*Full research paper*

# GRADUATE EMPLOYABILITY AS A KEY TO THE EFFICIENCY OF TERTIARY EDUCATION

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## ABSTRACT

In the 21st century there is a lot of attention on sustainability (whether social or environmental). However, unfortunately, the economic perspective has been largely neglected in the field of education. This article deals with a quantitative assessment of the efficiency of tertiary education in individual EU countries, which allows to include the economic aspect of the evaluation. Furthermore, we are expanding the commonly established evaluation system based on the number of graduates to include another area, namely the graduate's employability on the labor market. We believe that for a correct evaluation of individual education systems it is necessary to include the relevance and quality of acquired knowledge and skills. Although the efficiency assessment is carried out for the whole EU, the results are presented according to identified groups of countries that have similar education systems. Countries such as Ireland and France emerge as top performers because of their ability to produce large numbers of graduates given their resources. Malta and Luxembourg have also performed very well in the efficiency assessment, although they produce far fewer graduates in terms of resources, but thanks to the system set up, graduates in these countries are highly employable in the labor market.

## KEYWORDS

**Efficiency, EU countries, labor market, Malmquist index, tertiary education**

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***Highlights***

- *Six countries (Bulgaria, Croatia, France, Ireland, Luxembourg, and Malta) were identified in our analyses as efficient throughout the period under review.*
- *Germany and Spain have the lowest tertiary education efficiency in the EU.*
- *It is not appropriate to analyze the efficiency of education only based on the number of graduates, but also on their ability to find a job.*

## INTRODUCTION

The phenomenon of the ongoing fourth industrial revolution fundamentally affects the nature of the functioning of industry, trade, and many other parts of the economies of developed countries. In this regard, the need to recruit workers with a high-quality education corresponding to the needs and demands of technological development is increasing. Gleason (2018) deals with the issue of increasing qualifications as a condition for the implementation of Industry 4.0 in practice. He mentions that work needs to be done to create a digitally literate and technologically competitive society and, above all, with the help of experts who will be university-educated. Similar conclusions were reached by Jung (2020), who emphasizes that knowledge is the main driving force of economic growth in all world economies and, at the same time, becomes a new comparative advantage. In this way, Jung (2020) argues that the strengths that create the right environment for a knowledge economy are a skilled workforce with higher education and higher spending on research and development. Therefore, university-educated people and their applicability to the labor market come to the forefront of research.

The education sector (from primary to tertiary) has a very specific position. The efficiency of the education process itself also affects the effectiveness (and productivity) of other sectors in which graduates are later employed. If we were to support systems that produce low-quality labor, we would also negatively affect other sectors of the economy. In this regard comes another entity that closely monitors the education sector: national governments. The government must address the negative consequences of a poorly functioning education system in areas such as unemployment or insufficient GDP. Therefore, government reforms in areas such as unemployment should go hand in hand with reforms in education. However, this can only be done with an adequate evaluation of the efficiency of individual educational processes. The government is not just an entity that blindly receives the final products of the educational process but directly influences the educational system through its own actions. Firstly, we can mention the legislative framework (in terms of compulsory schooling, tuition fees, teachers' salary levels, etc.) and the expenditure on education. The amount of government expenditure will likely impact the quality of the educational process and, consequently, the quality of the students themselves. The results of efficiency assessments in the field of education are relevant not only for governments themselves but ultimately for everyone (companies and individuals), as the consequences of education are reflected in the overall economy of countries. Even taking into account the fact that the citizens of a given country generate government expenditure, it is necessary to assess the efficiency of its use.

It is possible to find studies that cover the evaluation of the educational process. Many analyses have been conducted at the individual school/university level. From the area of efficiency analysis, it is possible to name, for example, the analysis of Chilean (Cossani et al., 2022), Yemeni (AlMunifi and Aleryani, 2021), Vietnamese (Le et al., 2021), or Czech schools (Mikušová, 2017). These studies concentrate on secondary education and, moreover, on a single geographical area in which they are governed by the same legal regulations. If we want to look at the issue from a broader perspective, it would be necessary to make an international comparison.

Studies such as Mašková and Blašková (2021) or Stumbriene et al. (2022) focus on comparisons between EU countries based on aggregate data. Although individual EU countries are united by common efforts and regulations, due to a certain sovereignty, there are noticeable differences in individual countries in terms of the educational process. Regarding the focus on tertiary education, it can be stated that the greatest differences can be seen in the funding system. For example, in Germany or Austria, it is common for students to finance their studies for the most part themselves. Conversely, in Czechia or Slovakia, even prestigious universities have their studies fully covered by the state.

However, considerable efforts are being made for EU countries to minimize differences between graduates in terms of the outcomes of the education process across countries. A certain uniformity would then make it possible to dismantle the often complex and time-consuming processes of nostrification.

Major changes also connected with the so-called Europe 2020 strategy (European Commission, 2020b). Within the framework of this strategy, the task of the EU countries was that at least 40% of people aged 30–34 had a tertiary education. Furthermore, it sought to ensure the top level and quality of education and reduce the number of early school leavers below 10%. Thanks to these goals, there was an increase in the number of universities. Still, at the same time, it was a period when the number of potential tertiary education students decreased due to demographic changes. Thanks to this discrepancy, the need to evaluate the efficiency of the educational process has intensified.

Jelić and Kedžo (2018) addressed the efficiency of tertiary education from both a quantitative and a qualitative perspective. The authors examined EU countries in four periods between 2004 and 2015. Standard analyses based only on the number of students showed that some of the most developed countries in the sample, such as Austria and the Netherlands, were not efficient. In contrast, some less developed countries, such as Hungary, Estonia, and Bulgaria, were fully efficient in some periods. Due to these results, Jelić and Kedžo (2018) highlighted the need to correct the efficiency score to take into account the quality of educational processes sufficiently.

Similarly, studies can be found from various corners of the world evaluating efficiency at an aggregate level. However, these studies typically focus only on the number of students produced without evaluating their quality; see, for example, Kim et al. (2016), Andersson and Sund (2022), or Ma and Li (2021). In contrast to these studies, the analysis presented in this article includes the employability of graduates in the labor market. For this reason, the classic approach based on the number of graduates and the number of teachers is extended with information from the labor market. Our results should provide answers to the question of how efficient the tertiary education process is in each country regarding the graduates' labor market employability.

The main objective of the article is to evaluate the efficiency of individual EU countries in the field of tertiary education with regard to graduates' employability in the labor market. The period from 2014 to 2020 was chosen for the analyses considering EU regulations (especially the Europe 2020 strategy). However, it is not just a matter of compiling a ranking for individual EU countries but of complex analyses that will enable an assessment of how specifics in the education systems of individual countries affect the efficiency of tertiary education. As education systems are not identical in all EU Member States, our efficiency analysis allows us to assess which system is most suitable for students in terms of future employment. So, the analysis answers the following questions:

- What is the level of efficiency of tertiary education in EU countries?
- Is there a different efficiency level with respect to a different education system?
- Does the efficiency of individual countries change over time, or is its level relatively stable?

## Differences in education systems in EU countries

The EU aims to support countries in their efforts to provide the best possible education. Although we have legislative documents (Treaty on the Functioning of the European Union, articles 165 and 166), the EU provides only a very general framework. As a result, individual countries are free to shape their own education system. It can be assumed that differences in individual systems will determine the different levels of efficiency of a given system.

Probably the biggest differences between countries can be seen in how education is financed and the education system. Although all countries have compulsory schooling, the length of schooling is not always the same. Most countries have compulsory schooling until the age of 15. For example,


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in Ireland, the Netherlands, and Luxembourg, compulsory schooling starts at the age of 4, while in countries such as Denmark, Finland, and Sweden, it starts at age 7. Compulsory school attendance is tuition-free, and its financing is covered by municipal and state budgets. Countries such as Austria also provide free transport and school supplies for children.

The Belgian-French community allows its students to replace classical teaching with e-learning, which is then verified by a final exam. About 1.5% of children complete primary and secondary education in this way (Eurydice, 2023). The German education system is very different in that it "forces" students to choose their future path at a relatively early age. As early as 4th grade, students have to decide whether to study general education or a school with specific qualifications. After completing compulsory schooling, they move on to upper secondary education. Secondary education can be vocational or general. Vocational secondary education in Germany (but also in other countries such as Austria) is in the form of a dual apprenticeship system. After completing general upper secondary education, students can complete tertiary education. The tertiary sector encompasses institutions of higher education and other establishments that offer study courses qualifying for entry into a profession to students who have completed the upper secondary level and obtained a higher education entrance qualification. Even Czechia (Germany's neighbor) emphasizes the early choice of a student's vocational field. In Czechia, 70% of students have already chosen their field of study/occupation at the secondary level. By comparison, the EU average is just 48%.

In the case of the focus on tertiary education, the main differences can be seen in funding. For example, in countries such as Denmark, Greece, Cyprus, Malta, Finland, and Sweden, full-time students on first-cycle programs pay no tuition fees. Introducing tuition fees is a challenging political and economic undertaking for the country, see for example, Zámková and Blašková (2013). In countries such as Bulgaria, Ireland, Spain, France, Italy, and the Belgian-French community, fees are charged to students. However, some students may be exempt from paying them. Typically, the fee is collected from about half of the students (the frequency is higher in France).

The payment of fees in first-cycle higher education was addressed by Eurydice (2020). The distribution of European countries according to the amount of fees is shown in the reproduced Figure 1. Norway and part of the UK typically have the highest fees, but these are fees at private schools. However, both of these countries are an EU Member State, so they are outside the scope of our study.

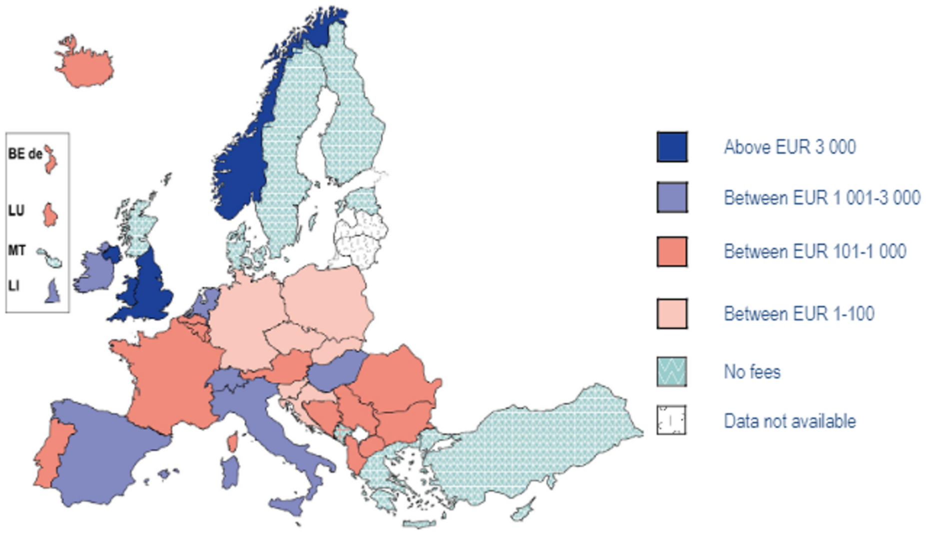


**Figure 1: Typical annual tuition fees (first-cycle higher education) in the 2020/2021 academic year in European countries (source: Eurydice, 2020)**

According to data from Eurydice (2020), in Poland, for example, while fees in first-cycle higher education are less than €100 per year, students are charged fees for repeated study of the course/subject. These fees are set differently for each higher education institution. Most countries that have tuition-free tertiary education have some percentage of private schools, and these schools already charge varying levels of fees. Germany, for example, has only around 15% of students in private schools, making the overall average fee for the whole of Germany just €1–100 per year. By contrast, Belgium, which has more than half of its students in private schools, has an average fee in the €101–1000 per year category.

The funding system for second-cycle programs is typically the same as for first-cycle programs. The exception is a group of six countries where there are significant changes. These are Greece, Ireland, Cyprus, Malta, Montenegro, Bosnia, and Herzegovina. In Greece, Cyprus, and Malta, the first cycle is free for students, but they have to pay fees for the second cycle. In Ireland, for example, the cost is €3,000, but this fee is not paid by the students themselves as it is covered by public authorities. Bosnia and Herzegovina have different systems for the first and second cycles. In the first cycle, some groups of students are exempted from the fee, but in the second cycle, everyone pays. In the case of Montenegro, there has been a systemic change in funding, and as of the academic year 2020/2021, even second-cycle students no longer pay a fee.

## MATERIALS AND METHODS

Parametric and non-parametric methods can be used to calculate efficiency. According to Hollingsworth (2003), parametric approaches are dominated by the stochastic frontier analysis (SFA) method; the non-parametric approaches are dominated by the data envelopment analysis (DEA) method. Both methods attempt to construct a frontier against which to measure the situation of the subject. However, each method has different assumptions and, hence, its strengths and weaknesses. The SFA method can distinguish inefficiency from noise, which the deterministic DEA method cannot. However, the main criticism of the SFA method is that econometric estimation of efficiency can produce inconsistent parameter estimates. In our paper, we decided to use the DEA method for several reasons (Staňková, 2020):

- the DEA method allows more than one output variable to be included in the analysis, which is typical in the field of educational evaluation;
- since the evaluation is performed at an aggregate level, the risk of the DEA method results being affected by data errors (to which the method is very sensitive) is minimized;
- the DEA method allows (via the Malmquist index) a detailed view not only of the level of efficiency itself but also of changes in the efficiency frontier;
- the DEA method is not bound by any assumptions about the probability distribution or the shape of the frontier.

For the reasons mentioned above, we believe that the DEA method is more suitable than the SFA method for our research. Our conclusions are supported, for example, by De La Hoz et al. (2021) and Halásková et al. (2022), as they too claim that it is the DEA method that is the most common method in the field of evaluation of the educational process.

Since our analyses cover a very wide area, we decided to use another tool that allows us to present results in smaller (more homogeneous) groups. Cluster analysis allows us to create groups of countries that are closest to each other in terms of education. If the level of efficiency varies significantly with respect to the different clusters, we can assume that a given "strategy" of one group of countries is better than another.

To clarify and summarize our workflow, in this section, we briefly present the different steps of the research:

1. obtaining the necessary data from publicly available databases;
2. identification of homogeneous groups with regard to their differences regarding the education system;
3. calculation of efficiency and subsequently calculation of Malmquist production index;
4. presentation of results for the EU as a whole and according to the groups (clusters) created.

### Data envelopment analysis model

The DEA method enables a quantitative comparison of so-called decision-making units (DMUs). In the case of the DEA method, we have many models available with different settings. The specific settings vary depending on the nature of the data and the purpose of the analysis. Considering the aggregated level of data, a model was chosen that assumes constant returns to scale like Mašková and Blašková (2021). To avoid having to determine the orientation of the model strictly, we decided to apply the non-oriented Slacks-Based Measure (SBM) model like Cossani et al. (2022). To compile a full ranking of the best countries, we decided to use the SBM model in the so-called super-efficiency variant. According to Cooper et al. (2007), we can define the super-efficiency of $(x_0, y_0)$ as the optimal objective function value $\delta^*$ from the following program:

$$\delta^* = \min_{\bar{x},\bar{y},\lambda} \frac{\frac{1}{m}\sum_{i=1}^{m} \bar{x}_i / x_{i0}}{\frac{1}{s}\sum_{r=1}^{s} \bar{y}_r / y_{r0}} \tag{1}$$

subject to

$$\bar{x} \geq \sum_{j=1,\neq 0}^{n} \lambda_j x_j \tag{2}$$

$$\bar{y} \leq \sum_{j=1,\neq 0}^{n} \lambda_j y_j \tag{3}$$

$$\bar{x} \geq x_0 \text{ and } \bar{y} \leq y_0 \tag{4}$$

$$\bar{y} \geq 0, \lambda \geq 0, \tag{5}$$

where

$$\bar{x}_i = x_{i0}\left(1+\phi_i\right)\left(i=1,\ldots,m\right) \tag{6}$$

$$\bar{y}_r = y_{r0}\left(1+\psi_r\right)\left(r=1,\ldots,s\right) \tag{7}$$

$$\phi \in R^m \text{ and } \psi \in R^s. \tag{8}$$

where $x_i$ and $y_r$ are observed activities belonging to the production possibility set; $\bar{x}$ and $\bar{y}$ are needed to create the production possibility set with $(x_0, y_0)$ excluded; $\phi$ is a semipositive variable in $R^m$ and $\psi$ is a semipositive variable in $R^s$. The model described above was constructed using DEA SolverPro version 15f.

### Data used for efficiency evaluation

The choice of variables was made with the main objective in mind and based on the findings of previously conducted research, see Table 1. The data used to analyze the efficiency of the EU countries were taken from the Eurostat databases. We consider this database to be the most appropriate as it contains information from all EU members based on national statistical authorities. The data in the Eurostat database are pre-analysed and verified by these authorities. Our analysis covers the period from 2014 to 2020. More recent data could not be used at the time of the research (i.e., 2022). Calculations were based on three input and three output variables with respect to data availability. In addition to the standard used variable representing the number of graduates (like in Wolszczak-Derlacz (2017) or Mousa and Ghulam (2019)), we included in the model other variables representing the employability of the graduates in the labor market. This variable will make it possible to examine the quality and readiness of these students for working life. Specifically, the employment rate of the tertiary educated population and the employment of university graduates. This combination of variables allows us to examine the quality and readiness of these students for working life.

As in Mašková and Blašková (2021), we wanted to include public expenditure among the input variables. However, unlike the aforementioned study, we decided to include not only tertiary education expenditure but also science and research expenditure. We assume that these expenditures impact the quality of the employees themselves and the content of the study courses. In practice, it is common for a university to use the allocated funds for science and research to build a laboratory, for example. However, this laboratory can also be used (to a limited extent) by students – typically to write their thesis. Therefore, benefits are not only for the direct research activities of the employees but also for students. The experience gained then positively impacts the quality of the students and their future employability in the labor market. The Eurostat database indicates expenditure on science and research in the form of a percentage of GDP. For our analysis, we calculated the expenditure on science and research in EUR thanks to the information on the size of GDP itself. Similar to Ma and Li (2021) or Andersson and Sund (2022), we include the number of employees among the inputs. The last input variable is the percentage of non-graduates, which is defined in a given country as the ratio of students who complete the university stage to all those who enter. Therefore, if a student transfers to another university during their studies and graduates, they are treated as a successful graduate.

| Authors | Input variables | Output variables |
|---|---|---|
| Andersson and Sund (2022) | Academic staff, other employees, number of students, area of office space | Number of employees, ECTS credits, PhD titles, publications |
| Mašková and Blašková (2021) | Public expenditure on tertiary education, the number of teachers in tertiary education | The employment rate of graduates of tertiary education, the number of graduates in tertiary education |
| Ma and Li (2021) | Academic staff and other employees, public expenditure on tertiary education, size of universities, number of books at the end of year, the value of long-term assets of higher education institutions | Number of graduates of Master's studies, graduates of Bachelor's studies or higher professional schools, published academic papers, published scientific papers, patents applied for by universities |
| Mikušová (2020) | Academic staff, other employees, operating costs, total expenditure, number of students, employees | Total PhD degrees awarded, number of students, graduates, grants, publications |
| Brzezicki et al. (2020) | Number of academic staff, total value of teaching income, government budget subsidy, value of fixed assets | Number of tertiary education graduates, doctoral degrees awarded, postgraduate certificates issued |
| Dumitrescu et al. (2020) | Core funding, additional funding, the value of doctoral grants | Number of students funded from the state budget (undergraduate and graduate) |
| Mousa and Ghulam (2019) | Academic staff, administrative staff | Number of publications in SCOPUS, graduates |
| Jelić and Kedžo (2018) | General government expenditure (tertiary education), financial aid to students as % of total public expenditure on education, ratio of the students and teachers | The ratio of the unemployment rate of graduates and the total unemployment rate, the population aged 15–64 with completed tertiary education, graduates aged 20–34, graduation rates |
| Wolszczak-Derlacz (2017) | Total income, number of academic staff, administrative staff, students | Number of publications, published scientific articles, graduates |
| Nazarko and Šaparauskas (2014) | Government budget subsidy, number of academic teachers and employees, licenses to award PhD degrees, licenses to award higher doctorate degrees | Weighted number of full-time students and full-time PhD students, employer preference for hiring alums, % of students studying abroad, international students, students with university scholarships |

**Table 1: Overview of major studies in the field of efficiency evaluation in the tertiary education sector (source: own processing)**

## Efficiency change over time

The analyses include the evaluation of all EU countries in the period from 2014 to 2020. Since our data is panel data, attention will also be paid to the change in efficiency over time. In this respect, either a window analysis (WA) like in Flegl et al. (2023) or a calculation via the Malmquist productivity index (MI) as in Staňková et al. (2022) are most often used. Considering the longer time period analyzed, we decided to use the decomposition of the MI in this article.

According to Křetínská and Staňková (2021), it is necessary to solve four DEA models to build the *MI*. The index itself is then compiled as a geometric mean of two efficiency ratios, where one is the efficiency change measured by the period 1 technology and the other is the efficiency change measured by the period 2 technology:

$$MI = \left[ \frac{\delta^1\left(\left(x_0, y_0\right)^2\right)}{\delta^1\left(\left(x_0, y_0\right)^1\right)} * \frac{\delta^2\left(\left(x_0, y_0\right)^2\right)}{\delta^2\left(\left(x_0, y_0\right)^1\right)} \right]^{1/2} . \qquad (9)$$

This index can be decomposed into two components, generally known as frontier-shift and catch-up effect. *MI* represents the overall change in the situation of a DMU. Frontier-shift (*F*) records within itself change in the frontier technology:

$$F = \left[ \frac{\delta^1\left(\left(x_0, y_0\right)^1\right)}{\delta^2\left(\left(x_0, y_0\right)^1\right)} * \frac{\delta^1\left(\left(x_0, y_0\right)^2\right)}{\delta^2\left(\left(x_0, y_0\right)^2\right)} \right]^{1/2} . \qquad (10)$$

Catch-up effect ($C$), on the other hand, provides information about relative changes in performance (i.e., efficiency):

$$C = \frac{\delta^2\left(\left(x_0, y_0\right)^2\right)}{\delta^1\left(\left(x_0, y_0\right)^1\right)}. \quad (11)$$

DEA models with the settings already described above were used to calculate the *MI* and its components. Further technical details and the DEA method can be found in Cooper et al. (2007). All DEA models were built using DEA SolverPro version 15f.

## Cluster analysis

Since education systems in different countries are influenced by many factors, a cluster analysis was used to identify groups of countries with similar characteristics. Eurostat data from 2014-2020 were used for the cluster analysis to characterize the educational attainment of the EU countries. Specifically, we used information on the graduates' employment rate, the number of graduates with tertiary education, the number of the population with complete tertiary education, employment of tertiary education, the number of teachers in tertiary education, and early leavers from education. Since the quality of education is reflected in many indicators of a country's level, the variables related to tertiary education were further supplemented with the Human Development Index (HDI). The size of the HDI is proxied by education expectancy and average years of education.
Since the selected variables are in different expressions, we decided to use the standardized Euclidean distance for the pairwise distance between pairs of observations, similar to the approach in Staňková and Hampel (2017). As part of this procedure, each coordinate difference between observations is scaled by dividing by the corresponding element of the standard deviation:

$$d_{st}^2 = \left(x_s - x_t\right)V^{-1}\left(x_s - x_t\right)', \quad (12)$$

where $V$ in the $n$-by-$n$ diagonal matrix whose $j^{\text{th}}$ diagonal element is $(S(j))^2$, where $S$ is a vector of scaling factors for each dimension. Ward's method has proven to be a good algorithm for computing the distance between clusters in the case of Euclidean distances in many analyses; see, for example, Beneš et al. (2018).

$$d\left(r,s\right) = \sqrt{\frac{2n_r n_s}{\left(n_r + n_s\right)}}\left\|\overline{x}_r - \overline{x}_s\right\|_2, \quad (13)$$

where $\|\ \|_2$ represents the Euclidean distance (in our case, in the standardized version); $\overline{x}_r$ and $\overline{x}_s$ are the centroids of cluster $r$ and $s$; and n is the number of elements in the cluster. The cluster analysis was performed using MATLAB computing system version 2023a. Specifically, the *pdist* (for pairwise distance between pairs of observations setting) and *linkage* (for agglomerative hierarchical cluster tree construction) functions were used.

# RESULTS

## Clusters of countries based on similarities in their education system

The division of countries (and, therefore, their education systems) is shown in Figure 2. Due to the large scale of the analyses, only two dendrograms are given in Figure 2, one from the beginning and one from the end of the study period.
For each period, it was possible to identify five clusters (color-coded in Figure 2), with Germany being so different in each year that it did not fall into any of the clusters created (this was also the case with France in 2020). It can be concluded that the groups have not undergone dramatic changes during the whole period under review. For example, the green cluster in 2014 contained nine countries, with seven of them remaining in the same group up to 2020 – see the blue cluster in 2020. These were Belgium, Denmark, Finland, Ireland, Luxembourg, Netherlands, and Sweden. In 2014, this group also included Austria and Cyprus. Countries in this cluster have, in the long term, a large share of the population with completed tertiary education. Furthermore, these are the countries with a really active promotion of multilingual education. For example, Belgium, Finland, and Sweden managed to enroll more than 10% of students studying in a language other than their mother tongue. If we focus only on large cities that can be described as centers of tertiary education, roughly one in two students (primary education) are involved (Eurydice, 2020). In these countries, multilingual education is supported in primary education. Students who succeed in primary and secondary education have good language skills. Countries falling into this cluster also have the highest rates of inward degree-mobile graduates. Thanks to this mobility and the development of cultural and linguistic skills, students from this cluster of countries have great potential for employability in the labor market (both local and foreign).
The brown cluster was another large group of countries in 2014. The main core of this cluster (Estonia, Latvia, Lithuania, and Malta) can be seen in the yellow cluster in 2020. In addition, Poland, Slovenia, Cyprus, and Austria are here this year. This cluster can generally be characterized as a cluster with a high percentage of underachieving students. However, over the years, there have been changes in this variable, and, therefore, the cluster has also transformed, with Bulgaria, Romania, and Hungary moving to separate clusters as the percentage of non-graduates remained high for these countries. A positive trend can be seen for the remaining countries, resulting in a reduction in the share of non-graduates by about four percentage points on average. The purple cluster in 2020 can also be characterized by the very low results of the most recent PISA tests (these were conducted in 2018). These are mainly the results of students in Bulgaria and Romania (European Commission, 2020a).
The countries in the yellow cluster in 2020 (especially Lithuania, Latvia, Slovenia, Poland, and Cyprus) have significantly lower rates of employment of medium-level vocational qualification (VET) graduates compared to the overall rate for that generation. This can be seen as a signal of inefficiencies in the VET system and the inability to prepare these students for the demands of future employers (European Commission, 2020b).


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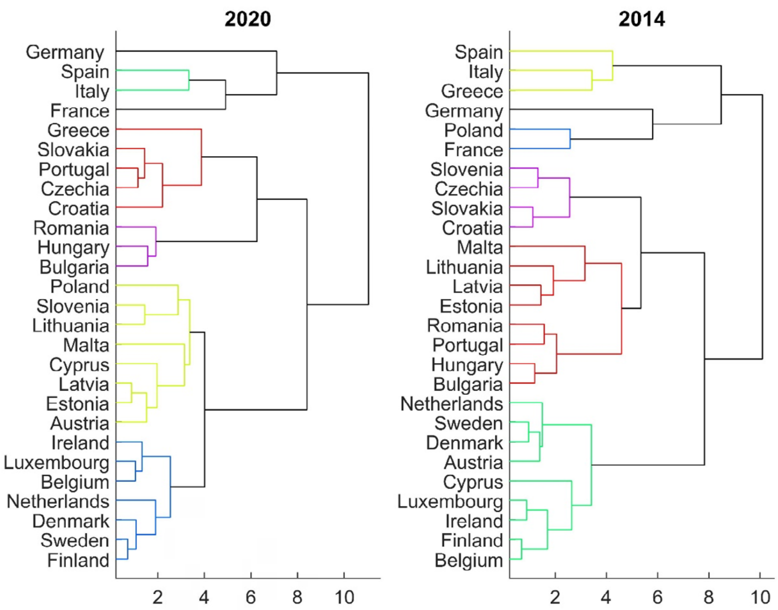


**Figure 2: Identified clusters at the beginning and end of the reference period (source: own calculation)**

The core of the purple cluster in 2014 (i.e., Czechia, Slovakia, and Croatia) can be found in the brown cluster in 2020. A common feature of these countries is the lower employability of tertiary graduates and the percentage of tertiary graduates between 18–25%. With the remaining brown cluster countries in 2020, they have similar employment rates.

In 2020, a purple cluster that contains only three countries was further identified. This purple cluster in 2020 is very close to the brown cluster countries in 2020. Their relative proximity can be seen in the lack of participation in early childhood education (age 4+). In these countries, there are also long-standing problems with the participation of students from disadvantaged families (European Commission, 2020a).

The last color group in 2012 was Spain and Italy (i.e., the green cluster). These two countries have education expenditure (measured as a percentage of GDP) below the EU average. The EU average is around 4.6% of GDP, but these countries have only 4%. Another typical feature of these two countries is the low level of graduate employment and the fact that vocational education is undergoing significant reform in both countries (European Commission, 2020a).

As already mentioned, Germany is not clustered with any other country. According to the cluster analysis results, this country is closest to France, but even France does not have enough common characteristics to be associated with the German system. This uniqueness of the German system is significantly influenced by the fact that students must choose their field of study at an early age.

Considering our analysis of the education systems and the resulting dendrograms, we decided to divide the EU countries into five clusters, see Table 2. Primarily, we based our analysis on the most recent results, i.e., the results of the cluster analysis in 2020. Four clusters containing at least three countries were identified this year. In addition to these four groups, four countries (Germany, Italy, Spain, and France) remained in the analysis that were quite distinct from the others. As there is a link between these countries due to the ongoing modernization of the VET system, we decided to form the last group of these four countries.

| Group number | Countries |
|---|---|
| 1 | Austria, Belgium, Denmark, Finland, Ireland, Luxembourg, Netherlands, Sweden |
| 2 | Cyprus, Estonia, Latvia, Lithuania, Malta, Poland, Slovenia |
| 3 | Bulgaria, Hungary, Romania |
| 4 | Croatia, Czechia, Greece, Portugal, Slovakia |
| 5 | France, Germany, Italy, Spain |

**Table 2: Resulting country groupings (source: own processing)**

## Efficiency evaluation

In terms of the efficiency of the tertiary sector for the whole EU area, it can be stated that it is at a relatively high level; see the median and average efficiency values in individual years in Table 3. Although these generalized values range from 70% to 82%, the level of efficiency varies significantly between countries. Countries in Groups 2 and 3 have the highest median (and average) efficiency. The third imaginary position would go to countries in Group 4. Countries in Group 5 have the worst efficiency scores.

Detailed results of the individual SBM non-oriented models in each year are presented in Figure 3. In this figure, the countries are sorted according to the defined groups in Table 2. Here, we can see that despite the formation of homogeneous groups, individual countries can have dramatically different efficiency outcomes within the group.

| Group | Char. | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| All | Median | 0.8213 | 0.7080 | 0.7878 | 0.7626 | 0.6995 | 0.7456 | 0.7823 |
| | Mean | 0.7829 | 0.7670 | 0.7916 | 0.7846 | 0.7763 | 0.7710 | 0.7765 |
| 1 | Median | 0.4427 | 0.4588 | 0.4760 | 0.4167 | 0.4261 | 0.4175 | 0.4033 |
| | Mean | 0.6414 | 0.6277 | 0.6625 | 0.6330 | 0.6265 | 0.6302 | 0.5939 |
| 2 | Median | 1.0329 | 0.8628 | 1.1175 | 1.1112 | 1.1014 | 1.0611 | 1.0367 |
| | Mean | 1.0492 | 1.0166 | 1.1017 | 1.1112 | 1.0887 | 1.0768 | 1.0856 |
| 3 | Median | 1.0810 | 1.0549 | 1.0377 | 1.0424 | 1.0634 | 1.0598 | 1.0247 |
| | Mean | 0.9194 | 0.9249 | 0.9089 | 0.9062 | 0.9157 | 0.9005 | 0.9237 |
| 4 | Median | 1.0481 | 0.8984 | 0.7878 | 0.7543 | 0.6995 | 0.7400 | 0.7510 |
| | Mean | 0.8464 | 0.8140 | 0.7739 | 0.7715 | 0.7463 | 0.7273 | 0.7796 |
| 5 | Median | 0.2351 | 0.2436 | 0.2527 | 0.2552 | 0.2649 | 0.2878 | 0.2952 |
| | Mean | 0.4182 | 0.4317 | 0.4410 | 0.4417 | 0.4621 | 0.4752 | 0.4865 |

**Table 3: Median and average efficiency values for the EU and individual groups in each year (source: own processing)**

In the case of Group 1, the results for Ireland and Luxembourg differ significantly from the other countries in this group. These two countries rank among the most efficient (or rather super-efficient) countries throughout the period under review. In contrast, the other countries have efficiency scores below 50%. Therefore, Ireland and Luxembourg have significantly increased the average values of Group 1 above their medians in Table 3. Ireland and Luxembourg are countries that have significantly higher tertiary education expenditure (including science and research expenditure) relative to the number of teachers in absolute terms than other countries; at the same time, they have a significantly lower percentage of non-graduates. This combination then resulted in an efficiency value of over 100%.

Within the created Group 2, the best performer is Malta, which is efficient (or super-efficient) throughout the period under review. By contrast, Estonia has the lowest efficiency in this group, but even for this country, the efficiency does not fall below 60%. This underperformance of Estonia relative to other countries in this group is primarily due to higher expenditure (per teacher).

Group 3 consists of only three countries. Bulgaria and Romania have similar efficiency scores, which are about 50 percentage points higher than Hungary in 2014. The ranking changed in 2020 when Romania took last place and Hungary took first place. This change in ranking is due to a significant increase in the number of graduates in that year, which was almost double the number compared to previous periods. Interestingly, this was a significant change only for this variable. The other indicators for Hungary remained at similar levels as in previous years.

In Group 4, Croatia performed best in terms of efficiency, being efficient (or super-efficient) throughout the period under review. Portugal was the worst performer in terms of efficiency. A detailed analysis of inputs and outputs for Group 4 countries shows the difference in the ratio of graduates to teachers. In this respect, Portugal lags behind other countries; for example, compared to Greece, which has an average of four graduates per teacher, Portugal has roughly half this ratio.

Our defined Group 5 consisted of four countries that were relatively significantly different from the rest of the countries in the EU. However, from the point of view of derived (in)efficiency, it would have been better to keep this group composed of only three countries, namely Germany, Italy, and Spain. These three countries have very low-efficiency scores (Spain is even the worst in the EU in terms of efficiency). The cause of this inefficiency can particularly be seen in the high rate of under-graduation.

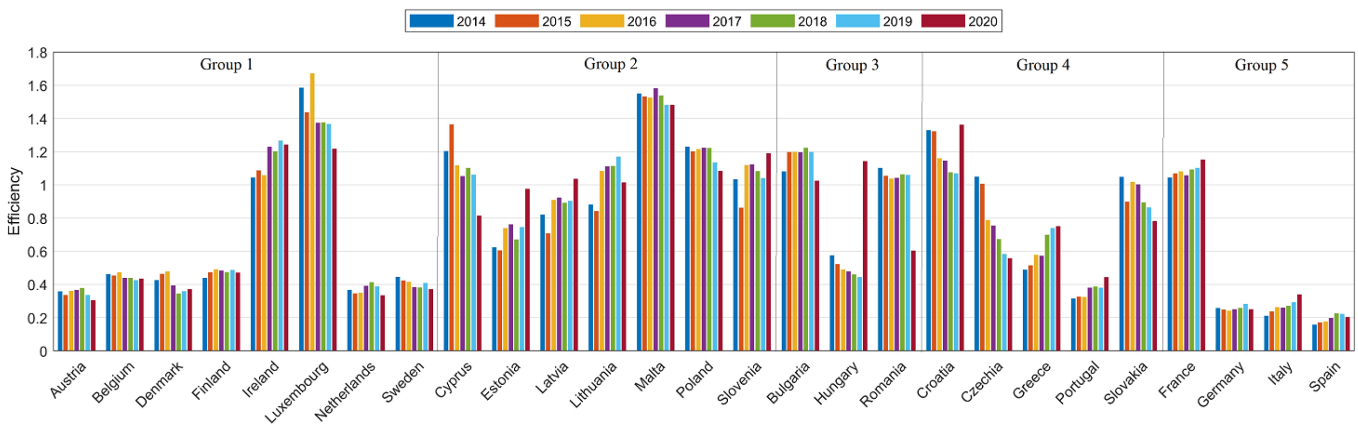


**Figure 3: Country efficiency results from individual years according to the groups formed (source: own calculation)**

To adequately assess changes in efficiency over time, the Malmquist index was calculated and then decomposed into a change in efficiency and a change in the production frontier. The results of the overall change (i.e., the change from 2014 to 2020) are recorded in Table 4.

| Country | Malmquist | Frontier | Catch-up | Country | Malmquist | Frontier | Catch-up |
|---|---|---|---|---|---|---|---|
| Austria | 0.9135 | 1.0715 | 0.8525 | Italy | 1.5603 | 0.9703 | 1.6081 |
| Belgium | 1.0519 | 1.1194 | 0.9397 | Latvia | 0.9645 | 0.7641 | 1.2622 |
| Bulgaria | 0.7617 | 0.8035 | 0.9479 | Lithuania | 1.0232 | 0.8888 | 1.1512 |
| Croatia | 1.0065 | 0.9820 | 1.0249 | Luxembourg | 0.5449 | 0.7093 | 0.7683 |
| Cyprus | 0.6777 | 1.0019 | 0.6764 | Malta | 0.8857 | 0.9268 | 0.9557 |
| Czechia | 0.5579 | 1.0478 | 0.5324 | Netherlands | 1.0248 | 1.1222 | 0.9132 |
| Denmark | 0.9973 | 1.1472 | 0.8693 | Poland | 0.7431 | 0.8427 | 0.8819 |
| Estonia | 1.3228 | 0.8454 | 1.5647 | Portugal | 1.3990 | 0.9944 | 1.4069 |
| Finland | 1.1488 | 1.0721 | 1.0716 | Romania | 0.5332 | 0.9729 | 0.5480 |
| France | 1.3418 | 1.2154 | 1.1040 | Slovakia | 0.7233 | 0.9691 | 0.7464 |
| Germany | 0.9676 | 1.0002 | 0.9674 | Slovenia | 1.1112 | 0.9643 | 1.1523 |
| Greece | 1.6145 | 1.0529 | 1.5333 | Spain | 1.2554 | 0.9795 | 1.2817 |
| Hungary | 1.8593 | 0.9361 | 1.9862 | Sweden | 0.9135 | 1.0947 | 0.8344 |
| Ireland | 1.3401 | 1.1262 | 1.1899 | Average | 1.0461 | 0.9860 | 1.0656 |

**Table 4: Total change in the Malmquist index, including the change in individual efficiency (catch-up) and the change in the production possibilities frontier (frontier) (source: own processing)**

According to the results of the overall change in the Malmquist index, Hungary and Greece experienced the greatest positive change. However, looking at the decomposition of the index into its sub-components, it can be seen that the reason for the rise in the Malmquist index was different for these two countries. In the case of Greece, there was an increase in both components, i.e., in individual efficiency (the so-called catch-up effect), but there was also an increase in the frontier of production possibilities. In the case of Hungary, it can be seen that in the case of a frontier shift, the resulting value is less than one, i.e., it is a drop, but this is compensated by a strong increase in efficiency and therefore the Malmquist index is also greater than one in the result.

At the other end of the ranking are Romania and Czechia, which have experienced a strong negative impact over the years (the Malmquist index shows that their situation has roughly halved from 2014 to 2020). In the case of Romania, we see a decline in both subcomponents of the Malmquist index. In the case of Czechia, this decline in the Malmquist index is by way of a decline in efficiency, outweighing the increase in the frontier.

In terms of Malmquist index values, 14 countries improved their overall situation between 2014 and 2020. On the other hand, 13 countries have an index value below one, thereby a deterioration of their overall situation during the period under review. Therefore, on average, there is a positive effect across the tertiary education sector in EU countries, as the average Malmquist index is greater than one. This positive change is driven by an average increase in efficiency with only a slight drop in the frontier. A detailed view of the year-on-year changes in the Malmquist index is shown in Figure 4.

Most striking in Figure 4 is the change in Hungary between 2019 and 2020. As indicated above, Hungary reported twice as many graduates in 2020, with other variables relatively unchanged. Therefore, the positive effect observed for Hungary in Table 4 was not a gradual improvement (as is the case, for example, of Spain, which has a Malmquist index score greater than one every year) but only a step change in a single period. Apart from Spain, only Portugal had systematic increases throughout the period under review. From this point of view, Czechia performed the worst, as its overall situation declined in every period, with the value of the Malmquist index always being lower than one. In the case of Czechia, a combination of several factors resulted in this bad situation for the country. Demographic factors also play a role here, as at that time, the population of weaker years was studying, and therefore, the number of graduates decreased. Furthermore, the employment rate of tertiary education graduates also decreased. For example, in 2017, this indicator was at 81%, but in 2020 it was only at 75.8%. However, in 2020, the impact of the COVID-19 pandemic may have already impacted this indicator. More detailed results for the year-on-year changes at the level of the different components of the Malmquist index are available in Figures 5 and 6.

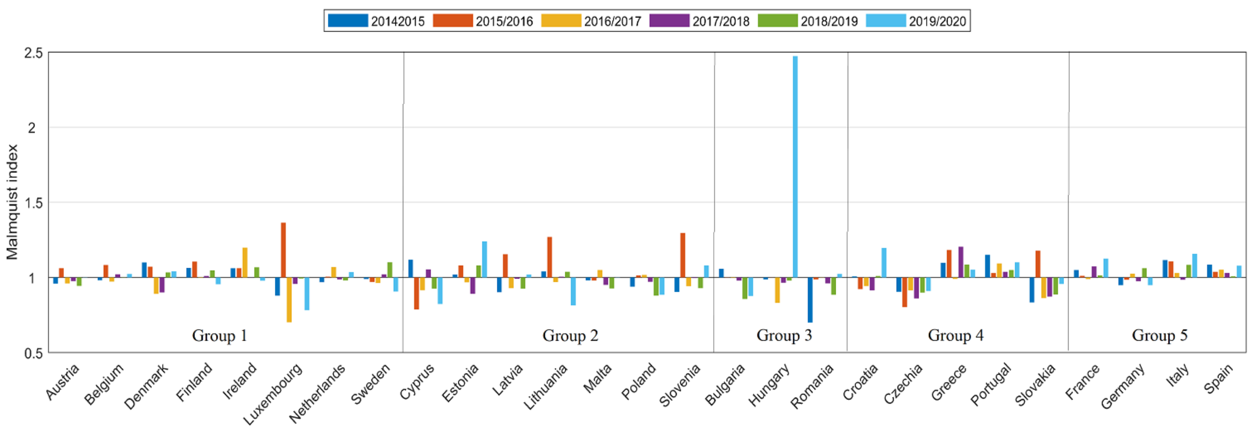


**Figure 4: Year-on-year Malmquist index results for individual countries according to the groups formed (source: own calculation)**

Figure 5 shows the results separately for the individual change in efficiency (the so-called catch-up effect). As mentioned above, Hungary underwent the greatest positive change in 2019/2020. On the other hand, Romania underwent the greatest negative change in 2019/2020. In the case of Romania, the inefficiency can be explained by the quality of graduates, as confirmed by the results of the World Bank (2020). The Romanian education system is currently struggling to provide graduates with skills that are currently in demand in the labor market. Unfortunately, this problem is already evident in the Romanian education system at the first stages of studies. The Romanian government is trying to reverse this situation by providing more subsidies for tertiary education. However, increasing the variable of tertiary education expenditure without adequately increasing the quality or at least the number of graduates has only reinforced the inefficiency of this country in our analysis.

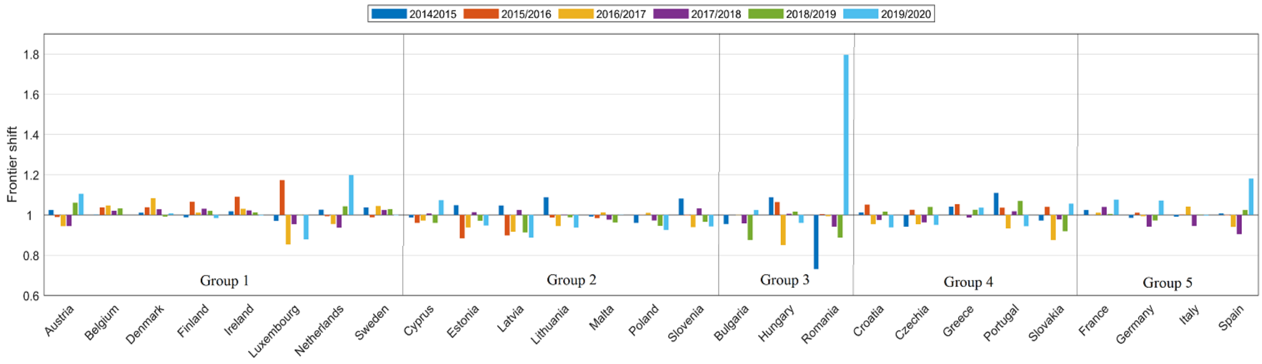


**Figure 5: Year-on-year catch-up effect results for individual countries according to the groups formed (source: own calculation)**

Conversely, France and Malta have the smallest year-on-year changes. However, these are two of the six countries that have efficiency scores greater than one over the whole period. Using conventional DEA models that have the highest possible efficiency score of 1 (i.e., 100%), such as the CCR model with input orientation, no change in efficiency would be identified for Bulgaria, Croatia, France, Ireland, Malta, or Poland. For this reason, the year-on-year changes in this variable can be considered negligible for these countries.

To complete the overall picture, Figure 6 also plots the year-on-year changes in the case of a frontier shift. Belgium performs best in terms of this indicator, with an increase in the frontier identified in each period. Although this is not a significant change in absolute terms, it is the only country in the EU where the frontier shift scores are greater than one throughout the period under review.

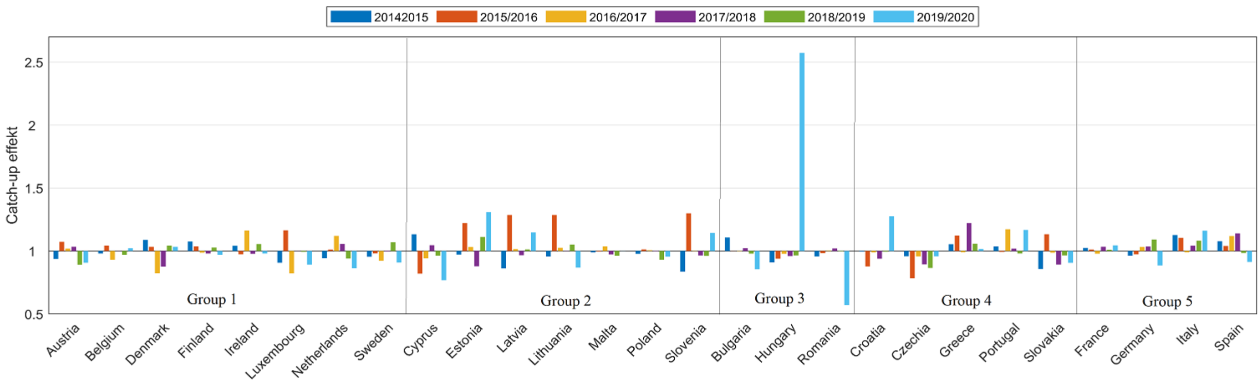


**Figure 6: Year-on-year frontier shift results for individual countries according to the groups formed (source: own calculation)**

## DISCUSSION

Only six countries were identified in our analyses as efficient (or super-efficient) throughout the period under review, i.e., Bulgaria, Croatia, France, Ireland, Luxembourg, and Malta. The results show that countries such as France and Ireland have a very high number of graduates per teacher (in the case of Ireland, 9.7 graduates per teacher on average). They have therefore ensured their level of efficiency by producing many graduates. On the other hand, countries such as Malta and Luxembourg have gained their efficiency through quite the opposite properties. These two countries rank among the countries with the lowest ratio of students to teachers and academic staff from EU countries, and they also have the lowest percentage of people in tertiary education. Thanks to this, special conditions and a stronger, more individual approach to students have been developed at universities there. As a result, they have better employability of tertiary education graduates in the labor market, which is reflected in the results of our efficiency analysis. Inefficient countries can, therefore, choose their own path to achieve a state of efficiency in this respect. If, within this ratio, we focus on Group 2, which has the highest efficiency in terms of median values, we find a sort of guide to the intermediate level between very low efficiency and relatively high efficiency (but not always 100%) at a ratio of two to three graduates per teacher. The identified Group 2 can generally be described as countries with relatively low expenditure on science and research and tertiary education relative to their economic strength. This relatively lower government expenditure has certainly contributed to the relatively high level of efficiency of Group 2 countries.

EU countries can largely be distinguished by the way they finance the tertiary sector. In addition to public funds, private sources can also be used. According to Andersson and Sund (2022), examining whether these government costs are used efficiently is essential. Their analysis focused on the Nordic countries. According to their results, these countries do well in using education expenditure efficiently. However, their analysis did not take into account the quality of graduates. In their analysis, Denmark and Sweden are among the best countries. Our analyses also take into account the graduate's ability to find a job in the market, with both Denmark and Sweden ranking among the highly inefficient countries. These countries were the first to devolve responsibility for the content of education to the educational institutions themselves. Moreover, these countries can be identified as countries where educational institutions have the greatest responsibility for the content of education (European Commission, 2020a).

Another option (used by other countries) is for the government to direct the process by issuing programs and development plans that regulate education content. In the case of Denmark and Sweden, however, there is strong liberalism in the content of education (European Commission, 2020a). We assume that the low efficiency of these countries can largely be explained as a consequence of this liberalism. If a situation arises where the responsibility lies primarily on the shoulders of institutions that do not adequately reflect the situation in the labor market, a mismatch will arise between the competences of graduates and the requirements of the labor market, resulting in an increase in graduate unemployment (Ho, 2015). According to the data obtained from the Eurostat database (described in the Materials and Methods chapter), this is the case for Denmark and Sweden.

Veiderpass and McKelvey (2016) combined quantitative and qualitative perspectives on education efficiency in their research. Their quantitative analysis results support our results. Both studies show that even very economically strong countries can be highly inefficient. This is particularly the case in Germany. In contrast to the EU results, Germany had a below-average share of tertiary educated people in the past decade. At the beginning of the reporting period (i.e., 2014), Germany reported only 23% of the population with a tertiary education. In contrast, by the end of the reporting period (i.e., 2020), the share increased to 27%. According to the requirements in the EUROPE 2020 strategy (European Commission, 2020b), countries should have at least 40% of the population with tertiary education (this is the share for the age group 25-34). However, Germany did not reach these required values. One reason for this may be the education system in Germany. Our analyses found that Germany has a high proportion of early leavers in tertiary education compared to other EU countries. In addition, Germany is very different from other countries and has, therefore, always stood alone in cluster analysis.

One reason it stood alone in our cluster analysis was that students in this country choose their majors earlier than is typical in surrounding countries. We also found that Germany has one of the highest numbers of early leavers. It can, therefore, be assumed that many students lack the motivation to complete their studies, and we believe that, in many cases, this is due to a hasty choice of future focus at a young age. Germany's distinctiveness may also be influenced by the fact that it is made up of individual Länder, who have their own particular authority and thus may have different educational requirements. Germany is also notable for its extensive network of vocational schools, where studies are primarily directed towards practical training as well as applied research (European Commission, 2020a).

Our results are also consistent with those of Jelić and Kedžo (2018), who looked at the efficiency of tertiary education across Europe from 2007 to 2015. Although our research period and theirs overlap in only two years, the main findings of the two studies are consistent. One of the main findings of Jelić and Kedžo (2018) is that some of the most developed countries perform worse than less developed countries. In their research, Austria and the Netherlands have fallen behind. According to our results, low-efficiency scores can be observed for these countries not only in 2014 and 2015 (which are also included in the Jelić and Kedžo (2018) analyses) but also in subsequent years.

However, the results of our analyses bring new findings that otherwise overlooked countries such as Malta or Luxembourg provide a high level of efficiency in the educational process in terms of labor market employability. These findings are also significant in contrasting migration both for educational and employment reasons. So far, people have generally had the idea of the necessity of migration from East to West, as evidenced by studies focusing on both labor migration (Johnston et al., 2014) and educational migration (Melzer, 2013). Our results show that moving to non-Western countries can also contribute to getting a good education and getting a job. Although it can be assumed that the quality of all universities will not be the same in each country, the reputation of a country, in general, may motivate the arrival of international students. Many of these students develop so many local contacts (both personal and professional) during their studies that they stay in the country after graduation (Lu et al., 2009). If these are talented and capable students who have been created through a properly set-up system, the country will improve economically. Positive results will be seen, for example, through increased labor productivity.

Education (including tertiary) was significantly affected by the COVID-19 pandemic. For example, de Boer (2021) describes the impacts in the Netherlands. According to him, due to the forced transition to online learning, schools/universities did not have a full overview of students' active participation in classes. He identified teacher-student interaction as the biggest barrier in teaching. Ahrens et al. (2021) point out that a large proportion of the students they surveyed (across different countries) complained about technical problems in online learning. However, according to the students, the pandemic also brought new opportunities – lectures and discussions with people from foreign countries who would not have come in the case of "classical" teaching. Erkut (2020) also sees the positives of restrictions due to the pandemic as an opportunity (albeit a forced one) to adjust Turkey's outdated education system.

Unfortunately, due to the (un)availability of data, it was not possible to fully explore this period in our analysis as we only obtained data for all variables up to 2020. The inability to adequately assess the impact of the pandemic can be seen as a limitation of this research. The restrictions that were in place at the time of the COVID-19 pandemic undoubtedly impacted not only staff but also students. There are several studies addressing the impact of the pandemic; see, for example, Hosen et al. (2022) and Sahoo et al. (2021). However, these are more qualitative studies that do not evaluate the efficiency of the entire education system. Before the COVID-19 pandemic, the legislative environment in some countries already allowed the implementation of distance/online learning. Still, the restrictions due to the pandemic literally came as a shock to many subjects. Schools and teachers were suddenly forced to change the system of teaching, and many subjects discovered hidden problems in the organization of the whole study.

Based on these findings, some EU countries have started to modernize their teaching systems along with increased digitization. However, the impact of these changes has not yet been adequately analyzed in contrast to efficiency. Future research should, therefore, focus on efficiency changes considering the impacts of the COVID-19 pandemic. A comprehensive assessment will only be possible several years after the end of the restrictions. The research should be conducted after students affected by the COVID-19 pandemic graduate and become part of the country's workforce. After a few years, it will be possible to monitor whether their employability is comparable to graduates who were not affected by the pandemic during their studies. Given that the countries had slightly different restrictions (or their strength), it will also be possible to examine the efficiency changes with respect to the different strategies of each country.

Analyses could also be carried out at the level of individual universities, where individual fields of study could be analyzed. Due to the aggregated nature of the data in our research, it was not possible to distinguish in detail between the different forms of financing. However, an assessment based on data from individual universities could distinguish, for example, donations, which may represent a significant source of funding for some entities. An evaluation by individual universities or fields of study could also provide important insights in relation to the aforementioned migration.

## CONCLUSION

This article focused on an evaluation of the efficiency of the tertiary education sector in EU countries. The efficiency values between 2014 and 2020 were calculated using the SBM non-oriented super-efficiency DEA model. Unlike the common analyses based on the number of graduates, we included the quality of graduates and their ability to enter the labor market. The results of our analysis show that the employability of graduates is crucial for a correct efficiency analysis. Efficiency is achieved not only by countries with a high ratio of graduates to teachers but also by countries with a low ratio and whose graduates have the necessary knowledge and skills that employers currently require in the market. Within several years, it would be appropriate to conduct an efficiency analysis with regard to the impact of the COVID-19 pandemic. It can be assumed that the restrictions have impacted students' abilities and, therefore, the efficiency of the whole education and, consequently, the employability of graduates in the labor market.

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