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Efficiency of MENA Region's Health Systems: Using DEA Approach

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Abstract:- The main purpose of this paper is to analyze the efficiency of the health systems of Middle East and North Africa (MENA) countries. The data used are annual and from the World Bank database for the period 1995-2011 and cover 18 countries in the region. To estimate efficiency scores, we used Data Envelope Analysis (DEA). In the DEA method, there are two orientations: an input orientation and an output orientation. The input orientation is to minimize the amount of input by keeping the same level of output. In the output orientation, it is a question of maximizing the output while keeping the same level of input. In this paper, we have chosen the direction of minimization of inputs, this choice seems appropriate to the problem of scarcity of resources that countries face. We used three models that differ in their inputs / outputs. The results of the first model show, on average, that countries in the MENA region can save almost 35% of the factors of production (number of doctors per thousand inhabitants and number of hospital beds per thousand inhabitants) while keeping the same values of infant mortality rates and adult mortality rates. These countries do not operate at the most productive scale. The results of the second model show that these countries can save almost 47% of the factors of production. Regarding the third model, the results show that, on average, the efficiency scores have increased compared to the two previous models. Despite this improvement, on average MENA countries are not benefiting in an efficient way from their health spending. This model indicates that countries in the MENA region can save 2.1% of health expenditures while keeping the same output values.

Keywords—Efficiency Analysis; Data Envelopment Analysis; Health System; MENA Region.

I. INTRODUCTION

Health is considered as one of the building blocks of human capital, as it mentioned by Ambapour [1]. It's a key factor in human development, nation development and economic growth, [2]. In fact, a healthy individual (physically and psychologically) is more energetic and more productive. He contributes to economic growth. Good health limits the productivity losses attributable to the incidence of morbidity, increases the chances of accessing higher paying jobs.

As a result, each country must act to ensure health security and reduce risks by detecting, forecasting and confronting diseases. This implies a strengthening of the health system and the establishment of means to prevent and combat epidemics likely to spread. These objectives can be achieved by treating communicable diseases responsible for mortality in poor countries. Thus, it is important to prevent diseases, make the right choices and invest in the health sector and other sectors that affect health (investing in Sport). According to Gurría [3], there is an economic interest in investing resources in health. Investing in the fight against diseases and pest control to avoid significant health expenditures later [4].

Improving health status is the result of people's efforts and the actions that make up (with other components) a health system. This system is formed by parties providing services, financing them or defining the policies that govern them [5]. Globalization, technological progress, growth and the emergence of new diseases, make the role of the health system more important. These phenomenons broaden the circle in which a health system is supposed to operate. The intervention of the health system goes beyond the care, the attenuation of the pains, the physical handicap towards the diets (obesity), the stress, etc

Efficiency evaluation plays an important role in improving quality and equity and decision support services, [6]. It can better mobilize available resources and provide decision makers and health managers with the information and evidence they need. Efficiency seeks to determine the extent to which the inputs (resources) of the health system are used to achieve health system objectives, [7]. According to Thoral, [8], in a context where medicine is becoming more complex, medical technologies are rapidly developing and diffusing, and economic constraints are increasing, the aim of the evaluation is to maximize efficiency under the constraint of resource allocation. Thus, the pursuit of efficiency should be a central objective of policy makers and managers, and to this end better tools for measuring and understanding efficiency are needed, [7]. As a result, in this work, we assess the efficiency of MENA countries health systems using the nonparametric approach, data envelopment analysis DEA.

II. RELATED WORK

Two approaches are used to assess efficiency, as explained in [9][10]. The first is nonparametric based on the optimum of a linear program, such as Data Envelopment Analysis (DEA). It consists in constructing a convex curve so that no point is outside. It is not necessary to impose a specific specification of the production, cost or profit function. These are the advantages of this approach. The second is parametric or econometric, such as Stochastic

Frontier Analysis (SFA) and Data Frontier Analysis (DFA). It is based on a functional specification. The deviation of the boundary is composed of two terms, one represents stochastic error and the other is efficiency. Stochastic error is often assumed to follow a normal distribution and inefficiency can be either semi-normal, truncated normal or exponential. In this approach, imposing a specification for the parametric boundary is a weakness. The use of one of these approaches is dictated by the type of data and objectives of the work. Several studies have focused on comparing these approaches, like the studies of Hollingsworth [11] and Chirikos [12].

The evaluation of the efficiency of production units is usually based on an approach that uses the econometric method to construct a production function. This method is commonly used but has a major limitation. Indeed, it requires a prior definition of the functional form supposed to characterize the production relationship (Cobb-Douglas function, CES function, translog function, etc.).

In Ravangard's study [13], the authors measured the efficiency of the health systems of the 10 countries of the Economic Cooperation Organization during the period 2004-2010. They used the Data Envelope Analysis (DEA) using two models. The first model uses GDP per capita, education and smoking as inputs, life expectancy and infant mortality rates as outputs. The second model used health expenditure per capita, the number of physicians per thousand people, and the number of hospital beds per thousand people as inputs. Life expectancy and under-five mortality rate as outputs. According to the first model, the average efficiency of the health systems was 49.7% and, based on the second, it was 56.3%. In both models, Turkey and Turkmenistan have the highest and lowest efficiency scores, respectively. These scores are 0.957 and 0.963 for Turkey and 0.267 and 0.327 for Turkmenistan. In the study [9] , the authors examined the efficiency of the health system of the 29 industrialized countries in 2009 using DEA and SFA. The results of the study showed that Australia had the highest efficacy score (99.1%) and Hungary the lowest (94.2%), for the DEA approach. For the SFA approach, Japan had the highest efficiency score (100%) and Turkey the lowest (86.4%). The study by [14] aims to assess the efficiency of health systems in 30 European countries for 2010 by applying data envelope analysis. The outputs are: life expectancy at birth, health-adjusted life expectancy and infant mortality rate and three inputs: number of physicians, number of hospital beds and public health expenditure as a percentage of GDP. The results reveal that there are a number of developed and developing countries on the efficiency frontier, while the vast majority of countries in the sample are inefficient. The study of Pinto [15] uses Data Envelopment Analysis (DEA) to analysis the efficiency of the health system in Italy by region. He concluded that the average efficiency score, assuming constant returns to scale, was 98.1%, while the average efficiency score was 98.8%, assuming returns of variable scale. As shown in the study of Faye [16], the results show that the efficiency of Senegal's public hospitals is on average 96.9%, which is higher than for African hospitals in general. However, Senegal has inefficient hospitals that can use fewer inputs for the same level of production.

To study the efficiency of health spending, Afonso and Aubyn [17] use the two input-oriented approaches DEA and FDH, for a sample of 24 OECD countries in 2002. The outputs used are the Infant mortality and life expectancy at birth and inputs are the number of doctors per thousand inhabitants, the number of nurses per thousand inhabitants and the number of hospital beds per thousand inhabitants. The results show that on average the efficiency varies between 83.2% and 94.6%. In [18], the authors analyze the efficiency of health systems in 27 OECD countries, using the DEA approach, input and output orientation. The inputs used are Gini coefficient, tobacco consumption and average number of years of education of the population. The second category of health system inputs such as the number of physicians per thousand people, the number of hospital beds per thousand people, the number of Magnetic Resonance Imaging (MRI per 1 million people) and the expenditures in health as a percentage of GDP. The two outputs are life expectancy at birth and the infant mortality rate per thousand live births. The results show that 13 countries are efficient. In [19], the authors used the output-oriented DEA method to study the efficiency of health systems for a sample of 51 developing countries. The sample studied is divided into two heterogeneous groups in terms of income. The first group has a per capita income of less than $ 1,500 and the second has a per capita income of between $ 1,500 and $ 4,500. In this study, the authors use as outputs the corrected birth expectancy for men and women, and infant mortality. One input used to know health expenditure per capita. The results show that the most inefficient countries are the African countries.

Lawanson [10] use the two approaches DEA and SFA to analyze the efficiency of the health systems of 45 countries in sub-Saharan Africa. Input is health expenditure per capita, while under-five child mortality has been used as health outcomes. The results suggest that there are disparities between the DEA and SFA model estimates. The estimates of the SFA models were relatively higher than those of the DEA models. However, there was not much difference in the ranking of individual countries in terms of efficiency performance. The results of the different model specifications show average health system efficiency scores of about 44% and 50% for DEA specifications, while 70% and 72% are estimated for SFA specifications. Novignon [20] estimate the efficiency of health centers in Ghana in 2015 using Stochastic Frontier Analysis (SFA). Outpatient consultations were used as outputs, while the number of staff, hospital beds, other capital expenditures and administration were used as inputs. The average efficiency score for all health centers included in the sample was estimated at 51%. In addition, the average efficiency was estimated at about 65% and 50% for private and public centers, respectively. Significant disparities in efficiency have been identified in the different administrative regions. In [21], the authors measure the efficiency of health systems in the Middle East and North Africa (MENA) region. The authors use stochastic frontier analysis and data for the

period from 1995 to 2012. They exploited a time-invariant model where efficiency effects are static over time and an efficiency time variant model, where the effects of efficiency have a temporal variation; a model for reporting heterogeneity. The results show that the estimated average efficiency score of health systems in the MENA region is 93.1%. Among the best performing countries, Lebanon, Qatar and Morocco still rank among the best according to the three specifications of the inefficiency model. On the other hand, Sudan, Yemen and Djibouti are among the first. On average, the two most efficient countries are Qatar and Lebanon, with an efficiency score of 97%.

Greene [22] re-estimates the efficiency of health systems for the same panel of Evans (Evans et al., 2000). He estimates a health production function using total health expenditure and the average number of years of education as inputs. In Evans's [23], the authors estimate the efficiency of health systems for a sample of 191 countries from 1993 to 1997. As output, they use disability-adjusted life expectancy (DALY) and as inputs public and private health expenditures and the average number of years of adult education. The results show that the most efficient health systems are those of France, Italy, Spain, Malta, Oman, San Marino and Japan while the least efficient are mainly African countries such as Botswana, Lesotho, Malawi, Zambia, Zimbabwe and Namibia. The authors used the Monte Carlo procedure to construct a confidence interval for the estimates of efficiency. Tandon, [24] estimate the efficiency of health systems for a panel of 191 countries from 1993 to 1997 by calculating a composite indicator of outputs and the inputs considered are health expenditure per population, public and the average number of years of education. France, Italy, Malta, Spain, Oman, Austria are among the most efficient countries while Sierra Leone, Democratic Congo, Myanmar, Nigeria and Zambia are among the least efficient countries.

III. DATA AND METHODOLOGY

A. Data and variables

The data used are from the World Bank site for the period 1995-2011 and refer to countries in the MENA region [25]. Generally, in the field of health, the analysis is at the micro level, at the hospital level, for example, whose objective is to evaluate the efficiency of a hospital compared to others such as the work of [26] [27]. In our study the analysis is at the macro level where we are interested in the evaluation of country health systems.

We adopt the idea of Ambapour [1], considering three combinations of inputs and outputs. Outputs are: life expectancy at birth, infant mortality rate (per 1000 live births) and mortality rate (per 1000 people). Inputs, we choose the labor factor, measured by the number of physicians per 1000 inhabitants and the capital factor, measured by the number of beds per 1000 inhabitants and health expenditure. However, we note that a transformation of the variables infant mortality rate and mortality rate, is necessary. It consists of considering survival rates instead of mortality rates. Indeed, for the estimation of the efficiency scores the variables must be increasing. The outputs and inputs are presented in Table I.

Models	Output	Input
Model 1	-Child mortality rate -Adult mortality rate	-Number of doctors per thousand inhabitants -Number of hospital beds per thousand inhabitants
Model 2	- Life expectancy at birth	-Number of doctors per thousand inhabitants -Number of hospital beds per thousand inhabitants
Model 3	-Child mortality rate -Adult mortality rate -Life expectancy at birth	-Health expenditure in% GDP

TABLE I. **:** COMBINATION OF OUTPUTS AND INPUTS

B. Methodology

1) Choice of the estimation approach

In this study we use the DEA approach [28], this choice is justified by that it is the method most used in the analysis of efficiency in the field of health. Hollingsworth [29], emphasize that more than 67% of studies in this area use this apprach. Also, this method has advantages in comparison with parametric methods. As an example, the DEA method analyzes each unit separately from the sample, requires no parameterization, takes more than one output into account, and simultaneously evaluates the contribution of all variables to the sample in the measure of efficiency.

The term "Envelopment" reflects that the production boundary contains all the efficient observations. Technically efficient observations are located on the border. Charnes, Cooper, and Rhodes [30] generalize the Farrel approach [28] to the multi-output and multi-input context, in the case of a constant-scaling technology. They build a mathematical optimization program whose solution provides us with a measure of the efficiency of the decision units. The Charnes, Cooper and Rhodes model (CCR), [30], is based on maximizing the weighted sum of outputs relative to the weighted sum of inputs (we can also minimize the weighted sum of inputs relative to the sum weighted outputs). This is to maximize the efficiency score for each unit while respecting the constraint that an efficiency score is less than or equal to the unit knowing that the weights are all positive.

2) Choice of orientation

Two approaches are considered depending on whether one is interested in the minimization of inputs or the maximization of output, [28]. The input-oriented approach defined as the possibility of reducing the amount of input while keeping the same level of production (output). The

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output-oriented approach is the ability to produce more output from the same amount of input. The orientation chosen for the estimation of efficiency scores is geared towards the minimization of inputs. This direction seems to us to be appropriate to the current international context facing countries. In this connection, we note that the majority of the works consider the minimization of the input vector by keeping the output level constant. A choice highlights the importance given to controlling spending in the health sector. Slowing spending has become the objective of countries if they want to preserve their systems.

3) Empirical results

Table II presents the average efficiency scores for the three input/output combinations, estimated by DEA. The technical efficiency scores under the assumption of constant returns to scale are defined by (crste), under the assumption of variable returns defined by (vrste) and the efficiency of scale is defined by (scale). Scaling efficiency is the ratio between crste and vrste (scale = crte / vrste).

	Model 1			**Model 2**			**Model 3**		
Country	**crste**	**vrste**	**scale**	**crste**	**vrste**	**scale**	**crste**	**vrste**	**scale**
Algeria	0.584	0.995	0.586	0.307	0.562	0.546	0.63	0.632	0.997
Bahrain	0.795	0.994	0.8	1	1	1	0.58	0.61	0.95
Djibouti	0.743	1	0.743	0.67	0.809	0.828	0.649	0.655	0.992
Egypt	0.65	0.999	0.651	0.177	0.47	0.376	0.679	0.682	0.995
Iran	0.396	0.995	0.399	0.72	0.949	0.759	0.685	0.688	0.997
Jordan	0.531	0.995	0.534	0.222	0.961	0.232	0.318	0.319	0.998
Kuwait	0.815	0.996	0.819	0.167	0.807	0.207	0.7	0.701	0.999
Lebanon	0.825	0.999	0.826	0.158	0.705	0.225	0.246	0.247	0.996
Libya	1	1	1	0.186	0.455	0.409	0.752	0.754	0.997
Marocco	0.283	0.995	0.284	0.693	1	0.693	0.674	0.676	0.996
Oman	0.774	0.997	0.776	0.17	0.607	0.279	0.722	0.723	0.998
Qatar	1	1	1	0.236	1	0.236	0.741	1	0.741
Saudi Arabia	0.781	0.998	0.783	0.185	0.693	0.267	0.888	0.89	0.998
Sudan	0.252	1	0.252	0.521	0.546	0.954	0.773	0.78	0.991
Syria	0.918	1	0.918	0.665	1	0.665	0.477	0.478	0.998
Tunisia	0.518	0.995	0.521	0.403	1	0.403	0.451	0.453	0.996
Emirate	0.751	0.993	0.756	0.317	0.921	0.344	1	1	1
Yemen	0.099	0.999	0.099	1	1	1	0.582	0.587	0.992
Average score	**0.651**	**0.997**	**0.653**	**0.433**	**0.805**	**0.523**	**0.641**	**0.66**	**0.979**

TABLE II. EFFICIENCY SCORES OF THE 18 MENA COUNTRIES IN THE PERIOD 1995-2011

We find that these scores vary according to the model studied. The results of the first model whose inputs are the number of physicians per thousand inhabitants and the number of hospital beds per thousand inhabitants and the outputs are the infant and adult mortality rates, show that the scores under the assumption of return constant, variable and scale are respectively 0.651, 0.997 and 0.653. The complementary to a measure of how much can reduce beds and doctors by maintaining the same mortality rate of adults and children. The average scale efficiency score over the entire period for the MENA region is 65.3%. Inputs (doctor and beds) could be saved by 34.7% to keep the same adult and infant mortality rates.

The second model uses the number of hospital beds and the number of doctors per thousand inhabitants as inputs and life expectancy at birth as output. From the results of this model, there is a decrease in mean efficiency scores. Under the assumption of returns of varying scale, Bahrain and Yemen are efficient throughout the study period. These countries are located on the frontier of production. The results also show a difference between the scores under the assumption of constant scale yields and variable scale yield (crste and vrste). This difference between the two scores constitutes inefficiency of scale and these countries do not operate on an optimal scale [31]. The average efficiency score is 52.3%. This results in a non-optimal use of the two factors of production and countries do not operate at the most productive scale.

Regarding the third model, the average efficiency score with a variable scale return is equal to 66%. Countries could save 34% of their expenditure and produce the same amount of output. The results show that the average technical efficiency score assuming constant scale efficiency is 64.1% and that the Emirate has a technically efficient health system, for the whole period (100%), this country is capable of manage your health expenses and avoid waste.

IV. CONCLUSION AND DISCUSSION

The results show that the majority of countries in the MENA region do not use their resources efficiently in their health systems. For the three models studied, the average efficiency scores are 65.3%, 52.3% and 97.9% respectively. There are differences between the results of these first models and the third in the distribution of countries according to the efficiency scores. In this third model, 16 of the countries have an above average efficiency score (97.9%). In terms of health spending efficiency, the United Arab Emirates is in first place. Regarding Tunisia, for all three models the results show that the health system is inefficient. For all three models, the efficiency scores are 52%, 40% and 99.6% respectively.

For health policies, the measurement of efficiency is important and necessary for decision-making. Also the question of the determinants of efficiency is a crucial issue. As perspective, we are interested in identifying these determinants and estimating their effects on efficiency, already calculated in this work. Also, in [21] the authors studied the efficiency of health systems in the MENA region using the SFA approach for the period 1995-2012, we plan to conduct a comparative study between our results and the results of the study. Similarly, several studies have focused on the quality of health services, so it will be possible to study the feasibility of reducing inputs such as the number of doctors and the number of beds without degrading the quality of health services.

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