Efficiency assessment of Tunisian public hospitals using Data Envelopment Analysis (DEA)

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Abstract.

In the recent past years, Tunisia pursued a national policy on health which was directed towards the performance. Although the lack of adequate resources presents the most important constraint, efficiency in the utilization of available resources is another challenge that cannot be overlooked. The objective of this study aims to assess the technical efficiency (TE) of a sample of Tunisian public hospital using the non parametric approach of Data Envelopment Analysis (DEA). In this perspective, we started with measuring, comparing and analyzing the TE of the three categories of the Tunisian public hospitals, then to investigate the difference in the level of efficiency by district and finally to Guide the decision and the policy makers in their decision making process through the developed decision making tools. The data were gathered from a sample of 134 public hospitals throughout Tunisia. These would cover about 80% of the total number of Tunisian public hospitals. The model estimates the technical efficiency for the whole sample as well as for each hospital. The entire sample was operating on average at 0, 78 level of technical efficiency. Only 28% of the total hospitals were found to be technically efficient in relative term while the remaining were inefficient. The Public health Establishment (PHE), the regional hospital (RH) and the District Hospital (DH) were operating on average at 0,9; 0,74 and 0,76 level of technical efficiency respectively. Only 45% of the PHE, 23% of the RH and 25% of the DH were technically efficient while the remaining were inefficient. The study identifies the inefficient hospitals and provides the magnitudes by which specific input per inefficient hospital ought to be more managed or to be reduced. It emphasizes also the disparity by districts in term of percentage of efficient and inefficient hospitals. Therefore, the highest percentage of efficient hospitals is also in the districts of North East (NE) and Center East (CE).

JEL Classification: C14, I18, H51

Keywords: Technical Efficiency measurement, Public Hospitals, Health sector, Tunisia, Non-parametric approach, DEA.

1. Introduction

More and more, the health occupies a prominent place at international, national and individual levels. It constitutes an important component of development policies. The health has carved out a significant and privileged position in the development models, of economic growth and fight against the inequalities and poverty. In a situation that is characterized by scarcity of the resources, the financing of health as well as the escalation of health expenditure are major issues for the developing countries. Allowing sustainable mobilization of sufficient resources to meet the needs of the populations as well as define and implement the health strategies remains as difficult questions to apprehend. This is because they are subjected to concerns that are sometimes difficult to reconcile in terms of efficiency and equity.

Therefore, health constitutes a key issue in the conduct of the economic policies because of the importance of the financial resources which are committed to it and the crucial role it plays in the determination of the social welfare and productivity. Given these stakes, improving the efficiency of the health system, raises particular difficulties of a theoretical and methodological nature. The strong socialization of the health sector is a major part of these difficulties. In the Sixties, Tunisia chose a socialized financing of the health expenditure and a regulation based on the principle of the public service for the hospital sector. The hospital sector has contributed immensely to the good coverage and health practice. According to WHO Tunisia is ranking high for affordable health care among the countries with low and middle incomes, having taken prominent steps in advancing the health sector. [1] (Arfa C. and Achouri H., 2008). As such, the Tunisian health indicators (life expectancy at birth, infant mortality rate etc.) were improved for examples the rate of infant mortality was 200 per 1000 in 1956 against 15 per 1000 in 2013. This decline of infant mortality has led to an increase in life expectancy at birth which went from 52 in 1960's to reach 74.5 in 2015[1]. Despite these improvements in the health sector, Tunisia is currently undergoing a double demographic and epidemiologic transition which will modify the hierarchy of the priorities and the health needs. These new needs demands more and heavier financial efforts and reforms of the health structure.

Therefore, according to the World Bank, the health expenditure has increased during the two last decades at an annual average growth rate of 11.7%. The share of the GDP that has been

[1] Source: http://www.who.int/gho/countries/tun.pdf?ua=1,

devoted to health increased from 4.2% in 1985 to 5.9 in 2005 and to 7.1 in 2013. The annual expenditure on health per capita has more than doubled between 2005 and 2013. It has increased from 39 DT in 1985 to 197.7 DT in 2004, and from 214.3 DT in 2005 to 493 DT in 2013. Therefore, to face this unrestrained increase of health expenditures the public authorities should bring them under control. However, the social and noncommercial characters of the public hospital make it difficult to define the criteria of rationalization to manage the resources which lead to inefficiency. Today, the public hospital faces the same constraints as the manufacturing companies. It must ensure an optimal service to the patients, given the status change from providing free service to customers to that based on customer satisfaction. This change required a major reform and change in the management of the health care facilities, in making the move from the logic of public administration to the logic of operating as a company. It is in this context, that an important policy of decentralization, in particular in hospital reform was implemented in 1998 to improve efficiency of the public health care facilities, whilst preserving their public service mission. And as we are facing a lack in the resources, efficiency in the utilization of available resources is another challenge that cannot be overlooked.

Henceforth, performance researches become a major concern for Tunisia's public hospitals. It therefore appears essential to carry out a total reflection on the performance of the public hospitals along the line of technical efficiency while respecting the medical stakes and the social constraints. The interest granted to our study, can be justified by the important role of the public hospitals to the attainment of the goals of the health policy and the lack of studies devoted to assess the performance of Tunisian public hospitals through measuring, analyzing and comparing the technical efficiency.

In that respect our study which falls under aegis of these issues is aimed first at measuring, comparing and analyzing the technical efficiency of the three categories of Tunisian public hospitals using the non-parametric estimation approach: the Data Envelopment Analysis (DEA). Then, at investigating the difference in the level of efficiency by district and finally to guide the decision and the policy makers in their decision making process through a developed decision making tools

The paper is organized as follows. Section 2 presents the brief literature review on the topic. In section 3, the methodology used as well as the data and variables are described. We then proceed with results and a discussion of the implications of our findings for providers and policy makers in section 4.The conclusion is provided in the final section.

2. Literature review

Over the two last decades, the numbers of studies that were conducted to assess hospitals efficiency have increased considerably. Non-parametric and parametric methods of efficiency analysis have been regularly used, to measure and analyze the technical efficiency of health care services. Few studies have used parametric techniques in order to assess hospital efficiency [2] In general non parametric techniques have been applied in several empirical studies measuring hospital's operational efficiency [3-6] Data envelopment analysis (DEA), the non-parametric programming method introduced by Charnes, Cooper, and Rhodes [7], present the most useful and appropriate tool that has been used to estimate hospital efficiency. In the beginning, the studies using DEA method were conducted in the USA but thereafter, an important number of studies have appeared in other countries, such as in Austria, Greece, Germany, Spain, Turkey, and so on [8]. Analytical literature review of studies using parametric and non parametric techniques were provided by O'Neil et al (2008) [8], Hollingsworth (2008, 2003,1999) [9-11] and Wothinghton (2004)[12]. These authors gave a synthesis of several studies of health care delivery which are different according to the type of production unit, the aim of the study, the used techniques, the formulation of the estimate model, the nature of data used and the specification of the production technology.

DEA, the nonparametric approach was useful to estimate the economic performance and to measure the efficiency of public and/or private hospitals in the United States and in European countries in the beginning of 1980s. The first application of the approach in the medical field is due to the pioneers Nunamaker (1983) [13] and Sherman (1984) [14] [2] and then the publications number did not cease increasing. Nunamaker (1983)[13] published the first paper in health care field focusing on nursing service efficiency. Although, Sherman began since 1981 but his paper was not published before 1984 [14]. He was testing and applying DEA to a sample of teaching hospitals and therefore considered it as a means to help measure and identify inefficiency. The study of Grosskopf and Valdmanis in 1987 is also considered as one of the pioneered studies using DEA to measure hospital efficiency. Basing on the survey of DEA application made by John S. Liu et al (2013) [15] we noted that most of the papers on the main paths surveyed hospital efficiency and performance. However, few papers studied other subjects among nursing homes, primary care, and care programs. Several studies were

[2] The first application of DEA is appeared in the thesis of H. David Sherman published in 1981. In 1983, Nunamaker published the first paper: "T.R Nunamaker, measuring routine service efficiency - has off comparison cost per patient day and dated envelopment analysis models", Health Services Research 18 (2) (1983) 183-205. In 1984, Sherman published the first paper "Hospital Efficiency Measurement and Evaluation: Empirical Test of a New Technique", Medical Care, vol. 22, n? 10, p. 922-38.

made comparison between DEA and others methods on the main paths. Using a sample of North Carolina hospitals, Banker et al. (1986) [16] compared DEA and the translog models. The efficiency of hospital and primary care services, respectively, with both the DEA and stochastic frontier analyses were investigated by Linna (1998) [17] and Giuffrida and Gravelle (2001) [18]. Nevertheless, there were innovations on the level of DEA studies applied to the hospital which are potentially useful for decision making. Some work concentrated on the association of efficiency measurement and the type of the hospital property (Burgress and Wilson, 2006, 1996) [19,20]. Other studies were interested in studies by region (Perez, 1992) [21], for rural hospitals (Ozcan and Lynch, 1992) [22], for urban hospitals (Lynch and Ozcan, 1994) [23] and for consolidation of the hospitals and performance of the rural hospitals (Ferrier and Valdmanis, 1996) [24].

However, few studies have been undertaken in some developing countries in Sub-Saharan Africa comparing to the important number in America and Europe .Papa Yona et al (2013) [25] analyzed the technical efficiency of three types of Senegalese hospitals: 13 small hospitals, 3 midsize hospitals and 4 big hospitals for the period 2006-2010. The number of outpatient cases and the number of inpatient days were selected as outputs while the number of Beds and the Staff were used as inputs. Tlotlego et al (2010) [26] analyzed the technical efficiency of 21 non-teaching hospitals in Botswana in the period 2006-2008. The outputs taken into account were the number of outpatients and the number of inpatient days whilst the inputs considered were the staff and the number of beds. Kiriga et al (2008) [27] applied the DEA method in the analysis of technical efficiency of 28 Public hospitals in Angola between 2000 and 2002. The number of outpatients' cases and the number of inpatient days were selected as outputs while the hospital staff, the number of beds and pharmaceutical and non-pharmaceutical spending was the inputs used. Zere et al (2006) [28] applied the non-parametric method to analyze the Technical efficiency of 30 Namibian district hospitals. The number of beds, medical staff and recurrent expenditures were used as inputs. The selected outputs were the number of outpatients' cases and the number of inpatient days. Zere et al (2001) [29] used the recurrent expenditure and the number of beds to analyze efficiency in the production of outpatient cases and inpatient days in three South African Provinces for three types of hospitals classified according to their size and the complexity of their activities.

For all these studies, selection of relevant inputs and outputs and using accurate data is very important, since the accuracy and the quality of the estimated efficiency measures depend on it. In Tunisia, the methodology was applied only one time to assess the efficiency of District hospitals in our knowledge (Arfa 2008)[30]. Therefore, there is a lack of studies focusing on efficiency assessment of the Tunisian public hospitals particularly those of the public health establishment (PHE) and regional hospitals (RH). The interest granted to our study, can be justified by the important role of the public hospitals to the attainment of the goals of the health policy and the lack of studies devoted to assess the performance of Tunisian public hospitals through measuring, analyzing and comparing the technical efficiency.

3. Methodology

3.1 DEA conceptual Framework

The methodology used is Data envelopment analysis (DEA) which was introduced by Charnes, Cooper, and Rhodes (1978) [31]. It is a non-parametric linear programming method for assessing and measuring the efficiency of Decision-Making Units (DMUs), It converts multiple outputs and inputs into a scale measure of efficiency and constructs a non-parametric piecewise frontier of DMUs that owns optimal efficiency over datasets for a comparative efficiency measurement [32]. Technical efficiency describes the ability of operating units to transform their inputs into outputs, such that when an operating unit is technically efficient, it works on its production frontier [33]. A DMU is considered technically efficient when it uses the minimum resources to produce a given level of output in the case of Input-orientation or, alternatively, if it produces the maximum feasible outputs for a fixed level of inputs in the case of Output-orientation. A DMU is considered technically efficient if it belongs to the efficiency frontier of the DEA model. DMUs located at the efficiency frontier have their maximum outputs generated among all the DMUs by taking the minimum level of inputs; these are the most efficient DMUs. The first DEA model developed by Charnes et al [31] was assumed constant returns to scale (CRS) and it is known as the CCR model in the literature. Banker, Charnes, and Cooper [34] extended the CCR model to account for variable returns to scale (VRS), which became known as the BCC model. An inefficient DMU in the BCC model is only benchmarked against DMUs of similar sizes. Much of the seminal work on technical efficiency and its relationship to production functions is due to Farrell [33] which is the pioneer. As a useful and appropriate tool, DEA has been used to estimate hospital efficiency, because it has a prominent advantages compared to a parametric techniques. It can deal with multi-outputs and multi-inputs production frontier and be free of behavioral assumption of profit maximization or cost minimization. The non-parametric methods are characterized by the fact that the production functions are not directly observable. Thus, contrary to the parametric methods, they do not specify a particular functional form of the production function. The efficient production frontier, as well as the localization of the decision making unit (DMU) around this frontier, are obtained by solving linear programs based on the data.

This approach is useful in general in the context of not-for profit sectors characterized by the missing of the prices for both inputs and outputs, and particularly in hospital sector. Therefore, the specificity and the characteristics of hospital production dictate the choice of the efficiency estimate method and incite us to prefer DEA method compared to the parametric approach. This study uses the input-oriented VRS model. First, because in the health economics literature, the intuition to follow an input-orientation is to model hospitals as it minimizes input rather than maximizes the outputs by increasing a patients' numbers. And then, Tunisian hospitals' don't have much control over outputs. Therefore, efficiency measurement enable to test whether a given hospital could reach a given output level with fewer resource. The assumption of variable return to scale (VRS) is assumed since that hospitals do not operate at their optimal scale. The variable return to scale (VRS) is less restrictive and is done by a simple addition of a convexity constraint, only requiring that the sum of weights is equal to 1.

$$\sum_{j=1}^{N} \lambda_{ij} = 1$$

This constraint ensures that each evaluated hospital is compared only with hospitals which are similar to it.

Thus, technical efficiency is estimated by solving the following linear programming problem independently for each hospital:

$$\begin{aligned}
&Min\ \theta \\
&St \quad \sum_j x_{ij}\lambda_j \leq \theta x_{i0} \quad for\ i = 1,\ldots,m \\
&\qquad \sum_j y_{rj}\lambda_j \leq y_{r0} \quad for\ r = 1,\ldots,s \\
&\qquad \lambda_j \geq 0 \qquad\quad for\ j = 1,\ldots,n \\
&\qquad \sum_j \lambda_j = 1
\end{aligned}$$

Where:

θ = The factor by which inputs should be minimized in order to make each DMU produces at the efficient frontier.

y_{rj} = amount of output r produced by DMU_j,

x_{ij} = amount of input i used by DMU_j,

s = number of outputs,

r = number of inputs,

N = number of DMU,

From this Model it is possible to derive scale efficiency. An intuitive interpretation of scale efficiency is that, given its output level or external demand, there is a hypothetical scale of operations that makes each hospital most productive or efficient. The general theory is that when a firm becomes too big or too small, scale changes can lower costs and efficiency. Scale efficiency in health care is a consequence of market and institutional constraints which ensures that production units do not operate at optimal size. Scale efficiency is calculated by dividing a hospital's technical efficiency score under the assumption of CRS by its technical efficiency score under VRS. Coelli (1996) [35].

$$\text{Scale Efficiency Score} = \left(\frac{\text{CRS TE score}}{\text{VRS TE score}}\right) \quad (1)$$

3.2 Data and variables

A sample size of 134 hospitals was determined based on the availability of complete data. 81 are part of first-level hospitals (**DH**: District Hospitals) having a territorial competence on the scale of one or several delegations. They provide services of general medicine, obstetrics and emergency with a number of beds' and means of diagnosis appropriated to the nature and volume of their activities. While, 31 are second-level hospitals (**RH**: Regional Hospitals). These hospitals provide all the educational, preventive and curative medical services' which is an essential matter for the mission of the basic health centers. Some regional hospitals can be recognized as teaching centers because of their equipment and the qualification of their staff. In addition to the services of general medicine, of obstetrics and emergency, the regional hospitals provide specialized care in medical and surgical character. And, 22 hospitals belonging to the third level hospitals **(PHE:** Public health establishments**)**. These hospitals are public health establishments with university vocation; they have a mission of training medical and paramedical staff and leading scientific researches. Their main mission is to provide highly specialized cares and to contribute in teaching medical specialties. Our Sample covered about 80% of the total number of Tunisian public hospitals belonging to these three categories.

Data collection (Input and output data) for individual hospitals for the year 2012 were obtained from the Ministry of Health. Special attention should be given to the variables choice as they may influence the results (Magnussen 1996)[36]. The choice of our inputs and outputs variables is based on the literature particularly from the studies reviewed by O'Neil et al (2008)[3] on one hand and on the data's availability in another hand.

Inputs

In our study, Hospitals were assumed to use mainly 5 inputs belonging to the main categories invoked in the literature which are: Number of Beds **(BED)**, Number of medical staff **(MSTAF)**, Number of Paramedical Staff **(PMSTAF)**, Number of Labors **(LABOR)** and Total operating expenses excluding payroll taxes and depreciation **(TOE)**.

- The number of Beds **(BED):** is almost used as a proxy for hospital size and capital investment in all reviewed studies.
- The number of Medical and Paramedical Staff **(MSTAF)** and **(PMSTAF)** most of studies such as Biorn et al (2003)[37]; Burgess et al (1998)[38]; Holingsworth (1995)[39] included the ''number of medical and paramedical staff'' as a proxy for their costs whereas the rest used ''labor costs'' instead. Medical and paramedical staff consists of physicians, nurses and other medical personnel.
- The number of Labors **(Labor)**: several studies such as (Puig (2004)[40]; Burgess et al (1998)[38]) included the number of labors as hospital input and as a proxy for labors cost. In our study, it is a part of ''non-clinical staff'' excluding ''technical, managerial and administrative staff".
- Total operating expenses excluding payroll taxes and depreciation **(TOE):** TOE is often used as a proxy for the capital investment. Sixteen US studies included ''operating expenses excluding payroll, capital, and depreciation'' as an input category (Bannick et al. (1995)[41]; Biorn et al. (2000)[42]; Burgess et al. [20](1996)). In this study, TOE contains mainly the cost of furniture and products for medical use, medicines, purchase of materials and equipment, fuel, medical and non medical subcontracting, repairing and maintaining and external services.

[3] The article of O'Neil et al. (2008) which is "A cross-national comparison and taxonomy of DEA-based hospital efficiency studies".

- In our study, hospitals were supposed to produce only two outputs which are: Number of outpatient cases **(OUTPC)** and Number of Inpatient days **(INPD)**. Our choice was limited by the lack of the data.

  Table 1 presents a summary of statistics for inputs and outputs variables of 134 Tunisian public Hospitals. It provides a general description of the input and output set of the hospital sample. The difference in hospital size in our sample is reflected by the high standard deviations. The data proves that Tunisian hospitals do have a considerable part of outpatient in their activity portfolio.

Table 1. Summary of statistics

All hospitals						
Variables	**Label**	**N**	**Mean**	**Std Dev**	**Min**	**Max**
Number of Inpatient Days	INPD	134	31862	58055	47	284674
Number of Outpatient visits	OUPC	134	55411	60377	0	359291
Number of Beds	BED	134	129	191	3	1045
Number of Medical Staff	MSTAF	134	33	46	2	230
Number of Paramedical Staff	PMSTAF	134	218	264	1	1364
Number of Labor	LABOR	134	89	125	4	760
Total operating Expenses (MD)	TOE	134	3,268	5,422	0,205	25,535

4. Results and discussion

The efficiency scores were calculated by DEA method with the software DEAP developed by Coelli et al (1996).

Table 2 provides summary of statistics of technical and scale efficiency scores. It is important to recall that technical and scale efficiency scores range from 0 to 1.

4.1. Estimating results of hospital efficiency

On average, the sample of 134 public hospitals included in the analysis were operating at 0.78 level of technical efficiency with 19% of standard deviation; implying that inefficient hospitals need to reduce or to more manage their inputs of about 22% in order to become efficient. The minimum Technical efficiency score was about 0.29. Figure 1 shows that 37(28%) of the total hospitals were found to be technically efficient, while the remaining 97 (72%) were technically inefficient. Among these inefficient hospitals, 10 (10 %) had a TE score less than 50%, 36 (37%) more than or equal to 50% and less than 70%, 20 (21%) more than or equal to 70% and less than 80%, 20 (21%) more than or equal to 81% and less than 90%, and 11 (11%) between 90 and less than100% (Figure 2).

This is an alarming result on a national scale: as the percentage of efficient hospitals was insufficient compared to the expected results. Indeed, we should expect better results, considering that the total expenditure on health which represents at least 5362,7 millions Tunisian dinars , or 493 dinars per capita corresponding to 7,1 % of GDP, is 0,9 percentage point higher than the average of the countries with similar incomes (as classified by the World Bank).

Similar studies have been undertaken in some developing countries in Sub-Saharan Africa. The result of the study of Africa.Papa Yona et al [25] that analyze the technical efficiency of three types of Senegalese hospitals show an average score of efficiency of 67. 6%. The result of the study of Tlotlego et al (2010) [26] analyzing the technical efficiency of 21 non-teaching hospitals in Botswana show an average score of efficiency of 70.4%.

Kiriga et al (2008) [27], in the analysis of technical efficiency of 28 Public hospitals in Angola, showed an average efficiency level of 68.5 %. The results of the study of Zere et al (2006) [28] analyzing the Technical efficiency of 30 Namibian district hospitals showed an average efficiency score between 62.7 % and 74.3 %.The results of our study indicated that the efficiency scores of Tunisian hospitals are quite similar to those of the hospitals of the developing countries in Sub-Saharan Africa. However, when using DEA method for estimating the efficiency frontier, the comparison of the efficiency scores from different studies wasn't always relevant for many reasons. The first one is that the studies include different outputs and inputs. In this context, Magnussen (1996) [37] noticed that the choice of the outputs and inputs influences the results in terms of hospitals ranking and scale effects. The outputs taken into account in the different studies listed in the developing countries such as (Papa Yona B (2013) [25] in Senegal; Lee et al (2008[44]) in Seoul, Zere et al (2006) [28] in Namibia) are almost the same as those we considered while the inputs differ somewhat. The second reason that may render the comparison of efficiency scores irrelevant is the sample size. The efficiency scores tend to be high with a small sample. Indeed, it is generally agreed that with the increasing number of the DMU to be analyzed, there is more chance that the obtained frontier by DEA will asymptotically come close to the true frontier.

Therefore in analyzing the results, it is important not to only consider the value of the efficiency score which is relative to the sample size. However these scores allow us to identify the hospitals having the best practices and to determine by how much the other hospital can improve their situation. Thus, if some hospitals appeared efficient in the analysis, it is only because they have the best practices compared to other hospitals in the same sample. Nonetheless it does not mean that their efficiency cannot be improved.

Table 2. Summary statistics of Technical and Scale Efficiency Scores

Scores	Mean	STD	Min	Max
Technical Efficiency	0.78	0.19	0.29	1
Scale Efficiency	0.87	0.18	0.23	1

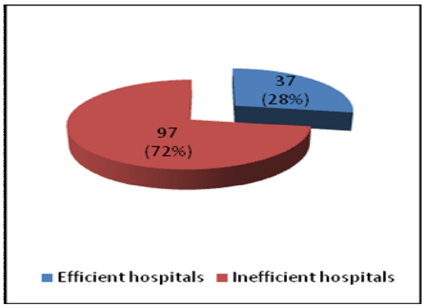

Figure1. Efficient and inefficient hospitals

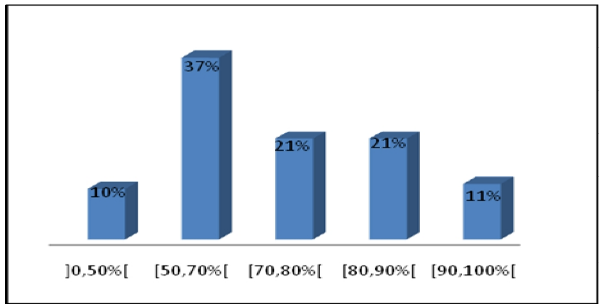

Figure2. Distribution of Technical Efficiency score for inefficient hospitals

On the other hand, our sample of 134 hospitals analyzed were operating on average at 0.87 level of scale efficiency with a 19% standard deviation; implying that there is room to increase total outputs by about 13%. Figure 3 shows that 110 (82 %) of the hospitals were at a scale efficiency less than unity; meaning that these hospitals didn't operate on an optimal scale of production. 22% (24) of them were operate with a decreasing return to scale while the remaining 78% (86) were operate with an increasing return to scale (Figure 4). This means that if we increase the resources used by the majority of the hospitals operating with an increasing return to scale, the production increases proportionally more than the increase in these resources.

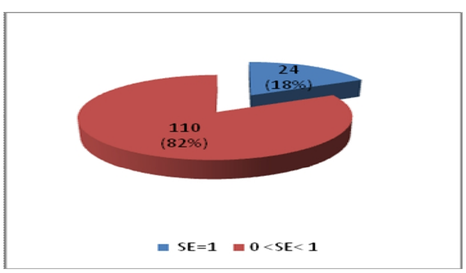

Figure 3.Hospitals Scale Efficiency

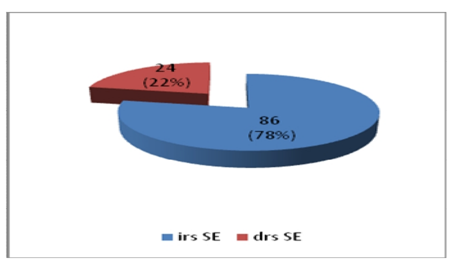

Figure 4. Nature of returns to scale for hospitals having SE<1

Based on figure 5, the results showed that 59% from the 22 Public Health Establishments, 84% from the 31 Regional hospitals and 88% from the 81districts hospitals had scale efficiency less than 1; implying that most hospitals were not operating on an optimal scale of production and especially the regional and the district hospitals.

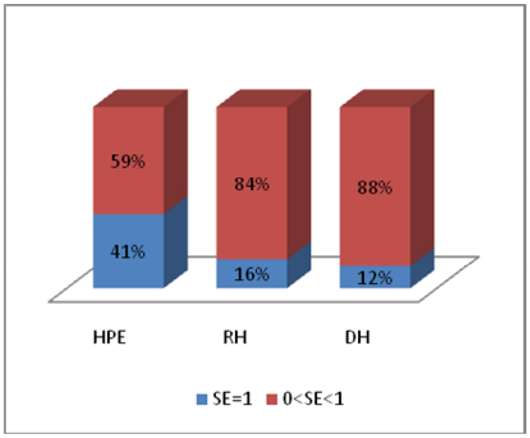

Figure 5. Scale Efficiency by hospital category (%)

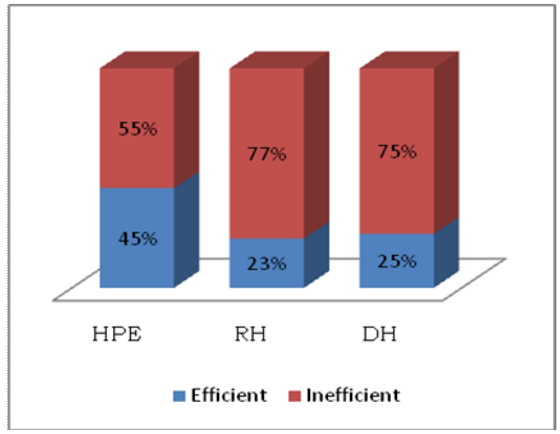

Figure 6. Efficient and inefficient hospitals (%)

The results presented in the figure 6 showed that 45% of the 22 Public Health Establishments PHE were technically efficient while the remaining 55% were inefficient and were operating at 0.9 % level of technical efficiency and 0.98 level of scale efficiency (Table 3), implying that they could reduce their utilization of all inputs by about 10% to get the same quantity of output. 23% among the 31 Regional hospitals were technically efficient while the remaining 77% were inefficient and were operating at 0.73 level of technical efficiency and 0.95 level of scale efficiency. And, 25% hospitals from the sample of the 81 District hospitals were technically efficient while the remaining 75% were inefficient and were operating at 0.76 level of technical efficiency and 0.80 level of scale efficiency.

Table 3. Means of Technical and Scale efficiency scores by hospital category

Hospital Category	TE mean	SE mean
PHE	0.90	0.98
RH	0.73	0.95
DH	0.76	0.80

Therefore, the analysis of the results indicated that the Public Health establishments which have the missions of training medical and paramedical staff, leading scientific researches and providing highly specialized cares are the most efficient among the three types of hospitals that exist in Tunisia. This is an expected result since that these hospitals are better equipped with human, financial and material resources. Thus, these hospitals absorb a big part of the activities of RH and DH. There is a very high demand for this category of hospitals. Such that even for simple cares that do not require the recourse unique to this type of hospitals, patients prefer to go to the PHE rather than going to RH or DH. This can explains the tendency to operate with a decreasing return to scale (77%) for the PHE, and an increasing return to scale for the RH (65%) and DH (93%) having scale efficiency less than one (Figure 7).

It means that if the majority of the PHE increase their resources, the production increase will be proportionally less, while for the most of the RH and the DH if they increase their resources the production increase will be proportionally more. This is also an expected result since that regional and district hospitals lack a lot of resources while the PHE have more turnover, more equipment, better work conditions and supervision as they are teaching hospitals.

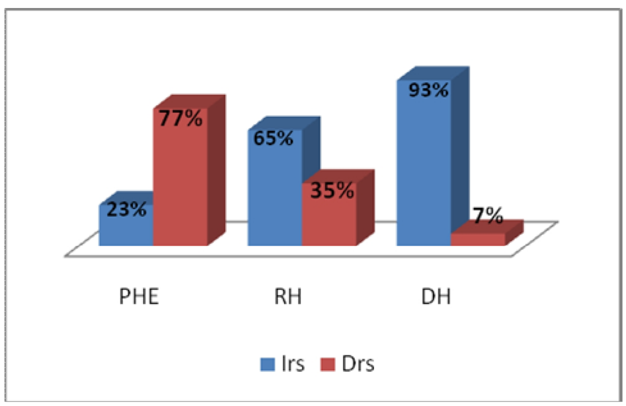

Figure 7. Type of Return to scale for Hospitals having SE<1 by category

Technical and scale efficiency scores as well as the type of return to scale, the peers count and the number of peers for the twenty two of the third level hospitals **PHE** can be found in Table 1 in the appendix.

Based on this table, we can remark that some hospitals were considered as a benchmark[4] many times over as for example the medical complex of Jbel el west (PHE16) which was a

[4]When we consider a hospital as a benchmark it doesn’t mean that it is a benchmark in all the practices.

benchmark for 37 hospitals, the hospital of Rabta (PHE10) was a benchmark for 20 hospitals, the hospital of Razi (PHE3) was a benchmark for 17 hospitals ect…

The number of peers represents the number of benchmark for the considered hospitals. Therefore, the decision maker can have an idea about the reference technologies or the benchmark for the inefficient hospitals.

4.2. The difference in the level of efficiency by district

The difference in the level of efficiency by district is investigated. Figure 8 shows the distribution of hospitals through six districts which are:

The district of Northeast **(NE)**, the district of North West **(NW),** the district of Center East **(CE)**, the district of Center West **(CW)**, the district of South East **(SE)** and the district of South West **(SW)**. Table 4 below presents the governorates belonging to each district.

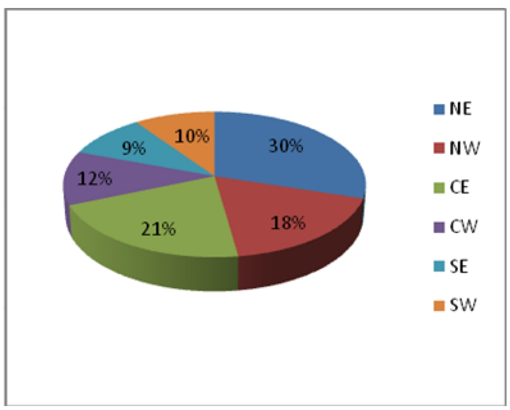

Figure 8. Distribution of hospitals by district

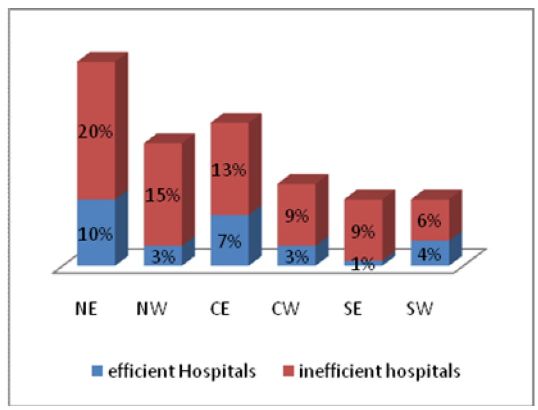

Figure 9. Distribution of efficient and inefficient hospitals

The distribution as well as the efficiency scores of the hospitals indicated a disparity among the districts. 51% of the hospitals are situated in the districts of Northeast (30%) and Center east (21%) which are the most important districts in terms of hospital and inhabitant concentration. These districts accounts for about 5.7 million inhabitants representing more than the half of the population of Tunisia. They have about 90% of the total beds of the PHE, 28% of the total beds of RH and about 36% of the total beds of DH. These districts also have the most important and developed governorates in Tunisia which are Tunis, Ariana, Mannouba, Ben Arous, Sfax, Sousse, Monastir and Mahdia. The majority of the hospitals in these districts are more equipped in terms of human, financial and material resources. All of these can explain the existence of the high percentage of efficient hospitals in these districts compared to the other ones with poor and less developed governorates. These governorates had a low index of regional development such as Sidi Bouzid, Kasserine, Gafsa, Tataouine , Medenine…ect.

Figure 9 presents the distribution of efficient and inefficient hospitals (%) by district. This figure emphasizes the disparity by districts in term of percentage of efficient and inefficient hospitals. Therefore, the highest percentage of efficient hospitals is in the districts of Northeast and Center east. As among the total number of efficient hospitals which representing 28% of the sample, 10% of them belongs to the district of NE, 7% to the district of CE, whilst the remaining 4% to the district of SW, 3% to both districts NW and CW and 1% to the district of SE.

Table 4. Distribution of governorates by districts

Districts	Governorates	Districts	Governorates	Districts	Governorates
NE	Tunis	**NW**	Jendouba	**CW**	Kasserine
NE	Ariana	**NW**	Kef	**CW**	Sidi Bouzid
NE	Ben Arous	**NW**	Siliana	**SE**	Gabes
NE	Mannouba	**CE**	Mahdia	**SE**	Medenine
NE	Zaghouan	**CE**	Monastir	**SE**	Tataouine
NE	Bizerte	**CE**	Sfax	**SW**	Gafsa
NE	Nabeul	**CE**	Sousse	**SW**	Kebeli
NW	Beja	**CW**	Kairouan	**SW**	Tozeur

4.3. Robustness of DEA results: comparison with FDH method

In order to study the Robustness of the results of the DEA method, we measured the technical efficiency of Hospitals with the FDH[5] method based on the EMS program We therefore conducted the Pearson test on the efficiency scores under DEA and FDH methods and we observed its significance to conclude on the robustness of the results of DEA method.

Table 2 in the appendix presents the technical efficiency score under DEA and FDH methods. It‘s clear that under the FDH method the scores of efficiency are more important than they are under DEA method. For example under FDH method the hospitals were operating at a technical efficiency level of 0;98 with 0;07 of Standard deviation while they were operating at technical efficiency of 0.78 and 0.19 of Standard deviation under the DEA

5 FDH is a nonparametric approach to estimate efficiency developed mainly by Deprins, Simar, and Tulkens (1984). It's is similar to DEA method, except that Deprins and Al (1984) relax the convexity assumption and maintains only the assumptions of strong free disposal of inputs and outputs and the variable returns to scale.

method. The Number of efficient hospitals was increased under FDH method when compared to the number of efficient hospitals under DEA method. Table 5 shows the results of the Pearson correlation test. The p-value of the test is equal to 0,000 which is a good result meaning that the test is significant. The hypothesis supposes that the correlation test is significant at the level of 0.01. Therefore, based on these results we can confirm the robustness of the DEA method results.

Table 5 Result of Pearson correlation test

TE(DEA)	**TE(DEA)**	**TE(FDH)**
Pearson correlation	1	0,520**
Sig. (bilateral)	-	,000
N	134	134
TE(FDH)		
Pearson correlation	,520**	1
Sig. (bilateral)	,000	-
N	134	134
TE(FDH)		

**The correlation is significant at the level of 0.01 (bilateral).

4.5. The developed decision making tools

From the results obtained for all hospitals, decision making tools were developed in order to indicate the percentage of target and mismanaged inputs compared to the initial values for all hospitals as well as for each hospital separately. These tools show that the hospital of the third level (PHEs) have the less percentage of mismanaged inputs for all the inputs followed by the regional and district hospitals respectively. (Figures 10, 11, 12 and13).

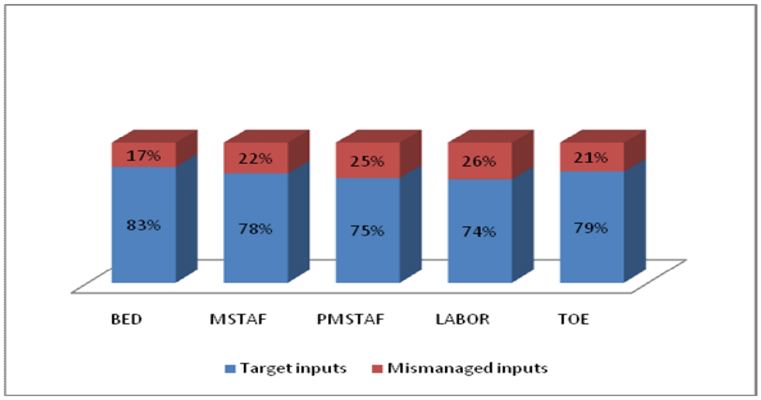

Figure 10. Target and mismanaged inputs for all hospitals (%)

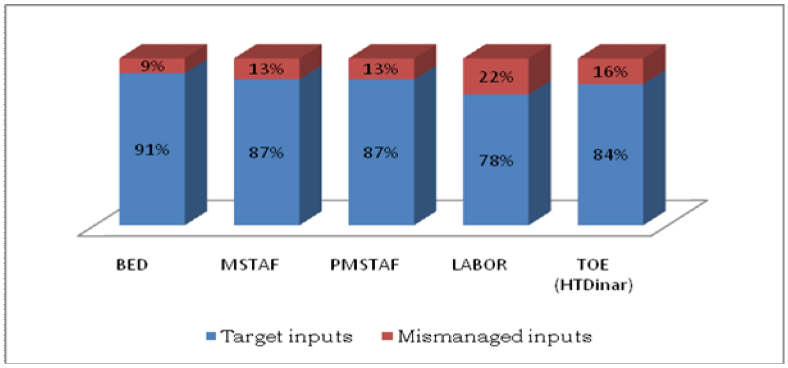

Figure11. Target and mismanaged inputs for PHE(%)

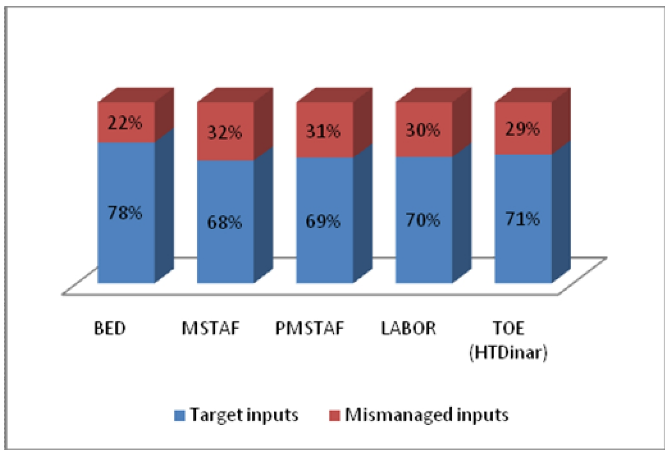

Figure 2.Target and mismanaged inputs for RH(%)

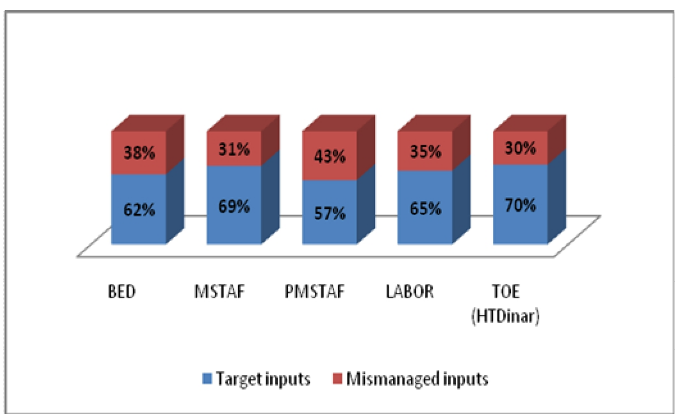

Figure13. Target and mismanaged inputs for DH (%)

Figure 10 below indicates the percentage of target and mismanaged input for all hospitals compared to the initial value. For example, with only 83% from the total number of beds for all hospitals we obtained the same results, which mean that there are 17% of mismanaged beds or beds in excess. This implies that we can get the same results by reducing or more managing 17% of the total number of beds.

The PHEs have only 9% of mismanaged beds while the RHs and DHs have 22% and 38% respectively. For the % of mismanaged MSTAF, PHEs have 13% against 32% for the RHs and 31% for the DHs. For the % of mismanaged PMSTAF, PHEs have 13% while RHs and DHs have 31% and 43%respectively. For the % of mismanaged Labors, PHEs have 22% against 30 and 35% for RHs and DHs respectively. For the percentage of TOE, PHEs have 16% while RHs and DHs have 29% and 30%respectively.

The figures below 14,15,16,17 and 18 present the second developed decision making tool that provide the magnitudes by which specific input per inefficient hospital ought to be more managed or to be reduced. Only the decision making tools relative to the PHE were presented[6],.

Figure 14 presents the target and mismanaged beds for inefficient PHE (%). We notice that PHE2, PHE7, PHE14, PHE9 and PHE6 had a remarkable percentage of mismanaged beds which were 35%, 32%, 26%, 25% and 20% respectively. Figure 15 shows the percentage of target and mismanaged Medical Staff for inefficient PHE. We can remark that PHE13, PHE1, PHE2, PHE21, PHE17; PHE14 had significant percentage of mismanaged Medical staff which where 50%,37%,35%,30%, 27% and 26% respectively. Figure 16 indicates the percentage of target and mismanaged Paramedical staff for inefficient PHE. We notice that PHE2, PHE14, PHE9 and PHE4 respectively had striking percentage of paramedical staff (64%, 48%, 27% and 26%).Figure 17 presents the target and mismanaged Labor for inefficient PHE. We observe that PHE14, PHE2, PHE12, PHE4, PHE7, PHE9 and PHE21 had a high percentage of mismanaged Labors which were 69%, 68%, 49%, 48%, 40%, 39% and 36% respectively. Figure 18 shows the percentage of target and mismanaged total operating expenses for inefficient PHE. We notice that PHE2, PHE14, PHE6 and PHE13 had a high percentage of mismanaged Total operating expenses which were 75%, 67%,58% and 55% respectively.

The percentage of mismanaged beds for the PHEs can be explained by an abusive beds occupation by patients who are waiting for consultation, surgery, medical checkup or medical imagery. While the percentage of mismanaged beds for RHs and DHs can be explained by an under occupation of the beds since the patients bypass the Hospitals of the first and the second line for go to the PHEs and seek consultation with specialists.

[66] All the figures relatives to RH and DH are available upon request

The percentage of mismanaged medical and paramedical staff as well as the labors can be interpreted by the high rates of absenteeism and extended leave of absence, wrong allocation of functions and inappropriate organization of work. These lead sometimes for the doctors to do the work of the nurse or the technician and even the work of the labor and for the nurses to do the work of technician or labors and so on. If we take the example of the PHE13 the percentage of mismanaged Paramedical staff is about 11% while in the reality they are suffering from a lack of paramedical staff because of the high rate of absenteeism and the extended leave of absence. (Figure 16).

The percentage of mismanaged technical operating expenses can be explained by mismanagement and wasting of resources on one hand and the outflow of the drugs, the equipments and the consumables on the other hand. The wasting of the resources can results from an overconsumption of the drugs; an abusive use of consumable and an excess in demand of analyses and radiological images. This can be avoided by the establishment of the shared electronic medical record. Also, there are some people who go to the hospital for treatment without having the right of access which induce mismanaged Technical Operating Expenses.

The results provided in this part can be useful for decisions at the macroeconomic as well as at the microeconomic levels. Armed with this information the ministry of health would be able to target all inefficient hospitals, to pick out the main sources of inefficiency and then help the policy makers to adjust resource utilization and to regulate their activities.It can help also hospitals' managers to identify the origin of their inefficiency and then target the actions that should be undertaken to become technically efficient.

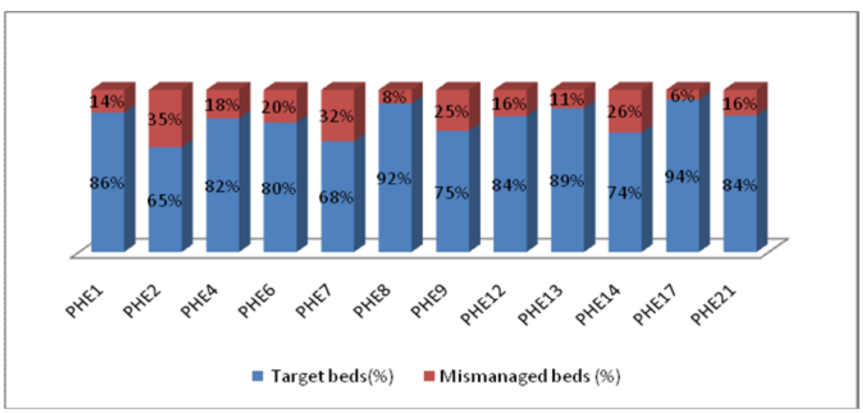

Figure14.Target and mismanaged beds for inefficient PHE (%)

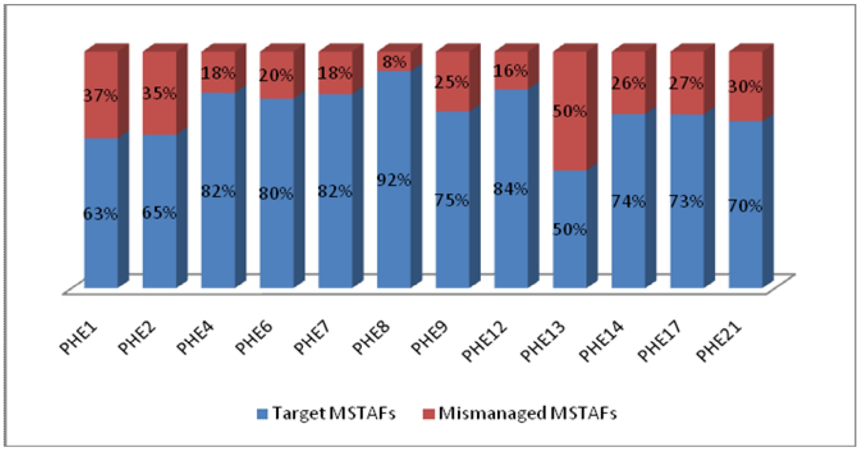

Figure15. Target and mismanaged MSTAF for inefficient PHE(%)

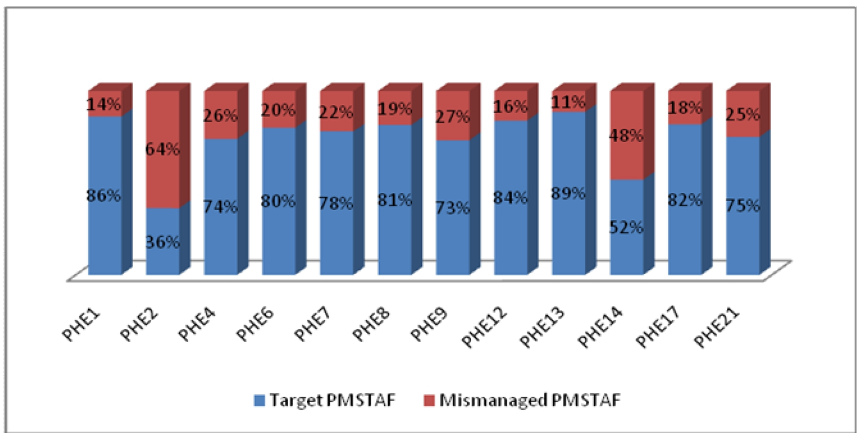

Figure16. Target and mismanaged PMSTAFs for inefficient PHE (%)

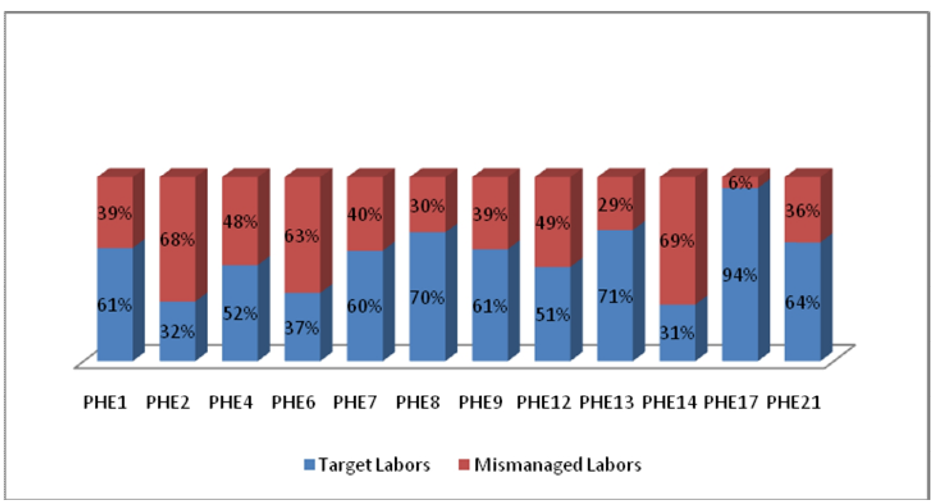

Figure17. Target and mismanaged Labor for inefficient PHE(%)

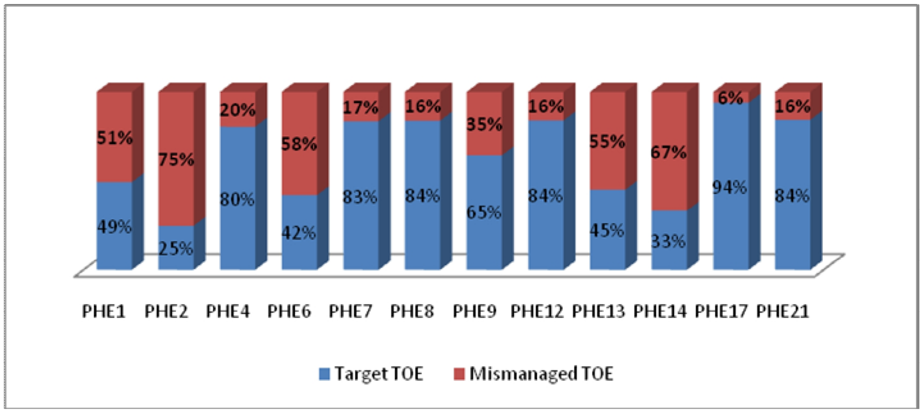

Figure18. Target and mismanaged TOEs for inefficient PHE(%)

As for those inefficient hospitals having mismanaged inputs, the Ministry of Health could provide more human, material and financial resources for regional and district hospitals using the mismanaged operating expenses. In fact this intervention may not be enough, so the merger of nearby hospitals can help to solve this problem. It's better to ensure a good health care service a little further rather than a poor one in the surroundings. This would remarkably strengthen the hospitals of the first and the second line

The MOH need to revise the procedures of the management of the public health structures by ensuring more autonomy and responsibility to the various actors of the hospital system, which implies a redefinition and an effective implementation of a decentralized management. In fact, the public hospital sector has a problem of the governance since that it's characterized by an excessive centralization of decision-making, in terms of investment and human resource mobilization which generates a behavior of non-responsibility and demotivation of hospital managers who cannot adjust the needs of these hospitals only with an authorization or reprogramming of the operational budget. Thus, the hospital director is sometimes a mere transmission belt of ministerial decisions, and the hospital board. Despite the existing legislation which adopts the autonomy of the hospitals, the strategic and operational decisions relating to the hospitals still remain taken without them.

Furthermore, the upgrading of the information system by establishing the unique digital medical records to ensure the coordination between the different lines of hospitals would be a priority in improving the efficiency of the public hospitals, since the lack of coordination between the different levels of hospitals would present an important source of inefficiency.

Finally, the establishment of DRG as well as the introducing of cost accounting for all hospitals is an important advancement that should be perfected by developing medical interpretation of groups and evaluating the dispersion of resources used during a stay. These would allow the possibility of getting more refined data and hence more reliable efficiency results. Undoubtedly, the implementation of refined program of medicalization information systems would enable the linking of the budget to the activities of public hospitals and then to assess the hospital productivity as well as its cost

5. Conclusion

A few studies have attempted to analyze TE of health facilities in Africa using DEA methodology comparing them to those of America and Europe (Kiriga et al (2000)[45], Kiriga et al (2001)[46], Joses et al (2002)[47] and Felix et al 2007[48]) [49,51]. The study reported in this paper is the first attempt[7] in Tunisia to estimate TE of the three categories of the public hospitals using DEA methodology. The efficiency measurement for the sample of 134 hospitals indicated an average efficiency score of 0.78 under the assumption of variable returns to scale. Therefore, hospitals can improve their efficiency by over 22 %, implying that inefficient hospitals need to reduce or better manage their inputs by about 22% in order to become efficient. The results also indicated that only 28% of the total hospitals were found to be technically efficient and operating relatively more efficient when compared to their peers, while the remaining 72% were technically inefficient. Our analysis indicated that the Public Health establishments which have the missions of training medical and paramedical staff, leading scientific researches and providing highly specialized cares are the most efficient among the three types of hospitals that exist in Tunisia. Also, the distribution as well as the efficiency scores of the hospitals indicated a disparity among the districts.

In conclusion, the study has demonstrated that DEA not only helps health policymakers and managers to answer the question “How well are the public hospitals performing?” but also “By how much could their performance be improved?” The policy makers must concentrate on the monitoring of the resource utilization using evaluation tools such as those developed and presented in this paper. Further researches, is focused first on further analyses of the hospitals which are performing best and their operating practices, with a view to establishing a guide to “best practice” for others to emulate. Then, on the analysis of the efficiency and productivity change over time using the Malmquist index approach. Thereafter, a statistical analysis of efficiency scores using the Bootstrap method to provide confidence intervals for

[7] Arfa (2008) was measuring the TE of some District Hospitals only.

the estimated efficiency measures and to show the sensitivity of the results to sampling variations is introduced since that the non parametric approach is often criticized due to its deterministic character. Finally, a two stage approach is applied in order to examine and determine the significant determinants of the DEA efficiency since that inefficiency could be affected by environmental factors, technological activities, and market structure.

APPENDIX

Table 1.Technical and scale efficiency scores for Public Health Establishment

PHE						
Hospitals Name	**Hospital code**	**TE(VRS)**	**SE**	**Type of Rts**	**Peers count**	**N° of Peers**
1.Abderrahmen Mami Pneumo	PHE1	0,861	0,998	Irs	0	3
2. Hospital of Ben Arous	PHE2	0,647	0,994	Irs	0	4
3. Hospital El Razi	PHE3	1	1	-	17	0
4. Institute M.Kassab of orthopedy	PHE4	0,825	0,999	Drs	0	4
5.Pregnancy and Neonat center	PHE5	1	1	-	11	0
6. Hospital of Aziza Othmana	PHE6	0,8	0,999	Drs	0	5
7. Hospital of Charles Nicolle	PHE7	0,834	0,852	Drs	0	3
8. Hospital of child	PHE8	0,917	0,999	Drs	0	3
9. Hospital of Habib Thameur	PHE9	0,746	1	-	0	4
10. Hospital of Rabta	PHE10	1	1	-	20	0
11. Hospital of Mongi Slim	PHE11	1	1	-	7	0
12.Institute H.Raies of ophthalmology	PHE12	0,839	0,998	Drs	0	6
13. Institute Salah Azaiez	PHE13	0,886	0,99	Irs	0	4
14. Institute M. B Hamida of Neurology	PHE14	0,736	0,999	Drs	0	4
15. National Institute of Nutrition	PHE15	1	1	-	16	0
16. Medical Complex of Jebel Oust	PHE16	1	1	-	37	0
17. Hospital Tahar Sfar of Mehdia	PHE17	0,94	0,957	Drs	0	5
18. Hospital Fat. Bourguiba	PHE18	1	1	-	2	0
19. Hospital Habib Bourguiba	PHE19	1	0,87	Drs	0	0
20. Hospital Hédi Chaker	PHE20	1	1	-	2	0
21. Hospital Farhat Hached	PHE21	0,842	0,998	Drs	0	3
22. Hospital Sahloul	PHE22	1	0,995	Drs	0	3
	Mean	**0,903**	**0,984**	**-**	**-**	**-**

Table 2. Technical efficiency score under DEA and FDH methods for all hospitals

Hospital code	TE (DEA)	TE (FDH)	Hospital Code	TE (DEA)	TE (FDH)	Hospital Code	TE (DEA)	TE (FDH)
PHE1	0,86	0,99	RH25	0,80	1,00	DH40	0,51	0,66
PHE2	0,65	0,94	RH26	0,81	1,00	DH41	0,98	1,00
PHE3	1,00	1,00	RH27	0,59	1,00	DH42	1,00	1,00
PHE4	0,83	1,00	RH28	1,00	1,00	DH43	0,87	1,00
PHE5	1,00	1,00	RH29	0,41	0,81	DH44	0,93	1,00
PHE6	0,80	1,00	RH30	0,61	1,00	DH45	0,51	1,00
PHE7	0,83	0,90	RH31	0,46	0,74	DH46	1,00	1,00
PHE8	0,92	0,99	DH1	1,00	1,00	DH47	0,52	1,00
PHE9	0,75	1,00	DH2	0,29	0,60	DH48	1,00	1,00
PHE10	1,00	1,00	DH3	0,71	1,00	DH49	0,49	1,00
PHE11	1,00	1,00	DH4	0,83	1,00	DH50	0,77	1,00
PHE12	0,84	1,00	DH5	0,41	0,81	DH51	0,81	1,00
PHE13	0,89	1,00	DH6	0,55	0,92	DH52	1,00	1,00
PHE14	0,74	1,00	DH7	0,65	1,00	DH53	1,00	1,00
PHE15	1,00	1,00	DH8	0,97	1,00	DH54	0,64	1,00
PHE16	1,00	1,00	DH9	0,78	1,00	DH55	0,59	1,00
PHE17	0,94	1,00	DH10	1,00	1,00	DH56	1,00	1,00
PHE18	1,00	1,00	DH11	0,76	1,00	DH57	0,61	1,00
PHE19	1,00	1,00	DH12	1,00	1,00	DH58	0,78	1,00
PHE20	1,00	1,00	DH13	0,55	0,86	DH59	0,80	1,00
PHE21	0,84	1,00	DH14	0,41	0,69	DH60	0,89	1,00
PHE22	1,00	1,00	DH15	0,67	1,00	DH61	0,88	1,00
RH1	0,37	0,97	DH16	1,00	1,00	DH62	0,87	1,00
RH2	0,62	1,00	DH17	0,77	1,00	DH63	0,59	0,91
RH3	0,81	1,00	DH18	0,93	1,00	DH64	0,83	1,00
RH4	1,00	1,00	DH19	0,66	1,00	DH65	0,71	1,00
RH5	1,00	1,00	DH20	0,40	0,80	DH66	0,64	1,00
RH6	1,00	1,00	DH21	0,58	1,00	DH67	0,74	1,00
RH7	0,73	1,00	DH22	0,74	1,00	DH68	0,57	1,00
RH8	0,52	1,00	DH23	0,67	1,00	DH69	1,00	1,00
RH9	0,58	1,00	DH24	1,00	1,00	DH70	0,94	1,00
RH10	0,72	1,00	DH25	0,54	1,00	DH71	0,74	1,00
RH11	1,00	1,00	DH26	0,39	0,85	DH72	0,71	1,00
RH12	0,64	1,00	DH27	1,00	1,00	DH73	0,64	1,00
RH13	0,98	1,00	DH28	0,57	0,86	DH74	1,00	1,00
RH14	0,52	1,00	DH29	0,84	1,00	DH75	0,65	1,00
RH15	1,00	1,00	DH30	0,85	1,00	DH76	1,00	1,00
RH16	0,48	1,00	DH31	0,67	1,00	DH77	0,64	0,91
RH17	0,67	1,00	DH32	0,97	1,00	DH78	0,68	1,00
RH18	0,61	1,00	DH33	0,77	1,00	DH79	1,00	1,00
RH19	0,56	1,00	DH34	0,70	1,00	DH80	0,54	1,00
RH20	0,75	1,00	DH35	1,00	1,00	DH81	1,00	1,00
RH21	1,00	1,00	DH36	0,85	1,00	**Means**	0,78	0,98
RH22	0,92	1,00	DH37	0,72	1,00	**STD**	0,19	0,07
RH23	0,57	1,00	DH38	1,00	1,00	-	-	-
RH24	0,97	1,00	DH39	1,00	1,00	-	-	-

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