Health Expenditure Efficiency: An Analysis Using DEA and Malmquist Index Methods

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Abstract: This article analyses the efficiency of public spending on health. Therefore, a literature review on the role of public spending in the health sector and explain the concept of efficiency is conducted. The study estimates the degree of efficiency using the DEA method and the Malmquist Index for a panel of 16 lower and upper middle-income countries over the period 2010-2020. The results show that to boost efficiency, countries do not necessarily need to increase public spending on health, as poorly managed public financing leads to wasteful inefficiency in the health sector. Thus, when one adds one more input (number of doctors, number of nurses, or number of beds per capita), efficiency improves and countries achieve similar health outcomes in terms of the "life expectancy" output.

Keywords: Efficiency, Data Envelopment Analysis, Public expenditure, Health, Malmquist Index.
JEL classification: D61, C60, H50, I20, I10.

INTRODUCTION

The question of the efficiency of public spending is particularly acute in key sectors such as health (WHO, 2008). The health system provides a vision of the health status of the population and, as a result, the constant increase in spending in this sector is crucial, regardless of the degree of development of the country concerned.

Health is a state of bodily, mental and social well-being and does not consist solely of the absence of pathology or infirmity. We recall that health considered from an economic point of view consists in applying the concepts and methodologies of economics to the medical and social-health fields. It evaluates the cost-health ratio and its impact on the general economy, on state and local budgets, on company management and on social policies. In this sense, the financing of health expenditure involves several actors: social security, the public domain (State and local authorities), mutual insurance companies and the private domain (households and insurance companies).

At this level, the concept of development is fundamentally positioned in the social circumstances of the nation; it designates a set of technical, social, territorial, demographic, and cultural transformations accompanying the growth of production. If development economics is a field of economic thought whose objective is to help lagging countries catch up with those that are ahead of them, especially in terms of per capita income, then it must be one of the oldest fields of current economics.

Ensuring the good health and well-being of citizens is essential if we are to eradicate poverty, achieve sustainable development, contribute to economic growth and ensure prosperous communities. Indeed, health is a matter of productivity and therefore of economic development. Indeed, "only a healthy man can get a good education and thus contribute to the productive capacity of a country," explained theorists. Hoang, T. D., Ky, N. M., Thuong, N. T. N., Nhan, H. Q., & Ngan, N. V. C. (2022). Several determinants related to social justice result from an unequal distribution of a multitude of social determinants such as gender, country of birth, family composition, income, education, occupation, social support, but also other more global determinants, such as social policies.

According to the World Health Organization, "The health system includes all organizations, persons and actions whose purpose is to promote, restore or maintain health. This includes efforts to influence the determinants of health as well as more direct health improvement activities" (WHO, 2007). While emphasizing that the two objectives that economies wish to achieve are improved health and financial security, the extent to which these objectives are achieved is measured by two criteria: efficiency and effectiveness.

Looking at the history of health systems worldwide, it appears that all countries share the same goals of providing support to poor patients, ensuring compensation for sick workers, and providing access to treatment for all. In this wake, developing countries have progressively committed to address the very limited resources to meet the basic needs of the entire population, with special attention to the health system. According to WHO (2017), half of the world's population does not have access to essential health services, added to this is the inefficiency of developing countries to mobilize resources for health and for human capital. Indeed, the performance of a health system is conditioned by the capacity of countries to respond to the health needs of all social strata in the most efficient way.

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For contemporary theorists, a profound discussion of the relationship between economic and efficiency interactions is crucial. At this level, IbrahimaThiam, Dan Entseya (2021) emphasize the need to focus more on the question of how these resources are used. Indeed, a significant improvement in the health situation could be obtained if health financing is ensured by technical and allocative efficiency gains.

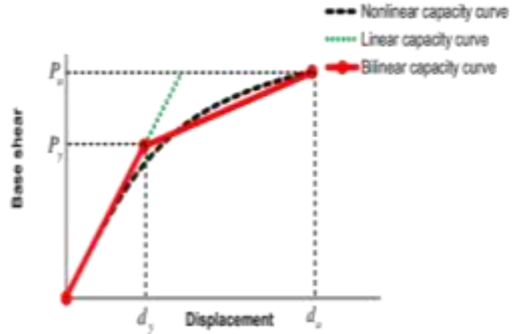
Thus, according to the work of Didier Houssin (2022), the efficiency of countries' health systems is judged on the following bases:

- The level of health and its distribution: At the national level, the State intervenes directly in the financing and organization of the health care offer. The State is the guarantor of the general interest, of the protection of the population's health and of the coherence of the initiatives of the health actors.
- The reactivity of health systems in poor areas: Areas with a poor population are, from a health point of view, areas at risk. Epidemiologically, the reappearance of diseases threatens inhabitants who lack financial resources and live in degraded and under-equipped environments (Marcel-Louis Viallard, 2022). Poor households without social security coverage prefer self-medication and the use of less expensive medicinal plants. These households wait until the state of health deteriorates before consulting a specialist doctor, and it becomes necessary to use all strategies to pay for the consultation, analyses, and medicines.
- Equity of financial contribution: Poor households with no social security coverage prefer self-medication and the use of less expensive herbal medicines. These households wait until their health condition deteriorates before consulting a specialist doctor, and it becomes necessary to use all strategies to pay for the consultation, tests and medicines.

The effect of public expenditure on health status is generally moderate, which implies a loss of intangible resources and leads to deep health crises. It should be noted that the latter consider the financial aspect as a crucial dimension for good governance and to achieve good results (efficiency). In parallel with the implementation of state and multi-dimensional control panels. This suggests that spending more is not necessarily the solution to improve health outcomes, but spending better may be a crucial axis for economic and human development (Bourdillon. F, 2022).

It is also paramount to consider that the efficiency of public spending and resources depends in principle on fiscal potential and also on the political will to make budgetary trade-offs in favor of health. And it is questionable whether governments are willing to allocate more resources to health and have more rational spending (Durand-Zaleski. I, 2013).

According to Geffroy. L, (2022), the preferences and needs of the populations are basic foundations of the efficiency of the expenses in the field of health, in particular the satisfaction considers itself an important pillar of efficiency. Also the phenomenal peculiarity of the citizens mentions a degree of satisfaction that changes in time and in the economic and social circumstances. This has been determined in the applications of the capacity curves highlighted in the works of efficiency of public expenses of Monier, A. Hocquette, J. Zeitlin (2022). They show realistic differences on public spending based on the principles of territoriality, it approves the capabilities of each region and its primary needs in terms of a single social or economic dimension determined by a simplified graphic illustration:



Most of the research that has analyzed health expenditure efficiency has focused on a single country or a specific geographic area. This paper proposes to analyze for the first time the efficiency of health expenditure in a wider panel of countries at different levels of development

We propose in this paper an empirical study to test the efficiency of health expenditures using the DEA (Data Envelopment Analysis) method and the Malmquist index for a panel of 16 lower and upper middle-income countries over the period 2010-2020. To this end, section 1 provides an overview of the theoretical and empirical literature and introduces the concept of efficiency. Section 2 describes the DEA method and the Malmquist index. The discussion of the results is presented in section 3.

1. LITERATURE REVIEW

In its general sense, efficiency refers to the evaluation of the productivity of a factor or unit of production. More precisely, it is a question of comparing the achievements to the means mobilized: efficiency measures the production capacity at the least effort or expense. It can be analyzed as an indicator of theefficient use of resources for the production of goods and services.

According to Farrell (1957), the concept of efficiency can be broken down into three types: technical, allocative and economic efficiency.

Technicalefficiency

Technical efficiency, also known as physical efficiency, refers to the optimal use of resources to achieve a given objective. It measures the ability to avoid waste. Thus, a country is said to be efficient when it is impossible to produce more without impacting expenditure, or, conversely, to produce the same quantity of goods or services with fewer inputs. In this context, and at an equal level of expenditure, efficient countries are those that maximize their production.

Allocativeefficiency or Price

The concept of allocative efficiency leads to the selection of the shares of the different inputs for which market prices are competitive. In this framework, we speak of efficiency when the marginal rate of substitution between factors of production and the share of prices are in equilibrium. In the framework of allocative efficiency, the price of the factors of production comes into play, in the sense that efficiency focuses, for a given production, on the combination of inputs that allows costs to be reduced.

Economicefficiency

This concept includes the products of both categories of efficiency (Coelli et al, 1998). Thus, a decision level that uses resources to increase output while reducing costs is considered efficient. According to Evans et al (2000), expenditure efficiency postulates the optimal use of inputs for the production of goods and services. It is assessed by comparing the output produced with the optimal output from a given input. In the context of efficiency measures, there are two approaches:

-the input-oriented approach consists of the capacity to produce goods or services from a given (low) level of inputs. Efficiency is then evaluated according to the quantity of inputs used in each level. At the state level, a state is considered more efficient when the share of GDP allocated to a given sector is greater.

the output-oriented approach is based on the maximum production of goods and services based on a given input, with efficiency being reflected in the objectives achieved. The most efficient states here are those with the highest levels of education and health, regardless of the level of resources or expenditure mobilized.

On the theoretical level, the literature identifies various theoretical approaches that deal with the importance of public spending in economic and social development. In this framework, the state plays the role of regulator insofar as it makes up for market failures (monopolies, etc.) in order to ensure the well-being of the population.

According to the thesis of Musgrave (1959), who considers the state to be an agent that exercises a fundamental regulatory function in the economy, with the following main functions: (i) the optimal allocation of scarce resources, in order to make the most of them for the well-being of the community (allocation function); (ii) the equitable distribution of income among individuals (redistribution function); (iii) ensuring macroeconomic equilibrium (stabilization function).

Peacock and Wiseman (1961) consider that public expenditure evolves in concomitance with social disturbances, particularly wars. The shift from one level to another is called the "displacement effect". This effect would demonstrate the reasons why government spending changes over time. When a social upheaval occurs, taxpayers are willing to make significant financial efforts. Otherwise, taxpayers accept the need to increase public spending in times of social crisis.

The role of public spending has been revived since the 1990s, spurred on by the work of Barro (1990), who developed an endogenous growth model incorporating public spending. According to this author, public capital is a form of physical capital that results from investments made by the state and local authorities. This public capital also includes investments in the education and research sectors.

Empirically, most work focuses on the efficiency of public spending in areas such as health and education. Given the multiplicity of factors (inputs, outputs, others) as well as the form of the production function, the literature has shown a strong interest in assessing the performance of this key sector.

We will focus on the only empirical studies that have employed the data envelopment analysis (DEA) method to assess the efficiency of the health system. In this regard, we could first mention the study by Asanduluia, and al (2014), conducted during 2010, an assessment of the level of efficiency of their health system within 30 European states. To do this, they used the DEA method and highlighted the inefficiency of most of the countries. They underline that having limited resources does not necessarily mean inefficiency. In Romania and Bulgaria, for example, despite the high infant mortality rate and a lower number of medical staff than in other EU countries, the efficiency rate is high. Paradoxically, while some states have a high GDP per capita, there is inefficiency in public spending on the health sector.

Djoufack (2016) also looks at the efficiency of public spending in the medical sector and finds that it has a more significant impact on GDP than the quantity of spending. To do so, he uses the DEA-Malmquist input-oriented method to assess the degree of efficiency and its impact on economic development based on the theoretical SOLOW growth model (augmented by the Mankiw, Romer and Weil model).

The author thus concludes that public spending on health is inefficient in the CEMAC zone and that the effect of this spending on economic growth depends on the efficient management of these resources.

Closer to home, the work of Antonelli and Valeria (2018) focuses on the level of performance of social public spending in European states, during 2013. They use two non-parametric approaches (DEA and FDH). The second step is to use an econometric study to highlight the various factors that explain the differences in efficiency between the states. The authors point out that states with greater efficiency have a higher GDP and level of education, a better level of social protection and less corruption.

For his part, Aron (2019), in a study carried out in Indonesia during 2015, in the framework of the DEA method, reveals that certain regions show better accessibility to care (higher technical efficiency), such as North Sumatra, DKI Jakarta, West Java (West), East Java (East) and South Sulawesi. On the other hand, three of Indonesia's 34 provinces show an insufficient level of care (and therefore a low efficiency rate): Bangka Belitung Island, Gorontalo and Maluku.

According to the author, this is less a result of insufficient funds or support from the central government than of the local management of these funds (especially how they are used and optimized). There are, in fact, several elements for optimizing these funds: technological advances, the form of financing, the degree of coverage and the administrative system.

We can also cite the work of Perpeiet al. (2019), conducted in 2015 in the provinces of China, highlighting differences in healthcare efficiency across the 31 provinces. Using data from the 2015 Annual Report on Maternal and Child Health, the 2016 National Health Reports,and from the China Center for Disease Control and Prevention, these authors highlight that improving health system efficiency represents a compelling element in maximizing resources and improving health.

On a larger panel of Asian countries, Sayem et al (2019) assessed the efficiency of public spending on health in 46 Asian countries for the year 2015. They first use the DEA method in 46 Asian countries to assess the efficiency of public spending per capita (inputs). In terms of outputs, they use the criteria of life expectancy at birth and infant mortality rate per 1000 inhabitants. Secondly, regression and the Bootstrap method are used to determine the factors that determine the efficiency of the health system. The physical variables used relate to the number of doctors (per 1000 inhabitants), the number of hospital beds, the prevalence of smoking, the rate of men (73% of adults) and the primary school completion rate (27% of the age group concerned).

In the same vein, Top et al (2020) examine the efficiency of health systems in 36 African countries using the DEA method over the period 2010-2015. Their results reveal that 58.33% are efficient. They also find that the number of nurses per 1000 people and the Gini coefficient variables significantly influence the inefficiency of health systems in Africa.

Studying the case of 3 Maghreb countries (Algeria, Morocco, and Tunisia), using the DEA method, Ziani (2021) finds that countries can achieve the same health outcomes by reducing their public expenditures by 9% to 10.7%. Morocco and Tunisia are shown to have the most efficient health systems in terms of health production, while Algeria remains the most inefficient.

In turn, Ghernouk (2021) finds that the degree of efficiency is captured by variables and components referred to as inputs. When adding one more input such as the number of doctors or nurses efficiency improves and countries achieve similar health outcomes as calculated by life expectancy or mortality rate using the DEA method and the Malmquist Index for a panel of 20 lower and upper middle income countries over the period 2011-2017. The results show that to boost efficiency, countries do not necessarily need to increase public spending on health, as poorly managed public financing results in wasteful inefficiency in the health sector.

Ghernouk et al. (2022) estimated the efficiency score in the health sector in the covid era19 . Several factorial axes were mentioned as elements of treatment and analysis. We would like to estimate by the scientific works of analysis DEA approved by the axis of efficiency stimulating the results of the financing strategies. The results show that the countries studied (Morocco, Algeria, France, Spain, and Tunisia) can achieve similar health benefits by reducing their expenditures by 6% to 4% on average. Therefore, adding one more input (number of doctors, hospital beds, ventilator, resuscitation hospital beds, resuscitation doctors) leads to an improvement in the efficiency of health systems.

1. METHOD

To evaluate the level of performance and efficiency of public intervention in the health sector, our work will be based on the application of the DEA (Data Envelopment Analysis) method, as it is simple and easy to implement and does not require the use of sophisticated econometric tools. And to analyze the evolution of technical efficiency, technical progress, and total factor productivity (TFP), we use the Malmquist index.

1.1. Theoretical Foundations of the DEA Method

The "Data Envelopment Analysis" methodology was introduced by Charnes (1978) with the objective of measuring the performance of the US federal system of resource allocation in certain school follow-up programs. This approach is used in a variety of fields, from private insurers, banks, commercial and manufacturing companies, to public organizations, because it requires relatively few constraints.

This method highlights the best-performing units from relatively homogeneous data and allows us to highlight the inefficiency scores of each unit compared to its practices. The approach adopted here is a benchmarking one, in the sense that it consists of evaluating the best practices by assigning them a score and then using them as a reference. It thus highlights the source of inefficiency, which is of undeniable interest from a managerial point of view (Epstein and Henderson, 1989).

To fully understand the DEA method, it is necessary to clarify that each decision unit uses a quantity of inputs $Xj = [xij](1,2, \dots .)$, with the goal of producing a quantity of outputs $Yj = [yij](1,2, \dots .)$, and thus the efficiency of each DMU is calculated using the formula:

Ek = weighted sum of outputs⁄weighted sum of $inputs$

With: k: the number of decision units.

There are two variants of the DEA method in the literature: the CCR model (Charnes, Cooper and Rhodes, 1978) which assumes constant returns to scale (CRS model) and the BCC model (Banker, Charnes and Cooper, 1984) which assumes variable returns to scale (VRS model). The CRS model assumes that an increase in inputs leads to a proportional increase in outputs. In the VRS model, the number of outputs is used to define the number of inputs in a proportional way.

1.2. Presentation of the Malmquist Index

The Malmquist index is defined as the ratio of Output/Input added to total productivity, which varies according to the efficiency of the production process and the type of technology used. Measuring the increase in productivity of a firm or a country over time implies decomposing this term into two basic components: the improvement in technical efficiency and the technological transition. Similarly, the Malmquist index measures the overall change in all-factor productivity relative to other benchmark years, thus distinguishing the change in efficiency over time (Färe, Grosskopf, Ross, 1994).

This metric is calculated empirically in terms of a distance function, based on linear programming, and compares the output received in period t to the inputs of that period to those realized in period t+1 to those of that period. The decomposition of this index allows units to track the speed of market leaders in innovation and technological performance increases over time.

This Malmquist synthetic index is the geometric mean of the two indices as defined by Caves, Christensen, and Diewert (1982) so as not to choose a particular benchmark, i.e. : In this formulation, the technology at time t serves as the reference technology. This distance function estimates the largest proportional change in output required to make (yt+1, xt+1) feasible relative to the technology at time t. It calculates the difference between an experiment and the technology frontier.

This index can be rewritten as follows following Färe et al. (1994):

$$M_0(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t) = \left[\frac{D_{0,CRS}^{t+1}(x_i^{t+1}, y_i^{t+1})}{D_{0,CRS}^{t}(x_i^{t}, y_i^{t})}\right]\left[\left(\frac{D_{0,CRS}^{t+1}(x_i^{t+1}, y_i^{t+1})}{D_{0,CRS}^{t+1}(x_i^{t+1}, y_i^{t+1})}\right)\left(\frac{D_{0,CRS}^{t}(x_i^{t}, y_i^{t})}{D_{0,CRS}^{t+1}(x_i^{t}, y_i^{t})}\right)\right]^{1/2}$$

ECH TCH

The first term in the equation denotes a transition in technical efficiency, i.e., a move toward or away from the best practice frontier. Färe et al (1994) decomposed technical efficiency into two forms: pure technical efficiency and technical efficiency of scale. The size of the production unit is referred to as the scale efficiency. Volume inefficiency refers to the insufficient size of the latter, while pure technical inefficiency refers to the non-optimal use of capital by the managers of the production unit. The second term in the equation represents the technological transition or innovation at time t+1 as a shift in the production frontier.

1.3. Data Selection and Sources

To measure the efficiency of the health systems in our sample, we first specified the inputs and outputs. In the health sector, the variables used are very broad. We will therefore choose those that are most relevant to the objective of our study and that are the most recurrent in the literature review.

Data related to public health were collected from national and international sources (World Bank, IMF, SESRIC, etc.).

A sample of 16 lower and upper middle-income countries was selected according to the new 2020-2021 classification (Appendix A). The calculation of the efficiency rate for this sector on an international scale and in a comparative manner, allows us to determine the efficient countries from those that are less efficient.

- The Choice of inputs

To have an efficient health system, various direct inputs must be brought together to provide a very wide range of services, namely financial resources (health expenditure), which must be well distributed among the many inputs used to provide the service, distinguishing between physical resources (number of nurses, number of doctors, number of beds, etc.) and others such as buildings and equipment.

In health care, as in other activities, investment decisions are crucial, as they are usually irreversible. We therefore choose as inputs in our study public health expenditure as a percentage of GDP and as a work factor we will use the number of doctors and the number of nurses.

- The choice of outputs

The output of a health system concerns the level of health of the beneficiary population. However, the choice of a health indicator is delicate. Indeed, several measures can be useful for comparing the efficiency of developing countries with that of developed countries. These indicators can be classified into simple and multidimensional measures (Audibert, 2009). Simple indicators include life expectancy at birth, mortality rates. While disability adjusted life expectancy (DALY) and disability adjusted life years (DALY) are multidimensional measures. Despite the relevance of these indicators, due to a lack of data, we will only use the basic measures in our research.

In addition, to measure the efficiency of the health systems of the countries in our sample, we have chosen an output. The most important one is life expectancy at birth, which is one of the most direct markers of health care efficiency. Moreover, it is often used as an outcome in international research, demonstrating its ability to assess the efficiency of health systems.

Table 1. Variables of the different models

DEA Models	Inputs	Output
DEA 1	Health expenditure as % of GDP	Life expectancyatbirth
DEA 2	Health expenditure as % of GDP + number of doctors	Life expectancyatbirth
DEA 3	Health expenditure as % of GDP + number of doctors + number of nurses	Life expectancyatbirth
DEA 4	Health expenditure as % of GDP + number of doctors + number of nurses +Number of beds (per 10,000 inhabitants)	Life expectancyatbirth

Source: the author.

2. RESULTS AND DISCUSSION

2.1. Estimates of the Different DEA Models

The overall efficiency scores range from 0.63 to 0.92, indicating that the 16 countries could achieve similar health benefits by reducing public spending by an average of 37% and 8% respectively. The lowest efficiency scores are found for countries such as Algeria, Côte d'Ivoire, Egypt, Ghana, Tunisia, Jordan, Iraq, and Turkey in 2010 and 2020, respectively (see tables in Appendix B).

We can deduce from our different models that our output is very sensitive in our sample. Indeed, we can highlight that when we add one more input (number of doctors or nurses), the overall efficiency improves.

For the case of Morocco, it turns out that between 2011 and 2013 it was on the same frontier as its counterparts, then it moved closer and closer to the frontier in 2017, as well as in 2015. This result indicates that strengthening the efficiency of the country's health system is a priority for Moroccan leaders.

In the different DEA models, we find that Benin, Cameroon, Albania, Maldives, Malaysia, Mauritania, and Indonesia are efficient countries. In our models, Algeria, Ghana, Egypt, Morocco, Tunisia, Turkey, and Jordan are the least efficient countries. The public health budgets of these countries are above the sample average.

Jordan or Morocco, for example, have the largest amount of public investment and yet have poor health outcomes. Given that the same effects will be achieved with even less spending, significant savings can be made, which could be reallocated to other areas affecting the welfare of the population.

Egypt and Algeria have the highest number of physicians in our sample. Ghana, Senegal, the Maldives, Benin, and Mauritania show the lowest number of physicians.

This can be explained by the continuum of state strategies and development plans linked mainly to sectoral and budgetary orientations. For the same principle, the explanation of this phenomenon requires the description and observation of the analysis of regulatory laws and the specificities of decisional implementation. (P. Svandra, 2007).

In total, middle-income countries are positioned in a progressive framework for the period (2010-2020), we note that Egypt takes the highest level compared to the whole sample. In second place, Algeria has a more modest rate presented by 87463 nurses. On the other hand, Jordan, Benin, Cameroon and Ivory Coast, underline a very low level.

Indonesia which has created in 2019 nearly 68 private and public schools to improve the number of nurses, which has resulted in a strong increase in the number of graduates in the health sector. On the other hand, Egypt has established nearly 30 semi-public schools and Albania with 23 public and 7 private schools. Turkey has based on 15 international conventions to increase the number of nurses.

The highest number of beds is presented in 2010 by Mauritania with more than 70 beds, as well as the Maldives Islands illustrate a number of beds equal to 64 in 2011. In addition, Cote d'Ivoire had 38 beds in 2010.

Morocco is distinguished by a stagnation between the year 2010 and 2015 presented by a number of 10 beds, In the same sense, it has experienced an increase that reaches 25 beds in 2020. This approach expresses the will to have a solid health performance in relation to the difficulties presented in the sector of financial, technical and human nature. In this sense, the health policy has demonstrated by way of health crises (Covid 19) failures of hospital policies expressed in particular by lack of beds.

2.2. The Evolution of Efficiency by Measuring the Malmquist Index

The results in Table 1 and 2 in Appendix C show the evolution of total factor productivity (TFP) in the countries in our sample between 2010 and 2020, which are divided into the evolution of technical progress and the evolution of technical efficiency.

When we use one output (life expectancy at birth) and three inputs (public expenditure as a percentage of GDP, number of doctors and number of nurses), we generally obtain a Malmquist index that is less than 1 and that is not constant over the period studied. We can also see that TFP growth depends on technical progress rather than efficiency. Between 2010 and 2020, the most inefficient countries in our sample (Cameron, Cote d'ivoire, Mauritania and Benin) have seen their efficiency increase.

In contrast, over the same period, the efficiency of Morocco, Malaysia, Indonesia, and Iraq decreased as they moved away from the border. Ghana, Benin, Cameroon, Maldives, and Gabon are the most efficient countries in our sample.

The disparity in the evolution of efficiency in our sample can be explained by the input used (public health expenditure). The second component of the Malmquist index measures technical progress. The latter has a long-run effect on technical progress. However, inefficiency can be reduced gradually over time, usually over a long period. In our study, the average TFP is between 0.8 and 0.9. Due to technical progress, life expectancy at birth increased slightly in all countries in our study between 2010 and 2020. In general, the countries in our sample have made technical progress since 2014.

CONCLUSION

The objective of this study is to use two complementary methods, namely DEA and the Malmquist index, to assess the technical efficiency of health systems in lower and upper middle-income countries. The results of this study lead us to conclude that the countries studied do not need to increase the amount of their inputs to boost efficiency. Because of the inefficiency of the health system, poorly managed public financing leads to dysfunction. Therefore, countries such as Morocco, Jordan, Turkey, and Algeria need to be cautious about increasing their health budgets, especially when they are already large.

It should also be noted that the results depend strongly on the specification of the production function, i.e., the number of variables and the inputs selected. Indeed, the addition or deletion of an input and/or an output will directly impact the efficiency of a country. Therefore, it is possible to use a multi-output specification, as it allows policy makers to make recommendations based on a variety of health outcomes. For example, a nation may perform poorly on one dimension of health status but well on another.

In terms of public policy prescriptions, developing countries would have to pay greater attention to the issue of efficiency of their spending, especially on health investment, especially as budget revenues shrink and the social needs of the population increase. Choices will have to be made while being aware of the sector's overall financing constraints and ensuring the efficient allocation of resources through strategic thinking, upstream of the budget preparation process.

APPENDICES

List of Abbreviations:

BCC = Banker,Charnes et Cooper

CCR = Charnes,Cooper et Rhodes

CRS = Constant scaleefficiencies

DEA = Data EnvelopmentAnalysis

DMU = Decision-making unit

ECH = Technicalefficiency

IMF = International MonetaryFund

IEA = International Energy Agency

TFP = Total factor productivity

SESRIC = Statistical, Economic and Social Research and Training Centre for Islamic Countries

TCH = Technicalprogress

VRS = Variable scaleefficiencies

Appendix A: Classification of Lower and Upper Middle-income Countries.

Lower Middle Income Countries	Upper Middle Income Countries
Morocco	
Algeria	Jordan
Tunisia	Turkey
Egypt	Iraq
Ghana	Malaysia
Cameron	Albania
IvoryCoast	Maldives
Mauritania	Indonesia
Bénin	

Appendix B: DEA Model Results

Table 1. Estimation Results of the" DEA1" Model.

Pays	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Morocco	0.722	0.763	0.788	0.778	0.981	0.911	0.911	0.911	0.977	1.000	1.000
Algeria	0.521	0.517	0.464	0.484	0.465	0.480	0.480	0.480	0.533	0.489	0.522
Tunisia	0.575	0.531	0.537	0.506	0.546	0.526	0.526	0.526	0.505	0.536	0.533
Jordan	0.271	0.282	0.327	0.375	0.382	0.452	0.452	0.452	0.451	0.500	0.423
Turkey	0.435	0.501	0.568	0.611	0.668	0.692	0.692	0.692	0.771	0.834	0.627
Egypt	0.705	0.675	0.777	0.751	0.818	0.603	0.603	0.603	1.000	0.948	1.000
Iraq	0.311	0.378	0.851	0.788	1.000	1.000	1.000	1.000	0.652	0.857	0.509
Malaysia	1.000	1.000	1.000	1.000	0.998	1.000	1.000	1.000	1.000	1.000	0.900

Indonesia	1.000	1.000	1.000	1.000	1.000	0.644	0.644	0.644	0.979	0.893	0.930
Ghana	0.232	0.282	0.373	0.354	0.487	0.391	0.391	0.391	0.475	0.735	1.000
Cameron	1.000	1.000	1.000	1.000	0.951	1.000	1.000	1.000	1.000	1.000	1.000
IvoryCoast	0.506	0.737	0.641	0.495	0.542	0.322	0.322	0.322	0.374	0.221	0.427
Albania	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Maldives	0.482	0.600	0.551	0.567	0.510	0.371	0.371	0.371	0.376	0.430	0.441
Mauritania	0.626	0.713	0.667	0.514	0.482	0.328	0.328	0.328	0.459	0.681	0.435
Benin	0.715	0.813	0.957	0.804	1.000	0.785	0.785	0.785	0.916	0.807	0.764

Source:Author's calculations

Table 2. Estimation Results of the" DEA2" Model.

Pays	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Maroc	0.798	0.803	0.820	0.843	0.986	1.000	0.971	0.983	1.000	1.000	1.000
Algérie	0.521	0.517	0.466	0.498	0.465	0.447	0.484	0.472	0.536	0.489	0.522
Tunisie	0.637	0.576	0.563	0.566	0.573	0.569	0.590	0.643	0.584	0.592	0.604
Jordanie	0.354	0.350	0.389	0.469	0.435	0.468	0.596	0.597	0.519	0.542	0.480
Turquie	0.435	0.501	0.568	0.611	0.668	0.685	0.692	0.720	0.771	0.834	0.627
Egypte	0.705	0.675	0.777	0.751	0.824	0.631	0.603	0.636	0.792	0.862	1.000
Iraq	0.552	0.622	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.558
Malaisie	1.000	1.000	1.000	1.000	0.998	0.984	1.000	1.000	1.000	1.000	0.900
Indonésie	1.000	1.000	1.000	1.000	1.000	0.767	0.644	0.602	0.979	0.948	0.930
Ghana	0.349	0.373	0.463	0.506	0.579	0.534	0.650	0.562	0.561	0.790	1.000
Cameron	1.000	1.000	1.000	1.000	0.951	1.000	1.000	1.000	1.000	1.000	1.000
Cote d'ivoire	0.561	0.738	0.641	0.495	0.542	0.343	0.322	0.370	0.211	0.310	0.427
Albanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Maldives	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mauritanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bénin	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.0000	1.000

Source: Author's calculations

Table 3. Estimation Results of the" DEA3" Model.

Pays	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Maroc	0.878	0.880	0.871	0.870	0.996	1.000	0.992	1.000	1.000	1.000	1.000
Algérie	0.568	0.551	0.483	0.515	0.470	0.447	0.502	0.580	0.578	0.525	0.572
Tunisie	0.654	0.601	0.580	0.576	0.580	0.586	0.600	0.640	0.584	0.592	0.604
Jordanie	0.361	0.383	0.409	0.487	0.450	0.547	0.608	0.654	0.592	0.604	0.553
Turquie	0.479	0.507	0.568	0.611	0.668	1.000	0.692	0.872	0.771	0.834	0.627
Egypte	0.932	0.805	0.903	0.862	0.851	0.631	0.603	0.894	1.000	0.948	1.000
Iraq	0.606	0.688	1.000	1.000	1.000	1.000	1.000	0.730	0.730	0.862	0.625
Malaisie	1.000	1.000	1.000	1.000	0.999	0.984	1.000	1.000	1.000	1.000	0.922

Indonésie	1.000	1.000	1.000	1.000	1.000	0.767	0.644	0.997	0.979	0.893	0.930
Ghana	0.349	0.374	0.476	0.506	0.579	0.534	0.534	0.523	0.561	0.790	1.000
Cameron	1.000	1.000	1.000	1.000	0.951	1.000	1.000	1.000	1.000	1.000	1.000
Cote d'ivoire	0.775	0.937	0.691	0.495	0.549	0.504	0.413	0.523	0.322	0.367	0.474
Albanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Maldives	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mauritanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bénin	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: Author's calculations

Table 4. Estimation Results of the" DEA4" Model.

Pays	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Maroc	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Algérie	0.766	0.673	0.616	0.623	0.563	0.563	0.617	0.513	0.666	0.602	0.772
Tunisie	0.969	0.705	0.696	0.697	0.710	0.741	0.786	0.549	0.773	0.856	0.987
Jordanie	0.549	0.478	0.533	0.611	0.582	0.739	0.877	0.720	0.845	0.864	1.000
Turquie	0.551	0.580	0.627	0.669	0.675	1.000	0.723	0.432	0.781	0.892	0.627
Egypte	0.933	1.000	1.000	1.000	0.851	0.725	0.777	0.814	1.000	1.000	1.000
Iraq	0.654	0.721	1.000	1.000	1.000	1.000	1.000	0.895	0.842	1.000	0.958
Malaisie	1.000	1.000	1.000	1.000	1.000	0.984	1.000	0.664	1.000	1.000	0.922
Indonésie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.986	0.957	0.930
Ghana	0.556	0.556	0.478	0.506	0.579	0.534	1.000	0.747	0.561	0.793	1.000
Cameron	1.000	1.000	1.000	1.000	0.951	1.000	1.000	1.000	1.000	1.000	1.000
Cote d'ivoire	0.775	0.937	0.695	0.674	0.549	0.532	0.564	0.930	0.498	0.516	0.611
Albanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.523	1.000	1.000	1.000
Maldives	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mauritanie	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bénin	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: Author's calculations

Appendix B. Malmquist Index Model Results

Table 1. The evolution of Technical Efficiency, Technical Progress and TFP of Countries between 2010 and 2020.

Country	**Year**	**Technical Efficiency**	**Technical Progress**	**TFP**	**Country**	**Year**	**Technical Efficiency**	**Technical Progress**	**TFP**
Morocco	2010-2011	1.000	0.630	0.630	Malaysia	2010-2011	1.000	0.630	0.630
	2011-2012	1.000	0.728	0.728		2011-2012	1.000	0.728	0.728
	2012-2013	1.000	0.772	0.772		2012-2013	1.000	0.773	0.773
	2013-2014	1.000	0.800	0.800		2013-2014	1.000	0.800	0.800
	2014-2015	1.000	0.833	0.833		2014-2015	1.000	0.833	0.833
	2015-2016	1.000	0.857	0.857		2015-2016	1.000	0.857	0.857

	2016-2017	1.000	0.875	0.875		2016-2017	1.000	0.875	0.875
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.889	0.889
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.900	0.900
	2019-2020	1.000	0.909	0.909		2019-2020	1.000	0.909	0.909
Algeria	2010-2011	1.000	0.628	0.628	Indonesia	2010-2011	1.000	0.665	0.665
	2011-2012	1.000	0.726	0.726		2011-2012	1.000	0.783	0.783
	2012-2013	1.000	0.770	0.770		2012-2013	1.000	0.800	0.800
	2013-2014	1.000	0.800	0.800		2013-2014	1.000	0.826	0.826
	2014-2015	1.000	0.833	0.833		2014-2015	1.000	0.843	0.843
	2015-2016	1.000	0.857	0.857		2015-2016	1.000	0.857	0.857
	2016-2017	1.000	0.875	0.875		2016-2017	1.000	0.875	0.875
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.889	0.889
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.900	0.900
	2019-2020	1.000	0.909	0.909		2019-2020	1.000	0.909	0.909
Tunisia	2010-2011	1.000	0.628	0.628	Ghana	2010-2011	1.000	0.695	0.695
	2011-2012	1.000	0.726	0.726		2011-2012	1.000	0.802	0.802
	2012-2013	1.000	0.771	0.771		2012-2013	1.000	0.850	0.850
	2013-2014	1.000	0.800	0.800		2013-2014	1.000	0.878	0.878
	2014-2015	1.000	0.833	0.833		2014-2015	1.000	0.895	0.895
	2015-2016	1.000	0.857	0.857		2015-2016	1.000	0.857	0.857
	2016-2017	1.000	0.875	0.875		2016-2017	1.000	0.875	0.875
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.923	0.923
	2018-2019	1.000	0.889	0.889		2018-2019	1.000	0.937	0.937
	2019-2020	1.000	0.909	0.909		2019-2020	1.167	0.940	1.098
Jordan	2010-2011	1.000	0.635	0.635	Cameron	2010-2011	0.932	0.791	0.737
	2011-2012	1.000	0.734	0.734		2011-2012	0.838	0.982	0.823
	2012-2013	1.000	0.780	0.780		2012-2013	1.280	0.937	1.280
	2013-2014	1.000	0.806	0.806		2013-2014	0.727	1.160	0.843
	2014-2015	1.000	0.833	0.833		2014-2015	1.376	0.974	1.341
	2015-2016	1.000	0.857	0.857		2015-2016	1.000	0.907	0.907
	2016-2017	1.000	0.875	0.875		2016-2017	1.000	1.632	1.632
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.876	0.876
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.753	0.753
	2019-2020	1.000	0.909	0.909		2019-2020	1.000	0.848	0.848
Turkey	2010-2011	1.000	0.629	0.629	IvoryCoast	2010-2011	0.992	0.747	0.741
	2011-2012	1.000	0.726	0.726		2011-2012	0.992	0.859	0.852
	2012-2013	1.000	0.770	0.770		2012-2013	0.993	0.907	0.901
	2013-2014	1.000	0.800	0.800		2013-2014	0.993	0.934	0.928
	2014-2015	1.000	0.833	0.833		2014-2015	0.994	0.950	0.944

	2015-2016	1.000	0.857	0.857		2015-2016	1.000	0.989	0.989
	2016-2017	1.000	0.875	0.875		2016-2017	0.929	0.908	0.843
	2017-2018	1.000	0.889	0.889		2017-2018	1.070	0.941	1.007
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.985	0.985
	2019-2020	1.000	0.909	0.909		2019-2020	0.999	0.978	0.977
Egypt	2010-2011	1.000	0.648	0.648	Albania	2010-2011	1.000	0.621	0.621
	2011-2012	1.000	0.749	0.749		2011-2012	1.000	0.717	0.717
	2012-2013	1.000	0.795	0.795		2012-2013	1.000	0.761	0.761
	2013-2014	1.000	0.822	0.822		2013-2014	1.000	0.800	0.800
	2014-2015	1.000	0.840	0.840		2014-2015	1.000	0.833	0.833
	2015-2016	1.000	0.857	0.857		2015-2016	0.996	0.960	0.956
	2016-2017	1.000	0.875	0.875		2016-2017	1.000	0.875	0.875
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.889	0.889
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.900	0.900
	2019-2020	1.000	0.909	0.909		2019-2020	1.000	0.909	0.909
Iraq	2010-2011	1.000	0.656	0.656	Maldives	2010-2011	1.000	0.623	0.623
	2011-2012	1.000	0.758	0.758		2011-2012	1.000	0.720	0.720
	2012-2013	1.000	0.804	0.804		2012-2013	1.000	0.763	0.763
	2013-2014	1.000	0.830	0.830		2013-2014	1.000	0.800	0.800
	2014-2015	1.000	0.848	0.848		2014-2015	1.000	0.833	0.833
	2015-2016	1.000	0.861	0.861		2015-2016	1.000	0.857	0.857
	2016-2017	1.000	0.873	0.873		2016-2017	1.000	0.875	0.875
	2017-2018	1.000	0.889	0.889		2017-2018	1.000	0.889	0.889
	2018-2019	1.000	0.900	0.900		2018-2019	1.000	0.900	0.900
	2019-2020	1.000	0.909	0.909		2019-2020	1.000	0.909	0.909
Mauritanie	2010-2011	0.886	0.937	1.000	Benin	2010-2011	0.995	1.000	1.000
	2011-2012	0.886	0.938	1.000		2011-2012	1.067	1.000	1.000
	2012-2013	0.885	0.937	1.000		2012-2013	0.996	1.000	1.000
	2013-2014	0.885	0.937	1.000		2013-2014	1.269	1.000	1.000
	2014-2015	0.885	0.937	1.000		2014-2015	0.996	1.000	1.000
	2015-2016	0.885	0.938	1.000		2015-2016	1.027	1.000	1.000
	2016-2017	0.885	0.937	1.000		2016-2017	0.995	1.000	1.000
	2017-2018	1.000	0.917	0.917		2017-2018	1.000	1.056	1.056
	2018-2019	1.000	0.930	0.930		2018-2019	1.000	0.876	0.876
	2019-2020	1.000	0.931	0.931		2019-2020	1.000	0.985	0.985

Table 2. Summary of Malmquist Index Averages.

Country	Technicalefficiency	Technicalprogress	TFP
Morocco	1.000	0.815	0.815

Algeria	1.000	0.814	0.814
Tunisia	1.000	0.814	0.814
Jordan	1.000	0.817	0.817
Turkey	1.000	0.814	0.814
Egypt	1.000	0.825	0.825
Iraq	1.000	0.829	0.829
Malaisia	1.000	0.815	0.815
Indonesia	1.000	0.832	0.832
Ghana	1.016	0.867	0.881
Cameron	1.000	0.971	0.971
IvoryCoast	0.995	0.914	0.910
Albania	1.000	0.811	0.811
Maldives	1.000	0.812	0.812
Mauritanie	1.000	0.863	0.863
Benin	1.000	0.904	0.904
Average	1.001	0.844	0.844

Source: Author's calculations.

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