
Educational efficiency and optimal use of resources: A comparative study through the use of data envelopment analysis

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ABSTRACT

Education is considered the basic tool for providing individuals with knowledge and skills in order to ensure development. It primarily ensures the accumulation of knowledge reserves, or which are known as the cognitive assets of society, and thus it builds a knowledge society and goes beyond that to building an economy based on knowledge through the added value that it creates. This study aims to Search for a method to estimate the optimal or best use of available educational resources, and relying on benchmarking through a quantitative method known as data envelopment analysis for a sample group estimated at 49 countries, and based on the BCC-O model with the hypothesis of benchmarking between countries, the study proved that The average efficiency under the assumption of changing returns to scale (TEVRS) was 88.7%, while the number of countries that achieved the level of complete efficiency reached 14 countries. As for Algeria, it achieved the lowest level of efficiency at 58.1% and ranked last among countries. That is, within the limits of current spending, Algeria achieved the lowest level of cognitive outputs in light of comparison with the results of other countries.

Keywords

Education, Efficiency, data envelopment analysis, educational efficiency, variable returns to scale (VRS).

Introduction

Most development literature agrees that education is the heart and core of development and that the success of development in any society depends greatly on the success of the educational system in that society, and education is the key to progress, the tool for renaissance, and the source of strength in societies. The development process includes two basic aspects: the human element and the material element. The human element (or the labor element) is the ruling element in development because what is considered an economic resource depends to a large extent on technical and administrative skills and expertise, and it is responsible for transforming various resources from strength to action and from possibility to existence. Indeed, natural resources cannot be utilized well without a good level of skills and education for the workforce. The educated

human element is considered the driving force for economic growth through the development of education and administration, which in turn leads the economy towards rising growth and accelerated development.

One of the main reasons behind the change in vision and thinking was the increased interest witnessed in the 1960s in the added value of education, which Bowman (1986) described as the investment revolution in economic thought. Before long, economists were trying to measure the contribution of education to economic growth. Schultz 1981 - 1983, Denson 1982 - 1996, and Krueger 1984 - 1995. This research activity has influenced many governments, planners, international agencies, and those working in the education sector around the world. On the other hand, it also helped increase the growing demand for education, which was reinforced by the political independence achieved by many developing countries, and all of this was

reflected in the policy of the World Bank, which recognized that education is a worthwhile and productive investment. He considered it the most important methods and means that contribute to social progress. The optimal use of available educational resources in order to achieve educational goals has been the main concern of educational policy makers for a long time, as education costs huge amounts of money, constituting a large percentage of the general budget of any country, and from here the question arose regarding how to use it. Optimization of funds allocated for education.

This study aims to search for a way to estimate the optimal or best use of available educational resources, and then use it effectively to achieve educational goals. From this standpoint, it can be asserted that this research is an essential complement to maximizing the cognitive outcomes of education, and through it we try to address three basic elements related to tools Control and ways to rationalize educational spending, the first of which is efficiency, which represents the relationship between outputs and inputs, followed in the analysis by pedagogical efficiency, which represents achieving the greatest outputs with the least costs or inputs, and whose concept is rooted in the principle of rationalization of educational resources.

Efficiency

The concept of efficiency in capitalist economic thought is linked to the basic economic problem of how to allocate the limited resources available to society in order to meet the needs of individuals' renewable and recurring desires. The concept of efficiency dates back historically to the Italian economist "Falfredo Partera," who developed the formulation of this concept and became known as "Bartier's examples." According to Pareto, any possible allocation of resources is either an efficient allocation or an inefficient allocation,

and any inefficient allocation expresses inefficiency. When comparing several decision-making units, we say that any decision-making unit is inefficient according to Pareto optimization, if another administrative unit or a combination of other administrative units is able to produce at least the same amount of output as this unit produces with a smaller amount of some inputs and without increasing any of the outputs produced by this unit. other inputs, and the unit is efficient if the opposite is true (Nazai & Belhaj , 2016). Efficiency is defined as: "accomplishing more with as little as possible, that is, working to reduce the resources used, whether human, material, or financial, and working to reduce waste and breakdowns in production capacity (Al-Quraishi & Hajj , 2018). Efficiency is also defined as completing work in an economical manner that ensures reaching the goals expected to be achieved. It means obtaining more at a lower cost (Dalal & Al-Hajj, 2017). Agbodan and Amoussouga define it as: it is the best way to use the available resources in the production process (Agbodan & Amoussouga: , 2015). In general, it can be said that efficiency represents the economic relationship between available resources and the results achieved by maximizing outputs under fixed inputs or reducing the quantities used to reach a certain size of outputs.

Types of efficiency The types of efficiency can be summarized into the following types

Economic efficiency

There are many definitions that touch on the phenomenon of economic efficiency, the most important of which is "the extent of the return that accrues to society from investing its resources in economic activity. An activity that results in a greater output from the use of resources will undoubtedly be more efficient from an economic standpoint." (Abu Zaid, 2017). It should be noted here that economic efficiency is widely used by economists in evaluating economic policy. Therefore, economists focus on the issue of efficiency, and the issue is related to either reducing cost or

maximizing profit, and therefore economic efficiency is related to increasing the welfare of society (Shapino). Economic efficiency is studied from two points of view: productive efficiency and distributive efficiency, where “productive efficiency” means determining the best quantity of productive resources that can be combined to produce a specific volume of production on the basis of the prevailing production technology in an industry and on the basis of these resources, As for "distributive efficiency", it means that society's resources have been distributed efficiently, since this distribution cannot be changed without this leading to some members of society becoming in a worse position than they were before the change (Khaled Taha , 2020).

the efficient allocation of resources

It refers to the way in which resources are optimally distributed over their various alternative uses, taking into account the costs of using them. So allocative efficiency refers to producing the best combination of goods by using a combination of production factors at the lowest possible cost (Bukhari & Ali Ben , 2021).

Structural efficiency

The concept of structural efficiency expresses the technical efficiency of an industry or sector. It was introduced by the American Farrell in 1957 and developed by Hajalmarsson and ForSund in their studies in 1974 and 1978. This type of efficiency aims to measure the extent of the continued development of the industry and improve its performance by relying on its best institutions. The structural efficiency of an industry, according to Farrell, is measured by calculating the weighted average or weighted average of the technical efficiency of the institutions that make up the industry (Al-Quraishi & Hajj , 2018). For sund and Hajalmarsson also showed in their study that structural efficiency is measured by taking the arithmetic average of both inputs and outputs (Hjalmarsson & For Sund , 1979).

Definition of educational efficiency

The economic view of education as an investment process has led to interest in rationalizing its expenses, by raising the level of internal and external efficiency and reducing educational waste. According to World Bank experts, efficiency is an equation that links production factors (inputs) and products (outputs). As for the economics of education, Education is a special industry that should not have low outputs like any other industry .(Nacuzon Sall & De Ketele). Dockrell defines it as “a function that explains the relationship between effectiveness and economy, that is, obtaining the greatest amount of output from a given set of inputs.” (Dockrell, 1990). It is also defined as the study of the relationship between educational inputs and outputs. Educational inputs include all the elements involved in education, such as buildings, equipment, tools, teachers, administration, students, curricula, and programs. The outputs also include successful students and professional development for employees (Morsi, 2013). Some believe that the most efficient educational systems are those that achieve the greatest amount of outputs using the least amount of inputs in the shortest time and with the greatest amount of satisfaction and satisfaction (Al-Sharm). In general, it can be said that educational efficiency, in light of this mixture of definitions, is the ability of schools or educational systems to use the resources available to them in order to obtain the required level of outcomes.

Types of educational efficiency

Educational efficiency is divided into the following:

Internal efficiency

This means that the educational system achieves its goals internally (Al-Nouri,). It also means the ability of the internal educational system to carry out the roles expected of it, and it includes all the internal human elements in education that are responsible for implementing educational programs, curricula, accompanying

and administrative activities... and others (Khalifa, 2021). Internal efficiency is divided into two parts:

Quantitative efficiency

is the ability of the educational institution to graduate its students within the specified period for the program in which they are enrolled. This means that the institution has high internal quantitative efficiency if the number of repeaters and dropouts decreases.

As for qualitative efficiency: it means the system's ability to produce a good quality of graduates, in terms of knowledge, skill, behavior, attitudes and values (Agency for Planning and Information, 2013).

External efficiency

What is meant by this is the quality of the student that the educational system produces, and the extent to which the educational system achieves its desired goals in producing a graduate with specifications that meet the purpose intended for it and in accordance with specific standards (Ghaith, 2018).

A comparative study through the use of data envelopment analysis

Historically, DEA returned to Farrell's work (Farrell 1957) but 20 years later, Charnes et. al. used the term DEA and contributed Farrell's ideas. (İÇöz & Harun, 2015) then, The DEA became a program Based on a linear mathematical technique for the efficiency percentage of decision-making collection (Fotova & Martinčević, 2022). In addition, we use it to calculate the efficiency ratio for bank branches and universities for example (Thanassoulis & Mika). Since its discovery in 1978, DEA has become the first non-parametric methodology used in many essential domains, such as agriculture, banking, supply chain, transportation, and public policy (Fotova & Martinčević, 2022).

DEA models vary according to efficient border assumptions called returns to scale assumptions and input or output orientation selection. The first DEA model called the CCR

model, is named after the founders of the model: Charnes, Cooper, and Rhodes. The second DEA model, called the BCC model, was invented by Banker, Charnes, and Cooper and is based on variable returns to scale (VRS), where the returns are not proportionate to increases in efforts.

What DEA does

1. DEA compares units, Then it identifies the best units with the best performance as well as the inefficient units whose performance can be improved. In short, DEA is considered the best means of benchmarking.

2. It enables to calculate of the amount and type of costs that can be saved, and this enables inefficient units to become as efficient as other units.

3. DEA enables inefficient units to rationalize their future spending based on the criteria of efficient units.

4. Management receives information from the performance of its service units that can be used to help transform the system and administrative expertise from good managers, as well as from efficient units to inefficient units using the DEA method. This enables improving results, reducing operating costs and increasing profitability (Sarar & Zakai, 2010).

conditions of use data envelopment analysis (DEA):

Some studies conducted by W.Cooper guarantee the success of using the DEA method by one of the following two rules, otherwise the model will lose its strength between efficient units and inefficient units.

The first rule: The sample size must be greater than the product of multiplying the inputs and the outputs by 3:

$$Ss \geq 3(I + O) :$$

SS =Decision making units DMU

O =Output

I =Input

The second rule: It is called the rule of one-third, where the quality of the model is confirmed in the results obtained so that the number of units with complete efficiency should not exceed 100% one-third of the sample studied (benlebbad, 2018).

$$Ss*1/3 < \text{Efficients}100 \% \text{ DMU.}$$

Data selecting

Through this study, a sample was selected for the study, which includes 49 countries that differ in terms of geographical location and income level. The study data also included 09 variables that are considered necessary in the process of studying the efficiency of educational systems.

The countries included in the study were selected on the basis of two basic variables: the first: the divisions of these countries according to income groups in the world. Which is adopted by the World Bank based on the Gross domestic product (GDP). As for the second variable: it is the distribution of these countries according to the different regions of the world. These variables can be summarized in the table below.

Table 1. Distribution of study countries by region

Countries	Region
East Asia and the Pacific	Indonesia, Japan, Malaysia, Mongolia, New Zealand.
Europe and Central Asia	Albania, Poland, Austria, Azerbaijan, Belgium, Bulgaria, Czechia, Denmark, Finland, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine.
Latin America and the Caribbean	Argentina, Chile, El Salvador, Honduras, Mexico.
Middle East and North Africa	Algeria, Iran, Lebanon, Malta, Morocco, Saudi Arabia, United Arab Emirates, Oman.

North America	United States of America
South Asia	India, Pakistan, Sri Lanka.
Sub-Saharan Africa	Guinea, Sierra Leone, South Africa, Zimbabwe

Source :<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>

Table 2. Distribution of countries by income level

Income level	Countries
Low-income economics	Guinea, Zimbabwe
Economics income below average	El Salvador, Honduras, India, Indonesia, Mongolia, Morocco, Pakistan, Sri Lanka, Ukraine
Upper-middle income economics	Albania, Algeria, Argentina, Azerbaijan, Bulgaria, Iran, Lebanon, Malaysia, Mexico, Romania, Russia, Arabs, South Africa, Turks.
High-income economics	Austria, Belgium, Chile, Czechia, Denmark, Finland, Norway, New Zealand, Malta, Luxembourg, Japan, Italy, Ireland, Hungary, Oman, Poland, Saudi Arabia, Spain, Slovakia, Sweden, Switzerland, the United Arab Emirates, the United States of America.

Source:<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>

Study Variables

The optimal selection of the set of inputs and outputs is considered an important basis for applying the data envelopment analysis method because this affects the interpretation, use and acceptance of the results. The study variables were divided into inputs and outputs, where the input category includes education expenses and, on the other hand, knowledge workers in terms of enrollment rates in university and pre-university education.

As for the outputs, they include the cognitive determinants of education, which are six basic variables: patent applications, scientific articles published per million people, the knowledge index, the education and human resources index, the creativity index, and information and communication technology. As for the year of study, the year 2021 was relied upon for various variables.

Empirical results

The first observations were on technical efficiency assuming constant returns to scale: TE CRS, where the number of countries operating at their optimal size level reached 9 countries, which is less than 1/5 of the sample. Thus, it uses the best combination of inputs and outputs. The number of high-income countries was 04 countries, one of the countries with an upper-middle income (Romania), two countries with a lower-middle income and two countries with a low-income. There was also one country that achieved the lowest levels of efficiency, which was Mongolia with 44.2%. The rest of the countries Its technical efficiency, when assuming constant returns to scale, was above 50%, while the average efficiency of this type was 78.2%.

On the other hand, the average technical efficiency under the assumption of variable returns to scale (TEVRS), which is the basis of this study, was 88.7%, while the number of countries that achieved a complete efficiency level of 100% reached 14 countries.

As the numbers indicate: The United States of America achieved 571,612 registered patents, 41,251.2 articles per million, a knowledge index of 53.6, an education index of 61.1, a creativity index of 5.2, and 5.4 for the information and communication technology index. Switzerland also achieved the highest knowledge index of 61.4, while Finland achieved the highest education and human resources index; also, Japan achieved the highest creativity index of 5.9. As for the highest information technology index, it was Finland. As for Algeria, it achieved the lowest level of efficiency at 58.1% and ranked last among countries.

Table. 3 Average output-oriented efficiency by region and income level

Income level	Average efficiency	Countries	Average efficiency
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Low-income economics	1	East Asia and the Pacific	0.838
Economic s income below average	0.88.6	Europe and Central Asia	0.913
Upper-middle income economics	0.815	Latin America and the Caribbean	0.981
High-income economics	0.919	Middle East and North Africa	0.873
		North America	1
		South Asia	0.856
		Sub-Saharan Africa	1

Source: DEAP .

07 high-income countries achieved complete efficiency, meaning less than a One third of the high-income countries. In contrast. in the total, their average efficiency was 91.9%. As for the rest of the countries that achieved complete efficiency, two countries are low-income, also two countries are income below average, and three countries are upper-middle-income with average efficiency of 81.5%.As for the average efficiency in the output orientation by region, North Africa and the Middle East are the regions that achieved the lowest level of output efficiency.

Economies of scale

scale efficiency is considered the basic tool for identifying the causes of inefficiency, and this is what appears in the results of the output-oriented study, where the causes of various inefficiency are weak technical efficiency when assuming constant returns to scale (TEcrs).According to this study, the number of countries that achieved complete volumetric efficiency reached 9 countries. In total, two low-income countries, two lower-middle-income countries, and one upper-middle-income country. The average volumetric efficiency reached 94.6%, meaning that there is a possibility of maximizing cognitive outputs by 5.4% through using the same inputs. Algeria, for

example, has achieved very high rates of volumetric efficiency, where the reason for this inefficiency is due to technical efficiency, which did not exceed 60%. As for volumetric efficiency, Algeria has achieved an efficiency rate of 92.6%, meaning there is the possibility of maximizing its knowledge outputs to 7.4% without increasing the volume of its expenditures on education or the rest of its inputs. Also, the reason for its inefficiency for Iran is due to low technical efficiency. On the other hand, it achieved a volumetric efficiency rate of 90.9%. That means, there is a possibility of increasing its cognitive output by 9.1%.

Table.4 Volumetric efficiency rates

Volumetric efficiency	Number of countries
less than 60%	1
% 70 - %61	3
% 80 - %71	5
% 90 - %81	12
% 100 - %90	22

Source: DEAProgram.

In the relative distribution of volumetric efficiency, Mongolia is the only country that achieved an efficiency rate of less than 60%, as its volumetric efficiency reached 57.6%. As for the countries that achieved a volumetric efficiency rate between 61% and 70%, there were three countries: Oman, Malta, and Mexico. Five countries achieved a volumetric efficiency rate. Volumetric efficiency between 71% and 80%, 12 countries achieved efficiency rates between 81 and 90%, 8 of which are European and Central Asian countries. As for the largest percentages of the sample. 22 countries, they achieved the highest percentages in efficiency up to complete volumetric efficiency.

Returns to scale also indicate that it is characterized by constant, increasing and decreasing returns to scale. Constant returns to

scale are based on the concept of an increase in inputs corresponding to the same amount of increase in outputs, and this group included 9 countries. As for increasing returns to scale, where there is an increase in inputs corresponding to an increase in outputs, the only country within the sample that achieved this characteristic is Lebanon, where it achieved a ratio Volumetric efficiency of 99.6%. As for the rest of the sample countries, they operate at diminishing returns to scale, meaning an increase in inputs is offset by an increase in outputs, but to a lesser extent.

Suggested improvements

In order to reach the stage of complete output efficiency, the program sets a set of output values that are considered goals for countries and decision-making units to reach. In the category of incomes below average, the program proposes that Ukraine, which has achieved the lowest level of efficiency in this category, raise the rate of patent applications by 66.45%, double the index of the number of scientific articles published per million, and raise the knowledge index from 3.2 to 4.83, and the education and human resources index from 37.9 to 66.2, the creativity index from 3.3 to 5.5, the information technology index from 3.9 to 5.9, and in the category of upper-middle-income countries.

The model suggests that Algeria, which achieved the lowest level of efficiency within the category, should increase patent applications more than 8 times, that is, from 840 applications to approximately 8,000 applications, and that the rest of the other indicators should be doubled until Algeria reaches full efficiency compared to the rest of the countries. According to these data, Algeria appears as a country that needs to make many efforts to maximize its knowledge outcomes. In the high-income category, where Poland achieved the lowest level of efficiency at 70.6%, where the program proposes to raise patent applications from 4411 to 46480, the number of published scientific articles from 28753 to 40724.8, the knowledge index from 29

to 41.1, the education and human resources index from 37.6 to 60.3, and the creativity index from 3.3. to 5.1 and the information technology index from 4 to 5.7.

Table .5 Suggested improvements in order to achieve full output-oriented efficiency

Conclusion

Education is considered the basic tool for individuals to acquire knowledge and skills in order to ensure development. It primarily ensures the accumulation of knowledge reserves, or what is known as the cognitive assets of society, and thus it builds a knowledge society and then builds an economy based on knowledge through the added value that it creates, which is embodied in reality through various Scientific products such as patents, high creativity and innovation index, knowledge index and other indicators that affect the reality of the industrial sector and thus the future of development. On the other hand, it is the most effective tool for raising the level of awareness among individuals and their formation, and ensuring that they are directed towards a public policy based on the two components of sustainability.

The structure of this study is to maximize cognitive outputs under the same level of spending. The program used in the study relies on the benchmarking feature. 49 countries were relied upon as a sample for the study and 9 variables, 3 of which were inputs to the education process and 6 were cognitive outputs. The study indicated that there is a non-direct relationship between Variants. The correlation relationship is not strong, which requires adopting variable returns to scale (VRS), or what is known as the BCC method, in the measurement process.

As an in-depth reading of the results of this study, despite the great strides that Algeria has taken in promoting education and spending on it, it is still far from the ranks of countries in this field. The reason is due to the lack of clear goals

in the field of spending on education that the state wants to reach. Therefore, its policy is based on The spending approach is in order to bring the learner to a certain level of awareness and not to push the learner to create added value in society, and this is what all developed countries achieve. The lack of spending on education and the educational system share these results, as it is based on the principle of banking education and nothing other than any request to return what Provided from knowledge on the day of exams or when the graduate is employed. Based on what we discussed in our research as well as the results we reached,

We decided to provide some recommendations and suggestions as follows:

We must develop our view of education and move away from the idea that it is consumer spending to being investment spending, spending on individuals that contribute to their skills and awareness and raise their level. The results of this spending will be for the individual and society alike.

The necessity of adopting a curriculum based on the principle of setting educational goals for the educational process so that educational costs become value-added in light of the adopted public policy.

Opening the way for the private sector in the field of education to either train within the limits of its own requirements, or to contribute to the training process by establishing private schools or universities.

Work to benefit from countries' policies in the field of education and sustainable development, especially those that were reference countries according to this study.

Develop a clear and thoughtful strategy in this field or a vision that will have an impact on the course of the educational system and aims to achieve more achievements in the field of education and sustainable development.

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