Measuring Technical efficiency of the Maghreb Health Care systems using DEA approach

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Abstract:

Since the Maghreb health care resources are rather limited, it is of interest to analyze whether any substantial differences in the efficiency can be detected. The study examines technical and scale efficiency of the Maghreb countries using DEA, the more advanced econometric and mathematical programming frontier technique that has been applied to health care systems. The results indicate a divergence in efficiency across countries, which may partly be due to differences in geographic area and Health public spending.

I. Introduction:

Health care system plays a crucial role in determining the state on health through its outputs. The objectives of health care systems are multiple and consist of improving the health of population, equity of access and the guarantee of financial insurance against poor health. The differences in health status can be examined according to efficiency of the health care system.

The research on health care system efficiency has become a major concern for policy makers. The reasons are obvious. The Maghreb health care expenditures are increasingly important. The health care expenditures per capita have grown on average ***from 62 (current US$) in 1995 to 179 (current US$) in 2010.*** *In response to this problem, several cost containment efforts have been implemented by the Maghreb health authorities. Among these initiatives are stimulation of competition, introducing cost accounting in public health care organizations and rate regulation. Decision makers must therefore ensure that these expenditures meet the preferences and the needs of population, particularly when many national sources of funding are already subject of heavy constraints.*

Research focusing on efficient allocation and use of limited resources can improve quality and effectiveness of health care services to achieve optimum impacts on population health outcomes. So, health care system efficiency depends significantly on the appropriate mix of input factors. Assessing the health efficiency is capable of informing policies to guide improved allocation of limited health care resources.

Most of Studies of health care system efficiencies have focused mainly on industrialized countries and none currently exists on developing countries such as Maghreb countries. Rising health care expenditures shares and a tightening of public budget constraints in the Maghreb increasingly justify the need for assessing efficiency of the national health system.

The report of WHO on health in the world (2000) has contributed greatly to disseminate concerns about the performance of health care systems. One of the major contributions of this report on measurement of the performance on health care systems was to propose a classification of 191 countries according to five performance *dimensions. It has generated significant debates at the international level and received harsh criticism, particularly on method used. But it remains that this report has unquestionably underlines the need to access the way which health care systems enhance their resources to produce results. Challenges of health care systems in developing countries transcend financial resource constraints to include also equity considerations in access and health manpower planning and expansion. Sources of inefficiencies, therefore, must be identified to implement reform strategies and policies.*

The conceptual approach of Efficiency measurement is to estimate a production function in considering health care systems as entities combining health inputs to produce a certain set of health outputs. Most studies have so far more interested on factors explaining performance differences rather than measurement of efficiency itself. The measure of efficiency is, indeed, a complex task and poses a number on conceptual and methodological challenges that leave a large place to measurement errors. Estimating the efficiency from multiple objectives requires not only special attention on the choice of inputs and outputs but also the choice a method for estimating the relation between the inputs of health care system and its outputs.

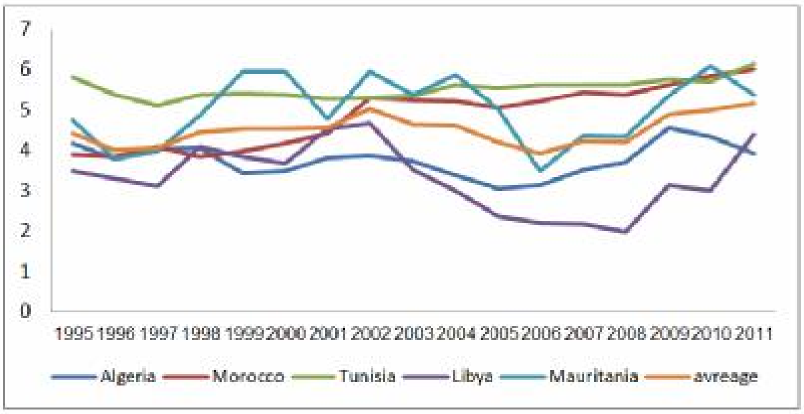
II. Trends of The Maghreb Expenditures On Health

Actually, in most courtiers, health expenditures have grown historically higher than the GDP. This situation has given rise to the establishment of policies to control health spending, which posted everywhere as a major health policy element.

In Maghreb countries, as in other countries, the problem of high health spending growth is acute in recent years. The Maghreb health expenditure which represents on average 5,17% of GDP in 2011 has not progressed at the same rate as known in developed countries (on average 7.7% of GDP). The growth rate in health spending has been very strong, as a result of combination of several factors: Aging population, demographic and epidemiological transition, building health care structures and the generalization of health insurance coverage. For these reasons, the Maghreb governments have implemented several reforms in recent years in attempt to limit the growth of the national health expenditures.

The Maghreb health expenditure to GDP slowed a non-regular progression; from 4.43% in 1995 to 5.02% in 2002 and 3.94% in 2006. This decrease in health spending was the result of measures taken by the governments of Maghreb Union in limitation of hiring and investment in health sector. But from 2009, they have involved to reach (on average) 5.17% in 2011 (figure.1).

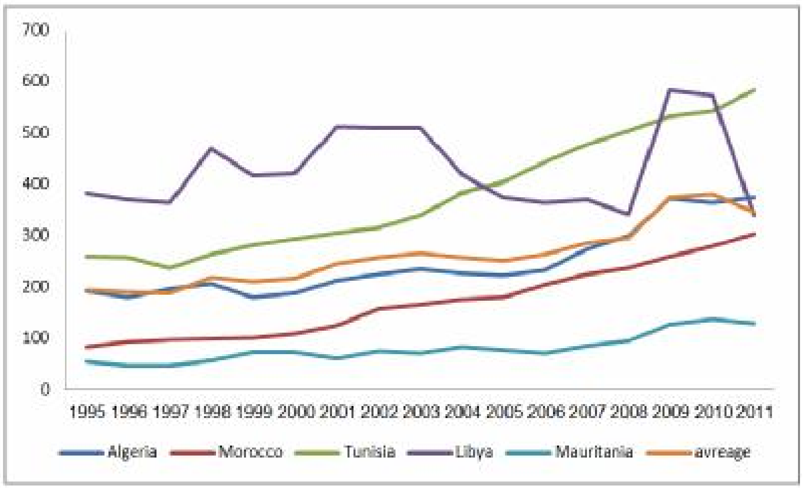
Figure 1. The Evolution of the Maghreb Health expenditures (% of GDP) during (1995-2011)



Source*: World Bank Data: http://databank.worldbank.org/data/home.aspx*

Concerning health spending per capita, they have involved significantly. They were increased on average 78% during the period (1995-2011). These increases are due mainly to the gradual withdrawal of the state funding for health, the emerging of private health sector and the deterioration of the quality of services provided by the public sector, which have encouraged households to contribute financially to the improvement of their health. Fugure.2 summarizes the per capita health expenditures of Maghreb countries.

Figure 2. The Evolution of the Maghreb Health expenditures per capita, PPP (constant 2005 international $) during (1995-2011)



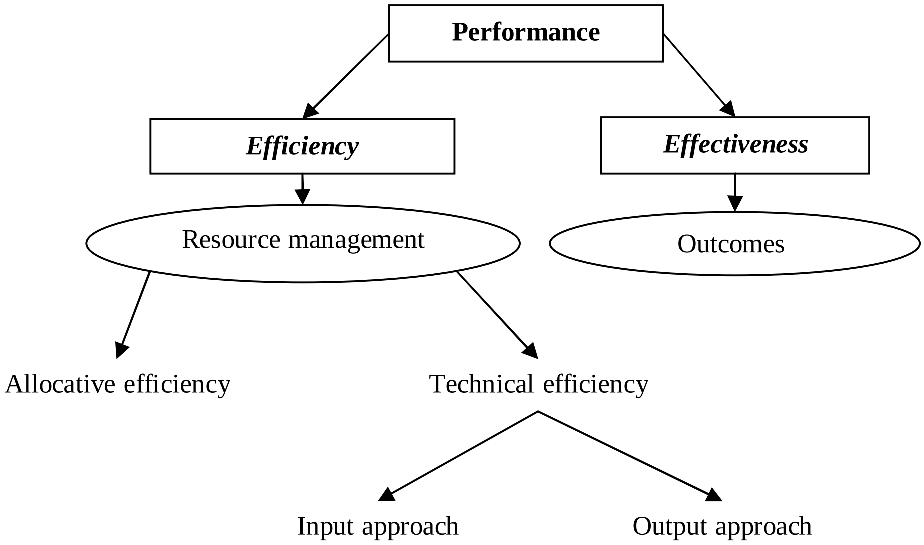
Source*: World Bank Data: http://databank.worldbank.org/data/home.aspx*

III. Literature Review: Technical Efficiency of the Health system

*From an economic point of view, the assessment of the performance of productive entity requires the measurement of its activity. The question of measuring the product of health system is complex seen the difficulty of the determination of the unit of measure of health status. Some authors conclude the vagueness of the health care product that improve the health state of patients or population, when others authors consider productions volume indicators to evaluate health care outputs like number of hospital days, number of medical acts, number of patients (**Sicott.C et al 1996**).*

It is important, however, to be aware that efficiency is only one part of the overall performance; as reported in Figure n° 2 a complete analysis also involves the measurement of effectiveness, and the degree to which a system achieves programs and policy objectives in terms of outcomes, accessibility, quality and appropriateness.

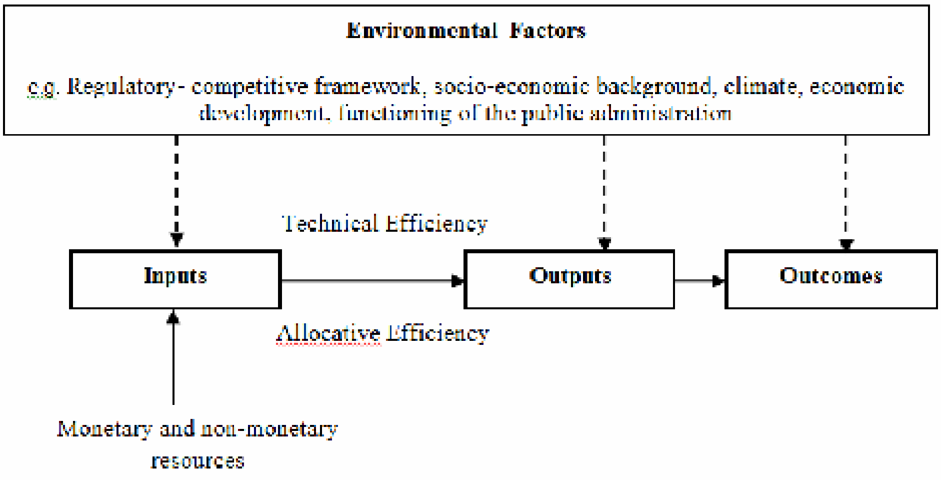
Figure n° 3. Framework for health care performance assessment



***Source**: Worthington and Dollery, 2000.*

Efficiency is the best use of resource in production process that is often confused with another important concept: Effectiveness. Effectiveness is a concept which connects health care system inputs or outputs to Outcomes (results). Outcomes are always linked to human being targets and can be influenced by multiple factors including inputs but also exogenous environmental factors like behaviors, nutritional end living conditions, physical environment. The distinction between outputs and *outcomes of health is often blurred in health care literature. The two concepts are often used interchangeably. Figure n° 3 shows the differentiation between these two concepts in health sector.*

Figure n° 4. Conceptual Framework of Efficiency and Effectiveness



***Source:** Mandl et al (2008).*

3-1. Technical and Allocative Efficiency

*The study of efficiency refers to the question of the use of the available resources. The Theorical framework of the measurement of efficiency was originally developed by M. J. Farrell in 1957 with his famous study "The Measurement of Productive Efficiency" in productions firms. Efficiency is the best use of resource in the production. Decision making units that are able to produce a maximum of outputs from a given inputs, or equivalently, a given set of outputs from a minimum of inputs can be considered to be efficient. The approach is particularly interesting because it uses the concept of **Relative Efficiency** and thus preventing the fixing of standards efficient situations. One producer will be inefficient if another producer uses less or equal inputs to produce more outputs.*

According to M. J. Farrell (1957) the concept of efficiency operates on two elements:

- ***Technical efficiency**: To be technically efficient, the firm produces a maximum of outputs with a given amount of inputs, or it produces a given set of outputs with a minimum amount of inputs.*
- ***Price (Allocative) efficiency**: a firm is allocativelly efficient, if in one hand, it is technically efficient and, if in another hand, it uses resources and produces outputs after taking into account the price to minimize the production costs or maximizing the revenues.*

Technical efficiency reflects the ability of the firm to maximize output for a given set of resource inputs while allocative efficiency reflects the ability of the firm to use the inputs in optimal proportions given their respective prices and the production technology.

Koopmans (1951) provided a definition of what we refer to as technical efficiency: an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input. Farrell (1957) extended the work initiated by Koopmans by noting that production efficiency has a second component reflecting the ability of producers to select the "right" technically efficient input-output vector in light of prevailing input and output prices. This led Farrell to define overall productive efficiency as the product of technical and allocative efficiency. Implicit in the notion of allocative efficiency is a specific behavioral assumption about the goal of the producer; Farrell considered cost-minimization in competitive inputs markets, although all the behavioral assumptions can be considered. Although the natural focus of most economists is on markets and their prices, thus on allocative rather than technical efficiency and its measurement, he expressed a concern about human ability to measure prices accurately enough to make good use of allocative efficiency measurement, and hence of overall economic efficiency measurement.

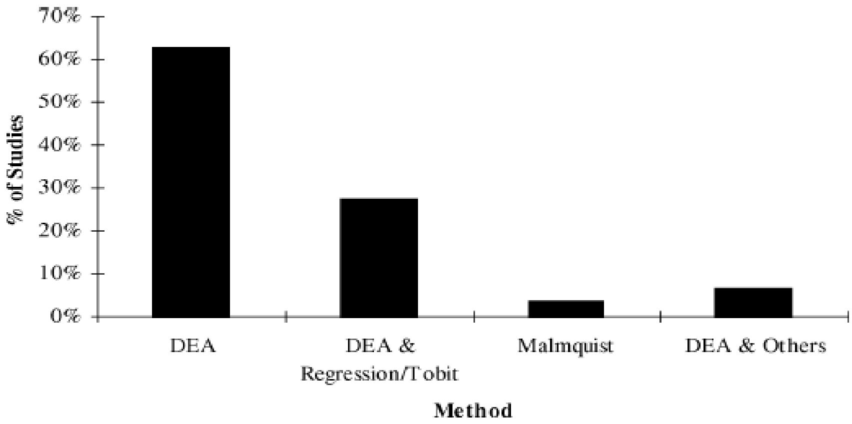
3-2. Measuring technical Efficiency

The literature suggests several alternative approaches to measuring efficiency in health care, grouped into non-parametric frontiers and parametric frontiers. Non-parametric frontiers do not imply a functional form on the production frontiers and do not make assumptions about the error term. These have used linear programming approaches and the most popular nonparametric approach has been the Data Envelopment Analysis. Parametric frontier approaches impose a functional form on the production function and make assumptions about the data. The most common functional forms include the Cobb-Douglas, constant elasticity of substitution and translog production functions.

*The most widely used version of non-parametric approach is the "Data Envelopment Analysis" (DEA). The "Data Envelopment Analysis" (**Farrell 1957**) assumes the existence of a border convex output constructed from the data. The "envelopment" terminology refers to the fact that the border envelope producing all observations, those on the border are called technically efficient. **Ozcan et al**. (1999) argue that the DEA approach is a useful methodology sought to assess the technical efficiency of health service providers to the extent that you can use several types of inputs and outputs also several in one analysis. Furthermore, this method does not require specification of the production function and no specification about bias caused by environmental heterogeneity, external shocks, measurement errors and omitted variables. Therefore, any deviation from the frontier is attributed to inefficiency.*

*The DEA approach has been widely used in research on the efficiency of health services (**Chilingerian and Sherman 1990; Huang and McLaughlin 1989; Ozgen and Ozcan 2002, Tyler et al. 1995**). According to Bruce Hollingsworth Over 60% of efficiency studies use DEA alone (see figure 5).*

Figure 5. Efficiency Methods used in reported studies



***Source**: Bruce Hollingsworth, P.J. et al (1999).*

IV. Data Envelopment Analysis Approach

*Data Envelopment Analysis is a mathematical programming technique that has found a much practical applications for measuring efficiency in health care. **Farrel** (1975) was the first to use this approach, but only with **Charnes, Cooper and Rhodes** (1978) it became popular.*

*DEA is an empirically based methodology that eliminates the need for some of the assumptions and limitations of traditional efficiency measurement approaches. It is generally used when the input and output prices of Decision Making Units are not available. DEA is "a multifactor productivity model for measuring the relative efficiency of a homogenous set of decisions making units" (**Talluri, S., et al 1997**). It accommodates multiple inputs and outputs and can also include exogenous fixed environmental variables (**Banker RD, et al 1984**).*

The method allows each decision making unit to choose its own weight of inputs and outputs in order to maximize its efficiency score. For each DMU, DEA calculates the efficiency score, determines the relative weights of inputs and outputs and identifies the technical inefficient DMUs.

*The Efficient Score (**ES**) is defined as:*

$$ES = \frac{Weighted\ sum\ of\ Outputs}{Weighted\ sum\ of\ Intputs}$$

*There are several ways to present the linear programming problem of DEA. The simplest general presentation was assumption include constant returns to scale (**CRS**). This model can be solved one of two linear programming formulations. The first is **CRS input-oriented model** which is expressed as the following:*

$$Max\ \ h_o = \frac{\sum_{r=1}^{s} u_r . y_{ro}}{\sum_{i=1}^{m} v_i . x_{io}}$$

$$s.t \quad \frac{\sum_{r=1}^{s} u_r . y_{rj}}{\sum_{i=1}^{m} v_i . x_{ij}} \le 1; \quad j = 1, \dots \dots, n \qquad (1)$$

$$u_r . v_i \ge 0; \ \ r = 1, \dots \dots, s \ \ i = 1, \dots \dots, m$$

Where (h_o) is Efficient Score, (y_{rj}) and (x_{ij}) are the inputs and outputs of the (j^{th}) DMU, (v_r) and (u_r) are the input and output weights.
The above fractional equation can be converted to a linear program problem as follows:

$$Max\ \ h_o = \sum_{r=1}^{s} u_r . y_{ro}$$

$$s.t \quad \sum_{i=1}^{m} v_i . x_{io} = 1$$

$$\sum_{r=1}^{s} u_r . y_{rj} - \sum_{i=1}^{m} v_i . x_{ij} \le 0; \quad j = 1, \dots \dots, n \qquad (2)$$

$$u_r . v_i \ge 0; \ \ r = 1, \dots \dots, s \ \ i = 1, \dots \dots, m$$

Equation (2) is solved (n) times to identify the relative efficiency score of all DMU's. In general a DMU is considered to be efficient if it possesses a score of 1, and a score less than 1 implies that it is inefficient.
The duel problem of (2) is expressed as follow:

$$Min\ \theta$$

$$s.t \quad \theta . x_{io} - \sum_{j=1}^{n} \lambda_j . x_{ij} \ge 0; \quad i = 1, \dots \dots, m$$

$$\sum_{j=1}^{n} \lambda_j . y_{rj} \ge y_{ro}; \quad r = 1, \dots \dots, s \qquad (3)$$

$$\lambda_j \ge 0; \ \ j = 1, \dots \dots, n$$

(θ) and (λ_j) are the dual variables of the linear program model (2). The scalar variable (θ) is proportional reduction which should be applied to all inputs of DMU_0 in order to make them efficient.

*The second is **CRS output-oriented model** which can be written as:*

$$Min\ q_0 = \sum_{i=1}^{m} v_i . x_{io}$$

$$s.t \quad \sum_{r=1}^{m} u_r . y_{ro} = 1$$

$$\sum_{i=1}^{m} v_i . x_{ij} - \sum_{r=1}^{s} u_r . y_{rj} \geq 0; \qquad j = 1, \dots\dots, n \qquad (4)$$

$$u_r, v_i \geq \varepsilon;\ i = 1, \dots\dots, m;\ \ r = 1, \dots\dots, m$$

And the dual for it is formulated as:

$$Max\ z_0 = \emptyset + \varepsilon. \sum_{r=1}^{s} Sr^+ + \varepsilon. \sum_{i=1}^{m} Si^-$$

$$s.t \quad \emptyset . y_{ro} - \sum_{j=1}^{n} \lambda_j . y_{rj} + Sr^+ = 0; \quad r = 1, \dots\dots, s \qquad (5)$$

$$\sum_{j=1}^{n} \lambda_j . x_{ij} + Sr^- = x_{i0}; \quad i = 1, \dots\dots, m$$

$$\lambda_j, Sr^+, Sr^- \geq 0;\ j = 1, \dots\dots, n;\ i = 1, \dots\dots, m; r = 1, \dots\dots, S$$

Where (ε) is a very small constant, (Sr^+) and (Sr^-) are “Slack Variables” which should be added to the model in order to convert inequality constraints to equality constraints.

In the duel model, maximum output augmentation is accomplished through the variable ($\emptyset$). If ($\emptyset$)> 1 and or the slack variables are not zero, then the DMU is inefficient. To improve inefficient DMU’s, first a proportional increase of ($\emptyset$) in all outputs is required, and then additional improvement to envelopment surface may be necessary based on positive slack variables.

*The CRS assumption is only appropriate when all Decision making units are operating at an optimal scale. Many factors like competition, finance constraints may cause a DMU to be operating at a non-optimal scale. **Banker, Charnes and Cooper (1984)** relaxed the assumption of CRS and suggested an extension of CRS DEA Model to account for Variable returns to Scale (VRS). If all DMU’s are not operating at optimal scale, CRS will result in technical efficiency measures which are confounded by scale efficiencies. The use of VRS will permit to calculate of technical efficiency devoid of these scale efficiencies effects (**Coelli., T:2008**).*

Baker et al. (1984) developed a model to estimate the technical efficiency and identify whether a DMU is operating in variable returns to scale. This model can be solved one of two linear programming formulations: input oriented or output oriented.

The ***VRS input oriented model*** *can be solved by the following linear program:*

$$Max\ h_o = \sum_{r=1}^{s} u_r . y_{ro} + u_0$$

$$s.t \quad \sum_{i=1}^{m} v_i . x_{io} = 1$$

$$\sum_{r=1}^{s} u_r . y_{rj} - \sum_{i=1}^{m} v_i . x_{ij} + u_0 \leq 0; \quad j = 1, \dots \dots, n \qquad (6)$$

$$u_r, v_i \geq 0; \ r = 1, \dots \dots, s \ i = 1, \dots \dots, m$$

$$u_0 \ free$$

The dual form of this program is expressed as:

$$Min\ \theta = \Theta - \varepsilon . \sum_{i=1}^{m} Si^- - \varepsilon . \sum_{s=1}^{s} Sr^+$$

$$s.t \quad \theta . x_{io} - \sum_{j=1}^{n} \lambda_j . x_{ij} - Si^- = 0; \quad i = 1, \dots \dots, m$$

$$\sum_{j=1}^{n} \lambda_j - Sr^+ \geq y_{ro}; \quad r = 1, \dots \dots, s \qquad (7)$$

$$\sum_{j=1}^{n} \lambda_j = 1; \ j = 1, \dots \dots, n$$

$$\lambda_j, Sr^+, Sr^- \geq 0; \ j = 1, \dots \dots, n; \ i = 1, \dots \dots, m; r = 1, \dots \dots, S$$

A DMU is efficient if and only $\theta^* = 1$ *and all slacks are zero. The envelopment surface is variable returns to scale and this is the result of the presence of the convexity constraint (*$\sum \lambda_j = 1$*) in the dual and, equivalently, the presence of (*u_0*), which is an unconstrained variable, in the primal problem.*

While the envelopment surface for the VRC output oriented model is the same as VRS input oriented one, the projection to the envelopment surface in the two models is different. The VRC is to maximize the output production while not exceeding the actual input level. The model (8) gives the primal formulation for the VRC output oriented model.

$$Min\ q_o = \sum_{i=1}^{m} v_i . x_{io} + v_0$$

$$s.t \quad \sum_{r=1}^{m} u_r . y_{ro} = 1$$
$$\sum_{i=1}^{m} v_i . y_{rj} - \sum_{r=1}^{s} u_r . y_{rj} + v_0 \geq 0; \quad j = 1, \dots\dots, n \qquad (8)$$
$$u_i, v_r \geq 0; \; i = 1, \dots\dots, m \;\; r = 1, \dots\dots, s$$
$$v_0 \; free$$

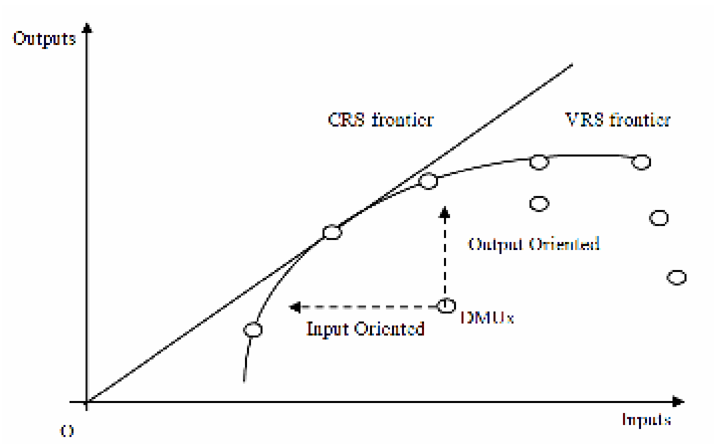
The dual envelopment form of the problem is as follows:

$$Max \; z_0 = \emptyset + \varepsilon . \sum_{r=1}^{s} Sr^{+} + \varepsilon . \sum_{i=1}^{m} Si^{-}$$
$$s.t \quad \emptyset . y_{ro} - \sum_{j=1}^{n} \lambda_j . y_{rj} + Sr^{+} = 0; \quad r = 1, \dots\dots, s$$
$$\sum_{j=1}^{n} \lambda_j . x_{ij} + Sr^{-} = x_{io}; \quad i = 1, \dots\dots, m \qquad (9)$$
$$\lambda_j, Sr^{+}, Sr^{-} \geq 0; \; j = 1, \dots\dots, n; \; i = 1, \dots\dots, m; \; r = 1, \dots\dots, S$$

For VRS output oriented models, similarly to the CRS output oriented models, maximal output augmentation is accomplished thought ($\emptyset$). Based on this model, a DMU is efficient if and only if ($\emptyset^{*} = 1$) and all slacks are zero.

Figure 6 summarizes the two models in. The envelopment surface can take the form of Constant returns to scale (CRS) or variable returns to scale (VRS).

Figure 6. Envelopment surface and Orientation



V. Applications

5-1. Health care system outputs and inputs

The development of relevant and homogenous measures of health system outputs and inputs is recognized as an important first step in order to assess and compare country's efficiencies and to establish targets for health policy. If these targets are to be achieved, it is also necessary to distinguish the factors behind the country differences in health efficiency.

*Health is difficult to define and more difficult yet to measure. The WHO has defined in its 1946 constitution **health** as "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (**WHO 1947**). This definition emphasizes that there are different, complexly-related forms of wellness and illness, and suggests that a wide of inputs can influence the health of individuals and groups.*

Many health status indicators are available and their choice depends on the research in question. Some indicators are related to health dimensions, others include specific illness.

*The literature review indicates that life expectancy and mortality were the most common indicators of health system outcomes. The **life expectancy** is usually used to measure the health status, because it refers to all group ages of the population. The most commonly used indicator is **life expectancy at birth** which is "the average number of years a new born baby could expect to live if current mortality trends were to continue for the rest of the new born's life (**haupt. A, Kane.TT:2004)**". It measures how long a person born today can expect to live; if there is no change in their lifetime in present rate of death for people of different ages. The higher is life expectancy at birth, the better is the health status of a country. **The mortality** usually can be measured by **the infant mortality rate** which measures Death of infants under age 1 per 1000 live births in a given year. It means how many children younger than 1 year of age will die for every 1000 who were born alive that year. This indicator is a powerful measure of health status of a country, most children younger than age of 1 year of age who die actually in the first month of life.*

The outputs of our study are the life expectancy at birth and infant mortality rate. The health status improvement is denoted by declines in infant mortality and increases in life expectancy at birth.

*The factors that influence health are complex and often confounded by different understandings of the concepts in question and how they are measured. Determinants of health are "the range of personal, social, economic and environmental factors which determine the health status of individuals and populations" (**CDC: 2003**). Following the most accepted health determinants studies, we select two kinds of inputs or variables: Health care services inputs and Social environment inputs. **Health services** mean access and use of services that prevent and treat disease influences health. **The Social environment** represents a complex determinant of health composed of social and economic safety, social stability, acceptance of differences, human rights, cohesion in a community, education, culture, poverty, community and road design, food, air, water, nutrition, housing.*

*We model number of **physicians**, **number of nurses and wives**, **hospital beds**, as well as the **health expenses** as variables of **health care services**. We select **The Income***

***index**, **Employment rate, Education Index, improved sanitations facilities and CO2 emission** to represent the **social environment**.*

*The health outputs and inputs statistics used in our efficiency estimation are presented in **table 1** in Appendix.*

*When the efficiency estimation is realized with reverse inputs and outputs, two methods can be used. The first approach consists to convert the decreasing variable (X_i) in increasing variable (X_i'): $X_i' = M - X_i$, with $M = Max(X_i)$ **(lewis. R.F, Sexton.T.R: 2004)**. The value of (M) must be important enough in order to obtain turned positive values. Often, $M = MAX(X_i) + 1$. The second approach which we have adopted is the inverse of the divided value of the decreasing value by the maximum value of the sample: $X_i' = 100 - \frac{X_i}{(M+1)}$.*

5-2. The Choice of Efficiency Orientation and Approach

The Estimation of efficiency of health systems aims to judge the quality of the relationship between the outputs and inputs, i.e. the relationship between the health outcomes achieved by each country's health care system and the level of resources used. The quality of this relationship can be studied by focusing either on the results (output orientation) or on the levels of used inputs (input orientation).

The output orientation allows us in our case to estimate the possible improvement of the results of health taking into account of the available resource of health care system. The input orientation input allows estimating the resource savings which could be achieved by countries without degrading the health results.

Often, the choice of orientation is not discussed in the literature. We must recognize that in the case of health care systems, none of the two orientations is a priori necessary but the choice remains important because the results and especially the implications in terms of policies to be implemented will be different according to the orientation.

In the case of health care systems, the choice of the output orientation seems most appropriate to the context of the developing countries where the aim is not so much of reducing resources but the increase of the health outputs. It is the reason why we initially selected the output orientation. But in fact, the input orientation is also important interest since it is possible to determine the resource savings, without degrading the health outcomes, if these were used more efficiently. We might then consider using these additional resources to finance the other neglected health activities known to have a beneficial impact on the health of populations (maternal education of mothers, infrastructure). Therefore, the estimation is made in a second time according to the input orientation in order to compare the implications involved from inputs reduction strategy with outputs increase strategy.

There are different approaches to estimate efficiency with DEA. We retain the approach that separates the inputs in controllable inputs (health care services) from non-controllable inputs (the social environment variables) because health care systems have no influence on most of these variables. This approach involves two stage DEA analyses:

Table 2. The efficiency Approach using in the Study

	Inputs

First Stage	Controllable inputs (Health Care Inputs)
Second Stage	Controllable inputs and Non- controllable inputs

5-3. Results

For the first stage, the results for the output oriented model are shown in table 3 and the results for input oriented model are shown in table 4.
The first two columns of the table 3 and 4 show the Technical Efficiency score with variable scale to returns using only health inputs for the two outputs. The next two columns represent the Scale Efficiency scores and the two last columns show the improvement in output and the reduction in inputs.
In table 3, when **life expectancy rate** is used as the output, the **Technical efficient** countries are Morocco, Tunisia and Mauritania. The inefficient countries are Algeria and Libya because its efficiency score is below 1. Algeria for example can increase its life expectancy rate to 97.66% of its current level without changing its current health inputs. This would allow a 2.34% improvement in life expectancy rate. According to **the Scale efficiency**, we see that out of 5 countries, 2 countries are scale efficient which are Morocco and Mauritania, while the remaining 3 countries are scale inefficient (Algeria, Tunisia and Libya). The average scale efficiency score is 62.26% which indicates that on average health care system may have to increase its scale by 37.34% beyond its best practice average targets under variable returns to scale, if it was to operate at constant returns to scale.
When **infant mortality** is used as the output, only Algeria is **technical inefficient**. It can reduce its current infant mortality rate by 0.03% without changing its current health care inputs. For **the scale efficiency**, table 3 evinces that out of 5 countries only one country is operating in optimal size which is Mauritania. The other inefficient scale countries are Algeria, Morocco, Tunisia and Libya. On average, the Maghreb health care system may have to increase its scale by 44.55% beyond its current practices.

Table 3. Output Oriented DEA Results (Health Care Inputs)

Scores	Technical Efficiency Scores		Scale Efficiency Scores		Percent improvement in Output	
Countries	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality
Algeria	0,9766	0,9997	0.4563	0.3708	2.34%	0.03%
Morocco	1,0000	1,0000	1.0000	0.8801		
Tunisia	1,0000	1,0000	0.3082	0.2433		
Libya	0,9976	1,0000	0.3486	0.2785	0.24%	
Mauritania	1,0000	1,0000	1.0000	1.0000		
Average	**0.9948**	**0.9999**	**0.6226**	**0.5545**	**1.29%**	**0.03%**

For the input oriented model **(table 4)**, when life expectancy rate is used as the output, two countries are Technical inefficient Algeria and Libya. The efficient countries are morocco, Tunisia and Mauritania. These countries can set an example of the best operating practice for the remaining 2 inefficient countries to follow. Algeria which is the most inefficient country can reduce its health care inputs by 24.32% without *changing its current life expectancy rate. For the infant mortality output, Algeria is the only country among the Maghreb union which is technically inefficient. It might reduce its health care inputs by 11.29% while holding infant mortality constant.*

Table 4. Input Oriented DEA Results (Health Care Inputs)

Scores	Technical Efficiency Scores		Scale Efficiency Scores		Percent improvement in Output	
Countries	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality
Algeria	0,7568	0,8871	0.5888	0.4179	24.32%	11.29%
Morocco	1,0000	1,0000	1.0000	0.8801		
Tunisia	1,0000	1,0000	0.3082	0.2433		
Libya	0,9539	1,0000	0.3645	0.2785	4.61%	
Mauritania	1,0000	1,0000	1.0000	1.0000		
Average	**0.9421**	**0.9774**	**0.6523**	**0.5639**	**14.46%**	**11.29%**

For the second stage, Table 5 and 6 show that one country of five countries is technical and scale efficient. This dominant country is Mauritania. The good position of this country which has poor health outcomes (life expectancy and infant mortality) is due to its low consumption of resources relative to the other countries in the Data.
Tables 5 shows for the life expectancy output that four countries are on the efficient frontier for both outputs except Libya. It may have to improve its current life expectancy rate by 0.24% while maintain the current health care and social environment inputs. For the scale efficiency, only Libya is non-optimal size, it might increase its actual scale by 17.18% beyond its best practices.
When the infant mortality is used to be the unique output of the model, all the Maghreb countries are technical efficient, but only one country is scale efficient which is Mauritania. The statistics indicate that the Maghreb union might have to increase its scale by 11.56% to operate at the constant returns to scale.

Table 5. Output Oriented DEA Results (All Inputs)

Scores	Technical Efficiency Scores		Scale Efficiency Scores		Percent improvement in Output	
Countries	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality
Algeria	1,0000	1,0000	1.0000	0.9324		
Morocco	1,0000	1,0000	1.0000	0.8801		
Tunisia	1,0000	1,0000	1.0000	0.8875		
Libya	0,9976	1,0000	0.8282	0.7223	0.24%	
Mauritania	1,0000	1,0000	1.0000	1.0000		
Average	**0.9995**	**1.0000**	**0.9656**	**0.8844**	**0.24%**	

The Technical efficiency results of the input oriented model (table 6) are the same for the Output Oriented DEA Results (all inputs). For the scale efficiency, three countries are below the scale efficiency average score (55.45%). This indicates the under utilization of existing scale-size in the Maghreb. Its allow to increase its scale on average by 44.55% beyond its best practices under VRS, if it was to operate at CRS.

Table 6. Input Oriented DEA Results (All Inputs)

Scores	Technical Efficiency Scores		Scale Efficiency Scores		Percent improvement in Output	
Countries	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality	Life Expectancy	Infant Mortality
Algeria	1,0000	1,0000	1.0000	0.3707		
Morocco	1,0000	1,0000	1.0000	0.8801		
Tunisia	1,0000	1,0000	1.0000	0.2433		
Libya	0,9539	1,0000	0.3646	0.2785	4.61%	
Mauritania	1,0000	1,0000	1.0000	1.0000		
Average	0.9907	1.0000	0.8729	0.5545	4.61%	

VI. Conclusion

In this study, we have examined two measures of efficiency: Technical efficiency and Scale Efficiency. In Methodological terms, we have employed a two- stage procedure. Firstly, Output and input efficiency scores were estimated using only health care inputs. Secondly, we have included social environment variables among inputs of the output-input DEA model to identify how much inefficiency is due to factors outside the control of health care management.

The results from the first stage imply that most Maghreb countries are technical efficient but the majority are scale inefficient. Our second stage shows that the introduction of social environment inputs has not a significant impact on the improvement of the scores efficiencies.

According to the statistics, the Maghreb countries suffered more from scale inefficiencies. This imply that the Maghreb health care organizations require to balance their budgets with the society health needs and should attempt to scale up health production in order to improve efficiency.

*The efficiencies scores show that largely geographic and high health public spending countries (Algeria and Libya) appeared to suffer mostly from technical and scale inefficiencies. The surface area of Algeria and Libya represent more than **71%** of the Maghreb surface area. The public spending on health in Libya represents 68% of total health expenditures in 2008. In Algeria was 79%.*

We conclude that the countries with good health finance and a large geographic area show a deeper commitment to finance the health care institutions use their resources inefficiently. These countries have a huge potential for improving efficiencies without injecting additional resources.

There are two limitations that need to be acknowledged and addressed regarding the present study. The first limitation concerns the availability of the Data. There is less data concerning Maghreb health care systems. The second limitation concerns the empirical analysis which is focused only on one year.

Despite these two limitations, the paper represents an attempt to apply DEA approach to the Maghreb Health Care Systems focusing on the implications for the national health policy makers.

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