Healthcare system efficiency and its determinants: A two-stage Data Envelopment Analysis (DEA) from MENA countries

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Abstract

Efficiency is becoming one of the central preoccupations of health sector due to mounting pressures on health care resources since many years. However, assessing efficiency at cross-country level has not been often directly evaluated by given inputs or outputs. In the first stage of the two-stage performance analysis, this paper assesses the technical efficiency of 18 health systems in the Middle East and North Africa (MENA) region using Data Envelopment Analysis (DEA) method for the years 1997, 2005 and 2014. We used both an input and an output-oriented approaches to measure the technical efficiency of those systems and we conducted a cluster analysis in terms of health production efficiencies and health outcomes of various countries upon three sub-periods in order to make the division of health production patterns of these countries clearer. The paper also analyzes the allocative efficiency upon the two approaches. In the second stage, the paper analyzes the determinants of health efficiency using a Tobit regression.

Descriptive analysis shows that life expectancy has increased since many years, although the important variations in terms of economic development among the considered sample. The DEA results indicated that the average efficiency scores for all health systems were, respectively for the years 1997, 2005 and 2014, 79% and 83.6% and 78.7%, under the input-oriented approach; and 98.2%, 98.5% and 97.9% according to the output-oriented approach. Results showed that efficient frontier includes countries with good health outcomes and those with modest health outcomes. In essence, the empirical evidence rejects some hypotheses, such as the low-income countries cannot be a reference in terms of health efficiency. Cluster analysis showed that both countries on efficiency frontier and countries far from this frontier are different from year to year. Analysis revealed also that some countries may learn from countries which are more economical in their allocation of health resources; and more spending is not necessary the best option. For the Tobit model, results upon the two approaches revealed that private expenditure as a percentage of GDP and control of corruption impact positively and significantly efficiency scores while public spending as a percentage of government expenditure has a negative effect. Adult literacy rate and population density have a positive and non-significant impact. Moreover, results showed no correlation between the efficiency of health system and the income group to which a country is belonging, and we cannot judge this efficiency through the gross national income per capita.

Keywords: Health system, MENA countries, Data Envelopment Analysis (DEA), Efficiency, Tobit.
JEL Classification: I100, I120, C140, C520

1. Introduction

Over the last two decades health efficiency has become a topic of great interest for both researchers and policy makers, especially starting from the premise that better health is a key factor of the human happiness and well-being (Sabatini, 2011), improves the quality life of citizens (Gimmler *et al.*, 2002), influences economic prosperity and sustainable development

(Bhargava *et al.*, 2001; Von Schrinding, 2002). Nowadays, the organization of healthcare services remains a key issue of concern. Improving health goals is becoming increasingly important at the local, national and international levels. As one example, four of the eight Millennium Development Goals (MDGs) concern outcomes related to health, including reducing child Mortality (MDG4), reducing maternal mortality and achieving universal access to reproductive health (MDG 5), and combating HIV/AIDS, malaria and other diseases (MDG6). Also, MDG1 which focuses on eradicating extreme poverty and hunger is closely related to health. Further, health is centrally paced within the 2030 Sustainable development Agenda (SDGs). Goal 3 stipulates "ensure healthy lives and promoting the well-being at all ages is essential to sustainable development". Its 13 targets cover all major health topics (child and maternal health, infection diseases, non-communicable diseases, Universal Health Coverage: UHC, etc.). Moreover, almost of other 16 SDGs are either directly related to health or indirectly contribute to health (Chisholm, 2010).

Many factors can affect the health status and a country's ability to deliver quality health services. According to the World Health Organization (WHO), the key determinants of health development are referring to the social and economic context, physical status, and the person's individual characteristics and behaviors. According to some reports from different organizations and studies, these factors include the availability of infrastructure and technology, capacity of staff, age, sex and heredity factors, education, work environment, unemployment, water and sanitation, drugs, alcohol and tobacco use, housing, and so on (Dahlgren and Whitehead, 1991; Wilkinson and Marmot, 2003; Belkić *et al.*, 2000; Makela *et al.*, 1997). In addition, good governance and control of corruption are essential in improving health outcomes and establishing successful law reform process (Azfar and Gurgu, 2008; Frag *et al.*, 2013).

The last decades have seen rapid increase of government expenditure on health services as well as gaps in quality, equity and access. Policy makers, private payers and systems leaders are looking for ways to improve the efficiency of healthcare services. The governments have undergone several legal, policy and program reforms, which are expected to meeting the increasing demand for health care services and reducing the rising cost of these services. To meet these commitments, many countries increased funds from domestic sources mobilization such as an increasing in the flow of taxes and other income sources into government treasures. Foreign aid is another alternative in terms of funding especially for poor countries. However, these measures would insufficient to fill the current gap between countries. Also, better practice and more efficiently use of the available funds will allow them to meet health challenges. Indeed, health systems will need to operate more efficiently, decrease their unit costs, improve their quality levels, and identify ways to optimize the value of their limited resources (Deloitte, Global Health Outlook, 2016), bring cost down and make an efficient allocation of available resources. Health expenditure efficiency increases immensely the level of outputs such as an increase in the life expectancy at birth, diminishing the infant and maternal mortality (OECD, 2011), and it bears losses in the absence of the outcomes being associated with efficiency, thus increasing the chances for successful reform and greater results. However, the first challenge that stakeholders face is quantifying efficiency (Herrera and Pang, 2005).

Improving outcomes of the healthcare system and containing its cost remains a significant issue for the Middle East and North Africa (MENA) region (World Bank, 2013). In the light of this, a cross-country analysis allows an identification of best practices and an establishment of baselines and steps to close the gap in operation. However, it is difficult to interpret the benchmarking results due to the difference in health system structures of countries which involve historical of each system, financing tools, and universal coverage principles. There is also a difference in terms of economic, social and demographic patterns. Moreover, there is no unique indicator for health outcome because of the intangibility nature of service provided by health sector, and the difference in health system goals between countries.

Given the structural, organizational, and other obstacles mentioned, it seems reasonable to refer to a mathematical framework that may offer useful tools to a more robust policy decision-making and to move away from unilateral and personal desire and intuition in a sensitive sector such health. From this and to measure the efficiency of health systems we state the problematic, which is the subject of this paper. The primary concern of the present study is to obtain empirical evidence and increase the level of awareness in relation to health expenditure. The specific objectives are twofold: first, to examine the efficiency of the health systems for a sample of 18 MENA countries to inform evidence-based health policy decisions, and second to shed light on the key determinants of efficiency using a Tobit model.

Thus the research questions are: What are the levels of efficiency of health systems in MENA countries mainly in resource utilization (input approach) and resource exploitation (output approach)? What are the key determinants of health efficiency? Based on the above questions and based on some previous studies that dealt with the efficiency of health systems and their determinants, the following hypotheses have been developed.

H1: The importance of efficiency in the management of the health system (reduction of resources or increasing outputs) in MENA countries.
H2: Health systems of MENA low-income countries cannot be a reference for high-income ones in terms of efficiency (either for the resources use or the outputs improvement).
H3: An increase in the amount of health resources is synonymous with misallocation of resources.
H4: An efficient country in the selection of resources (input approach) is necessarily an efficient country in increasing the output of the health sector (output approach).
H5: The efficiency of health systems is limited only to countries where health expenditure is high.
H6: Health efficiency do not affected by factors outside the health sector.

This study attempts to address these concerns and to ascertain the acceptability of various hypotheses. Following introductory motive, this paper is set out as follow. Next section provides a selective literature review. Section 3 provides some stylized facts. Section 4 describes the data and outlines the approaches to the measurement of efficiency and its determinants. Section 5 deals with empirical Data Envelopment Analysis (DEA) results and highlights Tobit regression analysis results and the paper is rounded off by section 6 with concluding remarks. The findings in this study may provide context for initiating constructive debates concerning the choice and exploitation of resources and ways to improve outcomes in a vital and crucial sector such as health.

2. Literature review

The health system of a country may be considered as a production system that can transform input to output (Auster *et al.*, 1969; Grossman, 1972). According to the World Health Organization, health system "consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health. This includes efforts to influence determinants of health as well as more direct health-improving activities" (WHO, 2007).

The history of health systems in the world has shown across different stages that all countries shared common goals (helping poor patients, ensuring compensatory income for sick workers, and ensuring access to treatment for all). The differences were in the quality of the institutions responsible for ensuring the demand for treatment (the role of government, cooperatives, etc.), the type of displayed treatment (the status of public hospitals, the role played by public doctors, etc.), and the health professions developed in the past (the importance of private medicine). These differences also reflect the differences in priorities for each system: inclusiveness in the coverage of the disease for some, the choice of the doctor and the retention of medicine for others, the priority given to the market, etc. There are four basic models for health systems in the world: the Beveridge Model where health care is provided and financed by the government through tax payments; the Bismarck model which uses an insurance system financed jointly by employers and employees through payroll deduction; the national health insurance model which resembling elements of the two previous type and it uses private-sector providers, but payment come from government; and, the out-of-pocket model where patients have to pay out-of-pocket or go without treatment.

As regard to the efficiency issues, technical efficiency refers to the physical relation between resources inputs (costs, in the form of labour, capital, or equipment) and final health outcomes (lives saved, longer lives, life years gained). A healthcare system is considered to be technically efficient when the maximum possible improvement in outcome is obtained from a set of resource input or through the proportional reduction of its inputs while its outputs proportions are held constant. Häkkinen and Joumard (2007) argue that measurement of efficiency can be proceeding at three levels: disease, sub-sector, and system. The disease level analysis does not allow assessing the impact of specific services on outcomes since data are often unavailable. A difficult with the sub-sector approach is that efficiency of resource allocation cannot be addressed. The system level approach has been widely implemented for measuring efficiency across countries and over times (Anton and Onofrey, 2012).
There is a wealth of research examining the health efficiency from developed economies in the last two decades. Only few studies have addressed health efficiency in developing countries despite the dramatic increases of healthcare expenditures. Those studies used the parametric approach which goes under the Stochastical Frontier Analysis (SFA) method, and/or the non-parametric approaches such as DEA or Free Disposal Hull (FDH).

One of the first studies on developing economies is conducted by Gupta and Verhoeven (1997). The authors measure the efficiency of government expenditure on education and health in 38 African countries in 1984-95 on the basis of standards established by other countries in Africa, Asia and Western Hemisphere, using the FDH method. For health, they employ health expenditure per capita (measured by PPP terms) as input and life expectancy, infant mortality, and DPT immunization as outputs. The results reveal that African economies are inefficient in providing health services relative to their peers. Also, the level of inefficiency is positively correlated with the level of government expenditure. The authors show that increasing budgetary allocation for health may not be the only or most effective way to increase health output.

The most important studies interested in measuring the efficiency of health systems at the international level were conducted after the publication of the WHO report in 2000 (WHO, 2000). This report has been the subject of much criticism, notably concerning the methodology used to determine health system efficiency and ranking. The use of more complex mathematical and statistical methods was explained by the lack of a common standard for judging the performance of health systems, through which countries can be classified as another, therefore multivariate analysis remains held.

Evans *et al.* (2000) adopt a fixed-effect panel data estimator and a corrected ordinary least square (COLS) to assess the efficiency of health spending for a sample of 191 countries for the period 1993-97. The authors use Disabilities Adjusted Life Expectancies (DALE) and a composite indicator of DALE as dependent variables, and health expenditure and years of schooling as input variables. The authors establish a ranking of countries and checked its robustness by changing the functional form of the translog regressions. The top three countries are Oman, Malta, and Italy, and the last three ones are Zimbabwe, Zambia, and Namibia. Efficiency is positively related to the level of health expenditure per capita, and this link started above roughly $60 in 1997 international dollars.

Jayasuriya and Wodon (2003) estimate health and education efficiency for a sample of 76 developing countries for the period 1990-98, using SFA method. To estimate the production frontier, life expectancy is used as outcome measure, and per capita GDP level, per capita expenditure on health and adult literacy rate, as input variables. Institutional and urbanization variables are used for the analysis of the determinants of efficiency. The results show large difference among countries in efficiency index, with an average of 85%. Bureaucratic and urbanization both have strong positive impacts on efficiency, while the evidence is not conclusive for the corruption variable.

Hollingsworth and Wildman (2002b) use the main data of Evans et al. (2000). They reestimate the models using panel data method, time varying panel data estimators, DEA with Malmquist indices, and SFA methods. The cross-section DEA results show a mean efficiency of 89% for the full sample, 97% for the OECD sub-sample, and 87% for the non-OECD sub-sample. Using SFA, efficiency was 84% for the full sample, 95% for the OECD sub-sample, and 83% for the non-OECD sub-sample. Efficiency is positively related to income per capita and to schooling.

Alexandar *et al.* (2003) address the efficiency of expenditure in health for a sample of 51 developing countries applying DEA and using 1998-99 data. Countries are divided into two groups based on income level: a first group with income per capita less than $1500, and a second group, with income per capita between 1500 and $4500. The only input used is health expenditure per capita and the outputs are life expectancy for men, life expectancy for women, and child mortality. The results show that countries with lowest efficiency in health indicators are mostly African. Efficiency is positively related to health expenditure per capita for the first group of countries, and negatively related for the second group.

Herrera and Pang (2005) examine the efficiency of public spending in the health and education sectors around 140 developing countries during 1996-2002, by employing both DEA and FDH methods. For health, the authors use the orthogonal component of the health's public expenditure to GDP as input, and life expectancy, DALE, and DPT and measles immunization, as outputs. The single input-output model results show an efficiency scores ranged between 68 and 70%, according to the output-oriented approach, and between 81 and 84%, according to the input-oriented approach. The multi-input output model results show an efficiency scores ranged, successively according to the two approaches, from 92 to 93% and from 84 to 87%. The authors find that inefficiency is associated with high expenditure amounts, high wages bills, high income inequalities, the prevalence of HIV/SIDA, and high public provision of services.

Greene (2005b) updates the 2005 study by Herrera and Pang using SFA. The data start from 1975 to 2002, and concern 232 countries and other political units. The model includes life expectancy, DALE, and DPT and measles immunization as dependent variables; and public and private health expenditure as explanatory variables. The author takes other variables such as aid, literacy rate, and an HIV/AIDS dummy. The findings suggest that literacy rate contributes positively to health outcomes, while the HIV/SIDA has a negative impact.

Zhang *et al.* (2007) use DEA to estimate health efficiency in certain Chinese provinces as a DMU for the years 1982, 1990, and 2000 respectively. They find that provinces in frontier in different years are not the same, but provinces far from the frontier keep unchanged. Also, the average efficiency of health production has made a significant progress from 1982 to 2000. In a second step, the authors analyze the relationship between efficiency and socio-environmental variables. They conclude that the population density significantly and positively contributes to health efficiency, while the proportion of public health spending in total expense exerts a negative impact.

Few studies have tried to examine empirically the efficiency of healthcare systems in MENA countries. Hamidi and Akinci (2016) conducted a study to measure the technical efficiency of twenty health systems in the MENA region for the time span 1995-2012 and using a stochastic frontier analysis. The authors tested the effect of alternative frontier model specification using three random-effects approaches. They found that the average efficiency in the region was 6.9% with a range between 5.7 and 7.9% across the three models. Results showed that Lebanon, Qatar, and Morocco have the highest scores while Sudan, Yemen and Djibouti ranked among the worst performers. According to the World Bank (2010), health equity and efficiency are a prerequisite for driving regional social justice and economic development in MENA countries.

Through the review of existing literature, the issue of health systems' efficiency has been addressed in various circumstances and there is no unique way or methodology in term of valuation and assessment. Giving the high budget allocated to health sector, it is vital to ensure maximum returns, as argued Kirigia *et al.*, (2004). In addition, it is crucial to know how efficiently health inputs are being used to optimize the use of available resources and therefore to improve health status of the population. Availability of information on efficiency would serve to further strengthen the research and decision making in health sector. Nevertheless, some pitfalls should be outreach. First, the efficiency index remain depend on the sample used and it is a relative and non absolute evaluation. Therefore we cannot judge definitely the efficiency of a health system. Also, the ultimate objective of the performance assessment is not to make a countries ranking; but to enhance efficiency for the best performers, in one hand, and to adopt best policy practices and borrow the most appropriate elements within a similar system for the weak performers, on the other hand. Furthermore, exploiting efficiency gains in health spending is crucial not only to achieve the aim of increasing outcomes; but also to meet rapid growing healthcare demand and to put public finance on a stable path, as stated Joumard *et al.* (2010).

According to prior researches, maximizing efficiency has become a key factor for enhancing health status. Therefore, this study has been taken up to estimates efficiency scores and to identify factors that determine this efficiency. In contrast to the previous empirical studies using either input-oriented or output-oriented models, our study contributes to the health efficiency literature by proposing the use of both models. After each model's result, the study identifies peers (reference countries in terms of efficiency), cluster analysis, and input and output targets; and we run a Tobit model (also according to input and output schemes). The topic of efficiency in the healthcare system is particularly relevant in the context of MENA countries. As far as we know, there is no previous study having adopted the mentioned approach in the context of MENA countries. Additionally, grouping countries in accordance to income per capita and therefore assessing efficiency issues helps to validate some hypothesis in our study. To the best of our knowledge, this is the first empirical study to investigate the efficiency in the health system under these circumstances. It is expected that evidence from this paper would enhance existing literature in this sphere.

3. Stylized facts

In MENA region, the health system performance, socioeconomic condition, and quality of governance are different from one country to another, including sometimes within the same State. In recent years, the economic growth in the MENA region has been affected by the economic conditions experienced by some countries, as well as the impact of declining oil export revenues for most of the oil producing countries. The weakness and limited recovery of the euro zone economies has not helped to boost demand for exports from countries such as Tunisia, Morocco and Egypt. The MENA region experienced a decline in the rate of growth of GDP which ranged from 6.3% in 2000 to about 2.5% in 2014, at constant prices. The average growth rate in the oil-producing countries ranged from 2% in 2013 to 2.4% in 2014. In contrast, for the countries with diversified economies the growth rates declined from about 3% to about 2.5% during the same period, according to the World Bank statistics.

Economic performance was varied among MENA countries. The region also varies in terms of their population size which is ranging from a population of less than 1.5 million in the case of Bahrain to a high of over 82 million in Egypt in 2014. About 50% (8/18) of the countries have population sizes of less than 10 million. The annual rate of natural increase of the population is less than 2% in 2/18 countries. The mean proportion of MENA region of people over 60 years is 6% compared to 12% at world level, according to the world population prospects. Some countries of the MENA region are currently in war (Syria, Iraq, Libya and Yemen). War generated a net inflow of people. Specific countries like Jordan, Lebanon and Egypt have experienced spillovers effects of refugee crisis on health systems. Therefore, it will be important to consider this demographic dynamics in the roadmap towards UHC.

The general government expenditure on health as a share of GDP increased from 2.4% in 2000 to 2.9% in 2014. The upper middle-income countries had a share of 3.9% in 2014, while those of the lower-middle income and high-income ones were 2.74% and 2.83% respectively. The differences are even more pronounced when measured in terms of health expenditure per capita, where outlays in high income countries are roughly more than twice and a half the amount in upper-middle income countries and 6 times the spending in lower-middle income countries. Between 2006 and 2011, MENA countries spent on average 8.2% of their budget on healthcare, compared to roughly 18% on education, according to the World Bank statistics. The out-of-pocket expenditure as a share of total expenditure on health declined slightly from 38% in 2000 to 33 % in 2014. Access to care is inequitable and quality of care is perceived to be poor. (World Bank, 2013).

The Human development indicator (HDI) reflects the ability of a country to achieve long and healthy life, the people being knowledgeable and have decent standard of living. The HDI for the 18 MENA countries was 0.721 in 2014, compared with 0.686 in 2005 and 0.553 in 1990, according to the United Nations Development Programme (UNDP). In general, MENA countries are ranked among countries with intermediate levels of development. The index is higher than its global counterpart at the world level which was 0.711 in 2014. The index for Eastern Asia and the Pacific, and Latin America and the Caribbean were 0.710 and 0.784 respectively for the same year. In the MENA region, there are significant disparities; some countries achieved high or medium indicators; while others are still below the regional average. Yemen has a HDI less than 0.55, and is classified as low human development countries. All of the high-income countries except Oman are classified as very high human development countries (>= 0.8). Upper-middle income countries recorded an average value of 0.734, with Iran and Lebanon being the top two countries with a high index of 0.788 and 0.769 respectively. The score for lower-middle income is 0.575. In the majority of MENA countries (13/18) GNI per capita rank minus HDI rank is positive, meaning that these countries are ranking better in GNI per capita than in HDI and therefore there is room to enhance their performance in terms of human development.

In terms of health outcomes, outputs are always correlated with health spending. A child is expected to live about 7.8 years longer in an average in a high-income country than in a low one. There is a similar dynamic for the maternal mortality ratio. In high income countries, this ratio is a drop in the bucket compared to rates seen in some very poor countries. In lower-middle income countries, for instance, the rate is 171.8 per 100,000, roughly about 15 times the high-income countries. The rate in upper-middle income countries is 52 per 100,000. On the other hand, the risk of a child dying before completing the first year of age was 32 per 1,000 live births in lower-middle income countries, over 3.8 times higher than that in the high income countries. However, there is no extreme difference in immunization rates because the worldwide organizations have made and still make incredible improvements in terms of delivering vaccines and immunization services as parts of their commitments to child survival in developing countries.

The proportion of births attended by skilled health staff varied also among MENA countries. In Tunisia, the rate is almost 100% in 2014, compared to 73.6% in Morocco. Most of the Arab Gulf countries have achieved coverage in the field of births attended by skilled staff, while Saudi Arabia and Algeria registered more than 95%. Yemen recorded the lowest rate of coverage. The countries of the Mashreq and the least developed countries still have high rates of early pregnancy and related risks. On the other hand, there is a disparity among MENA countries with regard to prenatal care, with 9 out of 10 pregnant women in the GCC countries, 8 out of every 10 women in Mashreq and Morocco and 6 out of 10 women in the least developed countries, according to World Bank statistics.

The prevalence of HIV/AIDS is still relatively low in the MENA region where it was 0.1% for the 15-49 age group, compared to 4.7% in sub-Saharan Africa and 0.5% in Latin America and the Caribbean, according to World Bank statistics. According to UNAIDS and WHO statistics, the prevalence of the epidemic in the MENA region remained unchanged between 2001 and 2008. On other hand, malaria eradication is almost entirely eradicated from the MENA region. Cardiovascular disorders (CVDs), mental and behavioral disorders, diabetes mellitus and malignant neoplasms represent more than 60% of the non-communicable diseases (NCDs) disease burden in most of the MENA countries. The mean prevalence of raised fasting blood glucose in the population aged 18 years and above is 16.2% for males and 15.9% for females. Four MENA countries (Kuwait, Egypt, UAE, and Bahrain) have among the world's highest male and female obesity rates (World Bank, 2013).

Economic and social indicators that expected to have a positive impact on health outcomes are less favorable in lower-middle income countries. Indeed, the income per capita is lower, and the people remain vulnerable to the impact of widespread poverty, decline in the quality of life, and grave inequalities in access to water sources and sanitation facilities. Educational attainment is also lower, as is the governance quality indicators. MENA countries have experienced strong commitment to finance education. About 5.5% of GDP is allocated to education as an average basis. This remains the second highest percentage in the world after North America and Western Europe. Adult literacy rate in the MENA region ranges from 43.7% in Iraq to 97.9% in Jordan, in 2014. Most of the countries (13/18) have a level of adult literacy that is higher than the global average of 83.4%.

The MENA region has achieved progress in expanding delivery networks. Some challenges still facing the ambulatory and hospital care such as inequalities, quality of care, patient satisfaction and inefficiencies. The development of national health system and the extension of free health care to all led to a conflict between social health insurance schemes (Jabbour *et al.*, 2012).

The challenges in term of heath financing in MENA region is a key concern. The issue is how heath should be financed so that all people are able to receive needed health services of sufficient quality without being exposed to financial hardship as a result of using the service.

4. Materials and methods

4.1. Measuring efficiency: DEA method

This paper followed a standard framework on analysis of efficiency based on two-step process. In the first step, the study evaluates the MENA health systems with direct inputs and output using DEA. In the second step, the study tries to explain the determinants of efficiency using Tobit model within a set of contextual factors. Table below summarize the variables which will be used in our study:

Table 1: MENA's countries health production input-output model

Input variables	*Output variables*	*Influencing factors to be analyzed*
• Health expenditure per capita, PPP (constant 2011, international $) • Physicians (per 1,000 people) • Hospital beds (per 1,000 people)	• Life expectancy at birth, total (years)	• GDP per capita, PPP (constant 2011 international $) • Health expenditure, public (% of government expenditure) • Health expenditure, private (% of GDP) • Urban population (% of total) • Literacy rate, adult total (% of people ages 15 and above) • Control of corruption

As in the most recent studies (e.g., Borisov *et al.*, 2012, Sinimole, 2012; Busse *et al.*, 2013; OECD, 2014; Medeiros and Schwierz, 2015), **we adopt the system level approach**. Accordingly, three inputs and one output are chosen in explaining cross-country differences in health efficiency. For the inputs, we take only inputs that considered being within the discretionary control of the healthcare system. The first input is health expenditure per capita, measured in terms of PPP constant US$2011, which represents the sum of public and private health expenditures as a ratio of total population. It incorporates preventive and curative services, emergency aid, family planning activities, and nutrition activities. We use this variable to measure the final consumption of health goods and services. The second input is number of physicians per 1,000 inhabitants to measure physician's density and health labour. The third input is the number of hospital beds per 1,000 inhabitants to inform about hospital capacity. Inputs variables illustrate in general health resources. Correlation between input variables is low and does not exceed 0.54 in the best case. (*see Appendix 7*).
As to output, we selected life expectancy at birth as the key output measurement of a health system. Life expectancy at birth is defined as how long, on average, a newborn can expect to live, if current death rates do not change. Life expectancy is considered to be one of the most direct and relevant indicator of the efficiency of the healthcare systems (Asandulu *et al.*, 2014). In addition, life expectancy is often considered as a powerful variable to assess health system efficiency in international studies (Tudorel *et al.*, 2009). Moreover, life expectancy

includes the influence of many variables such as education, gender, health status, income, marital status, etc. (Jaba *et al.*, 2011).

According to Lovell (1993), the productivity of a production unit can be measured by the ratio of its output to its input. This will, however, be dependent on differences in production process and technology, and difference in environment within which production occurs. The preeminent consideration here is in separating the efficiency component to assess its contribution to productivity.

Farrell (1957) provide a good measure of productive efficiency, a concept furthered with DEA, which introduced by Charners *et al.* (1978) and extended by Banker *et al.* (1984). DEA represents a non-parametric linear method used to measure efficiency of a homogenous set of DMUs. It shows frontier or (surface) over the data, so as to be able to calculate efficiencies relative to this frontier and indicate what improvements can be made to achieve efficiency (*see Coelli et al., 1998 for more detailed review*).

In this paper, the technical efficiency of the considered sample has been analyzed with a two-stage procedure: in the first stage, **DEA method is employed to measure and compare efficiency of health system** across MENA countries (Banker *et al.*, 1984). In the second stage, and in the line with the studies **using Tobit regression after DEA** scores (Wooldridge, 2002; Sikka *et al.*, 2009; Marschall and Flessa, 2011; Corrededoira *et al.* 2011; Zeng *et al.*, 2012; Nayar *et al.*, 2013), the study assess the determinants of health systems using a truncated regression. Indeed, the Tobit regression model is an alternative to OLS regression and is employed when the dependent variable is bounded from below or above or both, with positive probability pileup at the interval end (Spaho, 2015).
DEA is particularly appropriate when multiple outputs are produced from multiple inputs, and this is the case of health sector. DEA calculate efficiency scores although inputs and outputs can have very different units (for example, units of life expectancy, units of dollars, etc.). DMUs are directly compared against a peer or combination of peers, so DEA identifies best practices and highlights comparison between countries. Furthermore, a specific functional form for the production process does not need to be imposed on the model as it is required in the use of the SFA model.
The most widely used DEA models are the constant return to scale (CRS) model, developed by Charners *et al.* (1978), and the variable returns to scale (VRS) model, developed by Banker *et al.* (1984).
For the purpose of the present study, **we employ the VRS assumption** to solve the problem of relative efficiency of DMUs and thus for two reasons. First, the CRS assumption is only appropriate when all DMU's are operating at an optimal scale and this is not the case of health sector. Second, the scatter chart clearly shows that the relationship between a single input and a single output is a non-linear relationship and it tends either to be increasing or decreasing (*see Appendix 1*). DEA models can be either input-oriented or output-oriented models. With input-oriented DEA, the linear program is configured to minimize the level of inputs with an assumption of fixed level of outputs. In contrast, with output-oriented DEA, the linear program is configured to maximize the level of outputs, while the inputs proportions remain unchanged. The last approach is more suitable for developing countries for the sake of

improving public health and achieving the SDGs goals, whereas the input-oriented approach is more appropriate for developed countries as they often have high levels of health status closer to perfection. In this paper, **we take up both input and output approaches**. This has more than a benefit and multiplicity of methods is hoped to enhance health systems at various levels. As for the mathematical formula of DEA, this method calculates the efficiency of each decision-making unit E and the objective function mentioned in the mathematical formula aims at maximizing the efficiency index q, under constraint that any decision-making unit with the set u and v coefficients with the rest of units should not exceed 1 (100%), which means full efficiency:

$$function: \begin{cases} E_q = \dfrac{\sum_{i=1}^{r} u_i y_{iq}}{\sum_{j=1}^{m} v_j x_{jq}} \\ under\ constraint\ \dfrac{\sum_{i=1}^{r} u_i y_{iq}}{\sum_{j=1}^{m} v_j x_{jq}} \leq 1, q = 1,2, \dots, n \end{cases}$$

Where E_q is the efficiency of the DMU q; y_{iq} is the value of the output i of the DMU q; x_{jq} the value of the input j of the DMU q; u_i is the coefficient or weight assigned by (DEA) to the output i to reach the degree of efficiency (100%); v_i is the coefficient or weight assigned by (DEA) to the intput j to reach the degree of efficiency (100%). In more technical terms:

Input-oriented model

$$\min z = \sum_{j=1}^{m} v_j x_{jq} + \mu$$

Under constraint

$$\sum_{j=1}^{m} v_j x_{jq} - \sum_{i=1}^{r} u_i y_{iq} + \mu \geq 0$$

$$\sum_{i=1}^{r} u_i y_{iq} = 1$$

$$u_i, v_j \geq \varepsilon > 0$$

Output-oriented model:

$$\max z = \sum_{i=1}^{r} u_i y_{iq} + \mu$$

Under constraint

$$\sum_{i=1}^{r} u_i y_{iq} - \sum_{j=1}^{m} v_j x_{jq} + \mu \leq 0$$

$$\sum_{j=1}^{m} v_j x_{jq} = 1$$

$$u_i, v_j \geq \varepsilon > 0$$

The study considers many countries at various economic and social development levels to take advantages of good practices. The data used come from the World Bank (World Data Indicators). Our analysis uses data for the years 1997, 2005 and 2014 or most close data available for sub-period, for **18 MENA countries**. The following 18 countries of the MENA region are included in this study based on availability of data: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the United Arab Emirates (UAE), and Yemen. In this paper, the various countries are grouped according to the World Bank income categories for the year 2014. **High income group (HI)** includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE; **upper-middle income group (UMI)** consists of Algeria, Iran, Iraq, Jordan, Lebanon, Libya and Tunisia; and, the **lower-middle income group (LMI)** comprises Djibouti, Egypt, Morocco, Syria, and Yemen.

The data, especially the data concerning the number of physicians and number of hospital beds, are not widely available on a continuous annual basis. Thus, it is particularly difficult to carry out a panel assessment. In the case of missing data, any DMU that lack data for any input or output is dropped by the DEA. The remedies for missing data are quite limited (Zha *et al.*, 2013) and the parameters estimation under some replacement-based technique would be biased (Nakagawa and Freckleton, 2008). Roth and Switzer (1995) reveal that missing data can cause several negative effects. For these reasons, we use a cross-sectional sample upon three sub-periods. Also, the cross-sectional sample is more suited to prove and /or disprove some assumptions across countries and through time. Furthermore, it captures information based on data gathered in **1997**, **2005** and **2014**. The year **2014 is a specific point** that corresponds to the time between the end of MDGs Agenda and the beginning of SDGs Agenda. Therefore, the cross-sectional analysis of the health system efficiency can be assumed as an assessment of the MDGs and as a perspective for the SDGs.

4.2. Explaining Inefficiency variation across countries: Tobit model

Rapid changes in the economic and environmental contexts have led to complex cross-country health statuses which are not easily captured. Therefore, it is of considerable interest to examine those determinants influencing both input and output efficiency scores derived from DEA method. The determinants of health efficiency have intrigued economists for quite some times. Numerous empirical studies have been generated examining different aspects (e.g, Chang, 1998; Hauner and Kyobe, 2010; Samut and Cafri 2016). Hadad *et al.* (2011) made a distinction between determinants considered to be within the healthcare systems and determinants beyond healthcare systems' control.

The World Bank emphasizes four aspects which may influence health efficiency statues: *i)* macroeconomic background, *ii)* social and cultural factors, *iii)* infrastructure and human resources, and *iv)* institutional and policy environment (Gotteret *et al.*, 2006). From the available data, we incorporate variables on economic status, health financing mechanisms, demographic characteristics, and control of corruption as important and potential determinants of health systems efficiency.

*The potential economic variable is gross national GDP per capit*a, expressed in PPP $ 2011. Sun *et al.* (2017) found a positive relationship between efficiency sores and GDP per capita beyond a certain threshold. Herrera and Pang (2005) find a negative effect since in the high income group the wages are higher than the other countries. In our paper, we expect that economic status will produce a positive impact on efficiency only above certain threshold from which an increase in individual’s spending capabilities on health sector is possible. However, giving the disparities in patterns and trends of income and spending within and across MENA countries, this impact may be doubtful.

The potential health financing variable is health expenditure in percentage of government spending. Health expenditure in percentage of government spending, as proxies for public health expenditure, measures the commitment of the State to finance health sector. The relevance of the measurement of the health public resources efficiency has been brought to the forefront by several developments over recent decades. A large strand of literature finds significant inefficiencies in countries and higher expenditure is associated with lower efficiency scores (eg. Gupta and Verhoeven, 2001; Herrera and Pang, 2005; Afonso and St. Aubyn, 2005, 2006). Inefficiency arises especially when public sector is carried out at excessive costs (Afonso *et al.*, 2010). Based on these studies findings and on the MENA health financing diagnostic, we expect a negative relationship. Other studies showed that public spending is positively associated with the performance (*Zeng et al.*, 2012; *Sun et al.*, 2017). A number of investigations have found no significant impact (Filmer and Pritchet, 1999).

The variables reflecting the ability of people to use the health service effectively can be divided into two categories: human capital and health spending capabilities. We use the adult literacy rate, percentage of people ages 15 and above, as a proxy for human capital. Grossman (1972) shows that high level of education move up health production efficiency. For the health spending capabilities, we use private health spending ratio in percentage of GDP as a proxy. Puig-Junoy (1998) argues that private expenditure capabilities may have a key role in raising technical efficiency of health production. We expect positive relationships between these variables and the efficiency scores.

For the variable reflecting the health service accessibility we use a geographical factor, the urbanization level of the total population, as factor that may determine health efficiency. Gerdtam et al. (1992) hold that higher urbanization level is associated with effective and high quality health services. Herrera and Pang (2005) argue that the clustering of agents make it cheaper to deliver health services in urban areas rather than in rural areas. Consequently, we expect a positive sign for this coefficient.

The potential variable on governance is control of corruption. This variable reflects “perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests” (Kaufmann and Kraay, 2008). This indicator had a score ranging from -2.5 to +2.5, with a higher score indicating better performance. In developing countries, transparency of government practice and fighting against corruption in health sector has increased, boosting public pressure to use scarce resources more efficiently (Tanzi and Schuknecht, 2000; Heller, 2003; Joumard *et al.*, 2004). In countries with high level of corruption or a very ineffective bureaucracy, the public health spending will be ineffective at margin (Rajkumar and Swaroop, 2008). Therefore, we expect that higher control of corruption could contribute heavily to high health performance, especially when considering the input-approach model (resource spending management).

In econometric models where the dependent variable is bounded either to the right or to the left, or takes only values in the interval [0; 100%], the ordinary least squares (OLS) estimation method presents difficulties in minimizing errors. There are also disadvantages with OLS in particular when a substantial portion of the efficiency scores are equal to unity. In this case, neither a linear model nor the OLS method is appropriate for quantifying the relationships between the independent variables and the dependent variable. Thus, if the dependent variable is truncated or censored, and assuming that the error term is normally distributed, the Tobit model is better suited to estimate the parameters of the independent variables (Ozcan, 2008).

Following Schnedler (2005), a Tobit model will be used to examine the determinants of health efficiency. Efficiency scores are non-metric and differences between them are not meaningful with regard to substantive efficiency (Hirschauer and Musshoff, 2014). To avoid this problem, some studies use technical inefficiency rather than efficiency as the dependent variable. However, this may also induce both bias and inefficiency in the estimation (Scippacercola and D'Ambra, 2014). The solution consists on an assessment between inefficiency and other variables. In this paper, we apply the censored regression using technical inefficiency (TIN) instead of technical efficiency (TE), where, $\mathbf{TIN} = \frac{\mathbf{1-TE}}{\mathbf{TE}}$, as shown by Scippacercola and D'Ambra (2014). In this case, censored Tobit regression is applied as TIN scores are between zero and infinity (Nakil, 2007).

Following Tobin (1958), the Tobit model is a statistical model that is designed to estimate linear relationships between variables when there is either left or right-censoring in the dependent variable. The standard Tobit model is given as:

$$y_i^* = x_i^{'}\beta + \varepsilon_i, \varepsilon_i \sim \text{iid}\ (0, \text{e}^{-2})$$

$$y_i = max\{y_i^*, 0\} \qquad i = 1,2, \dots, n$$

Where y_i^* is a latent random vriable which is observed as y_i if it is positive, and is otherwise observed as equal to zero. The log of *technical inefficiency (TIN) instead of technical efficiency (TE)* is considered as dependent variable. Often, the authors take the log of inefficiency to measure the percentage under-production of outputs or over use of inputs which depend in turn on whether an input or output-oriented inefficiency are used.

The Tobit estimation on panel data for the year 2014 is defined as below:

$$ln(TIN) = \beta_0 + \beta_1 lnGDPC_i + \beta_2 lnGDPCsq_i + \beta_2 HEXPG_i + \beta_2 PRIV_i + \beta_2 URBAN_i + \beta_2 LITERC_i + \beta_2 CONTCORR_i, \qquad i \text{ represents ith countries}$$

Where TIN = Technical inefficiency scores computed from DEA technical efficiency scores
GDPC = Gross national income per capita,
GDPCsq = Square of GNIPC
HEXPG = Health expenditure, public (% of government expenditure)
PRIV= Health expenditure, private (% of GDP)
URBAN = Urban population (% of total)
LITERC = Literacy rate, adult total (% of people ages 15 and above)
CONTCORR = Control of corruption (-2.5 worst, +2.5 best)

All data on efficiency determinants were obtained from the World Data Indicator (WDI). The control of corruption variable was obtained from Worldwide Governance Indicators (WDI), constructed by the World Bank.

5. Empirical results

5.1. Descriptive statistics

Table 2 presents a short description of data expected to construct the efficiency frontiers employed in both input and output models. As that Table 2 shows, it can be observed that there is great variation across countries in most dimensions of the health production model, as indicated by the coefficient of variation. This is partially because there is wider gap in development levels between the sample countries.

Table 2: Descriptive statistics of input and output variables (2014)

	Min	*Max*	*Mean*	*Median*	*Std. Dev.*	*Coef. of variation*
Health expenditure per capita, PPP (constant 2011, international $)	202.16	3071.19	1221.73	869.16	883.45	72.31
Physicians (per 1,000 people)	0.23	2.65	1.48	1.52	0.77	52.29
Hospital beds (per 1,000 people)	0.10	3.70	1.64	1.60	0.92	56.09
Life expectancy at birth, total (years)	61.99	79.33	73.46	74.94	4.61	6.27

Source: Sorted by the author.

The lowest variation concerns the life expectancy at birth (6.27). This is explained by the fact that minimum and maximum of this variable are close to each other; and the "human nature" had stronger influence on life expectancy more than healthcare intervention. The "human nature" here refers to the ways of thinking and actions which are common to most people. It includes for example the widespread of disease prevention that can save lives (Kampen *et al.*, 2014) and the nutrition transition occurring worldwide which involves a shift from traditional grain-based diets to a dietary with more variety (Kennedy, 2006).

On average, life expectancy is 73.4 years for the sample countries. The lowest value is registered in Djibouti (61.9 years), while the highest value is in Lebanon (79.33 years). The most striking difference concern input variables. Yemen is the country that spends less on health per capita ($202.16, PPP). At the opposite extreme, Qatar spends $3071.2 PPP, followed by Saudi Arabia with $2466 PPP. However, those significant values of health expenditure do not mean necessarily that these amounts are being spent efficiently. The average of hospital beds per 1,000 inhabitants is roughly 1.64, and varies from 0.1 in Iran to 3.7 in Libya. The number of physicians per 1,000 inhabitants, however, varies less significantly across countries: from 0.23 in Djibouti to 2.65 in Jordan. The mean of the series is greater than the median, except for life expectancy and number of physician per 1,000 inhabitants. (For more detailed statistics, see *Appendix 2* and *Appendix 3*).

5.2. Input and output DEA results

5.2.1. MENA's countries health production efficiency

A-DEA overall scores

We have chosen two models, an input-oriented BCC model and an output-oriented BCC model. The aim is to measure productive efficiency of these health systems by calculating the distance between minimum attainable inputs for a given level of outcome (input model) and the distance between maximum attainable outputs for a given inputs (output model).

The DEA results indicate that the average efficiency scores for all health systems were 79%, 83.6% and 78.7%, respectively in 1997, 2005 and 2014, under the input-oriented approach. The health production efficiencies of all MENA countries kept rising in 1997-2005. This is a result of the increase in the number of countries on heath production frontier. In 2014, the average score decrease and reach 0.787. With reference to the output-oriented model, the health production efficiencies of all MENA countries kept rising in 1997-2005, with the average rise from 0.982 in1997 to 0.985 in 2005. This is a result of the increase in the number of countries on heath production frontier. In 2014, Tunisia and EAU became inefficient and therefore average score decrease and reach 0.979. Results mentioned below concern the year 2014.

Table 3: MENA's countries health production efficiencies

Health system	*Input-oriented technical efficiency BCC model*						*Output-oriented technical efficiency BCC model*					
	VRS TE 1997	*Rank*	***VRS TE 2005***	*Rank*	***VRS TE 2014***	*Rank*	***VRS TE 1997***	*Rank*	***VRS TE 2005***	*Rank*	***VRS TE 2014***	*Rank*
Algeria (UM)	0,569	7	0,805	2	0,644	5	0,951	10	0,983	3	0,987	3
Bahrain (H)	0,928	2	1,000	1	1,000	1	0,994	2	1,000	1	1,000	1
Djibouti (LM)	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1
Egypt (LM)	0,478	10	0,473	8	1,000	1	0,932	11	0,924	8	1,000	1
Iran (UM)	1,000	1	0,684	4	1,000	1	1,000	1	0,973	4	1,000	1
Iraq (UM)	1,000	1	1,000	1	0,577	7	1,000	1	1,000	1	0,915	10
Jordan (UM)	0,752	3	0,619	6	0,525	8	0,977	4	0,967	6	0,962	6
Kuwait (H)	0,539	9	0,668	5	0,312	11	0,964	8	0,972	5	0,948	7
Lebanon (UM)	0,564	8	1,000	1	1,000	1	0,984	3	1,000	1	1,000	1
Libya (UM)	0,463	11	0,437	9	0,454	9	0,959	9	0,956	7	0,920	9
Morocco (LM)	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1
Oman (H)	0,722	4	0,748	3	0,877	4	0,966	7	0,988	2	0,994	2
Qatar (H)	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1
Saudi Ar. (H)	0,616	5	0,612	7	0,319	10	0,976	5	0,972	5	0,945	8
Syria (LM)	1,000	1	1,000	1	0,880	3	1,000	1	1,000	1	0,973	5
Tunisia (UM)	1,000	1	1,000	1	0,579	6	1,000	1	1,000	1	0,980	4
UAE (H)	0,594	6	1,000	1	0,992	2	0,975	6	1,000	1	1,000	1
Yemen (LM)	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1
Average	**0,790**	-	**0,836**	-	**0,787**	-	**0,982**	-	**0,985**	-	**0,979**	-
Std. dev.	**0,22**	-	**0,21**	-	**0,26**	-	**0,02**	-	**0,02**	-	**0,03**	-
CV(%)	**27,68**	-	**24,57**	-	**33,12**	-	**2,13**	-	**2,15**	-	**2,96**	-
Min	**0,463**	-	**0,437**	-	**0,312**	-	**0,932**	-	**0,924**	-	**0,915**	-
Max	**1,000**	-	**1,000**	-	**1,000**	-	**1,000**	-	**1,000**	-	**1,000**	-
Effi.DMU	**8**	-	**10**	-	**8**	-	**8**	-	**10**	-	**9**	-
S ample size	**18**	-	**18**	-	**18**	-	**18**	-	**18**	-	**18**	-

Note: Obtained by BCC input and output-oriented models based on the input-output model in Table 1.
Note: VRS TE: variable returns to scale technical efficiency. Rank: ranking taking into account the VRS TE.
Note: HI, UMI, and LMI are the classification of countries by GDP per capita for the year 2014.
Source: Sorted by the author based on DEA results.

The DEA results indicate that the average efficiency scores for all health systems were, respectively, 79% and 83.6% and 78.7%, respectively in 1997, 2005 and 2014, under the input-oriented approach. The health production efficiencies of all MENA countries kept rising in 1997-2005, with the average rise from 0.790 in 1997 to 0.836 in 2005. This is a result of the increase in the number of countries on heath production frontier. The average score decreased and reach 0.787 in 2014 when Iraq, Syria, Tunisia and UAE became inefficient DMUs. With reference to the output-oriented model, the health production efficiencies of all MENA countries kept raising in 1997-2005, with the average score raised from 0.982 in1997 to 0.985 in 2005. This is a result of the increase in the number of countries on heath production frontier. In 2014, Iraq and Syria and Tunisia became inefficient and therefore the average score decrease and reach 0.979. Results mentioned below concern the year 2014.

In the case of the input model, estimates of technical efficiency suggest that 8 out of 18 countries transforming better in minimizing level of inputs giving fixed level of outputs, and therefore reaching an efficiency score of 100%. These good performers include 2 high-income country, 2 upper-middle income countries, and 4 lower-middle income countries. This evidence clearly indicates that all countries can be efficient despite their economic conditions. Efficiency scores may be, among others, 30%, 40%, 50%, 60%, 80%, 90%, or 100%, which suggest that the efficiency inputs-oriented scores of health systems of the sample countries can be either low, medium, high, or very high. A crucial issue to take into consideration is that countries with high efficiency index can further improve their performance, since they are perfect countries compared to the others countries in the sample and so they can be inefficient compared to other countries in the world. The improvement of efficiency can be achieved by identifying an efficient operating practice, as advocated by Martić *et al.* (2009). The relatively efficient countries have the same rating (100%), however, among them some are better than others at a setting a good example. Also, inefficient countries (where the efficiency index is below 100%) are inefficient relatively to the countries on the efficiency frontier, and therefore they can be efficient if we consider another sample.

The standard deviation relative to the mean is quite large (26%) meaning that the use of inputs is widely spread across and there are large disparities. The range of the efficiency score is 68.8%. Kuwait has the lowest input-oriented efficiency score which is only 31.2%, meaning that this country may, relatively to the other countries, decrease the inputs by 68.8% to sustain the same level of outputs. The Pearson-correlation between efficiency scores under minimizing resources approach and input variables (health expenditure per capita, physician number, hospital beds number) is, successively, -0.15, -0.57, and -0.47 (*see Appendix 8*). Thus, efficiency is adversely affected by the additive use of resources, especially a decrease concerning the number of physicians the number of hospital beds, where the correlations are significant at 5% level, and in a lesser extent with regard to the spending per capita. Therefore, increasing resources spending is a synonym of misallocation of resources.
Also, the results suggest that it is very difficult for countries to be good performers below expenditure per capita of approximately $2273, $987, and $202 (in 2011 international dollars) for, successively, the HI, the UMI, the and the LMI countries. Generally, this implies that health system requires minimum level of expenditure above which the system achieves efficiency. Evans et al. (2000) indicated a limit of $60 (in 1997 international dollars) for a sample of 191 countries.

In the case of the output model, results show that 9 of 18 countries (50 percent) have DEA score equal to 100% and therefore they are on the efficiency frontier. These 9 countries include all income groups (3 of high income, 2 upper middle-income countries, 4 lower middle-income countries). This substantial evidence allows again to the rejection of the hypothesis that middle-income countries cannot achieve the efficiency frontier. Thus, health efficiency can be reached despite unfavorable economic conditions. Similarly with DEA estimation, a country can be on the efficiency frontier although desirable outputs targets were not achieved like Egypt where life expectancy is 71.1 years compared to Qatar where life expectancy is 78.3, and the two countries are efficient.

The efficient countries according to the minimization approach are the same ones according to the maximization approach, except the UAE which is an efficient country under input approach but not under maximization approach. This indicates the good performance of the health sector in these countries, but this does not imply absolute acceptance of the assumption that any efficient country in using resources is necessarily efficient in increasing the outputs. The performance still linked to the success of health policies. The results show that the dominant countries include those with both good health outputs such as Lebanon, as well as those with poor health outputs such as Djibouti and Yemen. It is possible for countries with poor health outcomes such as Djibouti (life expectancy for 62 years) to be on the frontier due to their low consumption of resources. This demonstrates that at any level of health outcome, a country can be either technically efficient or inefficient in the use of its health resources. In addition, health efficiency is not limited only to the countries that spend high level of resources; it also exists and is becoming increasingly frequent, in the countries that are not spending big bucks. This finding is also been proved when we examine the correlations between the output-oriented efficiency scores and the input variables, which are 0.01, -0.40, and -0.44 (*see Appendix 8*), respectively, for the inputs health expenditure per capita, physician per 1,000 inhabitants, and hospital beds per 1,000 inhabitants. These low correlations, especially for the expenditure variable, show that efficiency is not only limited for countries that spend more or less resources.

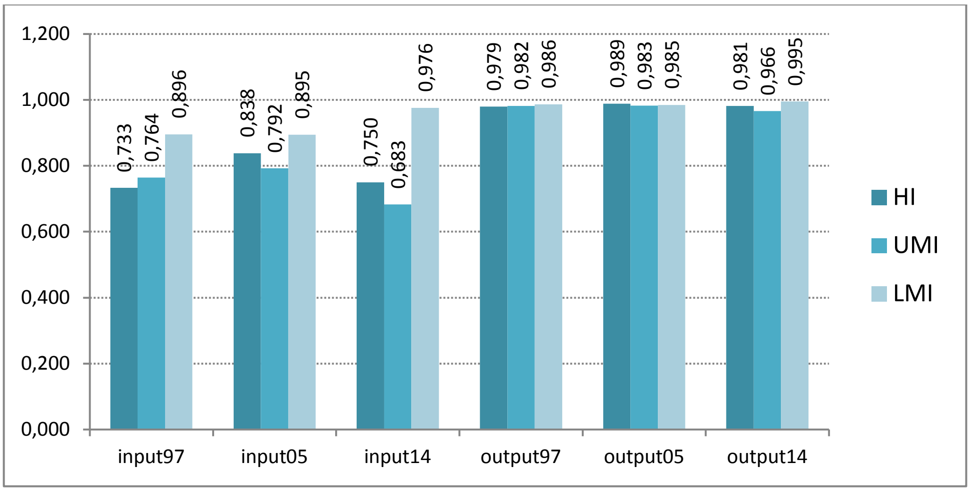
Efficiency scores exceed the mean (97.9%) by a standard deviation equal to 3%. This low value which measures dispersion indicates that the efficiency set tend to be close to the mean. This result is closely to that was found by Herrera and Pang (2005) by an efficiency sore of 93% for 140 developing countries. The difference between the largest and smallest value is 8.5%. Iraq has the lowest efficiency score (91.5%). The lowest value under the maximization approach (output-oriented approach) remains in an acceptable range, and therefore health systems in MENA countries, regarding the sample considered here, are in an acceptable output efficiency levels. The low extent to which distribution of health efficiency scores is explained by the "natural" limits imposed by health system production (resources exploitation), unlike in the case of input model when the difference among different countries in health resources use is extremely large (the coefficient of variation in 2014 is around 2.96% against 33.12% for the input-oriented approach).

B-DEA scores by income group

The analysis of the average efficiency score by income group provides results below. **In the case of input model**, the average health efficiency score varies across income groups. In 2014, for the 6 high income countries, the index is 75%. The lowest score is for Kuwait (31.2%) and also, this is the lowest index in the sample. The highest score (100%) is captured only by only two countries (Bahrain and Qatar). For the 7 upper-middle income countries, it is 68.3%. The lowest index is for Libya (45.4%). The highest index (100%) is for 2 countries,

i.e. 28.5% of the upper-middle group. In the 5 lower-middle income countries, the index is 97.6%. The average efficiency score for the low-income countries exceed the sample mean (78.7%). The lowest score is for Syria (97.6%), and the highest index is for 4 countries (80% of lower-middle group).
In the lower-middle income countries, available resources are oriented primarily to health sector. The lack of financial resources compels these countries to optimize the use of resources carefully and to take steps to prevent such misallocation, which has produced some good results concerning health efficiency with reference the input-oriented approach. In high income countries, the contribution of improved inputs use to health efficiency is significant. In upper-middle-income countries, institutional constraints are pulling down the capacity to minimize the use of inputs.

Fig.1: Health efficiency score average by income group (1997; 2005 and 2014)



Source: Sorted by the author.

In the case of the output model, the average efficiency score for lower-middle income countries is 99.5%. Those countries have experienced higher growth rates in terms of health outcomes than high-income countries. The global average life expectancy increased by 11 years between 1990 and 2014 in low-income countries, compared to 5 years in high-income countries according to the World Bank statistics. The average efficiency in upper-middle income countries (7 countries) is 96.6% and the lowest efficiency is for Iraq (91.5%) which is also the lowest value in the sample; and 28.5% of the countries have the highest score (100%).

The efficiency scores are high for low-middle-income and high-income countries. These scores decrease slightly in the upper-middle income countries. MENA countries make efforts to maintain the sustainable investment achieved in life expectancy by producing comprehensive primary health care. These achievements can drive mainly by others factors, outside the health system.
In the countries with similar economic background, the efficiency of health system can be widely different. For example, although Lebanon and Libya belong in the category of upper-middle income countries and spending per capita in 2014 was $987 and $806 respectively, 2.38 and 2.09 for physicians indicator and 3.5 and 3.70 for hospital beds indicator, we found huge difference in health outcome (life expectancy 79.3 vs., 71.7).

5.2.2. MENA's countries health production frontier

The efficiency frontier will be used as a benchmark for measuring the relative efficiency of the observations, as suggested Herrera and Pang (2005).

Table 4: MENA's countries health production frontier

	Frontier	*Farther from frontier*
	Input approach	
1997	Djibouti; Iran; Iraq; Morocco; Qatar; Syria; Tunisia; Yemen	Algeria; Egypt; Kuwait; Lebanon; Libya; Saudi; Arabia; UAE
2005	Bahrain; Djibouti; Iraq; Lebanon; Morocco; Qatar; Syria; Tunisia; UAE; Yemen	Egypt; Libya
2014	Bahrain; Djibouti; Egypt; Iran; Lebanon; Morocco; Qatar; Yemen	Algeria; Iraq; Jordan; Kuwait; Libya ; Saudi Arabia; Tunisia
	Output approach	
1997	Djibouti; Iran ; Iraq ; Morocco ; Qatar ; Syria ; Tunisia ; Yemen	Egypt
2005	Bahrain; Djibouti; Iraq; Lebanon; Morocco; Qatar; Syria; Tunisia; UAE; Yemen	Egypt
2014	Bahrain; Djibouti; Egypt; Iran; Lebanon; Morocco; Qatar; UAE; Yemen	Iraq; Libya

Note: Obtained from the analysis results in Table 3, of which, results of provinces farther away from the frontier are obtained by cluster analysis on provinces which are not on the frontier. Cluster distance is "squared Euclidean distance" and cluster analysis method is "between group linkage".
Source: Sorted by the author.

The analysis of MENA's countries health production frontier points out the following characteristics. First, with reference to the **input-oriented model**, countries on the health production frontier vary, slightly, from year to year. Three countries, Morocco, Qatar and Yemen kept their position as efficient heath systems during the three years 1997, 2005 and 2014, maintaining a high level of efficiency in heath production although the variation among their health output (life expectancy). Bahrain and Lebanon have become efficient since 2005 while Iraq, Syria and Tunisia weren't on the frontier in 2014. Eight countries were on the production frontier in 1997, ten in 2005, and eight in 2014, accounting for 44.4%, 55.5% and 44.4%, respectively, in the total number of observations. Similar conclusions for **the output model**, with UAE became efficient since 2005. According to this model, Egypt was in the production frontier for in 2014. This illustrates that it is feasible for all countries to reach the efficient frontier through the modification of health resources and providing healthcare services.

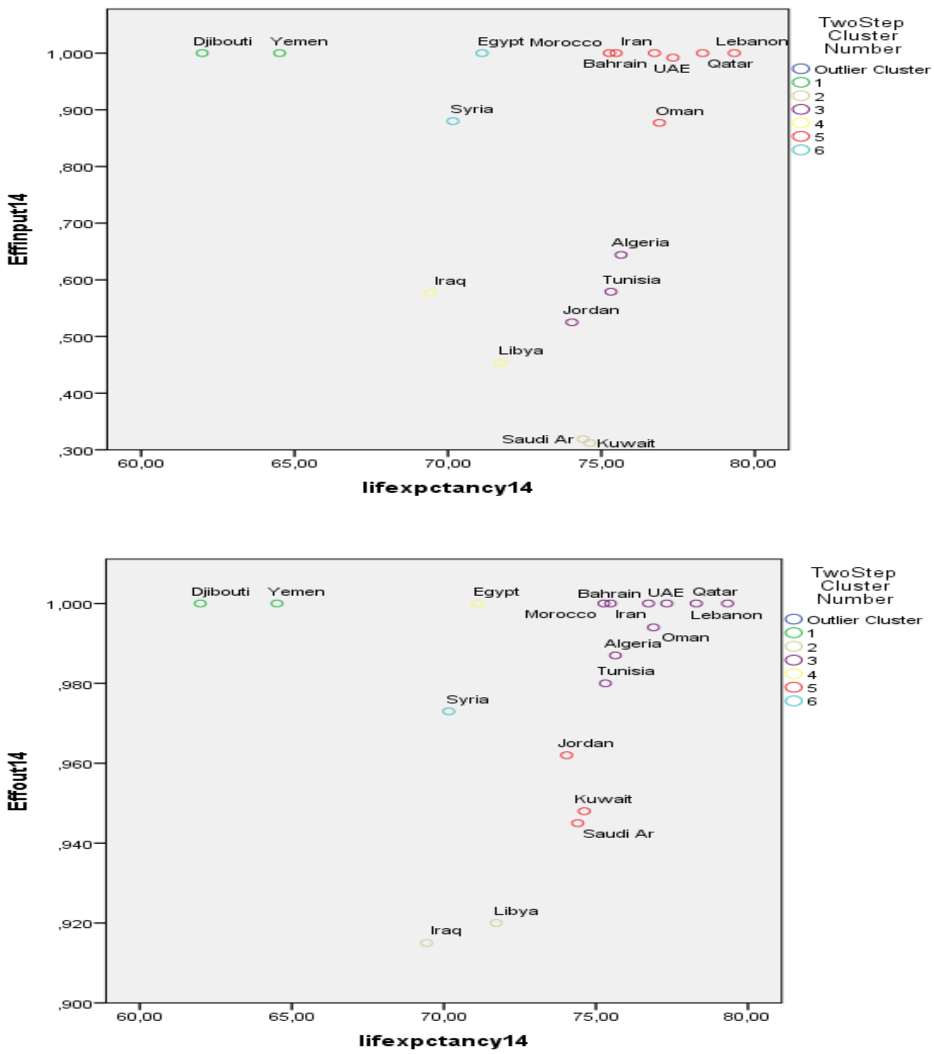
Now for heath systems farther from frontier, results show that these systems vary from year to year. According to the input minimization approach, the Libyan's health system stills far from the efficient frontier during the years 1997, 2005 and 2014. Egypt, Lebanon, Libya, Saudi Arabia and UAE have been able to move away from the farther area from efficiency frontier after 1997. Iraq, Jordan and Tunisia belong in this area in 2014. With reference to the maximization approach, few countries belong farther from frontier such as Egypt in 1997 and in 2005. Iraq and Libya are the least efficient countries in 2014, according to both approaches. This analysis proves that it is not easy for a country to keep its position on the efficiency frontier or to move away from the farthest area. All depend on the health reform progress.

Similar to the results from separate health outcomes, we found that efficiency varied substantially among countries. We illustrate the average efficiency of health systems by quartiles. In 2014, the mean input efficiency for quartile1 (the worst third of observations) was 56.7%, 84% for quartile 2, and 100% for quartile 3 (the best fourth of observations). For countries in the lowest quartile, much improvement could be done to enhance the efficiency, with a potential of resource saving of 43.6% of total resource. In 2014, Jordan, Libya, Saudi Arabia and Kuwait, successively, were in the list of low performance countries. The mean output efficiency for quartile 1 was 95.8, 99.7% for quartile 2, and 100% for quartile 3. For countries in the lowest quartile, much improvement could be done to enhance the efficiency, with a potential of output exploitation of 43.6% in 2014. Kuwait, Saudi Arabia and Libya successively, were in the list of low performance countries. (*see Appendix 4; Appendix 5*).

5.2.3. Different production models of various countries in MENA

We have conducted a cluster analysis in terms of health efficiencies and health output levels (life expectancy) for the year 2014. The aim is to make the division of health production models of various MENA countries clearer.

Fig. 2: Production models of MENA countries in 2014 (input and output models)



Note: Obtained from the analysis of the result of table 3, with Ward cluster analysis applied in terms of health production efficiency and output on the frontier and non-frontier provinces separately.
Source: Sorted by the author.

We have segregated the health production patterns into six categories: High efficiency and high output; High efficiency and middle output; High efficiency and low output; Middle efficiency and high output; Middle efficiency and middle output; and, Low efficiency and middle output. (*For more details see Appendix 6*). Several results may be highlighted:

High efficiency and high output

This category is represented by Bahrain, Iran, Lebanon, Oman, Qatar, and UAE in the case of **input model**; and by Algeria, Bahrain, Iran, Lebanon, Morocco, Oman, Qatar, Tunisia, and UAE in the case of **output model**. Their health system features both high efficiency (100%) and high life expectancy. Compared with countries on the production frontier, their inputs are relatively high. By adjusting health production patterns, these countries may reach the efficiency frontier, such as Lebanon in 2004 and Iran 2014. Tunisia and Syria fell off the frontier to non efficiency countries. The best strategy for this category is to adopt a fine-tuning for relative efficiency.

High efficiency and middle output

These areas are represented by Egypt and Syria in the **input model** and by Egypt in the **output model**, whose health production systems are characterized by high efficiency scores (100%) and middle-life expectancy, with the health system input level relatively lower than the category with the same output, thus allowing the heath systems to reach the efficiency frontier. The ideal strategy for this category is to increase inputs appropriately to improve the health output of the target population.

High efficiency and low output

This category is represented by Djibouti and Yemen both in **the input** and **output models**. Their health production systems feature low-level of output and high inputs level. These countries have the most effective expected returns to input. The reasonable path for these areas should be an increase in health inputs.

Middle efficiency and high output

These areas are represented by Algeria, Jordan and Tunisia in the case of **input model** and by Jordan, Kuwait and Saudi Arabia in the case of **output model**, whose health production systems feature high-level life expectancy and quite reasonable inputs level. Compared with countries with the same level of life expectancy, their inputs are relatively higher than countries on the frontier efficiency. The health production systems can reach an ideal state by using appropriately health inputs.

Middle efficiency and middle output

This is represented by Iraq and Libya in the case of **input** and Syria in the case of **output model**, featuring middle inputs and middle life expectancy. Compared with countries with the same level of life expectancy, their inputs are relatively higher than those of high efficiency countries and frontier countries. The ideal strategy for realizing relative efficiency is to increase health input, or raise output, or both.

Low efficiency and high output

This area is represented by Kuwait and Saudi Arabia in the case of **input model**, whose health production systems are characterized by low efficiency scores and high life expectancy. Compared with countries with the same level of life expectancy, their inputs are relatively higher than those of high efficiency. The best strategy is to reduce inputs.

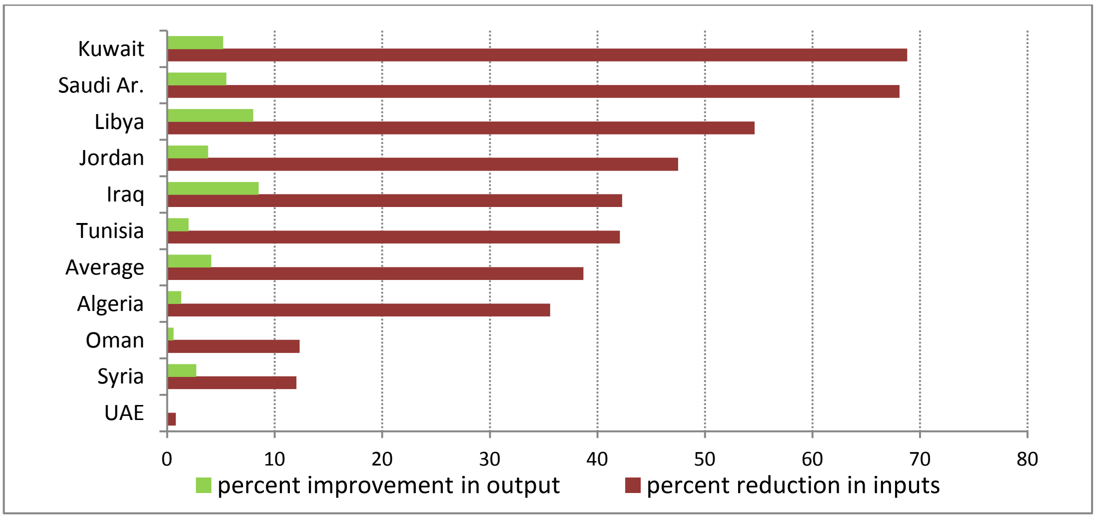
Low efficiency and middle output

This is represented by Iraq and Libya in the case of **output model**, whose health production system featured low inputs level and middle-level life expectancy. Compared to other categories, the inputs level is not the lowest, thus generating a low efficiency. For example, in Libya, the political instability, low quality of human resources, and high speed and expanded scale led to an extensive resource waste. In 2014, Libya' health inputs, especially the number of physician and hospital beds per 1,000 inhabitants, were higher than the average MENA level (successively, 2.1 and 3.7 compared to 1.5 and 1.6 for MENA region), but its life expectancy was only 71.7 years (MENA average is 73.45). Therefore for this category of countries, the best choice should be to change the extensive health production pattern, increase the quality of inputs, and diminish duplicated construction. By this way life expectancy and health production efficiency may increase. It is worth noting that countries which are characterized with low health outcome have to boost their efficiency index (Chisholm and Evans, 2010). In this context, additional resources (tax collection, obtaining more donor support, etc.) could address the population needs and health care reform agenda. Furthermore, improving efficiency is crucial not only achieving desired health outcome, but also in delivering health services. The generated gains could enhance fiscal space which will be, for example, reallocated to disease control (Heller, 2005).

5.2.4. Input and output targets

The results for both input and output targets for the two models are shown in the figure 3. Frontier countries are not shown because these countries, by definition, assume the value of 1.

Fig.3: Input and output targets (2014)



Source: Sorted by the author.

In the case of the input model, the input efficiency score is 0.579 for Tunisia. This shows that inputs reduced to 57.9% of their current level while holding life expectancy constant. This would be 42.1% reduction in inputs as shown in figure 3, while this would be more than 55% in the case of Kuwait and Saudi Arabia and in a lesser extent Libya. UAE have to reduce its inputs by only 0.8%. On average, inefficient countries may reduce their inputs by 38.7%. Retzlaff-Roberts et al. (2004) found that percent reduction in inputs in OECD countries is 21% on average. Some countries such Czech Republic, Denmark, Hungary and Portugal may reduce their inputs more than 30%.

In the case of the output model, the output efficiency score is 0.980 for Tunisia, using a weighted average of Morocco, Lebanon and Bahrain as the frontier composite. This means that Tunisia can potentially increase its life expectancy to 98% without increasing input consumption. This would allow a 2% increase in life expectancy. The most important and potential improvements concern Iraq and Libya (roughly 8%). for Algeria, Tunisia and Syria, the potential improvement is between 1.3 and 2.7% and only 0.6% for Oman, as shown in the figure 3. Retzlaff-Roberts *et al*. (2004) showed that the percent improvement in output is 2.1 years on average, 3.57% for Hungary: 8.57%; around 3% for Poland and Portugal and only 0.21% for Switzerland.

5.2.5. Inefficient countries and their peers

DEA provides results-based management information of both efficient and inefficient DMUs. For each inefficient unit, DEA identifies a set of relatively efficient units, which constitute a peer group for the inefficient unit. Following Martić *et al.* (2009), among others, the peer set for an efficient DMU represents the DMUs with the same optimum weights as the inefficient DMU, but with a relative efficiency index of 1.

The identification of peers groups should be very useful when an inefficient country wants to meet its health efficiency and therefore targets, by highlighting the weak aspects. Table 5 shows the countries that make up the efficient frontier composite for each of the inefficient countries. Morocco and Lebanon are a reference for the most inefficient countries when considering minimization inputs and maximization output approaches. Qatar is a reference mostly when considering the maximization approach. Although they belong on the efficiency frontier, Bahrain, Yemen and Egypt aren't a reference for health best practice, especially in maximization outputs. Djibouti (efficient with regard to both approaches) and UAE (efficient with regard to input approach) do not compose a reference member for any inefficient country. Thus, an efficient country can be a reference for best practice when considering either the minimization approach or the maximization approach or both approaches; or it cannot be a reference at all.

Moreover, under the maximization assumption as in the case of minimization assumption, a country can be a peer independently of its income level. Morocco, as lower-middle income country is a peer for some upper-middle income countries such as Algeria and Tunisia and also a peer for some High income countries such as Oman and Saudi Arabia. Therefore we can reject the hypothesis that poor countries cannot be a reference in term of heath efficiency relatively to the output-oriented approach.

Table 5: Inefficient countries and their peers (2014)

Inefficient countries	Approach	*Peers and weights*								
		Morocco (ii) (LM)	Lebanon (ii) (UM)	Qatar (ii) (H)	Iran (ii) (UM)	Bahrain (ii) (H)	Yemen (ii) (LM)	Egypt (ii) (LM)	Djibouti (ii) (LM)	UAE (i) (H)
Algeria (UM)	Input	0,886	0,062	0,032	-	0,019	-	-	-	-
	output	0,583	0,262	0,075	-	0,080	-	-	-	-
Iraq (UM)	Input	0,378	-	-	-	-	0,492	0,130	-	-
	Output	0,799	0,116	0,004	-	0,081	-	-	-	-
Jordan (UM)	Input	0,887	-	-	-	-	0,113	-	-	-
	Output	-	0,409	0,387	0,204	-	-	-	-	-
Kuwait (H)	Input	0,651	-	-	0,187	-	-	0,162	-	-
	Output	-	0,435	0,565	-	-	-	-	-	-
Libya (UM)	Input	0,671	-	-	-	-	0,329	-	-	-
	Output	0,335	0,665	-	-	-	-	-	-	-
Oman (H)	Input	0,510	0,203	0,264	0,022	-	-	-	-	-
	Output	0,395	0,274	0,320	0,011	-	-	-	-	-
Saudia Ar.(H)	Input	0,603	-	-	0,180	-	-	0,217	-	-
	Output	-	0,391	0,609	-	-	-	-	-	-
Syria (LM)	Input	0,526	-	-	-	-	0,474	-	-	-
	Output	0,711	-	-	-	-	0,289	-	-	-
Tunisia (UM)	Input	0,985	0,015	-	-	-	-	-	-	-
	Output	0,565	0,355	-	-	0,080	-	-	-	-
UAE (H)	Input	0,305	-	0,679	0,015	-	-	-	-	-
	Output	0,298	-	0,692	0,010	-	-	-	-	-
Time/Rank	Input	10t/1st	3t/3rd	3t/3rd	4t/2nd	1t/4th	4t/2nd	3t/3rd	0t/5th	0t/5th
	Output	7t/2nd	8t/1st	7t/2nd	3t/3rd	3t/3rd	1t/4th	0t/5th	0t/5th	0t/5th

Note: values indicate the weight
Note: (ii) Country is efficient both according to input and output approaches. (i) country is efficient only according to output approach.
Note: According to the World Bank Analytical Classifications of the year 2014, there are four categories of income in reference to the GNI per capita in US$ (Atlas methodology): LMI: Lower middle income (1,046-4,125US$); UMI: Upper middle income (4,126-12,735US$); HI: High income (> 12,735US$) and LI: low income (<=1.045).
Note: Time/Rank: ranking taking into account the number of times the efficient countries are peers of inefficient countries.
Source: Sorted by the author.

As shown by the table 5, a country may, independently of its income level, be a peer for inefficient countries. For example, Morocco, which is a lower-middle income country, is a reference for efficiency for many countries, including the high income countries (for example, Oman and Saudi Arabia). Thus, the hypothesis that poor countries cannot be a reference in terms of health efficiency is rejected under the minimization approach and also under the maximization approach.

5.2.6. Scale efficiency scores

On other perspective, a health system will be considered in a scale efficient situation if only its size of operation is optimal so that any modification on its size will render the system less efficient. The returns to scale scores given by the DEA model explain the behavior of the rate of increase in outputs relative to the associated increase in the inputs.

Table 6: Scale efficiency scores (2014)

Health system	*Input Scale efficiency scores*		*output scale efficiency scores*	
	Scale score	Scale type	Scale score	Scale type
Algeria	66,2%	drs	43,2%	drs
Bahrain	39,6%	drs	39,6%	drs
Djibouti	100%	crs	100%	crs
Egypt	97,2%	drs	97,2%	drs
Iran	100%	crs	100%	crs
Iraq	90,9%	drs	57,3%	drs
Jordan	76,9%	drs	42,0%	drs
Kuwait	86,3%	drs	28,4%	drs
Lebanon	25,2%	drs	25,2%	drs
Libya	61,4%	drs	30,3%	drs
Morocco	81,0%	drs	81,0%	drs
Oman	45,5%	drs	40,1%	drs
Qatar	44,5%	drs	44,5%	drs
Saudi Ar	87,0%	drs	29,3%	drs
Syria	66,5%	drs	60,2%	drs
Tunisia	63,5%	drs	37,5%	drs
UAE	51,8%	drs	51,5%	drs
Yemen	100%	crs	100%	crs
Average	**71,3%**	**-**	**56,0%**	**-**
Std. dev	**23,2%**	**-**	**27,2%**	**-**
Range	**74,8%**	**-**	**74,8%**	**-**

Note: drs: decreasing returns to scale; crs: constant returns to scale.
Source: DEA results.

In the case of the input model, the input-oriented measure of scale efficiency takes into account only health inputs. The results show there is no country with an increasing returns to scale, meaning that the outputs increase by more than that proportional change in inputs. There are three countries with constant returns to scale, meaning that the output increases by that same proportional change as all inputs change. Also, the results shows that there are 15 countries with decreasing returns to scale, i.e. an increase in all inputs leads to a less than proportional increase in output.

Generally, the optimal size of inputs refers to the maximum values for each input in case of increasing returns to scale. Where life expectancy at birth is between 62 and 75 years, it may be possible only to spend less than between 202$ and 1082$, physicians between 0.2 and 1.5, and hospital beds between 0.1 and 1.4. Under these circumstances, economies of scale of any health system are constant. Typically, the optimal size of inputs in this case is included between minimum and maximum values. Beyond this situation, health system becomes characterized by decreasing returns, meaning that increasing expenses will cause a decline in outcomes until reaching the lower return to scale reported by the Lebanon's health system (25.2%). Under the minimization approach, scale efficiency rating doesn't include increasing return to scale, thus there is no justification for raising health expenses and available resources to take advantage of the gap between increasing and constant returns to scale. If the result includes increasing return to scale, countries with increasing returns should reach the *Most Productivity Scale Size (MPSS)* after which decreasing returns to scale set in (Banker and Kemerer, 1989) by increasing health expenditure per capita up to 1082$, physician up to 1.5 per 1,000 inhabitants, and hospital beds up to 1.4 per 1,000 inhabitants. Usually, those bounds correspond to the maximum values of inputs in case of constant returns to scale.

In the case of the output model, the output-oriented measure of scale efficiency takes into account only health outcomes. Health systems production can be assimilated to a firm's production function which exhibit different types of returns to scale in different ranges of output. Hence, there could be increasing, constant, and then decreasing returns to scale. Table 6 reveals that on average MENA countries have scale efficiency score of 0.56%, less than the score in input approach. In detailed analysis, 3 health systems (16.6% of total) operate under constant returns to scale (or constant cost), meaning that health outputs increases exactly in the same proportion in which factors of production are increased. It is thus, the MPSS most productive scale size. The optimal sizes of inputs correspond to the maximum values of inputs in these health systems: 1082$ for the health expenditure, 1.5 physicians and 1.4 hospital beds. At those thresholds, health system gives an outcome of life expectancy less than 75 years. Above these bounds, health systems will be characterized by decreasing returns to scale, meaning that increasing inputs will give unsatisfactory results concerning the outcome. The country with decreasing returns to scale represents the majority by 83%. It means, if inputs are increased in given proportion, health outputs increases in a small proportion. For example, if we increase health expenditure from 1082 to 2320$, physicians from 1.5 to 2.6 per 1,000 inhabitants, and hospital beds from 1.4 to 2.2 per 1,000 inhabitant (case of Kuwait), life expectancy will increase only from 75.4 to 75.6 years. For the case of Qatar, life expectancy will increase from 75 to 78.3 years although expenditure increases from 1082 to 3071, roughly three times; physician from 1.5 to 2 per 1.000 inhabitants; and a small decrease in beds from 1.4 to 1.2 per 1,000 inhabitants. This emphasizes that this weak performance although the high levels of devoted inputs compared to health systems with constant returns to scale is explained by the fact that health systems, such as the Kuwaiti and Qatari ones, are affected by the decreasing returns to scale which reach only 28.4% in the case of Kuwait, equal to a negative impact on health outcome of 71.6%. Results show that Gulf health systems have the lowest scale efficiency scores.

5.3. Tobit estimation results

The Tobit estimation seeks to identify factors correlated with inefficiency scores variation across countries. Table 7 shows the results of the Tobit model estimation of the seven variables explained the output relative efficiency scores. The likelihood ratio chi-square of 15.72 with a p-value of 0.0153 shows that model 1 as a whole fits significantly better than an empty model (i.e., a model with no predictors). The same conclusion for the model 2 since the probability is 0.0033. The correlation between the predicted and observed values of output inefficiency index is 0.5243 in the first model. If we square this value, we get the multiple squared correlation, this indicates predicted values share about 27.4% ($0.5243^2=0.274$) of their variance with the input inefficiency index. In the output model, the value is about 36.4%. This is equivalent to an increase of 9% as regard to the model according to the input-oriented model. The value of the ancillary statistic/ sigma is 0.3985 in the first model (0.0264 in the second model) can be compared to the standard deviation of inefficiency index which was 0.4073 (0.0301 in the second model), a slight increase (slight increase in the second model). Results show that three out of the six variables were statistically significant ($p<0.05$) in the case of model 1 and model 2, and hence we focused on the result from those two models.

Table 7: Relation between health production efficiency and influencing factors (2014)

Variable	*Model 1(Input)*		*Model 2 (Output)*		*Model 3(Input)*		*Model 4(Output)*	
	Coef.	Prob.	Coef.	Prob.	Coef.	Pro	Coef.	Prob
GDPC	0.0512	0.823	0.0039	0.791	2.0383	0.453	0.2173	0.222
GDPCsq	-	-	-	-	-0.1078	0.463	-0.0116	0.229
HEXPG	**0.2697**	**0.043**	**0.0173**	**0.082**	0.2036	0.162	0.0097	0.312
PRIV	**-1.2124**	**0.027**	**-0.0818**	**0.040**	**-1.0483**	**0.045**	**-0.0630**	**0.066**
URBAN	-0.0037	0.828	-0.0001	0.917	0.0019	0.915	0.0004	0.672
Literacy	-0.0104	0.349	-0.0011	0.122	-0.0086	0.428	-0.0010	0.129
CONTCORR	**-0.8468**	**0.020**	**-0.0769**	**0.016**	-0.6405	0.141	-0.0509	0.126
Constant	0.4425	0.850	0.0526	0.732	-8.7699		-0.9226	0.253
Correlation between dependent variable and yhat*	0.5243		0.6038		0.5499		0.6825	
Correlation^2	27.4%		36.4%		30.2%		46.5%	
Log likelihood	-7.7664279		17.517008		-7.4749512		18.30618	
LR chi 2(5)	15.72		19.61		16.30		21.19	
Prob > chi2	0.0153		0.0033		0.0225		0.0035	
Ancillary statistic/sigma	0.3985309		0.0264334		0.393799		0.024577	

*yhat : predicted values.
Source: Stata 11.2 output.

The results from model 1 and model 2 showed that GDP per capita has a non-significant impact on the efficiency of health systems. The results reveal that technical inefficiency (TIN) instead of technical efficiency (TE) according to the input-oriented approach is positively and significantly related to health expenditure as a percentage of government expenditure, in both models. In fact, if this spending increases by one point, the expected inefficiency instead of technical efficiency would increase by 26.9% in the case of Model 1 and by 1.7% in the case of Model 2, all else being equal. This can be explained by the fact that the augmentation of input resources (financed by public finance) is even accompanied by a misallocation (under or over-use of resources) and generates a corruption process. However, the government budget could be financed by public and private providers, such as in some high income countries; or overall financed by public funding especially in middle income countries. Therefore, the contribution of this variable to efficiency should be taken with caution and it would be best to examine this relationship case-by-case.

For Models 1 and 2, the result shows that the higher the predicted value of private health spending ratio (as a percentage of GDP), the less inefficient is the selection of resources, all else being equal.

If urban population level increases by one point, the expected inefficiency instead of efficiency score would decrease by 0.3% while holding all other variables in the Model 1 constant. In Model 2, the urbanization level also pulled down inefficiency instead of efficiency. Thus, health service accessibility enhances the resources-use efficiency, meaning that the bigger the population density in an area, the lower the inefficiency (the higher the efficiency) and this finding may be associated with the easy access to health services. This shows that higher accessibility of health services is in significant correlations with higher efficiency (Zhang *et al.*, 2007) and a more share of people for particular health programs. Therefore, this may improve health production outputs.

Adult literacy has a negative but not significant impact on the predicted inefficiency instead of efficiency. The evidence is not conclusive for the education and this indicates, in a certain degree, that education in some countries may be not ideal although it has a crucial role in raising efficiency according to some studies. We note that the impact of schooling on inefficiency varied from one study to another. Jaouadi (2007) found a negative and non significant coefficient. Jayasuriya and Wodon (2003) and Afonso and Aubyn (2006) were found a negative and significant relationship. It will be erroneous to consider that schooling does not have enough negative (positive) and strong effect on inefficiency (efficiency). The spread of health culture in society and the improvement of human capital within health institutions would improve the selection (input approach) or exploitation (output approach) of health resources.

Inefficiency instead of efficiency is negatively and significantly related to the control of corruption in Models 1 and 2. The control of corruption is more important when considering health resources selection (input model) more than health resources exploitation (output model). The higher the index of control of corruption by one unit, the lower is the predicted value of inefficiency index by roughly 84.6% (input model) and 7.6% (output model), holding all variables constant. Therefore, control of corruption could positively affect the use inputs of health services and the health service delivery environment. This highlights the importance of control of corruption within health decision-making institutions, especially through the steps and measures necessary to prevent various forms of corruption, supervision and institutional guidance to achieve the needs of the community. Thus, establishing transparent and effective accountability mechanisms contributes to better selection of health resources and to improve health outcomes.

Now, in Model 3 and Model 4 we introduce squared GDP per capita. The point of adding this variable is that we assume that the relationship wears off at a certain point. Results showed that GDP per capita affects, but non-significantly, the efficiency. As the economic status improved, the inefficiency (efficiency) of the health system increased (retrogressed) until GDP per capita reached the level of $12,654 for the case of input approach (Model 3) and $11,388 for the case of output approach (Model 4); then the inefficiency (efficiency) declined (increased) as the economic status grew. These thresholds are obtained by solving the Tobit equation after taking the derivative with respect to GDP per capita. Sun *et al.* (2017) found a threshold of GDP per capita of $10,097 after which the efficiency declined as economic status grew, by implementing a pooled efficiency scores as dependent variable for a sample of 173 during the time span 2004-2011. The thresholds in our paper concern the year 2014 and since the coefficient is not significant we cannot judge this impact. Nevertheless, overall and based on the findings in the Tobit regression model, we reject the hypothesis that health efficiency does not affected by factors outside the health sector.

6. Conclusion and policy recommendations

The aim of this paper was to throw light on the health efficiency and its determinants in MENA countries, and therefore to provide a background for discussion. Analysis showed that the overall health situation, measured in terms of life expectancy at birth, in the MENA countries region has improved since the last decades. More importantly, the empirical results revealed the importance of measuring efficiency in order to achieve the objectives of health policies, such as optimal selection (input approach) or optimal exploitation (output approach) of the available resources. Therefore, measuring efficiency can be considered as an important tool to assess health policies and to identify strengths and weaknesses. By using DEA approach, the result showed that the input efficiency scores are somewhat different between countries, in contrast to the output efficiency indicators that appear more closely. This indicates that MENA countries are far on the selection of resources which still requires a great improvement compared to the efficiency of resource exploitation. It’s worth noting that efficiency is considered and interpreted as a relative rather than as an absolute index.

Based on the findings reported in this study, most of MENA health systems appear to be operating, on average and upon the output-approach model, with a reasonable high degree of technical efficiency compared to the input model. This comes as a result that these countries focus more on the health output, and the difficulties of improving the efficiency of resources utilization for many reasons, such as the institutional environment which still needs development and follow best practices.

In 2014, the DEA results indicated that the average efficiency scores for all health systems was 78.7%, under the input-oriented approaches, indicating a potential savings of 21.3% of total health resources to achieve current health status for population if all inefficient countries performed as well as their peers. The results also showed that the health outcome would be increase by 2.1% if the funding were appropriately allocated and used. The input efficiency gap between the top 25% health systems and the bottom 25% health systems is substantial (100% vs.56.4% in 2014) while for the output efficiency the gap is small (100% vs. 95.8% in 2014). Also, the paper explored how health system efficiency has changed over time and it showed that efficiency score increased for some countries and decreased for others; but overall, in average, MENA countries recorded a decline in 2014 which was more pronounced when considering the input model.

In addition, achieving optimal levels of efficiency is not associated with belonging to high income groups. Results show that lower-middle income countries can be a reference for efficiency and best practices in utilization and in exploitation of health resources. Thus, the degree of economic development is not a criterion to measure the efficiency of health system. It is crucial noting that in countries with similar economic status, the efficiency of health system can be widely different. Moreover, the findings indicate that desirable outputs targets could not be reached but the country could be on the efficiency frontier. The analysis suggests that there are considerable efficiency gains yet to be made by some MENA health systems. DEA result showed also that for countries with low efficiency score and low health outcome, enhancing the efficiency is a fundamental issue because large outcome gains can be realized by strengthening the efficiency scheme.

Overall and with reference to the first stage of the analysis, this study suggests some policy recommendation: *i)* Ensuring that the health system's policies are outcomes-based, *ii)* Creating incentives for adoption of best practices, *iii)* Follow-up and assessment of health reform through the implantation and adoption of the management by objectives approach, and *iv)* Make data concerning health resources (costs and charges) available and reliable by, for example, providing electronic information capabilities. Improving efficiency has advantages not only in terms of health outcomes but also in terms of the generated gains that may be reallocated, for example, re-prioritize health intervention and expand these generated gains to disease control.

This cross-country analysis of efficiency strongly confirmed that health systems have evolved in response with a host of economic, social and institutional backgrounds. Indeed, health systems are subject to some issues, especially in relation to financing, inclusiveness, geographic factors, or governance. The study of the determinants of efficiency addressed the factors that constitute bottlenecks to efficiency improvement both with resources use and with resources exploitation such high public spending, low private spending capacity, education-heath mismatch, dispersed population, and low control of corruption. It includes variables related to the health sector and others outside the scope of the health authorities. The coefficients of the second stage analysis have the expected sign. The results showed a negative (positive) impact of public health expenditure as a percentage of government expenditure on the efficiency (inefficiency). We argued that this relationship should be taken with caution and it would be important to examine it case-by-case. The results revealed also a positive effect of private health expenditure as a percentage of GDP, population density, adult literacy, and control of corruption on the efficiency indicators. Hence, it is important to check out these determinants to address the causes and extent of inefficiency and whether health decision makers in health organizations can directly control this sector, or it is also subject to other factors beyond the scope of these organizations.

Based on the mentioned findings of the second stage of the analysis, the study proposes some policy recommendations that have now become standard. Efficiency is a key pillar in the health system management and should be seen as the result of a complex production process that involves interrelationships among many variables including economic, demographic, and institutional factors. More importantly, increases in health expenditure alone do not necessarily ensure high level of efficiency. Improving the access and the ability of people to use the health service effectively, and removing unfavorable institutional environment could achieve health efficiency goals and therefore could enhance health outcomes in accordance with the fundamental principles of SDGs Agenda. The key suggestions concern a reduction of poverty and providing equitable access to health care among populations with different incomes. An improvement in the supervision of the performance of health institutions and an establishment of the principles of good governance and control of corruption that include a better understanding of what constitute best practices could also contribute heavily to achieve heath targets. Finally, concerns may include developing and boosting programs and strategies for the advancement of the health sector based on effective methods based on, economic, social, population and preventive measures, in a fluid and complementarily approach.

Further researches are considered necessary to inform future health policies aimed at boosting both the technical and scale efficiency and sustainability and inclusiveness of the MENA health systems. Also, future investigation with regard to the health systems' organization and funding in these countries would be essential to identify with accuracy the contribution of public spending, as a share of total government expenditure, to the health efficiency.

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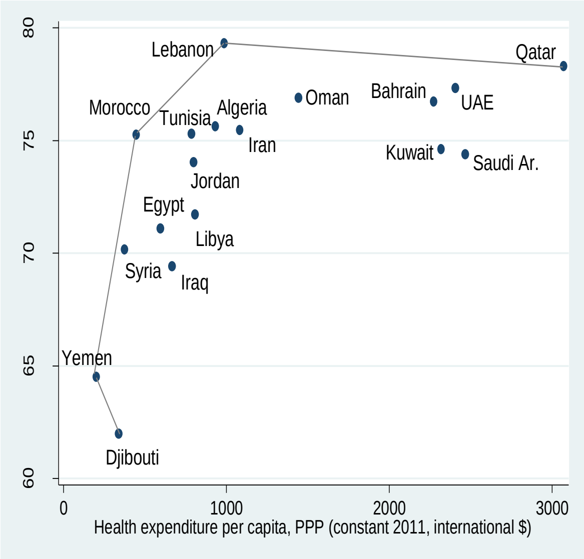
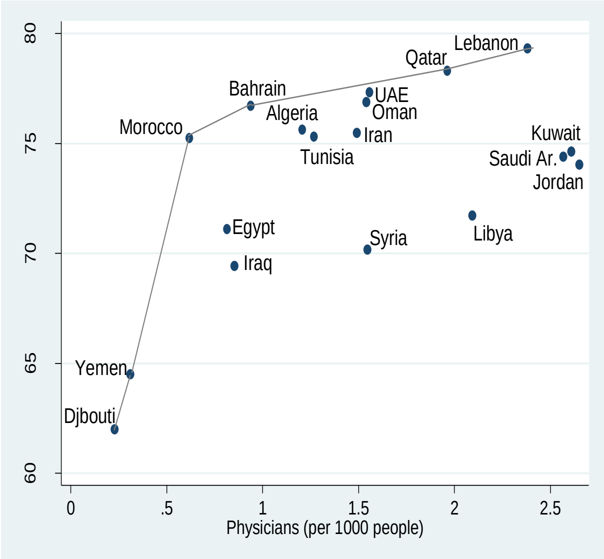
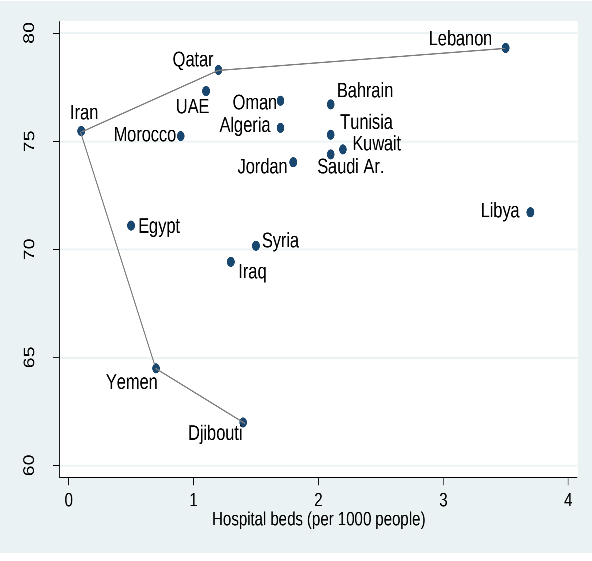
Appendix 1: Scatter plots of Life expectancy at birth with each input (2014; 18 countries)







Appendix 2: Selected economic and social indicators (2014; 18 countries)

		Indicators	Income group: All	High income	Upper-middle income	Lower-middle income
Health care resources	Health care labor	Physicians (per 1,000 people)	1.48	1.86	1.71	0.70
	Hospital capacity	Hospital beds (per 1,000 people)	1.64	1.73	2.03	1.00
	Health expenditure	Health expenditure, public (% of GDP)	3.22	2.83	3.90	2.74
		Health expenditure, private (% of GDP)	2.26	0.86	2.60	3.46
		Health expenditure, public (% of government expenditure)	8.76	7.62	11.06	6.90
		Health expenditure per capita, PPP (constant 2011 international $)	1221.73	2329.50	865.33	391.35
		Out-of-pocket health expenditure (% of total expenditure on health)	33.13	13.47	33.64	56.00
Health outputs/outcomes		Life expectancy at birth (years)	73.46	76.38	74.42	68.61
		Maternal mortality ratio (modeled estimate, per 100,000 live births)	71.7	11.3	52.0	171.8
		Mortality rate, infant (per 1,000 live births)	17.8	8.4	15.9	32.0
		Births attended by skilled health staff (% of total)	90.75	99.20	93.60	76.62
		Immunization, DPT (% of children ages 12-23 months)	88.56	96.33	89.86	77.40
		Immunization, measles (% of children ages 12-23 months)	88.39	98.00	88.43	76.80
Economic and social indicators		GDP per capita, PPP (constant 2011 international $)	28308.9	64982.9	13317.2	5288.5
		Human Development Index (2014)	0.721	0.826	0.734	0.575
		Gini coefficient	34.7	33.7	33.3	37.9
		Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population) (*)	-	5.42	18.68	47.23
		Fertility rate, total (births per woman)	2.68	2.21	2.70	3.22
		Adolescent fertility rate (births per 1,000 women ages 15-19)	25.60	13.61	24.36	41.71
		Population ages 65 and above (% of total)	3.95	1.95	5.35	4.41
		Urban population (% of total)	74.0	88.6	75.5	54.3
		Adult literacy rate, population 15+ years, both sexes (%)	83.41	95.40	82.19	70.72
		Employment to population ratio, 15+, total (%) (modeled ILO estimate)	49.9	68.0	39.6	42.5
		Improved sanitation facilities (% of population with access)	88.31	98.57	90.06	73.54
		Improved water sources (% of population with access)	92.28	98.17	93.33	83.96
Governance indicators		WGI political stability (-2.5 to 2.5)	-0.93	0.26	-1.39	-1.74
		WGI government effectiveness (-2.5 to 2.5)	-0.31	0.29	-0.43	-0.84
		WGI Regulatory Quality (-2.5 to 2.5)	-0.44	0.26	-0.67	-0.95
		WGI Rule of Law (-2.5 to 2.5)	-0.37	0.21	-0.56	-0.81
		WGI Control of Corruption(-2.5 to 2.5)	-0.39	0.29	-0.60	-0.92

(*) statistics are for developing countries.
Source: WDI, WGI, WHO and UNDP.

Appendix 3: Descriptive statistics (18 countries)

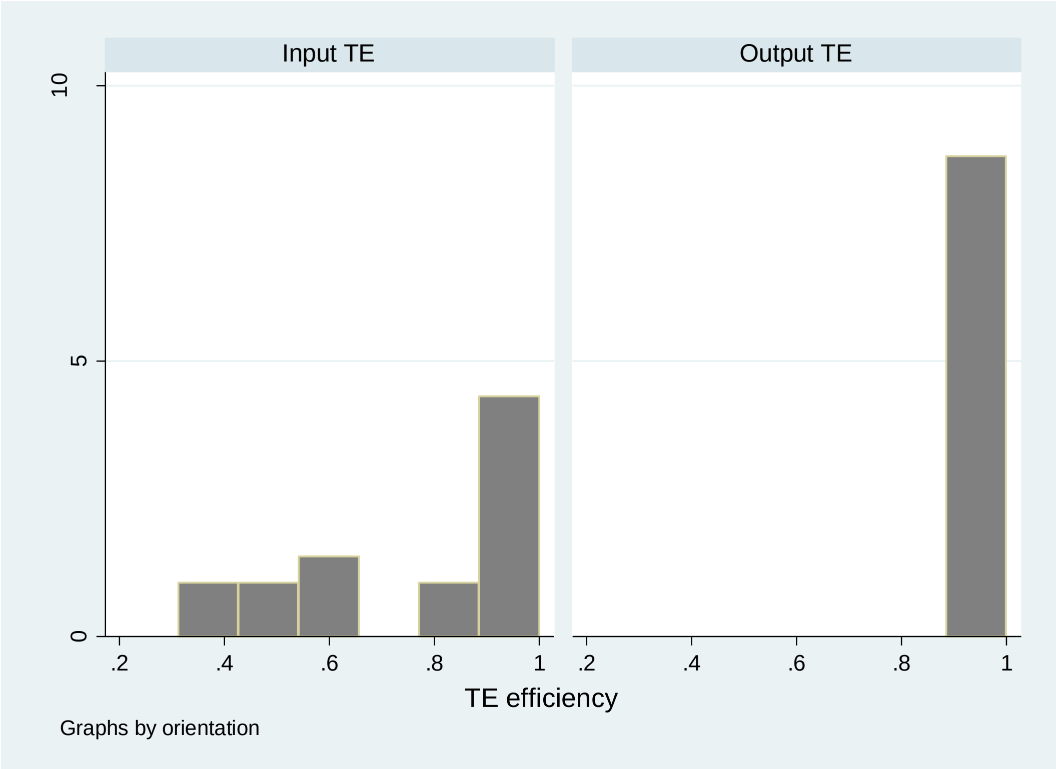
	Input variables								
	Expenditure per capita			Physicians per 1,000 inh.			Beds per 1,000 inh.		
	1997	2005	2014	1997	2005	2014	1997	2005	2014
Min	66.65	109.30	202.16	0.14	0.18	0.23	0.65	0.60	0.10
Max	2400.17	3120.86	3071.19	2.10	2.90	2.65	4.30	3.60	3.70
Range	2333.52	3011.56	2869.02	1.96	2.72	2.42	3.66	3.00	3.60
Mean	791.70	866.90	1221.73	1.11	1.39	1.48	2.05	1.96	1.64
Std dev	797.06	805.44	883.45	0.60	0.79	0.77	0.83	0.79	0.92
Coef varia	100.68	92.91	72.31	53.73	56.70	52.29	40.41	40.39	56.09
	Output variable			Efficiency scores					
	Life expectancy			Input efficiency			Output efficiency		
	1997	2005	2014	1997	2005	2014	1997	2005	2014
Min	57.01	57.98	61.99	0.463	0.437	0.312	0.932	0.924	0.915
Max	76.14	77.02	79.33	1.000	1.000	1.000	1.000	1.000	1.000
Range	19.12	19.04	17.33	0.537	0.563	0.688	0.068	0.076	0.085
Mean	69.87	71.83	73.46	0.790	0.836	0.787	0.982	0.985	0.979
Std dev	4.80	4.94	4.61	0.219	0.205	0.261	0.021	0.021	0.029
Coef varia	6.87	6.88	6.27	27.68	24.57	33.118	2.12	2.15	2.960

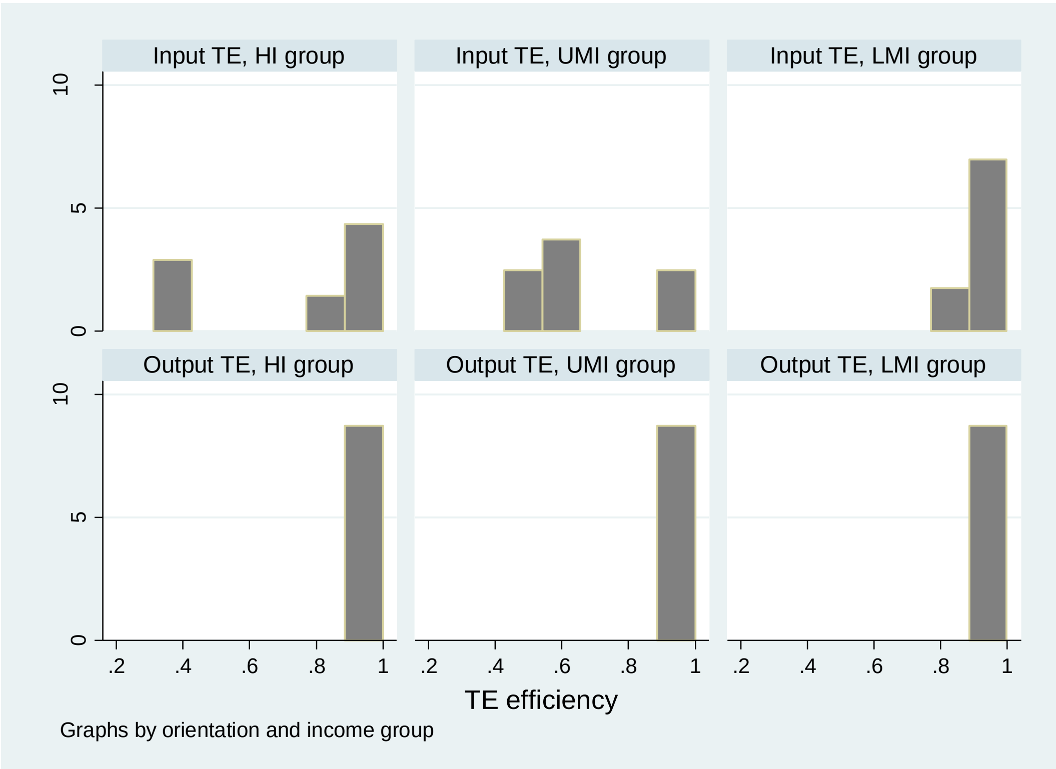
	Influencing factors to be analyzed (2014)				
	Pub. exp	Priv. exp	Pop.dens	Literacy	Corrup.
Min	3.93	0.31	3.53	43.70	-1.56
Max	17.53	4.37	1733.33	97.70	1.20
Range	13.60	4.05	1729.80	54.20	2.76
Mean	8.76	2.26	195.33	83.41	-0.39
Std dev	3.95	1.35	403.67	16.04	0.83
Coef varia	45.14	59.78	206.67	19.23	-212.04

Appendix 4: Efficiency of health systems by quartiles (1997, 2005 and 2014)

		Input-oriented model			Output-oriented model		
		1997	2005	2014	1997	2005	2014
Percentiles	25	0,567	0,655	0,564	0,965	0,972	0,958
	50	,840	1,000	0,936	0,989	1,000	0,997
	75	1,000	1,000	1,000	1,000	1,000	1,000

Appendix 5: Density of efficiency scores in 2014





Appendix 6: Summary of different production models of MENA countries

	1997		2004		2014	
	Input	Output	Input	Output	Input	Output
High efficiency High output	Bahrain Qatar Syria Tunisia	Bahrain Qatar Syria Tunisia	Bahrain Lebanon Qatar Syria Tunisia UAE	Bahrain Lebanon Oman Qatar Syria Tunisia UAE	Bahrain Iran Lebanon Oman Qatar UAE	Algeria Bahrain Iran Lebanon Morocco Oman Qatar Tunisia UAE
High efficiency Middle output	Iran Iraq Morocco	Iran Iraq Morocco	Iraq Morocco	Iraq Morocco	Egypt Syria	Egypt
High efficiency Low output	Djibouti Yemen	Djibouti Yemen	Djibouti Yemen	Djibouti Yemen	Djibouti Yemen	Djibouti Yemen
Middle efficiency High output	Jordan Oman	Jordan Kuwait Lebanon Oman Saudi Arabia UAE	Algeria Iran Jordan Kuwait Oman Saudi Arabia	Algeria Iran Jordan Kuwait Saudi Arabia	Algeria Jordan Tunisia	Jordan Kuwait Saudi Arabia
Middle efficiency Middle output	---	Algeria Libya	---	Libya	Iraq Libya	Syria
Low efficiency High output	Kuwait Lebanon Saudi Arabia UAE		---		Kuwait Saudi Arabia	
Low efficiency Middle output	Algeria Egypt Libya	Egypt	Egypt Libya	Egypt	---	Iraq Libya

Note: Obtained from the analysis of the result of Table 3, with Ward cluster analysis applied in terms of health production efficiency and output on the frontier and non-frontier provinces separately.

Appendix 7: Correlation between inputs and outputs

	Life expectancy (years)	Health exp. Per capita	Physicians/1,000 inhabitant	Beds/1,000 inhabitants
Life expectancy (years)	1.000			
Health exp. Per capita	0.060*(0.0077)	1.0000		
Physicians/1,000 inhabitant	0.5693*(0.0137)	0.5083*(0.0312)	1.0000	
Beds/1,000 inhabitants	0.2522(3126)	0.01181(0.6408)	0.5458*(0.0191)	1.0000

Appendix 8: Correlation between efficiency scores and input variables

	Input efficiency scores	Output efficiency scores
Health exp. per capita	-0.1503(0.5517)	0.0115(0.9640)
Physicians/1,000 inhabitant	-0.5755*(0.0124)	-0.4016(0.0986)
Beds/1,000 inhabitants	-0.4748*(0.0465)	-0.4429(0.0656)