University of Laval.
[29] Meeusen, W. and Broeck., J. D., 1977. "Efficiency estimation from cobb-douglas functions production with composed error." *International Economic Review,* vol. 18, pp. 435-444.
[30] Aigner, D. and Schmidt, C., 1977. "Formulation and estimation of stochastic frontier production function models." *Journal of Econometrics,* vol. 6, pp. 21-37.
[31] Leibenstein, H., 1966. "The allocative efficiency vs x-efficiency." *American Econometric Review,* vol. 56, pp. 392-415.
[32] Greene, W., 2005. *Econometrics*. 5th ed. New York: Education, Pearson.
[33] Banker, R. D., Charnes, A., and Cooper, W. W., 1984. "Some models for estimating technical and scale inefficiencies in data envelopment analysis." *Management Science,* vol. 30, pp. 1078-1092.
[34] Tandon, A., Lauer, J., Evans, D., and Murray, C., 2003. "Health system efficiency, Concepts. In health systems performance assessment, Debates, Methods and empiricism, ed. By c. J.L. Murray, D. B. Evans, Geneva, World health organization."
[35] Jacobs, R., Peter, C., and Street, A., 2006. *Measuring science ffi in health care, Analytic techniques and health policy*. Cambridge University Press.
[36] Gertler, P., 1989. "Subsidies, Quality and the regulation of nursing homes." *Journal of Public Ecoomics,* vol. 38, pp. 35-52.
[37] Audibert, M., Mathonnat, J., N., C., MA, A., and Yen, A., 2008. "Activity and performance of the municipal hospitals in rural China. An analysis of survey data in the province of shandong." *Journal of Development Economics,* vol. 16, pp. 63-100.
[38] LeLeu, H. and Deveux, B., 1997. "Comparison of different measures of technical efficiency, An application to hospital centres french." *Economy and Forecast.*
[39] Coelli, T., 1996. *A guide to rap version 2. 1, A data envelopment analysis (computer) program. Center for efficiency and productivity analysis*. Armidale, NSW: Departement of Econometrics, University of New England. p. 2351.
[40] Djimasra, N., 2009. "Technical effectiveness, Productivity and competitiveness of the major cotton producing countries." PhD thesis, University of Orleans.
[41] Sachs, A., Sarnow, P., and Hentze, M., 1997. "Starting at the beginning, Midle and end, Translation intitiation in eukaryotes." *Cell,* vol. 89, pp. 831-838.
[42] Brown, J. and Mathonnat, J., 1997. "The effects of external financing on the level of public expenditure on education and health in developing countries- an econometric analysis on data from panel. CERDI."
[43] Tizio, S. and Flori, Y., 1997. "The bamako initiative, Health for all or disease for each?" *Review of Third World,* vol. 38, pp. 837-858.
[44] Fouopi, D., 2012. "Quality of institutions, Ownership structure and effectiveness of the banks in the cemac. University of yaoundé ii, Soa."
[45] WJHO, 2013. "World health statistics."
[46] Nitiéma, P. A., Girard, J., and Ridde, V., 2003. "The effectiveness of public policies of health in a country of west Africa, Cases of burkina Faso." *International Political Science Review,* pp. 237-256.

# Annexes

A score of efficiency 2004

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 0.229 | 0.321 | 0.714 | Drs |
| C.Baguirmi | 1.000 | 1.000 | 1.000 | - |
| Guera | 0.269 | 0.508 | 0.528 | Drs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.333 | 1.000 | 0.333 | Drs |
| L.oriental | 0.625 | 0.874 | 0.714 | Drs |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | 0.422 | 0.929 | 0.455 | Drs |
| Means.Chari | 0.240 | 0.625 | 0.385 | Drs |
| N'Djamena | 0.012 | 0.228 | 0.052 | Drs |
| Ouaddaï | From 0.099 | 0.254 | 0.390 | Drs |
| Salamat | 0.096 | 0.096 | 1.000 | - |
| Tandjilé | 0.518 | 0.910 | 0.569 | Drs |
| Wadi-FIRA | 0.168 | 0.234 | 0.718 | Drs |
| Average | 0.429 | 0.641 | 0.587 | |

A score of efficiency 2005

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 0.514 | 0.580 | 0.887 | Irs |
| C.Baguirmi | 1.000 | 1.000 | 1.000 | - |
| Guera | 0.746 | 0.846 | 0.882 | Drs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.641 | 1.000 | 0.641 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | 0.619 | 0.807 | 0.766 | Drs |
| Means.Chari | 0.604 | 0.872 | 0.693 | Drs |
| N'Djamena | 0.024 | 0.083 | 0.287 | Drs |
| Ouaddaî | 0.339 | 0.360 | 0.940 | Drs |
| Salamat | 0.229 | 0.262 | 0.877 | Irs |
| Tandjilé | 1.000 | 1.000 | 1.000 | - |
| Wadi-FIRA | 0.731 | 1.000 | 0.731 | Irs |
| **Average** | 0.675 | 0.772 | 0.836 | |

A score of efficiency 2006

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 0.384 | 0.388 | 0.991 | Drs |
| C.Baguirmi | 0.666 | 1.000 | 0.666 | Irs |
| Guera | 0.638 | 0.655 | 0.974 | Drs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 1.000 | 1.000 | 1.000 | - |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .K.is | 0.588 | 0.752 | 0.782 | Drs |
| Means.Chari | 0.883 | 1.000 | 0.883 | Drs |
| N'Djamena | 0.040 | 0.149 | 0.27 | Drs |
| Ouaddaî | 0.2912 | 0.574 | 0.974 | Drs |
| Salamat | 0.308 | 0.372 | 0.828 | Irs |
| Tandjilé | Execution time: 0.816 | 1.000 | Execution time: 0.816 | Irs |
| Wadi-FIRA | 0.567 | 0.659 | 0.860 | Irs |
| **Average** | 0.683 | 0.752 | 0.870 | |

A score of efficiency 2007

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 0.476 | 1.000 | 0.476 | Irs |
| C.Baguirmi | 0.557 | 1.000 | 0.557 | Irs |
| Guera | 0.702 | 0.805 | 0.872 | Irs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.547 | 0.597 | 0.917 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | Execution time: 0.541 | 0.690 | 0.767 | Irs |
| Means.Chari | 0.572 | 0.620 | 0.923 | Drs |
| N'Djamena | 0.101 | 0.423 | 0.069 | Drs |
| Ouaddaî | Making 0.451 | 0.960 | 0.2413 | Drs |
| Salamat | 0.319 | 1.000 | 0.319 | Irs |
| Tandjilé | 0.721 | 1.000 | 0.721 | Irs |
| Wadi-FIRA | 0.476 | 0.702 | 0.774 | Irs |
| **Average** | 0.612 | 0.843 | 0.720 | |

A score of efficiency 2008

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 1.000 | 1.000 | 1.000 | - |
| C.Baguirmi | 0.893 | 1.000 | 0.893 | Irs |
| Guera | 1.000 | 1.000 | 1.000 | - |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.635 | 0.886 | 0.717 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .K.is | 0.625 | 0.856 | 0.730 | Drs |
| Means.Chari | 0.427 | 0.554 | 0.771 | Drs |
| N'Djamena | Time: 0.215 | 1.000 | Time: 0.215 | Drs |
| Ouaddaî | 1.000 | 1.000 | 1.000 | - |
| Salamat | 1.000 | 1.000 | 1.000 | - |
| Tandjilé | 0.729 | 0.940 | 0.776 | Irs |
| Wadi-FIRA | 1.000 | 1.000 | 1.000 | - |
| **Average** | 0.830 | 0.945 | 0.871 | |

A score of efficiency 2009

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 1.000 | 1.000 | 1.000 | - |
| C.Baguirmi | 1.000 | 1.000 | 1.000 | - |
| Guera | 0.825 | 0.827 | 0.998 | Irs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.539 | 1.000 | 0.539 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .K.is | 0.845 | 1.000 | 0.845 | Drs |
| Means.Chari | 1.000 | 1.000 | 1.000 | - |
| N'Djamena | 0.27 | 0.945 | 0.298 | Drs |
| Ouaddaî | 0.843 | 0.965 | 0.873 | Drs |
| Salamat | 0.797 | 0.801 | 0.995 | Irs |
| Tandjilé | 0.942 | 0.944 | 0.998 | Irs |
| Wadi-FIRA | 1.000 | 1.000 | 1.000 | - |
| **Average** | 0.862 | 0.963 | 0.896 | |

A score of efficiency 2010

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 1.000 | 1.000 | 1.000 | - |
| C.Baguirmi | 1.000 | 1.000 | 1.000 | - |
| Guera | 1.000 | 1.000 | 1.000 | - |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.781 | 1.000 | 0.781 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .K.is | 0.774 | 1.000 | 0.774 | Drs |
| Means.Chari | 1.000 | 1.000 | 1.000 | - |
| N'Djamena | 0.365 | 1.000 | 0.365 | Drs |
| Ouaddaî | 0.859 | 0.960 | 0.894 | Irs |
| Salamat | 1.000 | 1.000 | 1.000 | - |
| Tandjilé | 1.000 | 1.000 | 1.000 | - |
| Wadi-FIRA | 1.000 | 1.000 | 1.000 | - |
| **Average** | 0.913 | 0.997 | 0.915 | |

A score of efficiency 2011

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 0.766 | 0.863 | 0.887 | Irs |
| C.Baguirmi | 0.538 | 1.000 | 0.538 | Irs |
| Guera | 1.000 | 1.000 | 1.000 | - |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.395 | 0.797 | 0.495 | Drs |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | 0.397 | 0.715 | 0.556 | Drs |
| Means.Chari | 0.697 | 1.000 | 0.697 | Drs |
| N'Djamena | 0.076 | 0.438 | 0.304 | Drs |
| Ouaddaî | 0.518 | 0.683 | 0.759 | Drs |
| Salamat | 1.000 | 1.000 | 1.000 | - |
| Tandjilé | 0.645 | 1.000 | 0.645 | Irs |
| Wadi-FIRA | 1.000 | 1.000 | 1.000 | - |
| **Average** | 0.717 | 0.893 | 0.768 | |

A score of efficiency 2012

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 1.000 | 1.000 | 1.000 | - |
| C.Baguirmi | 0.486 | 1.000 | 0.486 | Irs |
| Guera | 0.839 | 0.861 | 0.974 | Irs |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.293 | 0.477 | 0.615 | Drs |
| L.oriental | 0.699 | 0.841 | Execution time: 0.777 | Drs |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | 0.554 | 0.752 | 0.736 | Drs |
| Means.Chari | 0.724 | 1.000 | 0.724 | Drs |
| N'Djamena | 0.303 | 1.000 | 0.303 | Drs |
| Ouaddaî | 0.189 | 0.236 | 0.800 | Drs |
| Salamat | 1.000 | 1.000 | 1.000 | - |
| Tandjilé | 0.776 | 0.974 | 0.798 | Irs |
| Wadi-FIRA | 1.000 | 1.000 | 1.000 | - |
| **Average** | 0.704 | 0.867 | 0.805 | |

A score of efficiency 2013

| The Regions | Crste | Vrste | Scale | |
|---|---|---|---|---|
| Batha | 1.000 | 1.000 | 1.000 | - |
| C.Baguirmi | 0.796 | 1.000 | 0.796 | Irs |
| Guera | 1.000 | 1.000 | 1.000 | - |
| Kanem | 1.000 | 1.000 | 1.000 | - |
| L.Occidental | 0.710 | 0.710 | 1.000 | - |
| L.oriental | 1.000 | 1.000 | 1.000 | - |
| Mandoul | 1.000 | 1.000 | 1.000 | - |
| Mayo .Kis | 1.000 | 1.000 | 1.000 | - |
| Means.Chari | 1.000 | 1.000 | 1.000 | - |
| N'Djamena | 0.267 | 0.889 | : 0.164 | Drs |
| Ouaddaî | 0.796 | 0.810 | 0.982 | Drs |
| Salamat | 0.480 | 1.000 | 0.480 | Irs |
| Tandjilé | 1.000 | 1.000 | 1.000 | - |
| Wadi-FIRA | 0.815 | 1.000 | 0.815 | Irs |
| **Average** | 0.841 | 0.958 | 0.877 | |

| | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The Regions | CRSTE[1] | VRSTE[2] | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE | CRSTE | VRSTE |
| Batha | 0.23 | 0.32 | 0.51 | 0.58 | 0.38 | 0.38 | 0.48 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.87 | 1.00 | 0.77 | 0.86 | 1.00 | 1.00 | 1.00 | 1.00 | **0.72** | **0.81** |
| Chari-Baguirmi | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 1.00 | 0.61 | 1.00 | 0.89 | 1.00 | 1.00 | 1.00 | 0.26 | 1.00 | 0.54 | 1.00 | 0.49 | 1.00 | 0.80 | 1.00 | **0.72** | **1.00** |
| Guera | 0.27 | 0.51 | 0.75 | 0.85 | 0.64 | 0.66 | 0.70 | 0.81 | 1.00 | 1.00 | 0.83 | 0.83 | 0.63 | 1.00 | 1.00 | 1.00 | 0.84 | 0.86 | 1.00 | 1.00 | **0.77** | **0.85** |
| Kanem | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 1.00 | 1.00 | 0.63 | 1.00 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **0.96** | **0.99** |
| Logone Occidental | 0.33 | 1.00 | 0.65 | 1.00 | 1.00 | 1.00 | 0.55 | 0.60 | 0.64 | 0.89 | 0.54 | 1.00 | 0.78 | 0.78 | 0.40 | 0.80 | 0.29 | 0.48 | 0.71 | 0.71 | **0.59** | **0.82** |
| L. Oriental | 0.63 | 0.87 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 1.00 | 0.70 | 0.84 | 1.00 | 1.00 | **0.92** | **0.97** |
| Mandoul | 1.00 | 1.00 | 0.62 | 0.81 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.52 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **0.91** | **0.98** |
| Mayo.K. Is | 0.42 | 0.93 | 0.60 | 0.87 | 0.59 | 0.75 | 0.53 | 0.69 | 0.63 | 0.86 | 0.85 | 1.00 | 0.77 | 0.77 | 0.40 | 0.72 | 0.55 | 0.75 | 1.00 | 1.00 | **0.63** | **0.83** |
| Chari means | 0.24 | 0.63 | 0.02 | 0.08 | 0.88 | 1.00 | 0.57 | 0.62 | 0.43 | 0.55 | 1.00 | 1.00 | 0.37 | 1.00 | 0.70 | 1.00 | 0.72 | 1.00 | 1.00 | 1.00 | **0.59** | **0.79** |
| NDjamena | 0.01 | 0.23 | 0.34 | 0.04 | 0.04 | 0.14 | 0.10 | 0.42 | 0.31 | 1.00 | 0.28 | 0.95 | 0.37 | 0.37 | 0.08 | 0.44 | 0.30 | 1.00 | 0.18 | 0.89 | **0.20** | **0.55** |
| Ouaddai | 0.10 | 0.25 | 0.36 | 0.94 | 0.55 | 0.56 | 0.45 | 0.96 | 1.00 | 1.00 | 0.84 | 0.97 | 0.86 | 0.89 | 0.52 | 0.68 | 0.19 | 0.24 | 0.80 | 0.81 | **0.57** | **0.73** |
| Salamat | 0.10 | 0.10 | 0.23 | 0.26 | 0.31 | 0.37 | 0.32 | 1.00 | 1.00 | 1.00 | 0.80 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.48 | 1.00 | **0.62** | **0.75** |
| Tandjilé | 0.52 | 0.91 | 1.00 | 1.00 | 0.95 | 1.00 | 0.72 | 1.00 | 0.73 | 0.94 | 0.94 | 0.94 | 1.00 | 1.00 | 0.65 | 1.00 | 0.78 | 0.98 | 1.00 | 1.00 | **0.83** | **0.98** |
| Wadi-Fira | 0.17 | 0.23 | 0.73 | 1.00 | 0.57 | 0.66 | 0.54 | 0.70 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.82 | 1.00 | **0.78** | **0.86** |
| **Average** | **0.43** | **0.64** | **0.68** | **0.77** | **0.68** | **0.75** | **0.61** | **0.84** | **0.83** | **0.95** | **0.86** | **0.96** | **0.91** | **1.00** | **0.72** | **0.89** | **0.70** | **0.87** | **0.84** | **0.96** | **0.70** | **0.85** |

```
Random-effects tobit regression                 Number of obs      =       140
Group variable: rgions                          Number of groups   =        14

Random effects u_i ~ Gaussian                   Obs per group: min =        10
                                                               avg =      10.0
                                                               max =        10

                                                Wald chi2(6)       =     32.04
Log likelihood  =  -33.94214                    Prob > chi2        =    0.0000
```

| crste | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lndepst | .1522921 | .0529276 | 2.88 | 0.004 | .0485559 | .2560284 |
| eau | .1576856 | .0815542 | 1.93 | 0.053 | -.0021576 | .3175289 |
| alpha | -.7216896 | .2765887 | -2.61 | 0.009 | -1.263793 | -.1795858 |
| lnpop | -.0079489 | .0914577 | -0.09 | 0.931 | -.1872027 | .171305 |
| lnaide_sant | .0791727 | .029154 | 2.72 | 0.007 | .022032 | .1363134 |
| lnr_cout | -.1285626 | .0325602 | -3.95 | 0.000 | -.1923795 | -.0647457 |
| _cons | -1.754063 | 1.72508 | -1.02 | 0.309 | -5.135157 | 1.627031 |
| /sigma_u | .2265146 | .0528719 | 4.28 | 0.000 | .1228876 | .3301416 |
| /sigma_e | .2453191 | .0168748 | 14.54 | 0.000 | .2122451 | .278393 |
| rho | .4602092 | .1222267 | | | .2409037 | .6927235 |

```
  Observation summary:         0  left-censored observations
                             125     uncensored observations
                              15 right-censored observations
```