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# Assessment of the European Union's Educational Efficiency

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**Abstract:** This paper assesses education sector's efficiency by comparing 28 European Union states at different levels of education using the mathematic approach of data envelopment analysis. We conducted the study from both the allocative and technical perspectives by considering all education levels separately and then as a whole, every three years, starting with 2006. The input and output variables were adapted to each particular level of education. In this way, we offered a complete image of the education system, creating a ranking for the countries, based on efficiency scores. Efficiency appears to be achieved when education results, such as the Programme for International Student Assessment scores, attainment level or other value-added outcomes, are reached with rather low levels of financial resources. The performance in education lacks sustainability in many countries, mostly belonging to Mediterranean and south-eastern European groups, with old member states recording efficiency scores closer to 1 compared to the new ones. Inefficiency derived from different causes and interactions between these causes (the mixture between public and private resources, the different population composition, gross domestic product per capita or levels of education attainment) and most often imply particular solutions from country to country.

**Keywords:** education expenditures; allocative efficiency; technical efficiency; data envelopment analysis; European Union; programme for international student assessment

## 1. Introduction

The economic thought has always been interesting to study the role and impact of human capital investments, especially via education and formal instruction, for economic growth and nations' development. Human capital and endogenous growth theories claim that education is a fundamental vector for creating and nurturing growth and development. A very close connection has been established between a population's education level and the quality of its education system on the one hand and economic and human performance on the other hand.

Education is acknowledged for having a positive impact upon the economic, social, political and demographic sectors. On the economic level, it allows individuals to improve their productivity, increase their revenues and employment outlooks and, at the same time, leads to increased competitiveness and attractiveness of national economy, as it benefits from a solid stock of qualified human capital.

At a social level, education facilitates social integration and creates equal opportunities, from both the gender (men/women) and location perspectives (rural/urban). Education also allows specialization in high value-added areas, which are dependent upon technology and innovation, whereas for developing countries it facilitates catching up and getting close to the technological frontier [1].

In addition, education and research allows sustainable endogenous economic growth, based on innovation and technology. Each innovation represents a new intermediate good that can be used to produce the final output more efficiently than before. For the more developed countries, education facilitates the recovery and approach of the technological frontier [2].

In the demographic plan, according to the theoretical literature, fertility and family size are known to decrease along with women's education level [3,4]. This relation between education and fertility is verified both at the microeconomic level (less educated women have, in general, more children) and at macroeconomic level (countries with more advance educated population display moderate and controlled demographic growth and fertility rates).

Education is a subject of interest for professors, specialists, public authorities and civil society, especially since public expenditures allocated for this sector have registered increases in both absolute and relative measures. Education brings benefits for individuals as well as for the economy and, as a consequence, the quantity and quality of this public good represents a permanent preoccupation for specialists and politicians.

As is well-known, education is a continuous process which does not end after completing a particular (higher or lower) educational level. There are cases in which individuals have to fulfill certain tasks, within their job for instance, for which they do not have the proper training and knowledge, either because they studied and prepared for something else, or because they did not receive the educational elements needed in order to be able to practically cope with the job's requirements. For example, we may find managers who have to take fiscal, financial or accounting decisions without having a complete educational background in this respect. The lack of information not only affects their direct activity and the way these managers run their business, but also their ability to communicate with external users or the way they could provide an accurate image of the company [5]. Broadly speaking, all education systems should provide all the necessary instruments so that each person is able to perform in his field of activity. This means that education should be more and more addressed from a practical point. Many national education systems should seriously readapt and identify the adequate ways for implementing on a larger scale internships and practical stages starting even from secondary education. The best way to learn is to experiment on your own, perhaps guided by those more responsible and experienced.

In these circumstances, one may argue about the optimal level of resources provided for education. The relationship between the resources allocated for education funding and this sector's performance is a continuous subject of debate, considering the difficulty of identifying and sometimes defining the measures needed to express the generated outputs. Efficiency and efficacy in education should be analyzed together considering the nature of the results of the educational process.

Education costs have increased constantly during the last decade and the current challenges confronting this sector have drawn attention to the necessity of using the financial resources allocated to education with both efficiency and efficacy.

The development and modernization of education have led to increasing financial resources allocated to this sector in all countries, both developed and developing. The education expenditures differ from one country to another and from one individual to another and they offer a picture of a country's capacity to uphold human capital development and the importance it holds in the long-term development strategies. The state's role in education funding also increased because, at an individual level, the expenditures allocated for education are uncertain and variable.

The new economic context (e.g., economic crises, the COVID-19 pandemic), which generates significant setbacks in the economic growth of virtually all world states, will also substantially reduce the state available resources and, hence, the resources directed toward the education sector. The analysis of efficiency vs. inefficiency of financial resources originating from the public budget becomes opportune and relevant.

Efficiency appears when education results, such as scores in testing or value-added outcomes are achieved with a decent (not very high, actually rather low) level of financial resources [6]. As education and professional training systems can perform a decisive role in achieving the strategic objective established by the Lisbon European Council, of making the European Union (EU) the most competitive and dynamic knowledge-based economy

of the world, member states are encouraged to invest sufficient resources so they can be directed and managed in the most efficient way possible.

The current study's purpose is to evaluate the EU's education system using the well-known mathematic program of data envelopment analysis (DEA). We consider our paper to be an original contribution as we have conducted a multilevel analysis, considering a longer period of time to evaluate performances of a particular education system, and separating the analysis according to the three main levels of education (primary, secondary, and tertiary). Finally, a global efficiency perspective of the education sector is also approached to observe whether the monetary resources allocated for education produced the desired results.

In addition to these methodological elements, described in more detail in the presentation of the Materials and Methods Section, the novelty of our research lies also in conducting the study from both the input and output perspectives, considering all education levels separately and then as a whole by adapting the input and output variables to each particular level. In this way, a tridimensional image of education systems across Europe is created and all the 28 countries are compared in terms of technical efficiency, as well as from a resource allocation perspective. It is a complex and desired approach since it offers a wider image of the education sector for researchers and other readers interested in such comparisons and analysis. According to one of our main results, spending more does not necessarily bring about better results and signals that education performance is first of all a matter of quality rather than quantity in allocating resources (financial, material, human, technological, informational, etc.). The research paper is organized into five main parts. The introduction places the study in a broader context, defining the purpose of the work and its significance, whilst the second section reflects on some literature findings with respect to education efficiency. The third part presents the methods used to evaluate the efficiency/inefficiency degree of EU education systems and introduces the variables processed for the efficiency analysis. The next chapter is divided into four subsections presenting the results and discussion, each of these subsections approaching a certain level of education. The fifth part concludes and gives some possible suggestions for further analysis.

## 2. Related Works

A review of the literature approaching the education sector's efficiency at various levels (primary, secondary, tertiary and others) has pointed out that most papers refer to higher education efficiency, followed by the ones concerning secondary education and other levels, whereas the least are dealing with national or multinational level educational efficiency, with and only a few focusing upon student level efficiency [7].

The efficiency of public expenditure expresses an optimal dimension of the ratio between financial efforts (the consumption of public financial resources) and observable estimated effects. As the ratio is lower, the efficiency of allocated public expenditure improves. A public project is considered efficient when it satisfies collective needs, is implemented rationally and is sustainable and durable.

To analyze education efficiency, the literature presents non-parametric methods based on mathematical optimization models, e.g., data envelopment analysis (DEA) [8–22] or free disposal hull (FDH) [20,22–24] as well as parametric methods, e.g., stochastic frontier analysis (SFA) [25–27]. In turn, efficacy is studied with difference-in-differences experiments and with instrumental variable estimations.

In a relatively short period of time, DEA has become a strong quantitative analysis instrument, used by different activity entities to measure performances [28]. The method was applied for macroeconomic performance measurement in the health sector [29–33], at a regional level in the public administration system [31], at a microeconomic level in the education system [34–36], in the private banking sector or in other sectors [37–39].

The literature approaching nonparametric methods of efficiency research is criticized as it largely ignores the possible detrimental effects of endogeneity (error correlations) upon efficiency [6]. DEA was used to measure the size, type and source of education operational

expenditures in view of explaining the faint relation between financial resources allocated to education and its performances. Budgetary inefficiency was significantly associated with budget size, with indirect expenditures and local revenues' related responsibility [8].

The excessive increase of public expenditures, the increased weight of salaries into public expenditures and income distribution inequality (which negatively influences education access and effects) are some of the determining factors of inefficiency. Urbanization usually supports efficiency increase, with the inverse also true [23].

DEA and multiple criteria evaluation (MCE) methods were employed to study education efficiency in EU member states for the 2010 to 2013 period to find that high efficiency met in some countries came at the expense of equity. From a policy perspective, the optimal results come when high education outputs are obtained without sacrificing the chances that less favored students have to obtain good results as well [9].

The DEA methodology was also used to analyze the efficiency of education public expenditures for 31 European countries, mostly EU member countries, from 2013 to 2017. The efficiency analysis of public expenditures funding higher education revealed that the European education system has but a few development poles, which can be considered as efficiency models, whilst most countries (and especially Mediterranean and eastern Europe ones) register lags and significant performance differences [10].

A DEA 25-year study (1988 to 2013) of Saudi Arabia's public expenditures showed a rather high degree of inefficiency. The paper argued that Saudi Arabia can improve its performances in matters of health, education and infrastructure without increasing the level of corresponding public expenditures [40].

The variable returns-to-scale data envelopment analysis (VRS-DEA) for 2009 and 2016 was employed to compare 27 EU countries. The results show that, in 2009, 13 countries were efficient, whilst, in 2016, only seven out the 27 analyzed proved to be efficient [41].

Another paper studied European countries' tertiary education for the 2004 to 2015 period. The researchers calculated efficiency scores using DEA, and then applied corrections to them, considering some qualitative factors that can alter the initial efficiency scores. They hence eliminated some countries (most of them not highly economically developed) that were previously deemed as efficient [11].

Brazil's higher education case was studied for the 2001 to 2011 period using several methods like the multivariate statistical analysis, DEA and multiple regression. Some federal states obtained good efficiency, such as Minas Gerais and Rio Grande do Sul, who have allocated reasonable budgets and have good evaluation scores. Other states, such as Maranhão and Pará, obtained unsatisfactory scores, yet had lower budget allocations [12].

The efficiency of public expenditures was addressed for 20 Organisation for Economic Cooperation and Development (OECD) member countries for the 2009 to 2013 period, using public sector performance (PSP), public sector efficiency (PSE) and DEA methods. Research showed countries with a higher weight of public expenditures into GDP are less efficient compared to the ones with a lower weight into GDP of these expenditures [13].

DEA and cluster analysis were taken into consideration for an analysis of the 2008 to 2012 period for 17 Shanghai districts, evaluating the Shanghai basic education system production efficiency. The districts were grouped according to resource input as rich or poor and efficiency results showed suburban districts were more efficient as compared to the rich urban districts [14].

DEA application in secondary and tertiary education was reviewed focusing on the opportunities it offers for institutional level benchmarking. At the secondary level, the disaggregation of efficiency measures into pupil-level and school-level effects were investigated. For higher education, performances of specific functional areas and of individual employees were approached [15].

In a study conducted in 2013, DEA was employed to evaluate fiscal expenditures spending efficiency in Hei Long Jiang province between 2002 and 2012. The conclusion was that education funds were not used reasonably and there was practically a waste of resources [16].

The DEA and Tobbit methods were used to study 23 Latin American and Caribbean countries for the 2001 to 2010 period. By measuring the efficiency of public spending, both from an input and output perspective, their results showed that the average output score of technical efficiency could be theoretically increased by 19% using the same inputs [17].

In a 2012 paper, 28 EU and OECD countries were analyzed for 2010 with DEA. The purpose was to measure the relative efficiency of using public education, research and development (R&D) expenditures in new EU member states in comparison to the whole of the EU (plus Croatia at that moment) and OECD countries. The empirical results suggested that, in general, new EU member states show relatively high efficiency scores regarding tertiary education, while lagging well behind in the R&D efficiency measures. Hungary, Estonia and Slovenia offer the best practice models when it comes to the primary, secondary and tertiary levels of education, while Cyprus and Hungary again are references for the R&D segment [18].

A survey of the DEA literature in the education context was developed a decade ago. The author's intention was to offer other researchers his findings in order to assist them in better understanding the status of this methodology for education, and in enhancing the field in the future [19].

DEA, FDH and Malmquist–DEA were employed to study the efficiency of 71 Philippines provinces in utilizing public resources for health and education for 1997 and 2000. In the Philippines, only 1% of the total budget is spent for health and 3% for education. The authors' results indicated that provinces could achieve higher health and education outcomes given their expenditures levels. They also found that the provinces where the inequality level is higher as well as those that received a larger portion of their budget as grants were among the least efficient [20].

The DEA and Tobbit methods were applied for an analysis conducted for 25 states in 2003, mostly OECD states, to measure expenditure efficiency for secondary education by comparing the Programme for International Student Assessment (PISA) results with allocated resources (number of professors for each student, time spent in school). After regressing the efficiency scores from an output perspective, it showed that inefficiency is strongly linked to GDP per capita level and parents' education level (a proper family study environment is an important condition for envisioning continuous personal development and finally getting good results in school) [21].

The FDH and DEA methods were used to analyze 140 countries for the 1996 to 2002 period. The results showed analyzed countries could have obtained better results and that lower efficiency countries should increase the level of public expenditures [23]. The same two methods were employed to analyze 24 OECD countries for the year 2000 in terms of the quantity of input necessary to reach a certain level of performance in health and education sectors. Each of the two methods produced exactly the same number of efficient countries in health and education sectors. With a similar volume of resources, the less efficient countries can improve their situation and obtain similar results to the more efficient ones. The accent should fall on the types of inputs considered, because there is a risk that after introducing certain variables a country could be appreciated as inefficient if the resources allocated are expensive or readily available in too large a quantity. That can happen even if, from a technical point of view, that country offers quality and efficient services compared with other similar countries. Three countries were identified as efficient—Republic of Korea, Japan and Sweden [22].

Another study employed Tobbit and FDH analysis to compare 38 African countries between 1984 and 1995. The analysis consisted of studying the efficiency of education and health government expenditures, by first comparing the 38 African countries between themselves and then by comparing them with countries from Asia and the western hemisphere. The results proved that most African countries are on average less efficient than the Asian or the western ones, which brings about the idea that Africa needs both higher budgetary allocations as well as major improvements in educational attainment and health delivery services [24].

The papers studying efficiency using the parametric method of SFA provided either a systematic review on the general usage of the SFA to measure higher education system efficiency [25] or evaluated the efficiency of different educational units (secondary education schools, public universities) [26,27].

The results obtained from the research, using parametric or non-parametric methods, offer to interested parties (decision makers, public authorities, specialists, academia, beneficiaries and others) an image of resource use efficiency in terms of outputs or signaling that there can be an improvement in outputs with the same level of allocated public financial resources.

## 3. Materials and Methods

Educational efficiency is often confused with educational effectiveness and, sometimes, the two terms are inappropriately used. Educational effectiveness is when a certain set of resources has or does not have a positive effect on achievements and, if so, how great this effect is. Since efficiency does not directly compare costs, what is effective is not necessarily the most efficient [42].

### 3.1. Methodology

Efficiency refers to a comparison of inputs and their related results. There are two important directions that might be implemented to develop efficiency analyses. First, one may want to know by how much costs or other non-financial resources may be reduced to obtain the same level of output or outcome. Second, an output perspective implies a maximization of results by maintaining the same input values.

Data envelopment analysis (DEA) is one of the most adequate methods that identifies efficiency and inefficiency among decision making units (DMUs) by comparing each entity with the others and not by referring to a non-existent ideal such entity. DEA is described as a state of resource allocation in which it is impossible to have an efficient DMU without identifying at least another one as inefficient/less efficient. The efficient DMU generates either the same output using a lower input or a higher output using the same input. The concepts of technical efficiency, which reflects the ability to obtain maximal output from a given set of inputs, and allocative efficiency, which reflects the ability to use the inputs in optimal proportions, given their respective prices, were first introduced more than half a century ago. The two assumptions are then combined to provide a measure of overall efficiency. Although developed in 1957, this approach of studying efficiency is still one of the most adequate and significant instruments available to compare DMUs [43].

As stated earlier in the introduction, the research paper aims at evaluating education sector efficiency by comparing all the 28 EU member states at different levels of education. The analysis has been carried out for the 2006 to 2018 period. The input and output indicators specific to primary, secondary, tertiary and the whole education system of the 28 DMUs were collected starting with 2006 and continuing with 2009, 2012, 2015 and 2018. In this way, we managed to compare these countries' education systems at a certain moment in time (considering only one year), as well as in dynamics, reconsidering the analysis every three years for a 13-year period. This approach was influenced by PISA results, which are published every three years, a variable included as an output in our secondary level and total education DEA analysis.

DEA is used to measure the efficiency of public spending on education. It identifies optimally performing DMUs and assigns them a score equal to 1. These DMUs serve to identify an efficiency frontier against which all DMUs are compared. The linear programming method used was the Banker, Charnes and Cooper (BCC) model, which explicitly states which resources should be used to get priority in the competition. The BCC model was first introduced in 1984 and it represented a very important moment in the DEA historical background as it laid the basis for estimating each DMU's pure efficiency with reference to the efficient frontier. It also identifies whether a DMU is operating in increasing, decreasing or constant returns to scale (CRS) [44]. If one cannot assume that returns to

scale do not change, then a VRS type of DEA model is an appropriate choice; otherwise, the CRS type is preferable. Most studies use the VRS method, as the relationship between inputs and outputs does not usually imply a constant rhythm of change in the output when the input increases or decreases by a certain percentage (output-oriented model) or in the input when the results change by a certain percentage (input-oriented version).

### 3.2. Data Analysis

The specification of the input and output indicators is a crucial first step in DEA, especially since the larger the number of these variables, the higher the expected number of efficient DMUs [23].

Basically, the data set to evaluate education sector efficiency (at different levels) includes input data, i.e., (public) expenditure per student, primary, secondary or tertiary (% of GDP per capita) or total expenditure on all levels of education (% of GDP) and output/outcome data, i.e., school enrollment, primary, secondary or tertiary (% of corresponding age group population), pupil–teacher ratio, primary completion or graduation rate, total (% of relevant age group), unemployment with advanced education (% of total labor force with advanced education), labor force with tertiary education (% of total labor force) and PISA average score. All of these indicators were collected for the 28 EU countries included in the analysis using the World Bank, OECD and European Commission databases.

Table 1 presents the different inputs and outputs/outcomes used in the non-parametric DEA mathematical approach in four distinct models. Each model was run for 2006, 2009, 2012, 2015 and 2018. Two of the output indicators presented in the third column of the table were adjusted in order to offer favorable characteristics of the analyzed phenomena. We are referring to the pupil–teacher ratio used for the primary and secondary education and the unemployment rate introduced for the tertiary level. The adjustments made for these variables are properly explained in the paragraphs following Table 1.

**Table 1.** Input and output/outcome set for the DEA—Education Sector (at different levels).

| Model | Inputs | Outputs |
|---|---|---|
| 1 (Primary) | Expenditure per student, primary (% of GDP per capita) [1] | School enrollment, primary (% of age group population) [1] <br> Pupil–teacher ratio in primary education [1] <br> Primary completion rate, total (% of relevant age group) [1] |
| 2 (Secondary) | Public expenditure per pupil, secondary (% of GDP per capita) [1] | PISA Average [2] <br> School enrollment, secondary (% of age group population) [1] <br> Pupil–teacher ratio in secondary education [1] |
| 3 (Tertiary) | Expenditure per student, tertiary (% of GDP per capita) [1] | Unemployment with advanced education (% of total labor force with advanced education) [3] <br> Labor force with tertiary education (% of total labor force) [1] <br> School enrollment, tertiary (% of age group population) [1] |
| 4 (Total) | Total expenditure on education, (in % of GDP) [1] | PISA Average [2] |

[1] The World Bank database [45], [2] OECD database [46], [3] Eurostat database [47].

Two financial indicators were included in this analysis—government expenditure per student and total expenditures on education as a percentage of GDP.

The education expenditures prove to represent a real investment in the society as they accomplish an important role in a nation's economic progress and performance. It involves expenditures made to the education sector for enhancing the knowledge of individuals and thus creating a society of knowledge. A higher percentage of government expenditure for education shows a high government emphasis on education relative to other public investments. However, when interpreting this indicator, one should keep in mind that

some governments have more or less means and therefore larger or smaller overall budgets, and countries with younger populations may spend more on education in relation to other sectors such as health or social security or vice versa.

Government expenditure per student quantifies the average general government expenditure (current, capital and transfers) per student in the given level of education, expressed as a percentage of GDP per capita.

Total education expenditures are expressed as a percentage of GDP; they include expenditures funded by transfers from international sources and are an amount of the total government budget of a country, allotted for different educational activities. General government usually refers to local, regional and central governments.

After studying the relevant literature in the field [6,14,16,18,19,36], we chose as output variables school enrollment, teacher–pupil ratio, PISA test results, employment and labor force.

Student enrollment refers to the number of persons enrolled in a school at a particular level. In line with economic theory, school enrollment portrays a positive and significant influence on human capital development. It is often observed that the level of school enrollment is highly correlated with national productivity. This is not only because educated people are more productive, but also because they may positively affect the productivity of others with whom they work [48]. A 2013 paper further strengthens the grounds that human capital is indeed an important component and acts as an economic growth engine [49].

The school enrollment ratio is the total gross enrollment, regardless of age, divided by the population of the age group that officially corresponds to the level of education shown. While increased enrollments may suggest that school systems have increased their capacity to accommodate more children, this does not necessarily translate into improved educational quality.

Primary education provides children with basic reading, writing and mathematics skills along with an elementary understanding of subjects such as history, geography, natural science, social science, art and music. Primary education normally starts between the ages of five and eight, after preschool, and it is believed to produce many positive effects. For example, The United Nations Children's Fund (UNICEF) considers that it decreases poverty and child mortality rates, encourages gender equality, increases environmental understanding, etc.

Table 2 allows a more exhaustive description of the differences between analyzed countries in terms of the starting and leaving age for primary education [50].

**Table 2.** The starting and leaving age of students in primary education across EU.

| Starting Age | Leaving Age | Country |
|:---:|:---:|:---:|
| 5 | 11 | Cyprus, Malta, The United Kingdom |
| 6 | 10 | Austria, Germany, Hungary, Slovakia |
| 6 | 11 | Czech Republic, France, Italy, Romania |
| 6 | 12 | Belgium, Greece, Ireland, Luxemburg, the Netherlands, Portugal, Slovenia, Spain |
| 6 | 13 | Denmark |
| 7 | 11 | Bulgaria, Croatia, Lithuania, Poland |
| 7 | 13 | Estonia, Finland, Latvia, Sweden |

Source: European Commission, 2018.

According to specific literature, a higher entry age has a positive effect on the grade point average and increases the likelihood of passing a grade [51,52]. The results of exploiting the exogenous variation in school starting age later indicate a positive age effect on reading, mathematics and science skills, which basically represent PISA performance.

From this perspective, the countries appearing on the last two rows of Table 2 are expected to be more efficient than the others, at least when referring to primary education.

Secondary education completes the provision of basic education that began at the primary level and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers. It covers two phases: lower secondary education, which is considered the final phase of basic education (children typically enter this stage around the age of 11), and upper secondary education, when young people of about 14 or 15 years old go to high school or attend other professional or vocational schools.

As for primary education level, the different ages at which pupils start lower secondary education and finish upper secondary education might be a sign of higher efficiency. The relative age effect is proved to involve a relatively better performance in academic settings for older students because they are more experienced and mature [53]. Entering school at a younger age increases the risk of repeating at least one school year by seven percentage points and reduces academic performance (measured through the PISA score) by 6 to 10 score points in mathematics, reading and science. However, there is no clear evidence that the early entrance effect is different between genders or for urban and rural locations [54].

Table 3 highlights the starting and leaving age for students following secondary level of education.

**Table 3.** The starting and leaving age of students in secondary education across the EU.

| Starting Age | Leaving Age | Country |
|:---:|:---:|:---:|
| 10 | 18 | Austria |
| 10 | 19 | Germany, Hungary, Slovakia |
| 11 | 18 | Cyprus, France, Malta, United Kingdom |
| 11 | 19 | Bulgaria, Croatia, Czech Republic, Italy, Lithuania, Poland, Romania |
| 12 | 18 | Belgium, Greece, the Netherlands, Spain, Portugal |
| 12 | 19 | Ireland, Luxembourg |
| 12 | 20 | Slovenia |
| 13 | 19 | Denmark, Estonia, Finland, Latvia, Sweden |

Source: European Commission, 2018.

Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level. Tertiary education is the highest level of education, provided by universities and other higher education institutions and comprises short-cycle tertiary education, a bachelor's degree or equivalent education level, a master's degree or equivalent education level, or even doctoral degree or equivalent education level according to the International Standard Classification of Education (ISCED 2011) [55]. As the whole education system, the tertiary one is generally seen to play an essential role in society, by fostering innovation, increasing economic development and growth, and improving more generally the well-being of citizens.

The pupil–teacher ratio is calculated dividing the average number of pupils enrolled (primary or secondary) to the number of teachers in primary or secondary school. The impact of the pupil–teacher ratio on educational outcomes is among the most researched areas in education. A high pupil–teacher ratio suggests that each teacher has to be responsible for a large number of pupils. In other words, the higher the pupil–teacher ratio, the lower the relative access pupils have to teachers. It is generally assumed that a low pupil–teacher ratio signifies smaller classes, enabling the teacher to pay more attention to individual students, which in the long run may result in a better pupils' performance [56].

According to The United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Institute of Statistics, the ratio of students to teaching staff is an important indicator of the resources devoted to education. Smaller classes are often perceived as allowing teachers to focus more on the needs of individual students and reducing the amount of class time needed to deal with disruptions. They contribute to a better learning environment for the students and to improved working conditions for teachers and staff. Overall, evidence on the effects of reduced class size on student performance is weak [57]. Furthermore, there is no consensus on what the best ratio of students to teachers should be at different education levels, but there is wide agreement that younger children need more time and interaction with teachers for a quality education, supporting a lower ratio of students per teacher in early education. There is also some evidence showing that smaller classes may benefit students from disadvantaged backgrounds [57]. The literature also indicates a positive association of smaller class size and higher teacher satisfaction. It is important to note, however, that the ideal student–teacher ratio will vary depending on a few different factors. Among other things, one may have to consider the age of the students as well as their academic needs. For example, younger students and students who face learning challenges require more time and individual attention from teachers. That is the main reason why this variable was included as an output measure in our analysis only with respect to primary and secondary education. When answering the question: "How important is the student-teacher ratio for students?", the Children's Educational Services mentioned factors such as teachers' skills, experience and efficacy, as they are not all equal [58]. A more highly skilled and experienced teacher might be able to handle a larger class than one who is less experienced [57].

As the pupil-teacher ratio is an output variable and considering the previous conclusions identified in the literature, this variable's displayed values should be as low as possible to generate good results for that country. In other words, the efficiency measurement techniques imply that outputs or outcomes are measured in such a way that more is better [22,30]. Starting from these assumptions, we decided to make a change in the initial data collected by using an inverted report so that a higher value of this indicator shows a good characteristic of that state. In this way, we created a teacher-pupil ratio.

The completion rate describes the proportion of students entering a particular educational level/program and completing it successfully. The primary completion rate or gross intake ratio to the last grade of primary education is the number of new entrants (enrollments minus repeaters) in the last grade of primary education, regardless of age, divided by the entrance age population for the last grade of primary education. Data limitations preclude adjusting for students who drop out during the final year of primary education.

PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges. The PISA average is calculated as the average score of mathematics, science and reading. It is a comprehensive international assessment of student learning outcomes and, hence, is important for both education systems and education professionals. Around 600,000 students in 79 countries and economies completed the test in 2018, representing about 32 million 15-year-olds. Because a high ranking on PISA correlates to economic success, researchers have concluded that PISA is one indicator of whether school systems are preparing students for the 21st century global knowledge economy [57,59]. High-paying jobs and high-profit industries require workers who can think critically, connect ideas and work across international borders. Rich countries no longer require a large workforce to perform menial tasks, yet school systems have been traditionally slow and difficult to change.

Unemployment with advanced education is measured by the unemployment rate, which is the number of people who are unemployed and finished a higher education level as a percentage of the labor force (the total number of people unemployed added to those employed) with advanced education. A major benefit of education is the lower risk of unemployment at higher educational levels. According to data from the U.S. Bureau

of Labor Statistics (BLS), earnings increase and unemployment decreases as educational attainment rises. Data shows that those with more education have higher earnings and lower rates of unemployment than those with less education [60]. As discussed in the case of the pupil–teacher ratio indicator, in order to respect the DEA requirement regarding outputs, the higher their value the better; the unemployment rate of those with higher education should occupy a small share in the total number of those representing the labor force that has graduated from a higher education cycle. As a consequence, we have subtracted the initial unemployment rate with tertiary education from 100%, so that there is a higher percentage to bring about the desired outcome for each country.

The labor force with tertiary education represents the share of the total labor force that attained or completed tertiary education as the highest level of education and should be as high as possible.

## 4. Results and Discussion

The assumptions made in Section 2 and the variables introduced for each model brought about some unexpected results. It is a three-dimensional cross-sectional efficiency approach (five years, four models describing the education levels and two orientations of each model every year) for a number of 28 DMUs, a reasonably complex scenario which is not so frequently found in specific literature. Under these circumstances, to create a relevant and easy to follow presentation of our results, we decided to analyze and briefly discuss both input-oriented and the output-oriented scores for each level of education separately.

### 4.1. Primary Education

The efficiency of primary education was studied in the 1 input–3 outputs scenario. The best performers with respect to primary education level are, by far, Sweden, Luxembourg and Greece. These countries are the only ones that have both allocative and technical efficiency scores equal to 1 throughout the whole period.

Elementary school in Sweden is mandatory for children age 6 to 15 (primary and lower secondary levels). In Sweden, when children turn six, they start the compulsory preschool class, which acts as a transition phase between preschool (which is free for low-income families and subsidized to a certain limit for all families) and comprehensive schools. There are various types of primary education, including special needs schools for pupils with intellectual disabilities and special schools for those suffering from other disabilities, such as deafness. The education system offers different introductory programs or adult primary and secondary level of education for those who fail the completion of compulsory education. Data collected for 2012, 2015 and 2018 show that the enrollment degree and graduation rates are fairly high in this country. Although expenditures in education are not particularly low, standing around the average for the 28 countries, there is a good ratio between the amount spent per pupil attending primary education as a percentage of GDP per capita and the results with respect to the enrollment degree, teacher–pupil ratio and graduation rate.

Luxembourg is among the strictest countries in terms of compulsory schooling. Pupils between the ages of 4 and 16 have to attend school. The school year is very long, spanning about 10 months of the year (short holidays and weekends excluded). The weekly schedule is quite unusual as the children attend school for three full days (Monday, Wednesday and Friday) from 8 a.m. to 4 p.m. (with a break of two hours at lunch) and two half days on Tuesdays and Thursdays. Another particular issue is that the education in Luxembourg is multilingual (Luxembourgish, German and French) starting even from the fundamental education. As compared to Sweden's situation, all five annual percentages expressing the expenditure ratio into GDP per capita are considerably lower than the average. This is the main reason why the country was identified as efficient.

The Greek education system seems to be a more accessible one. In the first two years of primary education (ages 6 to 8), pupils do not get official grades. Written exams are only

introduced starting from the fifth year. The enrollment to the next tier of compulsory education, the Gymnasium, is automatic and pupils receive a primary school leaving certificate which gives automatic admission to lower secondary education. Identifying Greece as 100% efficient is somehow a surprise since different barometers and authorities sustain the existence of some negative education issues. For instance, the Global Corruption Barometer states that Greek public schools lack a human resource development program, having huge corruption at all education levels. Reports from the Greece National Transparency Authority show there are a lot of criminal offences, complaints and lawsuits in Greek schools. Other reports refer to the use of ethically offensive language, copyright infringement, fraud, personal data theft, illegal fees and all forms of bullying on a larger scale than in many other countries. In such a context, the efficiency characterizing Greek's primary education might be explained by the fact that, at this level of education, such undesired phenomena are not that frequent. However, when comparing the input to outputs, we may observe a balanced situation, Greece succeeding in spending less than the EU28 average and obtaining about average outcomes.

Figure 1 presents the allocative efficiency scores for the primary level of education for all countries and for each of the five years of analysis.
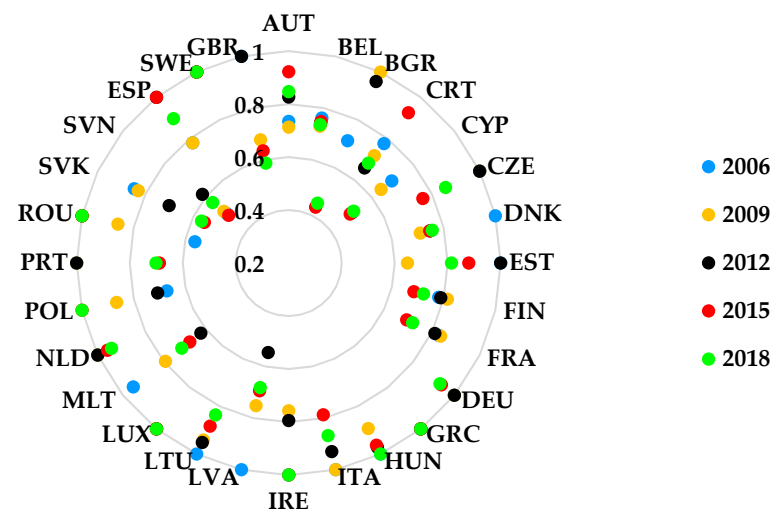


**Figure 1.** The allocative efficiency scores—primary education.

There are ten countries identified as efficient in 2006: the Czech Republic, Denmark, Estonia, Greece, Ireland, Lithuania, Luxembourg, the Netherlands, Portugal and Sweden. In 2009, only six of them were still considered a benchmark, while the list is completed for this year with Germany and Italy. Three years later, there was the same number of states with 100% efficiency as in 2009; however, Italy and the Czech Republic were replaced by Spain and Romania. In 2015 and 2018, besides Greece, Luxembourg and Sweden, only four other countries registered an efficient allocation of their financial resources: Ireland, Romania, Spain (only for 2015) and Hungary (only for 2018). In the last year of analysis, Hungary replaced Spain. Most countries found to be efficient in one year or another have low rates of expenditures into GDP per capita, while the results with respect to the degree of school enrollment, the inverse of pupil-teacher ratio and completion rate are mostly above the average so that the input-output ratio is a favorable one.

The lowest average allocative efficiency score for the entire period of time is observed for Slovenia (0.5369) as a result of a high percentage of education expenditure into GDP per capita. The primary level education system in Slovenia might have reached the same level of output by using on average of 46.31% fewer resources. In Slovenia, children enter primary school at about the age of 6 and finish at about the age of 15. There is a permanent challenge at all levels of education of using resources efficiently, allocating them where they will have the greatest impact on equity and quality in education. Nevertheless, education

outcomes did not reach the desired levels as the country is characterized throughout the five years by a primary school enrollment ratio below the EU average by more than 1.6 percentage points and by higher than average pupils per teacher ratio (an average large number of pupils each teacher has to work with).

The technical efficiency scores presented in Figure 2 for primary education are much higher than the allocative ones highlighted in Figure 1.
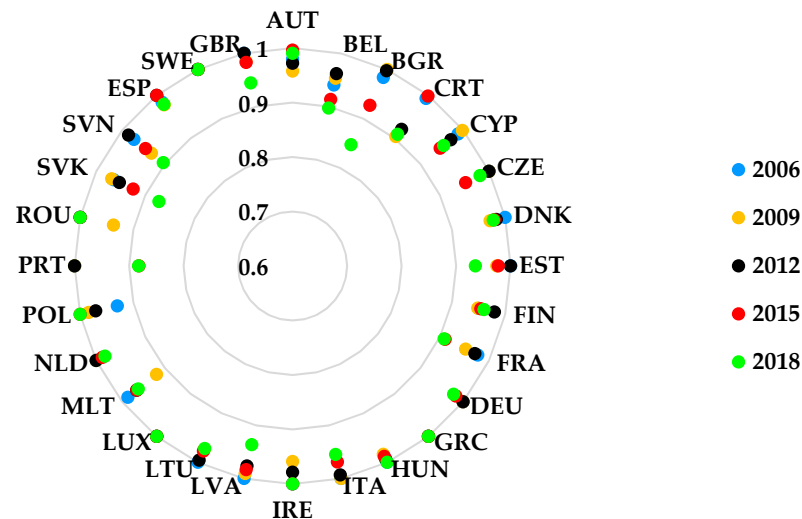


**Figure 2.** The technical efficiency scores—primary education.

If in 2018, for instance, the allocative score proved that the EU-28 countries could have spent on average about 20% less resources to reach the same level of results, the technical score for same sample countries shows that outcomes might have been at least 4.5% higher investing the same amount of money for education per pupil. Such differences between the two scenarios are to be seen also for the other four years of analysis. However, out of the five selected years, the last year is characterized by the lowest average (both allocative and technical) scores.

*4.2. Secondary Education*

For secondary education, PISA results are one of the most important and widely used outcomes in measuring efficiency. The allocative DEA efficiency scores for secondary education prove there are three states that were 100% efficient from 2006 until 2018— Belgium, Finland and Romania.

Education in Belgium is regulated and financed by one of the Flemish, French or German-speaking communities. Each community has its own school system, with small differences among them. A particular element in case of Belgium is that education is compulsory not until the age of 16 but until 18 or even until the pupil graduates from secondary education.

Since Belgium spends about the average level of EU on education in each of the five years, its efficiency comes from the high performance of secondary education in terms of all three outcomes introduced. For example, the Belgian secondary education grants the pupils more choices as they enter a higher cycle within this level. The first cycle provides a broad general basis, with only a few options to choose from. This should enable students to orient themselves in the most suitable way towards the many different optional courses available in the second and third stages. While the youngest pupils have few options, the oldest ones have the opportunity to choose between several different subjects. They are then able to shape the largest part of their time spent in school. However, some core lessons are compulsory. This mix between compulsory and optional lessons grouped in menus makes it possible to keep class structures even for the oldest students. In addition, as

compared to many other EU countries, private education, including international schools, is quite popular.

As opposed to this situation, when analyzing Belgium's primary education technical efficiency scores, we have recorded a surprising five-year average score of only 0.9331, which means Belgium could improve its output values, on average, by 6.69% with the same amount of money per pupil as a percentage of GDP. Although it has a very good pupil-teacher ratio in all five years of analysis, the enrollment degree and graduation rate for primary education appear to be below EU average and not very correlated with the financial resources allocated for this level of education.

Returning to secondary level education, and as mentioned before, Finland and Romania are other DMUs that appear to have a good input–output ratio.

In 2006, 2009 and 2012, Finland had the highest PISA results among all the studied countries, while in 2015 and 2018 it was slightly overtaken by Estonia. It is well-known that Finland has one of the best education systems not only at a European level, but worldwide. The country has initiated over the years a number of novel and simple changes that have completely revolutionized the field of education. Finland is leading the way because of common-sense practices and a holistic teaching environment that strives for equity over excellence. Data collected prove that education expenditures are quite high in Finland. However, we found this state efficient throughout the whole period of time and we consider it to be a real benchmark because of the extremely high values of its outcomes, especially PISA results and the school enrollment ratio. According to the World Economic Forum's studies, there are at least 10 reasons explaining why Finland manages to have and maintain a sustainable education system: no standardized testing; no accountability for teachers; cooperation (not competition) between students, on the one hand, and between teachers, on the other hand; turning back to basics and making the school environment a more equitable place; starting school at an older age and having only nine years of compulsory school; providing professional options; the late start times of the schooldays; consistent instruction from the same teachers; a more relaxed atmosphere; and last, but not least, less homework and outside school hours required [61].

Whilst Finland's education system is found among the most efficient mostly because of its outcome measures, Romania's is identified as efficient for other reasons. It is characterized by a very low level of public expenditure per pupil as a percentage of GDP per inhabitant, with a five-year average of only 13.67% as compared to the EU's average of 24.43%, almost 50% below the average. The PISA results, enrollment degree and number of pupils per teacher are not spectacular at all, but the fact that education investments are one of the lowest in EU presents Romania as an efficient DMU. Education in Romania is based on free tuition. Compulsory schooling usually starts at the age of 6 until the age of 16 or 17 (tenth grade). Even though there are some general problems related to school dropouts before this age, Romania ranks sixth in the all-time medal count at the International Mathematical Olympiad, with a total of 316 medals, dating back to 1959, and the same worldwide position at the International Olympiad in Informatics, with a total of 107 medals, dating back to 1989, all of these obtained during gymnasium (fifth grade until eighth grade) and high school (ninth grade until twelfth grade).

Romania's education system resembles the French one; however, during the communist era, it was influenced by the Soviet education system and it included political propaganda and hours of compulsory patriotic work by school children under the supervision of their teachers (usually in agriculture).

Figure 3 presents the efficiency scores obtained for the EU-28 countries for each of the five years considered in the analysis.
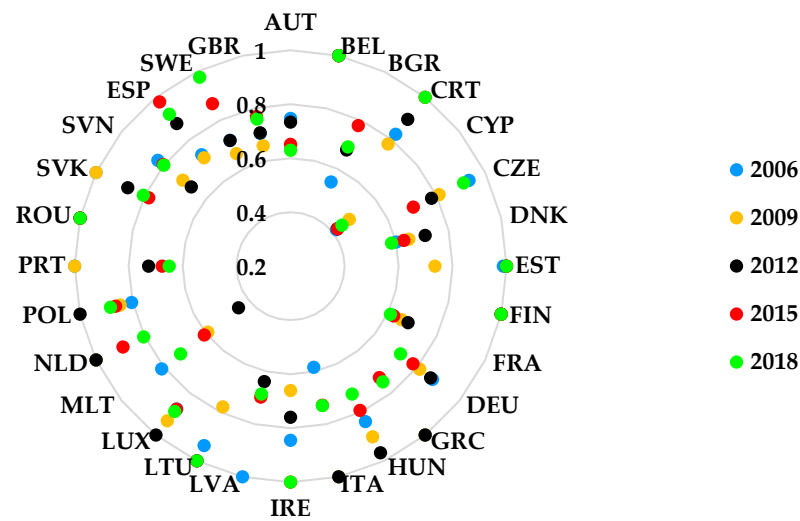
**Figure 3.** The allocative efficiency scores—secondary education.

As compared to primary education results, for the secondary level of education there were only eight efficient countries in 2006 and 2009, and 10 in 2012. In 2015 and 2018, only seven countries were located on the efficiency frontier. Besides the three countries described before, close to performance in all the five years are also the Netherlands, Estonia, Lithuania, Slovakia, Luxembourg and Croatia.

The lowest five-year average allocative efficiency score was obtained by Cyprus, 0.4367. The country is spending too many resources on education and obtains modest results. The country could have spent about 56% less resources in order to achieve the same results.

As seen in Figure 4, which covers technical efficiency for the secondary education, Cyprus is one of the worst performers also in terms of output-oriented scores, its average score placing this country in the 27th position, the last rank established as a five-year average being attributed to Bulgaria.
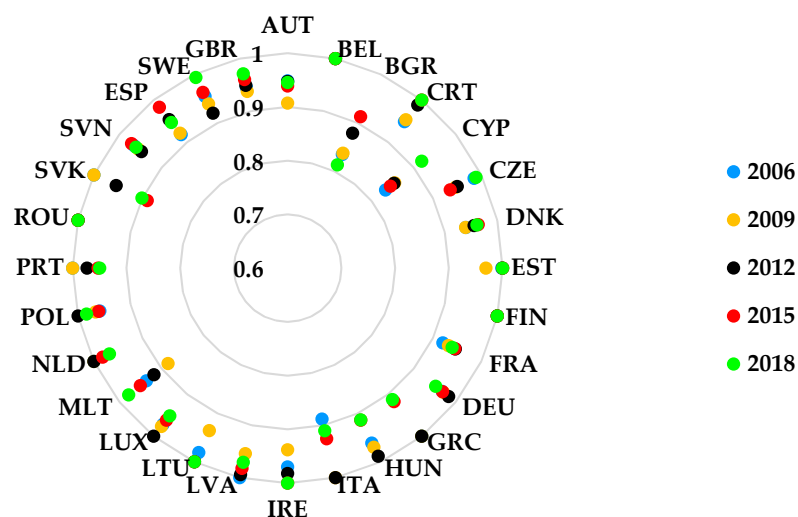


**Figure 4.** The technical efficiency scores—secondary education.

As underlined in the previous analysis of primary education system, the secondary level is also characterized by technical efficiency scores higher than the allocative ones. The five-year average for all the DMUs is almost 0.96, which means the results obtained from the investments made in the secondary education level might be improved by four percent.

### 4.3. Tertiary Education

For this upper level of education, we kept the same input as for the primary and secondary education, i.e., the tertiary education expenditures for each student as a percentage of GDP per capita.

On the output side, we have collected data for three indicators, among which only the enrollment degree expressed as a percentage of the corresponding age population is the same as for the other education levels, obviously referring this time to the tertiary education. The two new outcomes introduced are the unemployment rate of those who completed an advanced cycle of education (expressed as the percentage of the total labor force that attained tertiary education) and the labor force with tertiary education (expressed as the percentage of the total labor force). Both of them are appropriate measures to identify the best education systems across the EU. Nevertheless, since the objective of an output measure is to record values as high as possible, the unemployment rate was deducted from 100% and as such we have created an employment rate of those with advanced education within the total labor force graduating from an advanced level of education.

Figure 5 offers the allocative efficiency scores of each country for the tertiary level of education.
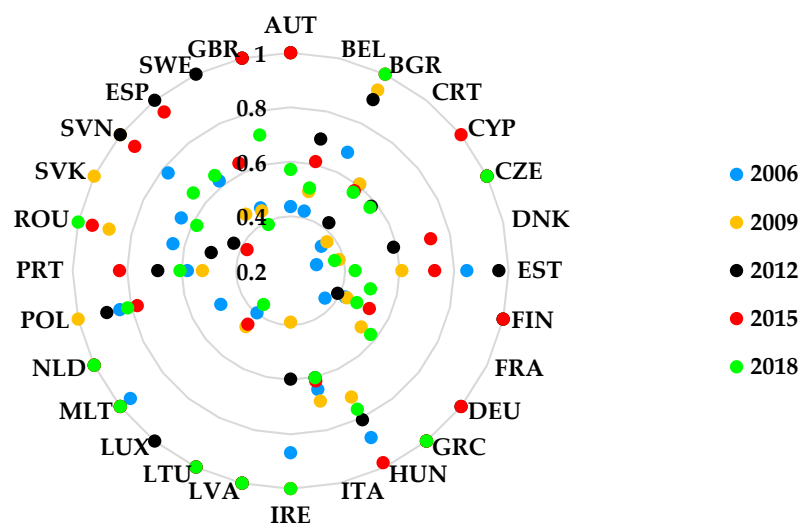


**Figure 5.** The allocative efficiency scores—tertiary education.

There were six countries identified as efficient in 2006—Finland, the Czech Republic, Greece, Latvia, Lithuania and Great Britain. In the other four years of research, four of them—the Czech Republic, Greece, Lithuania and Latvia—are still found on the efficiency frontier, while other DMUs embrace efficiency only in some years and in others record different degrees of inefficiency. In 2018, the last year of analysis, nine countries were identified as efficient, the four best performers throughout the whole studied period—the Czech Republic, Greece, Lithuania and Latvia—plus Bulgaria, Ireland, Malta, the Netherlands and, for the first time with respect to tertiary education, Romania.

The best performers in tertiary education have surprising results compared to the ones recorded for primary and secondary levels. The Czech Republic is efficient only for its primary education in 2006, 2009 and 2012. Lithuania is on the efficiency frontier in three years for secondary education (2012, 2015 and 2018) and for one year (2006) in the case of primary education. Latvia appears to be efficient only in 2006, for both primary and secondary education. As opposed to these results, Greece's primary education DEA results during the whole studied period reveal efficiency, while for secondary education efficiency appears for the first three years, i.e., 2006, 2009 and 2012.

Tertiary education in Greece is free of charge for bachelor's and doctoral programs. Admissions to first-degree tertiary programs are not open; a fixed number of student

places is set at the central level and students must undergo compulsory examinations with a minimum level of admission results to gain access to tertiary institutions. The average tuition fee for master's programs is about USD 4100. This might explain why only about four percent of Greek adults hold a master's degree as their highest qualification. Employment rates increase with educational attainment, but they are lower than the OECD average. Adults with bachelor's or master's degrees have the lowest employment rates across all OECD countries.

The technical efficiency scores presented in Figure 6 for the tertiary education are much higher than the allocative ones highlighted earlier. Considering the five-year average, Croatia is the least efficient with a score of 0.9494, which is 0.0397 percentage points under the EU average. The five-year average for all DMUs is almost 0.99, which means that the results obtained from the investments made at the tertiary education level might be improved by only 1%.
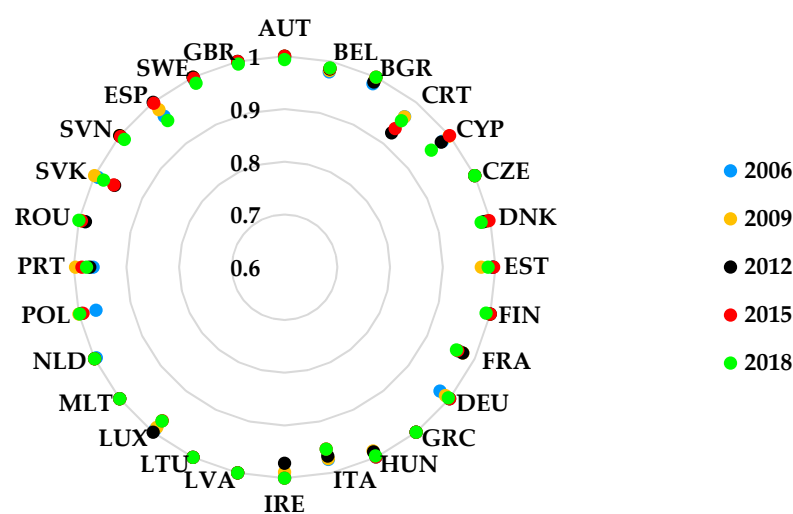


**Figure 6.** The technical efficiency scores—tertiary education.

Greece has experienced a general decrease in its total general expenditures and as a percentage of GDP in the last years. Tertiary education expenditures per student into GDP per inhabitant are 10 percentage points below EU 28 average (29.28%). The country has the highest enrollment rates in the EU. Moreover, as provided in "Education at a Glance: OECD indicators", Greece has the fourth highest enrollment rate among OECD countries [59]. Between 2008 and 2018, the country has experienced an increase in tertiary education attainment.

The Czech Republic's education and research have a long history dating back to the 14th century. In 1348, Charles University in Prague was founded, thus becoming the oldest university in central Europe. Today, Charles University is ranked 291st in the QS World University Rankings and is followed by seven other Czech universities, found in the top 1000 universities globally [62].

Depending on their educational background, Czech students can choose from a bachelor's, master's, or PhD degree. With a diverse range of study programs, students are also offered the flexibility to choose from a long list of internationally recognized qualifications and specializations depending on their interests. By law, higher education at public institutions is free of charge for citizens of all nationalities.

Total expenditures on primary through tertiary education are relatively low in the Czech Republic; most of the funding is publicly sourced. The value of input calculated as a five-year average is almost 4.5 percentage points below the EU average (24.79% as compared to the EU average of 29.28%). The outputs are not spectacular for the Czech Republic; however, the low share of allocated expenditures per student into GDP per capita provides an overall efficiency status. Evidence that highlights the Czech Republic's modest

outcomes are the share of 25-to-64-year-old tertiary-educated adults, which is 15 percentage points below the OECD average (24% as compared to 39%), even if tertiary attainment is higher among 25-to-34-year-olds (33%); however, it is still below the OECD average. In addition, while most tertiary-educated adults in the Czech Republic hold a master's degree, their employment advantage over those with upper secondary or post-secondary non-tertiary education is among the lowest across OECD countries. As opposed to these facts, the labor force with an advanced education is near the EU-28 average [63].

In Lithuania, tertiary educational attainment levels have increased in the past decade and tertiary-educated adults have strong employment opportunities. Attainment levels are much higher among younger generations than for the adult population. In 2018, 42% of adults (25-to-64-year-olds) had attained a tertiary education, three percentage points above the OECD average. According to OECD data collected for our research, the total expenditure per student in Lithuania is rather low compared to the EU average, especially at a tertiary level. The country's five-year average is 9.17 percentage points below the EU average, whilst on the output side, all three indicators are above average, with the employment rate up by 0.85 percentage points, labor force rate up by 3.77 percentage points and enrollment rate up by 12.46 percentage points.

Study programs in Lithuania are evaluated according to the European Credit Transfer System (ECTS) and are offered in terms of cycles, following the Bologna system. Universities in Lithuania also offer integrated study programs, which combine first and second cycles such as students can graduate with a master's degree and then apply for PhD studies if they want. There are two types of higher education institutions in Lithuania—colleges and universities. Colleges are focused on practical training for professions. The largest university in Lithuania and the oldest in the three Baltic states, Vilnius University, is currently ranked 481–490 in the world.

Lithuania has achieved a high level of participation in tertiary education and its graduates, on average, experience labor market outcomes typical for OECD and EU member countries. This is accomplished with modest levels of per pupil spending by institutions that operate with substantial autonomy, and within a system of transparent funding driven by student demand. However, the tertiary sector now faces serious challenges. Lithuania's tertiary institutions are too numerous and small to achieve the levels of efficiency and quality the nation needs. From 41 higher education institutions, only one is within the top 1000 in global rankings. The university system has not reached a level of satisfactory performance in research and development and the wider tertiary system has not substantially benefitted from international mobility among students and researchers.

The Latvian higher education system is a part of the Bologna process and follows the three-cycle system, with the short cycle generating the academic or professional bachelor's degree programs, the academic or professional master's degree programs and the Ph.D. degree programs.

A gradual increase in investment and incremental changes in quality assurance are welcome in the Latvian higher education system, yet the sector remains fragmented and with low international competitiveness. None of the 51 higher education institutions included in universities' global ranking is among the top 1000 in the world. Government expenditures on education are comparatively high at all education levels. Tertiary education expenditures per student represent about 20.41% of per capita GDP and are almost nine percentage points below the EU average. Latvia's general government expenditures on education were well above the EU average in 2017, both as a weight into GDP (5.8% vs. 4.6%) and as a share into the total public expenditure (15.2% vs. 10.29%). Public spending on education increased by 10% between 2016 and 2017 in real terms, the highest rate of increase in the EU, to compensate the drastic cuts imposed following the 2008 financial crisis. Expenditure per student expressed in the purchasing power standard (PPS) is comparatively high relative to the country's GDP per capita, and although it has been rising steadily in recent years, it remains below the EU average at all levels of education.

The share of young adults with tertiary education decreased in 2018 compared to the previous year yet remained above the EU average. Despite above-average tertiary entry rates (almost 10 percentage points above the EU average), the cross-cohort probability of completing a short-cycle tertiary or bachelor program by its theoretical duration remains relatively low; however, it is higher for women [64].

Although they are not benchmarks for the entire period of time, the United Kingdom (UK) and Finland record remarkable results.

Higher education in the UK is provided by a diverse range of organizations. A total of 166 institutions currently have their own degree-awarding powers. The majority of these also hold the title of 'university', which is only granted to those institutions that meet certain criteria. With over 100 universities offering various degree programs for students from the UK and around the world, there is no shortage of options. In the UK, about one-third of all students go on to some form of higher education and this number is well over 50% for students from Scotland. This makes competition for schools fierce, and so it is advised to apply early for courses. The UK's higher education institutions (HEIs) are not owned or run by the government(s). They are independent, autonomous legal entities, with councils or governing bodies that have the responsibility for determining the strategic direction of the institution, for monitoring their financial health and ensuring they are effectively managed [65]. The country is one of the best performers (100% efficient) in 2006, 2009, 2012 and 2015, but not in 2018.

Another benchmark is Finland. The country is characterized by an above-average level of public expenditures per student as a percentage of GDP per capita, a five-year average of 34.7% as compared to the 29.28% five-year average of the EU. The enrollment rates are also spectacular—24.37 percentage points above the five-year EU average. The high enrollment rate could be a result of 42 of its universities being in global rankings, of which nine are ranked in the top 1000 universities in the world. Furthermore, one of them is ranked in the top 100 universities and four rank in the top 500 universities.

Finland's higher education system is the best in the world according to the 2018 Universitas 21 Ranking. This ranking has a broader approach than other university rankings, as it assesses the performance of whole country's higher education system instead evaluating individual institutions. Finland's position as the leading higher education system comes from looking at the country's level of economic development. According to the ranking, Finland has the fifth most favorable environment for higher education [66]. Finland also scores highly in web impact and higher education government expenditures. It also has 14 research universities and 24 universities of applied sciences with more than 20,000 international degree-seeking students in total.

The lowest average allocative efficiency score for the entire period is held by France (0.4470), as a result of its high percentage of expenditure per student into GDP per capita. The tertiary level education system in France might have reached the same level of output by using on average of 55.30% fewer resources. Education in France is organized in a highly centralized manner and is characterized by the coexistence of universities and of a non-university sector, including elite schools, with a highly selective admissions policy open to baccalaureate holders having attended two years of preparatory classes. Educational outcomes did not reach the desired levels as the country is characterized throughout the five analyzed years by tertiary enrollment ratios below the EU average by more than 7.37 percentage points.

As for the other two levels of education, the technical efficiency scores for tertiary education are much higher than the allocative ones. Considering the five-year average, Croatia is the least efficient with a score of 0.9494. The five-year average for all DMUs is almost 0.99, which means that the results obtained from the investments made at the tertiary education level might be improved by only one percentage point, while Croatia could improve its educational outcomes by more than five percentage points.

Studies in Croatia are divided into two categories—university and professional studies. Data ranging from the academic year 2005/2006 until 2018/2019 indicate an extremely

high difference between the number of enrolled and the number of graduate students at both types of studies (university and professional). According to the Knowledge Base for Higher Education and Research of Western Balkans, in 2009, for example, out of 118,792 enrolled in university studies, only 24,993 students graduated (about 21%) [67]. Moreover, the enrollment rate itself is quite low. Throughout the studied period, it was well below the EU average, especially during 2006, 2009 and 2012.

In 2017, the percentage of 16-to-74-year-olds that reported having basic or above-basic overall digital skills was the second lowest in the EU (41%, as compared with an EU average of 57%). The government is making efforts to improve equity due to the fact that the 2018 to 2021 National Plan for Enhancing the Social Dimension of Higher Education (adopted January 2019) highlighted 16 categories of students facing challenges in accessing higher education or being at risk of dropout.

Low PISA and Trends in International Mathematics and Science Study (TIMSS) scores compared to some peer countries reflect quality gaps in schooling. The number of tertiary education graduates in science, technology, engineering and mathematics (STEM) is low due to limited attention to STEM classes in the curriculum throughout the education pipeline and deficits in training for teachers. Graduation from STEM fields in tertiary education is below the EU average (22% in Croatia versus 25% in the EU) and shows large differences between males and females.

### 4.4. Total Education

This final subsection describing the main results refers to whole education system and the input- and output-oriented scores of the EU-28 member states. We decided to approach the total education by referring to a more synthetic scenario of 1 input/1 output. The input is given in this case by the total education expenses as a percentage of GDP. The total expenditures and GDP are no longer expressed per student, respectively, per capita. The output is represented only by the PISA results available for the years considered—2006, 2009, 2012, 2015 and 2018. We included the PISA results since PISA is the most standardized test, followed all across Europe, and since it does not present specificities that could make the interpretation and generalization of results difficult.

Since we are dealing with only one input and one output, the number of efficient entities decreased considerably as compared to the previous three analyzes. Figure 7 identifies only three efficient education systems in 2006, 2012, 2015 and 2018 and four benchmark education systems in 2009. In addition, we cannot find a single country that was efficient from 2006 until 2018 as we were able to identify when taking into account each education level individually.
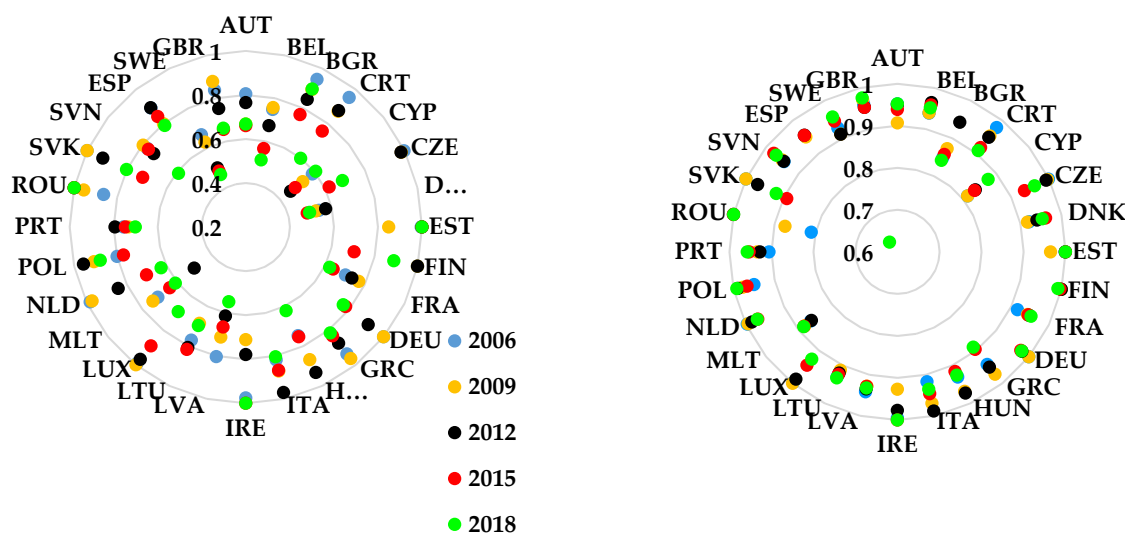


**Figure 7.** The allocative (**left side**) and technical (**right side**) efficiency scores—total education.

Estonia, Finland and Romania recorded the maximum efficiency score in three out of the five years; Ireland, Germany and Slovakia embraced efficiency in two years; Luxembourg only achieved maximum efficiency once, in 2009.

From a financial allocation perspective and taking into account the five-year average scores, the highest score is obtained by Estonia, 0.9691, followed by Romania, 0.9635, and Finland, 0.9185. These three countries are also the only ones to be seen on the efficiency frontier in 2012, as illustrated in Figure 8.
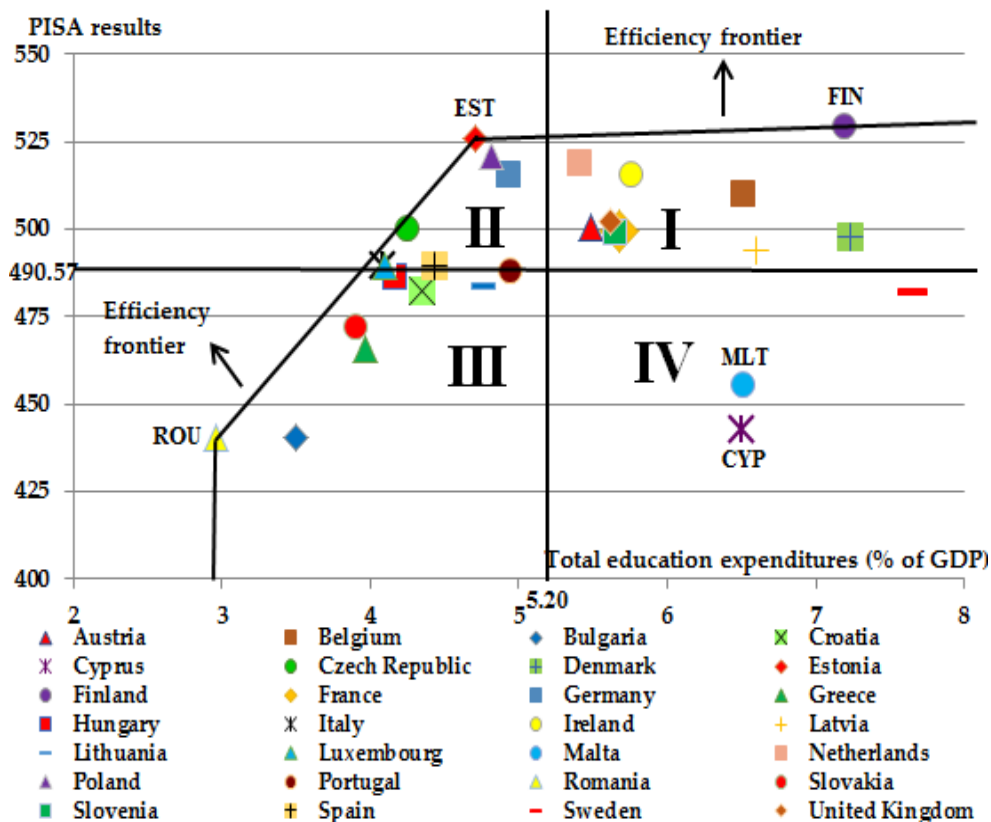


**Figure 8.** The input–output total education spread of countries in 2012.

Figure 8 was created using the data regarding the total education expenditures, expressed as the percentages of GDP for 2012, which is represented on the horizontal axis, and the data regarding the PISA results in 2012, represented on the vertical axis. The EU input and output averages are represented by two perpendicular lines that cut the chart into four areas or quadrants. The average expenditures in education as a percentage of GDP are 5.20% and the average PISA result is 490.57.

In 2012, Romania's total education expenditures were among the lowest in Europe, below three percent of GDP, and the PISA score was about 441. The yellow triangle, which represents Romania, is included in quadrant III, among the countries with below EU average expenditures as a percentage of GDP and below EU average PISA test results. Estonia, the red diamond, is part of quadrant II, where the best performing education systems are to be found because of their good input–output ratio: below average input and above average output. Placed in quadrant I, Finland is the country in which education receives more than seven percent of its GDP. Only two other northern European states surpass Finland in terms of education expenses: Sweden with 7.65% and Denmark with 7.24%. Nevertheless, none of the latter two record PISA results as good as Finland's (represented by the purple circle).

The other 25 countries are enveloped by efficiency frontier borders, recording a higher or lower degree of inefficiency. In 2012, Malta and Cyprus seem to have had the most

inefficient education systems as they are placed in quadrant IV, which is associated with the worst input–output combination, with high inputs (above the average) and low outputs (below the average). Both of them have an input of about 6.5% and an output PISA test result of about 450.

The situation described so far with respect to the 2012 DEA results is similar to a great extent to the one describing the five-year average efficiency scores. We have already pointed to Estonia, Romania and Finland as the top three performers in 2012, as well as during the entire 2006 to 2018 period, whereas the worst performers were Denmark (0.5244), because of its high amount of money spent for education (7.49% of GDP) as compared to the EU average of only 5.10%, and Cyprus (0.5340), with a high expenditure input (6.33% of GDP) and a low output (443.87 PISA result as compared to the EU average of 486.2).

The top five best EU performers according to their five-year average in the output-oriented scenario were Finland (0.9977), Estonia (0.9928), Germany (0.9866), the Netherlands (0.9828) and Ireland (0.9798). Since they obtained good output results, all these countries were placed above the EU average PISA scores of the five years. Figure 8, presented earlier, is a piece of evidence for previous statement for the particular case of 2012. As we may observe, the blue square (Germany), the pink square (the Netherlands), and the yellow circle (Ireland), along with the red diamond (Estonia) and the purple circle (Finland), are situated above the horizontal line separating the countries with above-average PISA scores from the ones with below-average PISA scores. Moreover, except for Finland, these countries' education expenditures are around the average.

Cyprus has the lowest technical efficiency score, scoring only 0.8351. Since it spends an average of 6.30% of its GDP on education, which is 1.2 percentage points more than the five-year EU average, its students' average results on the PISA should have been at least 16.5% higher. The top three worst performers regarding the output-oriented five-year average efficiency score is completed by Bulgaria (0.8725) and Malta (0.8755).

Table 4 presents the synthetized EU-28 average efficiency scores for all five years of analysis and all the levels of education, including the total education, for both the input-oriented and the output-oriented scenarios.

**Table 4.** The allocative and the technical average efficiency scores for the 2006 to 2018 period, for the EU member states and for all levels of education.

| DEA 5-Year Average Efficiency Score | Primary Education | Secondary Education | Tertiary Education | Total Education |
|---|---|---|---|---|
| BCC-I | 0.8352 | 0.8151 | 0.7611 | 0.7856 |
| BCC-O | 0.9740 | 0.9590 | 0.9891 | 0.9431 |

As compared to the input analysis, the output-oriented research scores are not as low, as the PISA values are closer to the average and so are less dispersed than the input values. The standard deviation for the standardized-to-1 PISA scores is about 0.04, whereas for the standardized-to-1 education expenses as a ratio of GDP, the standard deviation is almost 0.16.

Figures 9 and 10 illustrate the five-year average for each of the 28 EU countries for their whole education systems.
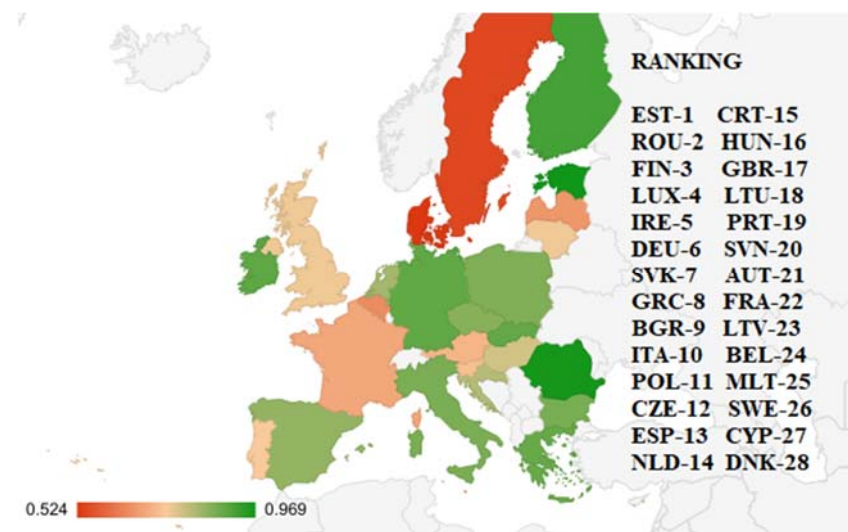
**Figure 9.** Average five-year allocative efficiency scores—total education.
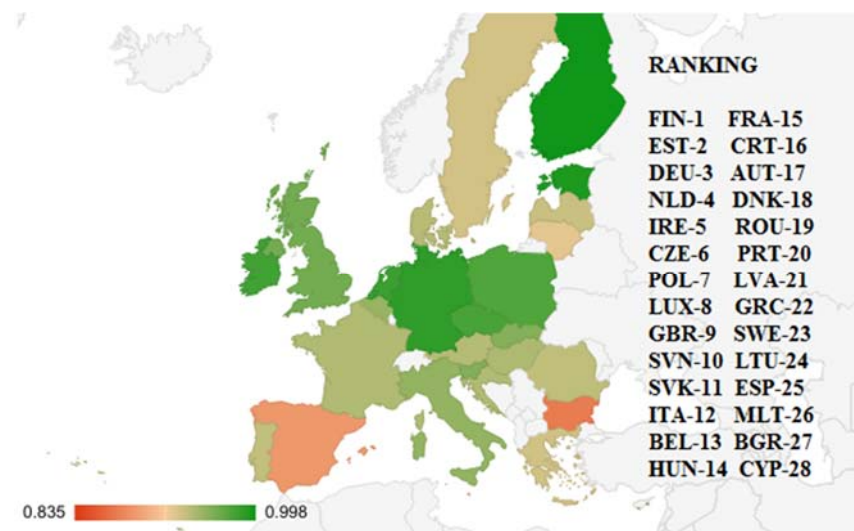


**Figure 10.** Average five-year technical efficiency scores—total education.

After examining the scores and ranks for each EU country's entire education system, one major pattern emerged: countries with lower expenditures as a ratio of GDP compared to the $\mu + \sigma/2$ limit tend to have, for both allocative and technical efficiency, higher efficiency scores (0.8251 in the input case and 0.9464 in the output case) compared to entities whose education expenditures are above the limit mentioned before (0.6406 for the input and 0.9309 for the output). The $\mu$ value represents the simple arithmetic average of the inputs, whereas $\sigma$ represents the standard deviation of the inputs.

The lowest allocating efficiency (of financial resources) scores and, consequently, the last positions in the 5-year ranking system were taken by Denmark (0.5244), Cyprus (0.5340), Sweden (0.5470), Malta (0.6404) and Belgium (0.6510), all of them recording input values well above the EU average.

The lowest technical efficiency scores and, consequently, the last positions in the five-year ranking system are attributed to Cyprus (0.8351), Bulgaria (0.8725), Malta (0.8755), Spain (0.8882) and Lithuania (0.9237), all of them recording output values below the EU average.

In addition to the main analysis in which each country has been studied individually, the research could also refer to some other dimensions as well. On the one hand, we found

it appropriate to identify and discuss the final results (the allocative and technical efficiency scores) considering the division of these countries according to the date they joined the EU structure.

1. The former member states (integrated before 2004) are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.
2. The new member states (integrated starting with 2004) are: Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

On the other hand, we thought it appropriate for the final part of our analysis to discuss the efficiency scores by referring to the geographic position in Europe of the 28 countries. Some states are not necessarily just northern, western, southern or central European states, as in the case of Portugal, which is a south-western country. However, we have placed them into the most suitable group to avoid creating too many categories identified by only one or two countries from our sample. All in all, we have the following groups of states:

1. The northern group: Denmark, Estonia, Finland, Latvia, Lithuania and Sweden.
2. The western group: Belgium, France, Ireland, Luxembourg, the Netherlands and the UK.
3. The southern group: Cyprus, Greece, Italy, Malta, Portugal and Spain.
4. The central European group: Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Poland, Romania, Slovakia and Slovenia.

Most central European states are also found in the category of new member states that joined the EU structure in 2004 or later. According to our results, the new members registered above the EU-average input-oriented efficiency scores (0.7948 > 0.7776) which means from a financial and economic point of view their capacity of allocating substantial funds towards education is limited, but somehow adequate for obtaining, eventually, a good input-output ratio. As compared to the output-oriented scores, characterizing the old member states, the new ones are generally characterized by below EU-average scores (0.9323 < 0.9525).

With respect to the education expenditure ratio into GDP, the countries belonging to the central European part record the highest average allocative efficiency score of 0.8369. Slightly above the EU-average are also the scores reached by the western group (0.7882), while the southern and, especially, northern groups are recording below EU average results (0.7525, respectively 0.7305).

The PISA results according to each country's geographic membership show that the best performers are the six countries included in western group (0.9648), followed closely by the northern states (0.9527). The central European group presents average technical efficiency scores (0.9486), above the average (0.9431), while the worst PISA scores are found for the southern group (0.9027). On average, southern countries should have improved their PISA results by almost 10% taking into account the financial resources allocated for education.

## 5. Conclusions

Considering the average efficiency scores obtained in the analysis, the observed countries could have generated the same level of educational outputs using fewer resources. In other words, an increased amount spent for primary, secondary or tertiary education does not guarantee increased performance. At the same time, the countries could have achieved a better use of funds available for educational services if pupils' and students' needs had been better satisfied. Basically, total education expenditures could drop by 21.44% and still reach the same outcomes level, while technical efficiency scores could increase by 5.69% considering the amounts spent.

One of our main conclusions is that efficiency appears to be achieved when education results such as PISA scores, attainment level or other value-added outcomes are reached with rather low levels of financial resources. This conclusion was also found in several papers [6,14,41]. For instance, Saudi Arabia can improve its performances in matters of public service delivery, including education, without necessarily increasing the level of corresponding public expenditures [41]. Nevertheless, efficient DMUs have allocated reasonable budgets and succeeded in having good evaluation scores, while other DMUs obtained unsatisfactory scores as a consequence of lower budget allocation [13].

All in all, the performance in education measured through the relationship between the financial resources used and the quantity and quality of the offered educational services lacks sustainability in many countries, belonging mostly to the Mediterranean and south-eastern Europe groups. In line with economic theory, school enrollment portrays a positive and significant influence on human capital development. It is often observed that the level of school enrollment is highly correlated with national productivity. This is not only because educated people are more productive, but also because they may positively affect the productivity of others with whom they work. These results might be correlated to the fact that countries have different population densities or compositions, different GDP per capita or levels of education attainment. Furthermore, this idea may be expanded to the development of science and technology because it requires, as the literature portrays, the involvement of highly qualified personnel. Successful international technological transfer as well as absorption of technology and knowledge into recipient organizations depend prodigiously on the types of policy adopted in the education and training of individuals [68]. There is no doubt that education plays an essential role in advancing research and innovation. Public and private institutions need top professionals in addition to a technological base. Investments in training and further education are necessary wherever new technologies and processes are fostered [69]. Even the mix of public and private funding of education is specific to each country. As a result, inefficiency could derive from all these interactions and might imply particular needs from country to country. Inefficiency might also be explained as being the result of allocating financial resources for inadequate investment projects and/or their inefficient management by responsible public authorities.

According to the DEA methodology, performance score is affected by the cost incurred in achieving the outcome and depends on the input–output ratio used by the peers. One of the main advantages of employing DEA is that it is based on reality and that comparisons are made between similar DMUs and not by using some optimal hypothetical standards.

Highly educated and qualified human capital represent factors that can significantly stimulate both economic advancement as well as economic growth quality. As a result, the education sector is vital for country development. Because of its importance, education should remain a first-priority sector that deserves state funding all over the world.

Besides financial funding indicators, future studies may enrich the input side by adding also some relevant non-financial variables. DEA results are very useful to identify efficiency and inefficiency. Moreover, they can be used for explaining causes and identifying improvements. The latter will lead to achieving better results in providing public goods and services, in general, and in offering sustainable educational opportunities, in particular. A future development of the research would be to study education via the efficiency effectiveness nexus and employing some other analysis methods.

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## Abbreviations

The following abbreviations are used in the manuscript:

| | |
|---|---|
| BCC | Banker, Charnes and Cooper |
| BLS | Bureau of Labor Statistics |
| CRS | Constant Returns-to-Scale |
| DEA | Data Envelopment Analysis |
| DMU | Decision-Making Units |
| ECTS | European Credit Transfer System |
| EU | European Union |
| FDH | Free Disposable Hull |
| GDP | Gross Domestic Product |
| HEIs | Higher Education Institutions |
| ISCED | International Standard Classification of Education |
| MCE | Multiple Criteria Evaluation |
| OECD | The Organization for Economic Cooperation and Development |
| PISA | Programme for International Student Assessment |
| PPS | Purchasing Power Standard |
| PSP | Public Sector Performance |
| PSE | Public Sector Efficiency |
| R&D | Research and Development |
| SFA | Stohastic Frontier Analysis |
| STEM | Science, Technology, Engineering and Mathematics |
| TIMSS | Trends in International Mathematics and Science Study |
| UK | United Kingdom |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNICEF | United Nations Children's Fund |
| VRS | Variable Returns-to-Scale |

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