African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 21, Décembre 2023

A comparative analysis of the efficiency of international education systems Applying Data Envelopment Analysis (DEA).

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Pour citer cet article : **BEN HEMZA .A & ESSARDI .M O (2023) « A comparative analysis of the efficiency of international education systems Applying Data Envelopment Analysis (DEA) », African Scientific Journal « Volume 03, Numéro 21 » pp: 0664 – 0698.**

Date de soumission : Novembre 2023

Date de publication : Décembre 2023

DOI : 10.5281/zenodo.10461161

African Scientific Journal
ISSN : 2658-9311
Vol : 3, Numéro 21, Décembre 2023

Abstract

The purpose of this study is to identify and examine the efficiency of the education system from a cross-national perspective. We used Data Envelopment Analysis to examine data from 43 countries from various world regions and income groups. The goal of this study is to fill a gap in the existing literature by focusing on other outcomes of the education system rather than the standardized test scores of students, which have been mainly used by the authors. The results reveal that disparities exist between countries in the same region and socioeconomic category. Thus, regardless of the country's economic level, the country's education system can be improved. Our findings also provide us with a detailed analysis of the input and output slacks, with the goal of highlighting areas where a country can improve its performance by increasing output levels without requiring additional inputs on the one hand, or providing insights into opportunities for improvement and resource allocation to increase outputs without requiring additional resources, simply by using its existing inputs more efficiently or fully on the other hand.

Keywords

Technical efficiency, Education system, DEA, Cross-country Analysis.

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ISSN : 2658-9311
Vol : 3, Numéro 21, Décembre 2023

Introduction

The economists were always interested in the estimation of the production function parameters. However, it is Farrell who made the argument that "these “averaging” estimators were estimating the average, rather than the “best practice “technology." (M. J. Farrel, 1957) Farrell’s arguments provided an intellectual basis for redirecting attention from the production function specifically to the deviations from that function, and respecifying the model and the techniques accordingly.

In fact, according to Farrel” it is important to know how far a particular industry can increase its production simply by increasing its efficiency.” The adoption of this principle, has led to the development of different tools and techniques to provide managers with the efficiency analyses, in order to facilitate the decision-making process. Among them, Data Envelopment Analysis (DEA) presents itself as a robust tool with a wide range of uses. The DEA proposes to obtain relative efficiency between two or more production units that use multiple inputs to produce goods and/or services (outputs).

The study of technical efficiency in the education sector is verry specific, mainly due to the fact that the process of education is considered highly complex and multifaceted production process. To represent this production function in a simple form, the economist has suggested an education production function, where the output of this production (educational outcome or achievement) is a function of the different resources and factors that interfere in the education process.

In this article, our aim is to conduct a comparative analysis of the efficiency of international educational systems, applying Data Envelopment Analysis method . Our work is a part of the continuity of existing work, as we aim to fill a gap in existing studies by using the number of graduates by specialty, rather than traditional measures like the PISA test results, to assess the economic impact of education systems. This approach considers both the economic relevance of graduates and the quality aspect by accounting for differences in specialties, providing a more comprehensive analysis.

The results of this research are twofold: first, we identify the countries that are considerd as benchmarks and second, we calculate the input and output slacks that now exist in inefficient educational systems.

The structure of the paper is as follows: As a first step, we present a summary of the literature on education performance analysis, and we provide a review of articles using the DEA approach in their analysis . Then, we examine the existing research gap that leads our choice of the variables, the methodology, and the selection of countries as the decision-making units. In the

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ISSN : 2658-9311
Vol : 3, Numéro 21, Décembre 2023

second paragraph, we describe the methodology used in our study .And finally we present the findings of our study .

Literature Review

From the perspective of the economists in the economics of education field, education is viewed as a production process in which a variety of inputs are employed to produce a variety of outputs for a particular production technology.

The theoretical approach of linking resources to educational outcomes at school level is based on the production function proposed in Levin (1974) and Hanushek (1979): For a particular school ss the function is defined as follows:

$$AAss = ff(BBss, SSss)$$

where $AAss$ represents the educational output, normally measured through scores on standardized tests. It is clear that it is not an easy task to quantify the education received by an individual, due to its inherent intangibility and necessity to consider the quality beyond several years of study.

However, there has been a consensus in the literature about considering the results from a standardized test as educational outputs. They are difficult to forge and they are taken into account by policy makers and families when making decisions in education.

In the equation above, the inputs are divided into $BBss$ and $SSss$, which denote the average student's family background and the educational resources assigned to school ss respectively. Classically, they consider the main inputs required to carry out the learning process: raw material, physical and human capital.

However, unlike other industries, education presents certain characteristics that hinder the estimation of a production function. (Manceb & Bandrés, 1999) mention the intangible and multiple nature of the output, the time-lag in achieving its results, its cumulative nature and that the educational process is carried out by the customers themselves.

For these reasons, it has been a consensus between the economists on using non-parametric techniques such as Data Envelopment Analysis (DEA) as a convenient way to measure the efficiency of education systems**.**

1.1. Data Envelopment Analysis Theoretical Framework

Data Envelopment analysis was introduced by Charnes, Copper and Rhodes extending Farrell's concept to estimate efficiency by comparing each production unit with the efficient production frontier.

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In this context, the DEA is used as a non-parametric method that determines the efficiency curve through linear programming, without requiring the specification of any functional relationship between the inputs and outputs. However, since it is deterministic, this technique is vulnerable, to the prevalence of extreme observations (outliers), and errors of measurements. (Rodrigues et al., 2022).

In general, the approach applied to the efficiency measure is guided by the definition of Pareto Koopmans: a unit is Pareto-efficient when an attempt to improve on any of its inputs or outputs will adversely affect some other inputs or outputs. In other terms, the Pareto–Koopmans efficiency occurs when it is not possible to improve the objective function in terms of inputs or outputs without deteriorating other input(s) or output(s).

1.2. Performance Evaluation with DEA in the literature

In the literature we find that, Charnes et al. (1981), were the first authors to investigate the efficiency of an educational program in USA using the DEA methodology, since then, several work have continued the study of efficiency in the field of education. Afonso and Aubyn (2006a; 2006b), Agasisti (2011;2014;2019),Mota and Meza (2020) , Marto and al.(2022) and others, worked on international data to asses a comparison across international countries . While other authors limited their study on a specific economic Region or country (Thieme and Giménez (2012), Jakaitrine and al.(2018), Koçak and Örkcü (2021) , Aparicio (2022)). In the author hand , we find author authors who focused their studies on the efficiency of universities to compare the performance of different countries in higher education (Gunn (2018),Agasisti(2021),El Gibon and al.(2022) , Lee and Johnes(2022) ,Temosa and al.(2023) and others) , or to measure the impact of introducing technology on the education efficiency (Liu and Sum 2023).

The existing studies in the literature differ in their choice of the inputs. For instance, some studies concentrate on the educational spendings (Aristovnik (2011), Agasisti (2014)), while others concentrate on the environmental variables (like the type of school, the socio-economic class of the student …) [Portela and Thanassoulis (2001), Giménez et al. (2007) which introduced the concept of managerial efficiency, Mancebón et al. (2012),Frenette (2019) and Lagravinese and al.(2020)]

However, most of the existing studies have chosen the same output: Standardized test Scores, in their study. This choice can be justified by the fact that indicators derived by standardized test scores are homogeneous, comparable across countries and more difficult to manipulate Casperson (2017). In this regard, the PISA program, which was introduced in 2000 and is

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ISSN : 2658-9311
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administered every three years, serves as a crucial informational tool for examining student competencies and comparing them across nations and economies.

- ***Research Gap***

To the best of our knowledge, few studies have chosen other education outcome measures as outputs in their analysis. Even though, the PISA standardized test, concerns the young students under 15 years old, a population that can hardly contribute to a nation's economic growth, at least directly. And in addition to that, these studies focus primally on the performance of educational system of schools.

To fill this gap, we used the number of graduates by specialty as a comparable output of the various educational systems in our analysis. In fact, from an economic point of view, we want to choose a variable that identifies the best the human capital, that is the outcome of the education system.

From another hand, we attempt to take into account the quality aspect of the education system by taking into consideration the differences of the graduates' specialties.

2. Methodology

By using linear programming, a frontier of best-practice units is constructed based in observed data. The efficient frontier is used as a benchmark against which the performance of less efficiency units can be assessed. The estimated frontier envelops all the available observations, and each deviation from that frontier is interpreted as a measure of the inefficiency of the units. In DEA, efficiency is defined in a technical sense. That is to say, as the ability of transforming inputs into outputs for a given technology. At first, the model proposed in 1978 by Charnes, Copper and Rhodes, known as CCR, sought to adapt analysis with constant scale returns. The model was then extended by Banker, Charnes, and Cooper in 1984 to include variable returns at scale. As a result, one has the VRS model. Both models can be oriented in two ways to maximize efficiency:

- Reduce the consumption of inputs, maintaining the level of production
- Increase outputs by preserving input levels

Based on the work of (Agasisti et al., 2021), who have verified the rationality of the variable return-to-scale hypothesis with statistical test methods, so our analysis also takes a variable return-to-scale as the premise. At the same time, because the inputs of the education system are not entirely controlled by the schools and universities themselves, the evaluation of the

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efficiency of universities should be based on the output-oriented perspective and attach importance to the maximization of output.

The choice of the Data Envelopment Analysis (DEA) method to carry out a comparative analysis of the efficiency of several educational systems is based on a solid epidemiological positioning and a robust analytical approach.

Referring to the systematic study conducted by Haddad (2021) , that aims to synthesize the existing literature on educational efficiency, focusing on techniques for assessing Decision-Making Units (DMUs). This study is covering 1500 articles from 2010 to 2021, and it identifies Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) as primary methodologies .

By adopting a pragmatic perspective, the DEA method allows to assess the effectiveness of educational systems by taking into account multiple variables, going beyond a one-dimensional vision. The epistemological positioning of research is part of a desire to capture the complexity inherent in contemporary educational systems, incorporating factors as diverse as the quality of teaching, the resources available, and the results obtained. The reasoning of the DEA offers a methodological flexibility for understanding educational reality in a holistic way, thus transcending the limitations often associated with more traditional approaches. By choosing Data Envelopment Analysis, research aspires to a thorough and nuanced understanding of educational performance, paving the way for informed recommendations for the continuous improvement of education systems.

In the following study, we use the output-oriented DEA-BCC. The following is a description of its theoretical computation process.

2.1. DEA-BCC theoretical computation method

Technical efficiency is used to evaluate the degree to which the production process of a DMU reaches the technical level of its industry, reflecting its ability to transform input into output. That is, in the context of output orientation, given the input level, the higher the output level, the higher the technical efficiency (Huguenin, 2012) .

Suppose we want to measure the technical efficiency of n DMUs (Decision making units), recorded as DMUj (j = 1, 2, . . . , n): each DMU has m inputs, which are recorded as xi (i = 1, 2, . . . , m), and the weight of inputs is vi (i = 1, 2, . . . , m). There are q outputs, which are recorded as yr (r = 1, 2, . . . , q), and the output weight is ur (r = 1, 2, . . . , q).

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Record the DMU to be considered as DMUk, and its output-oriented efficiency (Eff) under CRS hypothesis can be calculated as:

$$EFF_k = min \frac{\sum_{\dot{x}=1}^{m} v_i x_{ik}}{\sum_{i=1}^{q} u_r y_{rk}}$$

$$\text{s.t} : \frac{\sum_{i=1}^{q} u_r y_{rk}}{\sum_{\dot{x}=1}^{m} v_i x_{ik}} \leq 1 \qquad \text{v,u} \geq 0 \qquad (1)$$

Of course, the current programming model is not a linear programming model, so we need to convert it into a linear programming model through the Charnes-Cooper transition and then we have the following model:

$$min \sum_{\dot{x}=1}^{m} v_i x_{ik}$$

$$St: \sum_{r=1}^{s} u_r y_{rj-} \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad (2)$$

$$\sum_{r=1}^{q} u_r y_{rk} = 1$$

$$\text{v,u} \geq 0$$

Then, the dual of model (2) can be written as follows:

$$\text{Max } \phi$$

$$\text{S.t:} \sum_{j=1}^{n} a_j x_{ij} \leq x_{ik}$$

$$\sum_{j=1}^{n} a_j y_{rj} \geq \phi y_{rk} \qquad (3)$$

$$\text{a} \geq 0$$

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Add the constraint of $\sum_{j=1}^{n} a_j = 1$ and we can obtain BCC model:

$$\text{Max } \phi$$

$$\text{S.t: } \sum_{j=1}^{n} a_j x_{ij} \leq x_{ik}$$

$$\sum_{j=1}^{n} a_j y_{rj} \geq \phi y_{rk} \qquad (4)$$

$$\sum_{j=1}^{n} a_j = 1$$

$$a \geq 0$$

In our analysis , we use DEAP software ,to compute the algorithm automatically .(Coelli, 1996;Huguenin , 2012)

2.2. Description of the sample and variables

Our study concerns 43 countries considered as a sample from different World Regions, from different income groups, in order to take into consideration, the differences related to the country's geographical appurtenance and income .

Tableau N°1 : List of the countries

FIRM	REGION	INCOME GROUP
SINGAPORE	East Asia & Pacific	High income: non OECD
KOREA	East Asia & Pacific	High income: OECD
CHINA	East Asia & Pacific	Upper middle income
MALAYSIA	East Asia & Pacific	Upper middle income
FRENCH	Europe & Central Asia	High income: OECD
IRELAND	Europe & Central Asia	High income: OECD
UKRAINE	Europe & Central Asia	Lower middle income

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TURKEY	Europe & Central Asia	Upper middle income
COLOMBIA	Latin America & Caribbean	Upper middle income
PANAMA	Latin America & Caribbean	Upper middle income
KUWAIT	Middle East & North Africa	High income: non OECD
QATAR	Middle East & North Africa	High income: non OECD
UNITED ARAB EMIRATES	Middle East & North Africa	High income: non OECD
YEMEN	Middle East & North Africa	Lower middle income
ALGERIA	Middle East & North Africa	Upper middle income
JORDAN	Middle East & North Africa	Upper middle income
TUNISIA	Middle East & North Africa	Upper middle income
UNITED STATES OF AMERICA	North America	High income: OECD
NEPAL	South Asia	Low income
SRI LANKA	South Asia	Lower middle income
ETHIOPIA	Sub-Saharan Africa	Low income
KENYA	Sub-Saharan Africa	Low income
RWANDA	Sub-Saharan Africa	Low income
UGANDA	Sub-Saharan Africa	Low income
SENEGAL	Sub-Saharan Africa	Lower middle income
SUDAN	Sub-Saharan Africa	Lower middle income
MAURITIUS	Sub-Saharan Africa	Upper middle income

Source : World Bank

In order to conduct a comparative analysis , we have chosen comparable variables.

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For the inputs, we consider the human, financial and material resources of the educational systems, without forgetting to take into consideration the quality aspect of the inputs.
Whereas, the output variables are the Percentage of graduates in different specialties, for the reasons we mentioned above.

Table 1: List of output variables

CODE	OUTPUT VARIABLES
PerGradS	Percentage of graduates from Science, Technology, Engineering and Mathematics programmes in tertiary education, both sexes (%)
PerGradA	Percentage of graduates from tertiary education graduating from Arts and Humanities programmes, both sexes (%)
PerGradB	Percentage of graduates from tertiary education graduating from Business, Administration and Law programmes, both sexes (%)
PerGradN	Percentage of graduates from tertiary education graduating from Natural Sciences, Mathematics and Statistics programmes, both sexes (%)
PerGrad1	Percentage of graduates from tertiary education graduating from Services programmes, both sexes (%)

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Table 2: List of input variables

CODE	INPUT VARIABLES
PerAccCo	*Proportion of lower secondary schools with access to computers for pedagogical purposes (%)*
PerAccC1	*Proportion of upper secondary schools with access to computers for pedagogical purposes (%)*
GEVEXP	*Government expenditure on education as % of GDP (%)*
PerQualT	*Percentage of qualified teachers in lower secondary education, both sexes (%)*
PerQual1	*Percentage of qualified teachers in primary education, both sexes (%)*
PercQual	*Percentage of qualified teachers in secondary education, both sexes (%)*
PercQua1	*Percentage of qualified teachers in upper secondary education, both sexes (%)*

3. Results

The results of the application of the models indicated in the methodology section that capture the technical efficiency of each country are summarized in the table below:

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Table 3: Efficience Summary

Firm	Crste [1]	vrste	scale	
China	1.000	1.000	1.000	-
Singapor	1.000	1.000	1.000	-
Korea	1.000	1.000	1.000	-
Malaysia	1.000	1.000	1.000	-
Finland	0.795	0.802	0.991	drs
Ireland	1.000	1.000	1.000	-
Sweden	0.661	0.662	0.998	irs
France	1.000	1.000	1.000	-
Germany	0.980	0.980	1.000	-
Italy	0.889	0.890	0.999	drs
Tajikist	0.709	0.710	0.998	drs
Turkey	1.000	1.000	1.000	-
Ukraine	1.000	1.000	1.000	-
Chile	0.813	0.855	0.951	drs
CostaRic	0.846	0.846	1.000	-
Mexico	0.965	0.970	0.995	irs
Brazil	0.838	0.854	0.982	irs
Colombia	1.000	1.000	1.000	-
Panama	1.000	1.000	1.000	-
Malta	0.923	0.923	1.000	-
Qatar	1.000	1.000	1.000	-
UnitedAr	1.000	1.000	1.000	-
Algeria	1.000	1.000	1.000	-
Jordan	1.000	1.000	1.000	-
Kuwait	1.000	1.000	1.000	-
Egypt	0.775	0.778	0.995	drs
Morocco	0.925	0.954	0.970	drs
Tunisia	1.000	1.000	1.000	-
Canada	0.841	0.842	0.998	drs
UnitedSt	1.000	1.000	1.000	-

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Nepal	1.000	1.000	1.000	-
SriLanka	1.000	1.000	1.000	-
Kenya	1.000	1.000	1.000	-
Mali	0.873	0.933	0.935	irs
Mauritiu	1.000	1.000	1.000	-
Senegal	0.899	1.000	0.899	irs
CotedIvo	0.906	0.940	0.963	irs
Uganda	1.000	1.000	1.000	-
Yemen	1.000	1.000	1.000	-
Ethiopia	1.000	1.000	1.000	-
Rwanda	0.983	1.000	0.983	irs
Sudan	1.000	1.000	1.000	-
Mean	0.943	0.951	0.992	

Source: Software Release

The third column indicates the technical efficiency, from VRS Model, of the educational system of each country. Values equal to unit indicate that the management of the educational system of a country is efficient, this is the case in these 27 countries:

Table 4: Efficient countries

Firm	**Region**	**Income Group**
Singapore	East Asia & Pacific	High income: non OECD
Korea	East Asia & Pacific	High income: OECD
China	East Asia & Pacific	Upper middle income
Malaysia	East Asia & Pacific	Upper middle income
French	Europe & Central Asia	High income: OECD
Ireland	Europe & Central Asia	High income: OECD
Ukraine	Europe & Central Asia	Lower middle income
Turkey	Europe & Central Asia	Upper middle income

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Colombia	Latin America & Caribbean	Upper middle income
Panama	Latin America & Caribbean	Upper middle income
Kuwait	Middle East & North Africa	High income: nonOECD
Qatar	Middle East & North Africa	High income: nonOECD
United Arab Emirates	Middle East & North Africa	High income: nonOECD
Yemen	Middle East & North Africa	Lower middle income
Algeria	Middle East & North Africa	Upper middle income
Jordan	Middle East & North Africa	Upper middle income
Tunisia	Middle East & North Africa	Upper middle income
United States of America	North America	High income: OECD
Nepal	South Asia	Low income
Sri Lanka	South Asia	Lower middle income
Ethiopia	Sub-Saharan Africa	Low income
Kenya	Sub-Saharan Africa	Low income
Rwanda	Sub-Saharan Africa	Low income
Uganda	Sub-Saharan Africa	Low income
Senegal	Sub-Saharan Africa	Lower middle income
Sudan	Sub-Saharan Africa	Lower middle income
Mauritius	Sub-Saharan Africa	Upper middle income

Source: Software Release

In the table above we observe that these countries belong to different economic and geographical Regions .However , there are countries who VRS efficient and CRS inefficient.

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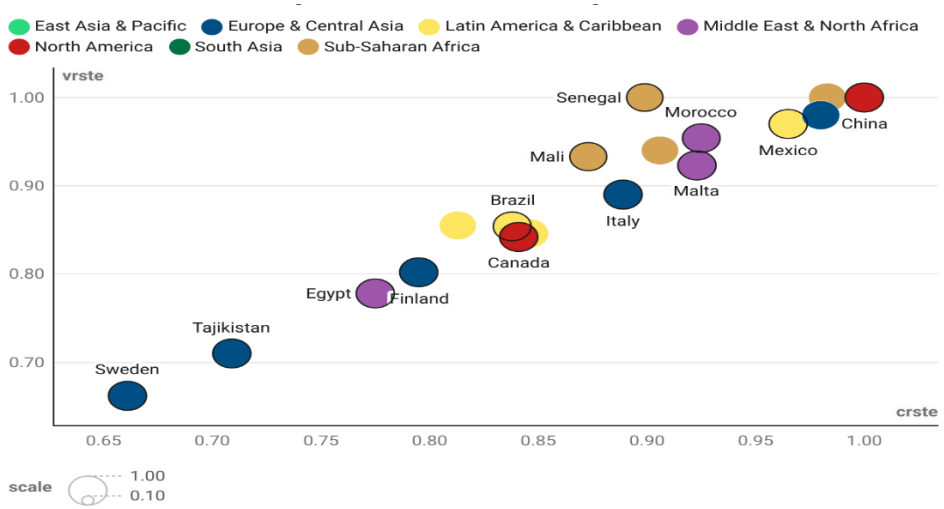
For instance, we have represented in the graph below, the distribution of countries according to their VRSTE and CRSTE scores.

Figure 1 : Technical Efficiency of the education system of the countries



Source: Developped by the authors

Countries like Sweden and Tajikistan and Egypt are shown that are both VRS and CRS inefficient, while the countries like China, Germany and Sudan are both VRS and CRS efficient. In another hand , we find countries like Senegal and Rwanda who are VRS efficient and CRS inefficient , in case of these countries , in order to become CRS efficient they need an increase in the scale or the size of their production .While the countries : Finland, Italy, Tajikistan, Chile, Egypt, Morocco are in a decreasing returns to scale situation , which means that the potential increase in their inputs will not be fully matched by an increase in the outputs, leading to higher average costs per unit of production.

The average managerial technical efficiency level in the countries considered in the study is 0.951. This implies that controlling for environmental conditions, these countries have to, on average, raise the percentage of graduated students in different specialties by 4.9% with their existing supply of resources.

In the case of the countries in the following Regions: East Asia & Pacific and South Asia, the average technical efficiency index is 1, which means that their educational systems are operating efficiently,

while the educational systems of the countries in the Regions: Sub-Saharan Africa, Middle East & North Africa, North America, Latin America & Caribbean, Europe & Central Asia have to

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respectively raise the percentage of their graduated students in different specialties by: 10.6%, 7.9%,7.9% ,3.4%,1.4% to attained the maximum possible output of their existing inputs, and became efficient.

Table 6 : The average managerial technical efficiency level in the World Regions

Region	**Average VRSTE**
Europe & Central Asia	0,894
Latin America & Caribbean	0,921
North America	0,921
Middle East & North Africa	0,966
Sub-Saharan Africa	0,986
East Asia & Pacific	1,000
South Asia	1,000

Source: Software Release

For a more detailed analysis of the performance of the education system of the different countries,

we analyze their output and input slacks, in aim to highlight the areas where a country can improve its performance by increasing its output levels without requiring additional inputs from one hand, or provide insights into opportunities for improvement and resource allocation to increase outputs without requiring additional resources, simply by using its existing inputs more efficiently or fully.

- Analyzing the output slacks

We present in the table below a summary of output slacks of each country in order to identify inefficiencies and implement strategies to enhance productivity and achieve higher output levels without increasing resource usage.

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Table 7 : Summary of output slacks

Region	firm output:	PerGradS	PerGradA	PerGradB	PerGradN	PerGrad1
East Asia & Pacific	China	0	0	0	0	0
	Korea	0	0	0	0	0
	Malaysia	0	0	0	0	0
	Singapore	0	0	0	0	0
	mean	0	0	0	0	0
Europe & Central Asia	Finland	0	0	0	1,419	0
	French	0	0	0	0	0
	Germany	0	1,071	0	0	0,121
	Ireland	0	0	0	0	0
	Italy	0	0	0	0,12	0
	Sweden	0	1,289	0	0	2,706
	Tajikistan	0	0	13,635	0	0
	Turkey	0	0	0	0	0
	Ukraine	0	0	0	0	0
	mean	0	0,262	1,515	0,171	0,314
Latin America & Caribbean	Brazil	0	2,568	0	1,343	0
	Chile	0	2,843	0	0,87	0
	Colombia	0	0	0	0	0
	Costa Rica	4,944	1,204	0	0	0

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	Mexico	0	3,088	0	1,031	0
	Panama	0	0	0	0	0
	Mean	0,824	1,6172	0	0,541	0
Middle East & North Africa	Algeria	0	0	0	0	0
	Egypt	11,489	0	0	6,417	0
	Jordan	0	0	0	0	0
	Kuwait	0	0	0	0	0
	Malta	0	0	0	0,795	0
	Morocco	8,284	0	0	0	0
	Qatar	0	0	0	0	0
	Tunisia	0	0	0	0	0
	United Arab Emirates	0	0	0	0	0
	Yemen	0	0	0	0	0
	Mean	1,9773	0	0	0,7212	0
North America	Canada	0	0	0	0	0
	United States of America	0	0	0	0	0
	Mean	0	0	0	0	0
South Asia	Nepal	0	0	0	0	0
	Sri Lanka	0	0	0	0	0
	Mean	0	0	0	0	0
	Cote d'Ivoire	0	0,851	0	0	0

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Sub-Saharan Africa	Ethiopia	0	0	0	0	0
	Kenya	0	0	0	0	0
	Mali	0	0,049	0	0	0
	Mauritius	0	0	0	0	0
	Rwanda	0	0	0	0	0
	Senegal	0	0	0	0	0
	Sudan	0	0	0	0	0
	Uganda	0	0	0	0	0
	Mean	0	0,1	0	0	0
Mean		0,588	0,309	0,325	0,286	0,067

Source: Software Release

Considering the First output: Percentage of graduates from Science, Technology, Engineering and Mathematics programs in tertiary education, we observe that the countries that have a lack in producing graduates in these specialties, giving their existing resources are Egypt (by 11,489%), followed by Morocco (by 8,284%) in the Region MENA, then Costa Rica (by 4,944%) in the Region LAC.

For the second output: Percentage of graduates from tertiary education graduating from Arts and Humanities programs, it is mostly the countries in the Region LAC that have inefficiencies: Mexico by 3,088%, Chile by 2,843%, Brazil by 2,568% then Costa Rica by 1,204%. While the countries Sweden and Germany have to increase their output by 1,289% and 1,071% respectively to attained their maximum possible output giving their existing resources.

As for the third output: Percentage of graduates from tertiary education graduating from Business, Administration and Law programs, the only country that have a slack is Tajikistan by 13,635 % in the ESA Region. While considering the fourth output : Percentage of graduates from tertiary education graduating from Natural Sciences, Mathematics and Statistics programs , we observe that the countries who have a slack in this output are mostly the countries in the Regions MENA (Egypt by 6,417% and Malta by 0,795%) and LAC Region (Brazil by 1,343% , Chile by 0,87% and Mexico by 1,031%) that register inefficiencies in this output followed by

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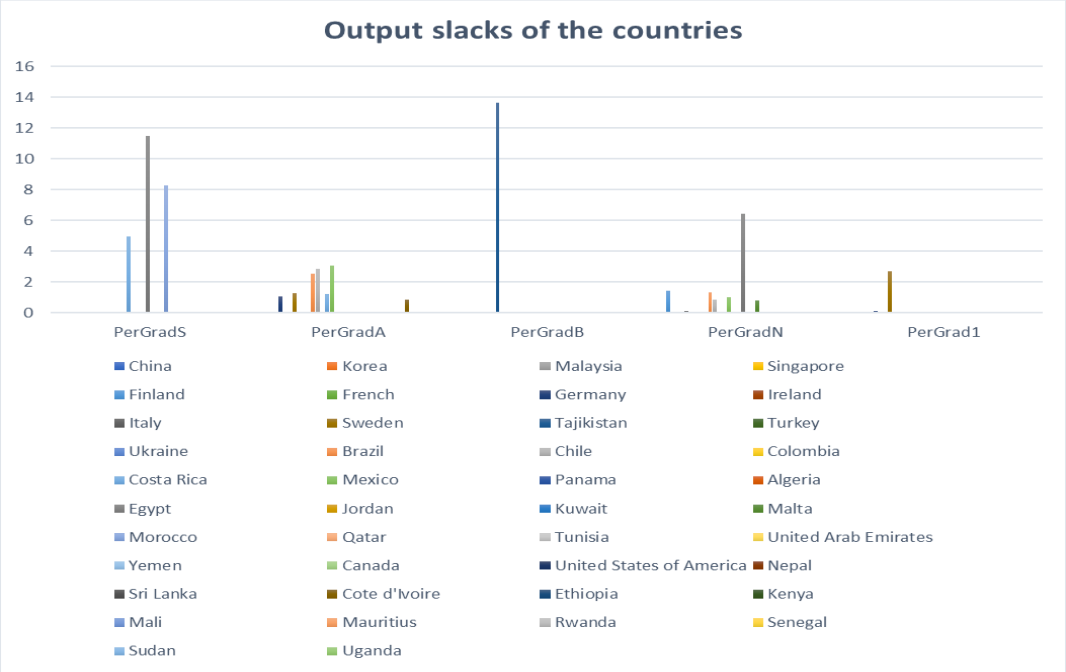
the countries Finland by 1,419% and Italy by 0,12% in the ECA Region .Finally , considering the fifth output : Percentage of graduates from tertiary education graduating from Services programs , we find that Germany register a slack in this output by 1,071% and Sweden by 1,289% .

Figure 2: Output slacks of the countries



Source: The Authors

- Analyzing the input slacks

The Input Slacks represent the potential for the countries to increase their input usage without affecting their current output levels. In other words, input slacks indicate the extent to which a country is not fully utilizing its available inputs.

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Table 8 : Summary of input slacks

Region	firm input	PerAccCo	PerAccC1	GEVEXP	PerQualT	PerQual1	PercQual
East Asia & Pacific	China	0,000	0,000	0,000	0,000	0,000	0,000
	Korea	0,000	0,000	0,000	0,000	0,000	0,000
	Malaysia	0,000	0,000	0,000	0,000	0,000	0,000
	Singapore	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region East Asia & Pacific		0,000	0,000	0,000	0,000	0,000	0,000
Europe & Central Asia	Finland	3,517	5,340	1,080	9,042	0,748	5,322
	French	0,000	0,000	0,000	0,000	0,000	0,000
	Germany	5,763	0,000	0,000	6,206	1,836	4,322
	Ireland	0,000	0,000	0,000	0,000	0,000	0,000
	Italy	11,559	6,732	0,000	11,057	0,113	6,925
	Sweden	9,270	6,150	2,523	10,755	0,927	6,420
	Tajikistan	0,769	0,000	0,303	0,000	0,000	1,261
	Turkey	0,000	0,000	0,000	0,000	0,000	0,000
	Ukraine	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region Europe & Central Asia		3,431	2,025	0,434	4,118	0,403	2,694
Latin America & Caribbean	Brazil	0,000	13,392	1,770	2,018	0,000	0,000
	Chile	4,718	3,010	1,751	8,829	5,677	10,452
	Colombia	0,000	0,000	0,000	0,000	0,000	0,000
	Costa Rica	0,252	0,000	2,485	3,279	0,000	1,339

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	Mexico	23,240	0,000	0,000	1,913	0,000	1,435
	Panama	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region Latin America & Caribbean		4,702	2,734	1,001	2,673	0,946	2,204
Middle East & North Africa	Algeria	0,000	0,000	0,000	0,000	0,000	0,000
	Egypt	13,690	0,000	0,000	13,142	4,412	8,911
	Jordan	0,000	0,000	0,000	0,000	0,000	0,000
	Kuwait	0,000	0,000	0,000	0,000	0,000	0,000
	Malta	0,516	0,107	0,380	3,000	0,000	1,929
	Morocco	7,549	0,000	1,283	13,777	3,625	7,843
	Qatar	0,000	0,000	0,000	0,000	0,000	0,000
	Tunisia	0,000	0,000	0,000	0,000	0,000	0,000
	United Arab Emirates	0,000	0,000	0,000	0,000	0,000	0,000
	Yemen	1,250	0,000	0,037	3,021	0,000	0,890
Mean of the Region Middle East & North Africa		2,301	0,011	0,170	3,294	0,804	1,957
North America	Canada	0,000	0,000	0,000	0,000	0,000	0,000
	United States of America	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region North America		0,000	0,000	0,000	0,000	0,000	0,000
South Asia	Nepal	0,000	0,000	0,000	0,000	0,000	0,000
	Sri Lanka	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region South Asia		0,000	0,000	0,000	0,000	0,000	0,000
	Cote d'Ivoire	0,000	0,000	0,000	0,000	0,000	0,000

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Sub-Saharan Africa	Ethiopia	0,000	0,000	0,000	0,000	0,000	0,000
	Kenya	0,000	0,000	0,000	0,000	1,423	0,000
	Mali	0,000	0,000	0,000	0,000	0,000	0,000
	Mauritius	0,000	0,000	0,000	0,000	0,000	0,000
	Rwanda	0,000	0,000	0,000	0,000	0,000	0,000
	Senegal	0,000	17,850	0,000	0,000	17,598	16,270
	Sudan	0,000	0,000	0,000	0,000	0,000	0,000
	Uganda	0,000	0,000	0,000	0,000	0,000	0,000
Mean of the Region Sub-Saharan Africa		0,000	1,983	0,000	0,000	2,113	1,808
General Mean		1,955	1,252	0,276	2,049	0,866	1,746

Source: Software Release

From the table represented above , we find that , the countries that need to increase their use of their material resources , represented by the variables : Proportion of lower secondary schools with access to computers for pedagogical purposes (%) and Proportion of upper secondary schools with access to computers for pedagogical purposes (%) , are the countries from the Regions LAC , MENA and ECA : Mexico by 23,24% ,Egypt by 13,69% ,Italy by 11,559% ,Sweden by 9,27% ,Morocco by 7,549% ,Germany by 5,763% ,Chile by 4,718% ,Finland by 3,517% ,Yemen by 1,25% ,Tajikistan by 0,769% ,Malta by 0,516% ,and Costa Rica by 0,252% .Most of these countries have inefficiencies using their financial resource as well , for instance Sweden has to increase their use of Government expenditure on education as % of GDP by 2,523% ,Costa Rica by 2,485%,Chile by 1,751% ,Morocco by 1,283% ,Finland by 1,08% ,Malta by 0,38% ,Tajikistan by 0,303% and Yemen by 0,037% ,in addition to these countries we find that also Brazil have to increase the slack in its input by 1,77%. However, considering the human resources, represented by the variables: Percentage of qualified teachers in different levels, we find that the countries: Italy, Tajikistan, Chile, Costa Rica, Egypt, Morocco, Yemen, Senegal and Kenya are underutilizing their human resources in all the levels, while Sweden,

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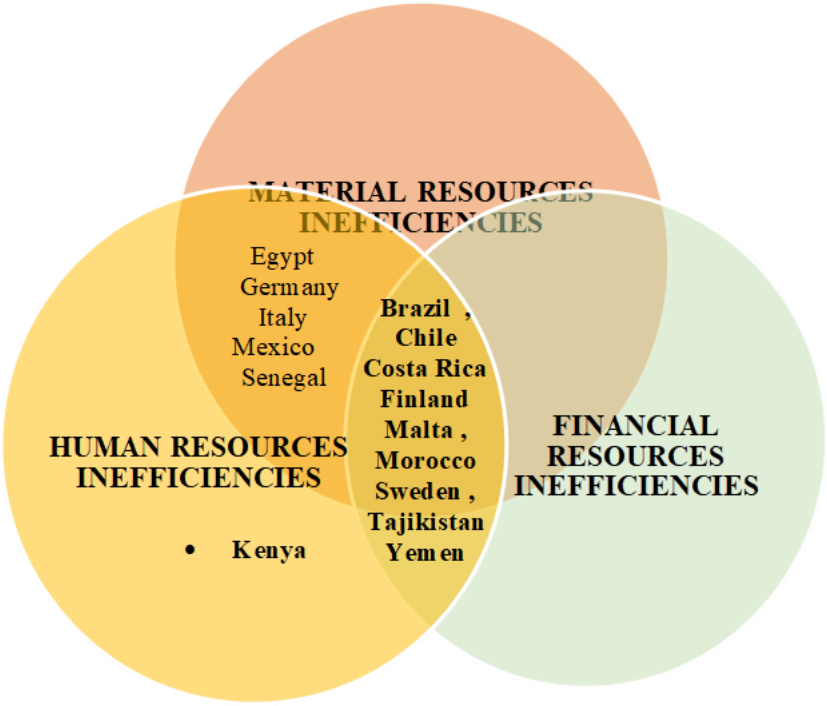
Finland, Germany, Mexico and Malta have inefficiencies in the secondary and lower secondary levels.

Figure 3 : Comparison of countries according to their resource's inefficiencies



Source: Developped by the Authors

- **Benchmark of the countries**

In the tables below, we represent a summary of each country peers and their weights. The interpretation of peer weight refers to the significance or importance assigned to each peer unit in the evaluation of the efficiency or performance of the target unit. Peer weights play a crucial role in determining the relative influence of each peer unit on the efficiency assessment. And they also allow us to identify benchmark units or best practices: For instance, units with higher weights are considered to be more similar to the target unit in terms of their production processes or input-output structures. By analyzing the more influential peers, valuable insights can be gained regarding potential best practices or strategies that the target unit can adopt to improve its efficiency.

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Table 5 : SUMMARY OF PEERS

firm	peers:								
China	China								
Singapor	Singapor								
Korea	Korea								
Malaysia	Malaysia								
Finland	Mauritiu	UnitedSt	Tunisia	Malaysia	Algeria				
Ireland	Ireland								
Sweden	Singapor	Tunisia	Malaysia	SriLanka					
France	France								
Germany	Singapor	Sudan	Nepal	Tunisia	SriLanka	Mauritiu			
Italy	Sudan	China	Algeria	United St	Panama				
Tajikist	Nepall	Panama	Sudan	Tunisia	United St	Algeria	Yemen		
Turkey	Turkey								

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Ukraine	Ukraine								
Chile	Panama	Malaysia	Colombia						
CostaRic	Panama	Nepal	Colombia	Mauritiu	Yemen				
Mexico	Malaysia	Nepal	Panama	Colombia	SriLanka	Mauritiu	Yemen		
Brazil	Colombia	UnitedAr	Panama	Mauritiu	Nepal	Ethiopia	Yemen		
Colombia	Colombia								
Panama	Panama								
Malta	UnitedAr	China	UnitedSt	Mauritiu	Yemen	Algeria			
Qatar	Qatar								
UnitedAr	UnitedAr								
Algeria	Algeria								
Jordan	Jordan								
Kuwait	Kuwait								

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Egypt	UnitedSt	China	Sudan	Nepal	Algeria				
Morocco	Nepal	Algeria	Sudan	Mauritiu	France				
Tunisia	Tunisia								
Canada	Yemen	Algeria	UnitedSt	France	Tunisia	Mauritiu	Nepal		
UnitedSt	UnitedSt								
Nepal	Nepal								
SriLanka	SriLanka								
Kenya	Kenya								
Mali	Panama	Mauritiu	Sudan	Senegal	Yemen	Malaysia	Ethiopia	Sri Lanka	Nepal
Mauritiu	Mauritiu								
Senegal	Senegal								
CotedIvo	Mauritiu	Nepal	Sudan	Panama	Yemen	SriLanka	Malaysia		
Uganda	Uganda								

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Yemen	Yemen								
Ethiopia	Ethiopia								
Rwanda	Rwanda								
Sudan	Sudan								

Source: Software Release

Table 10 : SUMMARY OF PEER WEIGHTS (in same order as above)

firm	peer weights:								
China	1.000								
Singapor	1.000								
Korea	1.000								
Malaysia	1.000								
Finland	0.027	0.236	0.379	0.314	0.044				
Ireland	1.000								
Sweden	0.010	0.393	0.567	0.030					
France	1.000								
Germany	0.059	0.108	0.001	0.577	0.199	0.056			
Italy	0.064	0.062	0.613	0.168	0.093				
Tajikist	0.041	0.163	0.038	0.326	0.136	0.283	0.013		

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Turkey	1.000								
Ukraine	1.000								
Chile	0.531	0.341	0.128						
CostaRic	0.026	0.088	0.632	0.217	0.038				
Mexico	0.204	0.280	0.004	0.361	0.043	0.054	0.054		
Brazil	0.212	0.003	0.143	0.340	0.219	0.021	0.062		
Colombia	1.000								
Panama	1.000								
Malta	0.400	0.127	0.257	0.056	0.024	0.135			
Qatar	1.000								
UnitedAr	1.000								
Algeria	1.000								
Jordan	1.000								
Kuwait	1.000								
Egypt	0.284	0.052	0.301	0.013	0.350				
Morocco	0.060	0.289	0.291	0.262	0.099				
Tunisia	1.000								
Canada	0.025	0.087	0.150	0.367	0.122	0.231	0.018		
UnitedSt	1.000								
Nepal	1.000								
SriLanka	1.000								
Kenya	1.000								

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Mali	0.043	0.039	0.165	0.067	0.076	0.008	0.296	0.206	0.101
Mauritiu	1.000								
Senegal	1.000								
CotedIvo	0.081	0.038	0.099	0.069	0.198	0.452	0.063		
Uganda	1.000								
Yemen	1.000								
Ethiopia	1.000								
Rwanda	1.000								
Sudan	1.000								

Source: Software Release

The countries: China, Singapore, Korea, Malaysia, France, United States of America, Panama, Tunis … are considered benchmark countries. Therefore, other countries, can adopt their practice in order to enhance their education system.

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Conclusion

In this article, we attempt to investigate the technical efficiency of the education system of different countries. Using the DEA method, we were able to conduct a comparative analysis between the different countries, and thus identify the units or the countries that are considered benchmarks or best practices. We were also able to analyze the input and output slacks of various countries in order to provide policymakers in the education system with a view of alternative ways to maximize output without maximizing resources. However, the findings of our study are only the product of our selection of input and output factors. So, different choices of variables could conduct to different results. This observation led us to assume that is important to execute multiple investigations dependent on various outcomes in education and compare the findings with the aim to determine the best benchmarks.

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