Sustainable Development Goals and Higher Education: An Efficiency Analysis

Maja Mihaljević Kosor
University of Split, Faculty of Economics, Business and Tourism, Cvite Fiskovića 5, 21000 Split, Croatia
majam@efst.hr

ARTICLE INFO

Original Scientific Article

Article History:
Received February 2023
Revised August 2023
Accepted September 2023

JEL Classification:
Q01, I23, C40, H52

Keywords:
Sustainable development goals (SDGs)
Higher education
Data envelopment analysis (DEA)
SDG 4
European countries

UDK: 378:502.131.1
DOI: 10.2478/ngoe-2023-0014

Cite this article as: Mihaljević Kosor, M. (2023). Sustainable Development Goals and Higher Education: An Efficiency Analysis. *Naše gospodarstvo/Our Economy, 69*(3), 12-23. DOI: 10.2478/ngoe-2023-0014.

Abstract

Higher education (HE) is a significant factor in a country's economic prosperity and plays a vital role in addressing sustainability issues and actively promoting sustainable development. While many EU member countries have well-developed education systems in terms of rankings and SDGs' attainment, little is known about the progress of other European countries. The goal of this research is to estimate the efficiency of higher education in the attainment of Sustainable Development Goals (SDGs) in 40 European countries. The method used to estimate efficiency is Data Envelopment Analysis (DEA) with output-orientation and variable returns to scale approach. In the final model specification, two input variables and one output variable are used. Results indicate that the average technical efficiency of the 40 European countries is relatively high and equal to 0.94. Nine countries emerge as fully efficient in achieving SDG 4 with a coefficient equal to 1. The four largest higher education systems achieved an above-average efficiency score of 0.97 or higher. Six countries are recognized as the worst performing. However, more analysis is necessary to examine the sources of inefficiency in the worst-performing countries. Due to specific data limitations indicated in this research, it remains a challenge to evaluate the precise impact of higher education and its contribution to SDGs.

Introduction

In the area of higher education, hundreds of universities across the world have signed various charters and agreements committing their efforts towards sustainability. Higher education has a vital role in promoting sustainable development and achieving the Sustainable Development Goals (SDGs). Within the HE framework, higher education institutions (HEIs) have considerable influence on society, the economy, and the environment and have a responsibility to address sustainability challenges and foster a culture of sustainability. HEIs may act as catalysts for sustainability by fostering inter and trans-disciplinary collaborations and partnerships with community, industry, and government. In this aspect, the SDGs offer a useful framework for HEIs to align their sustainability efforts with broader global goals. However, there is still limited research on the various means, processes, and methods through which sustainability is being practiced and implemented in higher education and even less research on the efficiency of achieving SDGs. This is an important area of investigation given the role of education in promoting economic growth. The impact of higher education on a country's economic prosperity is realized through three established mechanisms acknowledged in the relevant literature (e.g., in Aghion & Howitt, 2009). First, education is linked to the labor force and its productivity. Human capital combined with physical capital is used to produce a country's GDP. Furthermore, education increases the innovative capacity of a country and facilitates the development of new products, technologies, and processes. Lastly, education enhances the transmission and dissemination of knowledge, as well as the adoption of new technologies.

The 17 Sustainable Development Goals were adopted by all UN Member states in 2015 as a part of the 2030 Agenda for Sustainable Development. With less than a decade left to achieve the SDGs, there is a need for more action in terms of financing, better national implementation, and stronger institutions. As the deadline for achieving the SDGs draws closer, there is a crucial need for extensive examination of sustainable development research, implementation, and the attainment of SDGs. The importance and urgency of expanding society's capacity to solve complex challenges has never been greater (SDSN, 2020). The SDGs also include improvements in education, relying on the collaboration of higher education institutions (HEIs). These institutions possess the capacity to actively embrace sustainability efforts and play a role in realizing these objectives, as highlighted by Chankseliani and McCowan (2021).

The recent data from OECD (2022) shows that the rapid expansion of tertiary education continues. The share of 25–34-year-olds with tertiary education has increased by 20 percentage points from 27% to 48% in the last two decades; the employment rates of 25–64-year-olds with tertiary education are about 10 percentage points higher on average than that of those with non-tertiary qualifications and compared to those with upper secondary qualification the average earnings advantage of those with bachelor's degree is 44%, rising to 88% for a master's or Ph.D. degree.

In the EU, Eurostat data shows there were 18 million tertiary students in 2020 (ISCED levels 5-8). The country with the largest number of students is Germany with 3,3 million (18.2% of the EU total), followed by France (15.3% of the total), Spain (11,9%), and Italy (11,3%). Approximately 90% of students were studying for bachelor's degrees and master's degrees with higher shares reported for Croatia, Poland, Italy, Lithuania, and Bulgaria (about 97% of total tertiary students in those countries). Public higher education institutions dominate in higher education and the vast majority of students, almost 80%, attend public institutions.

Higher education plays a vital role in advancing sustainable development for millions of learners in Europe. This is achieved through fostering research, and education, implementing campus initiatives, and making curriculum changes that encompass environmental, social, and economic aspects (Leal Filho et al., 2023; Lozano et al., 2015; Tilbury, 2011). Higher education institutions carry the responsibility of tackling sustainability issues and actively promoting sustainable development. They achieve this by integrating sustainability into their curricula, encouraging sustainability research, and actively engaging with local communities. Many EU countries have well-developed education systems in terms of world rankings and SDGs attainment (Sachs et al., 2022), and as Hanushek and Woessmann state (2020, 238) they "rightfully highlighted the importance of improving education across the EU". However, little is known about the progress of non-EU countries. Since the financial crisis in 2008 and, more recently, due to the impact of the COVID-19 pandemic and the war in Ukraine, there has been a significant increase in the pressure related to funding and public spending on education. Many countries face challenges in maintaining their present levels of research and education or improving their current positions.

Given this rapid expansion of tertiary education and the strain on the higher education systems across the world, especially with the two recent major crises – COVID-19 and the war in Ukraine, it is important to examine and assess the efficiency of higher education in achieving Sustainable Development Goals. This is a relatively new area of analysis and only a few studies contribute to the field.

The goal of this research is to assess the efficiency of higher education in the realization of Sustainable Development Goals (SDGs) in 40 European countries. Non-EU member countries are also included thus contributing to knowledge about their role in achieving SDGs. The method used to assess technical efficiency is the Data Envelopment Analysis (DEA). Assessing technical efficiency will help us determine which countries use their resources most efficiently in the higher education sector.

It will also highlight less efficient countries and draw attention to ways they can achieve more progress. Research in this area is of increasing importance. If inputs are used inefficiently, they will fail to produce the desired educational outcomes and, consequential, may fail to promote economic growth. The estimation of the efficiency of higher education in achieving SDGs is an important step in obtaining relevant information about the functioning of European higher education systems, especially given the current emphasis on sustainability, accountability, and cost-effectiveness in higher education.

The paper is structured as follows. In the next section, the literature is reviewed, focusing on research papers on sustainability in European higher education with the application of Data Envelopment Analysis. This is followed by a description of the methodology, data, and model specifications, a presentation of the research findings with discussion, suggestions for future research, and a conclusion.

Literature Review

This section provides an overview of the literature on the analysis of efficiency in education. It briefly summarizes the earlier attempts, inputs, outputs, and other related variables, as well as the main findings in the field of efficiency in education.

Two main methods to analyze efficiency in education can be divided into parametric and non-parametric. Parametric methods are related to the economics of education literature and typically use education production functions. These studies examine how various inputs in the educational process (such as student characteristics, peer effects, financial resources, teacher quality, etc.) relate to educational outcomes (e.g. student achievement). One of the first studies examining the relationship between educational inputs and outcomes was the notable Coleman report (Coleman et al., 1966) which led to several analyses of educational production functions for all levels of schooling. Using statistical methods, mostly regression analysis, these studies have furnished direct evidence regarding the efficacy of diverse educational policies (Hanushek, 2020). Many of these studies reached a controversial conclusion that there is no systematic relationship between school resources and student achievement (Hanushek, 1989, 1991), but this has been reexamined (e.g. in Knoeppel et al., 2007; Verstegen and King, 1998). A recent analysis of education production function applications and their main results can be found in Hanushek (2020). Despite the reported mixed results, education production modeling serves as a valuable tool for informing policymakers and enhancing our knowledge of the education system.

In the efficiency of education literature, the most widely used non-parametric methods are the Free Disposable Hub (FDH) and the Data Envelopment Analysis (DEA). The FDH model was pioneered by Deprins et al. (1984) and DEA is a non-parametric technique based on linear programming and developed by Charnes et al. (1978). Linear programming methods assign an observation-specific set of weights to outputs and inputs in such a way that the ratio of weighted output to weighted input is maximized for each observation, subject to certain constraints. This approach amounts to constructing a piecewise linear surface over the data so that the actual input/output quantities are either on or in the interior of this frontier. The DEA can handle multiple inputs and multiple outputs and this makes it an appealing choice for measuring the efficiency of HEIs. A review of existing scientific works shows that DEA has been often used in the economics of education, especially to examine the efficiency of higher education institutions. Various outputs can be used in the context of efficiency assessment, e. g., Johnes (2006b) uses DEA to calculate teaching efficiency in the UK, while Johnes and Yu (2008) use it to examine the efficiency of research in Chinese HEIs. A more detailed analysis can be found in De Witte and López-Torres (2017). However, the use of DEA in higher education and the examination of efficiency in reaching one or more SDGs is more recent. In this area of research, the availability of data is limited, and thus only a few studies contribute to this field.

For example, Malešević Perović and Mihaljević Kosor (2020) examine the efficiency of European universities in achieving Sustainable Development Goals. Their research aimed to find which European universities are fully efficient and which ones should improve their use of existing resources. The research was conducted at the micro and macro level, i.e., at the level of 25 European countries, whereby public consumption in the tertiary sector was observed at the macroeconomic level, i.e., at the country-level, while at the microeconomic level, i.e., at the university-level the authors estimated the efficiency of available resources in achieving the best possible SDG. From a microeconomic point of view, the results showed that only 16% of countries are efficient, more precisely - most countries should strive to meet a greater number of Sustainable Development Goals.

In terms of efficiency research in HE, Wolszczak-Derlacz (2017) analyses the efficiency of universities in Europe and America using data bounding analysis and concludes that European universities are more efficient. For Europe, Wolszczak-Derlacz and Parteka (2011) investigated the efficiency of 259 European public tertiary institutions, with the results showing that the number of women on academic staff and greater resource financing increase efficiency. Since these authors did not use SDGs in their research, we will focus next on papers using DEA analysis in measuring the achievement of SDGs, albeit not in the higher education environment.

Grochova and Litzman (2021) focus on all SDGs and assess the efficiency of countries in approaching the SDGs. The authors also estimate whether the countries can fulfill their commitments by 2030, as required by the Agenda if continuing with their current strategies. They apply DEA to compute how individual countries are efficient relative to the targets and other countries in achieving all SDGs. They find that the best performers are Finland, Japan, and Iceland and only five countries in the world are on track to become relatively efficient by 2030.

Progress in achieving the SDGs is also investigated by Schmidt-Traub et al. (2017) who conclude that given the heterogeneous starting positions of 193 countries in the sample every country has its weaknesses in various goals and needs tailor-made improvements. Furthermore, many of the goals are interwoven (Blanc, 2015). Therefore, to foster the attainment of SDGs, the countries will have to prioritize and focus on the most important targets (also noted in van Zanten & van Tulder, 2020; Allen et al., 2019).

Methodology, Data, and Model Specifications

Methodology

Data Envelopment Analysis (DEA) is a non-parametric linear programming technique used for the estimation of the relative efficiency of decision-making units (DMUs). In just forty years, DEA became the central technique in a whole series of productivity and efficiency studies used when comparing organizations, enterprises, regions, and countries. The development of DEA can be traced to the 1978 model used by Charnes, Cooper, and Rhodes (CCR) and based on the original work of Farrel (1957). The CCR model is based on constant returns to scale. In more detail, in this model, a proportional increase or decrease in input quantities results in an equivalent proportional increase or decrease in output quantities. This means that the scale of production does not affect the efficiency score. The advantage of the CCR model lies in the simplicity of its formulation and interpretation due to its assumption of constant returns to scale. The CCR model can be input and output-oriented and the efficiency scores will be equal regardless of the selected orientation.

In the case of variable returns to scale the Banker, Charnes, and Cooper (BCC) model is used (Banker et al., 1984). The BCC model is applied for increasing or decreasing returns where a proportional change in input results in a more or less proportional change in output. This model allows for more flexibility in capturing the efficiency of various decision-making units (DMUs). An additional advantage is that it is more representative of real-world scenarios where different DMUs operate under different scales. Efficiency is calculated for DMUs that have variable returns to scale and the efficiency limit (envelope) is a convex curve.

In Data Envelopment Analysis, two additional approaches may be used: input-oriented and output-oriented. Both orientations aim to measure the efficiency of DMUs, but they highlight different aspects of the analysis. In the input-oriented approach, the aim is to assess the efficiency of a DMU in minimizing inputs while holding outputs constant. Relative to other DMUs, this approach considers how well a DMU uses its resources to produce a given level of output(s). In the output-oriented approach, the goal is to assess the efficiency of a DMU in maximizing output(s), holding the inputs at their actual levels. More specifically, this approach evaluates the efficiency of a DMU in using its inputs to achieve the highest level of output(s).

DEA is applied in education (all levels), banking, health economics, national defense, manufacturing, market research, and many other areas, which proves its importance and various possibilities for applications in the public and private sectors. The method assigns weights to inputs and outputs used in the analysis. The ratio of weighted inputs and outputs is maximized for each observation and the efficiency of each unit is the ratio of weighted outputs to inputs.

In the last two decades, DEA has been used in estimating technical efficiency in higher education. Given that the research on higher education often has several inputs and outputs, DEA combines them and gives coefficients of technical efficiency according to selected models. The efficiency of one observed unit is compared and ranked to all other decision-making units and their achieved efficiency in the analysis. The most efficient unit is the one that uses the least amount of input to produce the most output. The efficiency coefficient is determined in the range from 0 to 1 (or 0% to 100%), where 1 (or 100%)

represents the most efficient decision-making unit in the observed sample. Bougnol and Dula (2006) highlight that DEA analysis serves as a suitable tool for assessing efficiency in higher education. DEA can successfully handle various challenges associated with calculating technical efficiency in a framework with multiple input-output elements, as commonly found in higher education (Greene, 1980). Moreover, the DEA model, extended by Banker et al.(1984), is especially adequate to evaluate the efficiency of non-profit entities that operate outside the market. A more detailed analysis of the concepts of efficiency in education and, more specifically higher education, can be found in Mihaljević Kosor (2013). For more theoretical details on DEA see Coelli et al. (1998) and Cooper et al. (2006), and on its application in education see Johnes (2006).

In a survey of DEA-related journal articles from the last 40 years, Emrouznejad and Yang (2018) found over 10,000 DEA-related journal articles published until 2016. This number does not include conference proceedings, working papers, or book chapters. A more detailed analysis of recent developments and challenges in DEA analysis can be found in Emrouznejad et al. (2022).

According to the brief on measuring SDGs progress with Data Envelopment Analysis (DEA), Thore et al. (2014) find that the DEA scores surpass the standard measures of economic, social, and environmental performance and can serve as the basis for broad-ranging sets of policy advice for regional, industry, and global programs.

Data

In the empirical part of our research, DEA is used to calculate the efficiency of higher education in achieving SDG 4 in 40 European countries. As noted, within Sustainable Development Goals, SDG 4 (Quality Education) aims to education policies that are critically important within the international development agenda. Furthermore, in a study of global SDGs-related research trends Salvia et al. (2019) found that SDG 4 (Quality Education) is one of the top SDGs investigated. Their finding also extends to Europe. The key element of SDG 4 is to "ensure inclusive and equitable quality education and promote life-long learning opportunities for all" (OECD, 2019). This goal is widely defined and includes lifelong learning, equity, and curriculum content to promote a sustainable future. Moreover, given the focus of this research on higher education, the Sustainable Development Target 4.7 is more relevant. This Target states that by 2030 "all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and culture's contribution to sustainable development" (OECD, 2019). The main challenge in monitoring the wide range of SDG 4 targets is related to data availability. There are continuous international efforts underway to identify suitable data sources and methodologies to monitor Target 4.7. However, data on Target 4.7 are not yet available. Although SDG 4 is not strictly related to higher education, due to data limitations it was not possible to use a more precise measure.

The list of European countries was based on the United Nations official statistics (retrieved in November 2022 from the website of the United Nations Human Rights Office of the High Commissioner). Most of the previous research on higher education in this area focuses mostly on the EU member countries. In our research, the number of countries is expanded to include the EU non-member countries. The rationale for this sample is that the EU non-member countries share similar culture, heritage, and educational structure as the EU member countries, therefore including them in the sample will provide more information about their efficiency in achieving SDGs and contribute to knowledge in this area of research. Not all European countries are included in the final sample due to data considerations (e.g., Andorra, Liechtenstein, Monaco, San Marino).

Model specifications

Several model specifications were estimated. Three inputs and two outputs were considered. The inputs examined in the analysis are the *total number of students enrolled in tertiary education, government expenditure per student in tertiary education, and current education expenditure*. The outputs are the SDG 4 score and the overall SDG score. The focus is on higher education, represented in data as tertiary education and corresponding to International Standard Classification of Education (ISCED) levels 5-8. Tertiary education includes short-cycle tertiary education, Bachelor's or equivalent level, master's or equivalent level, and doctoral or equivalent level.

In the final model, this paper uses two inputs and one output in the evaluation of technical efficiency. These are presented in Table 1. The inputs used in the final model are the *total number of students enrolled in tertiary education and government expenditure per student in tertiary education*. The output is the SDG 4 score of the European country in the Sustainable Development Goals (reported by Sachs et al., 2022). The data on output is from the Sustainable Development Report (Sachs et al., 2022). For all input variables, the latest available data was used. However, the latest data for the variable government expenditure per student in tertiary education is for 2020. It may be assumed that government expenditures do not change significantly from year to year, given the nature of this variable and the consistency of government financing. Hence, this variable can still adequately represent the financial and funding aspects of higher education in a country.

Results and Discussion

Summary statistics for the variables used in this research are presented in Table 2.

Three variables are selected in the final model representing 40 European countries (Table 2). The average number of students in European countries is just above 700,000, varying from the smallest education system in Luxemburg to the largest in the Russian Federation. Government expenditures per student are largest in Malta (44.4%), and smallest in Greece (11.2%). The average SDG4 score is relatively high and equal to 93.69. The lowest SDG4 score in the dataset is in Bosnia (64.1), followed by Bulgaria (68.5).

Previous research in this area uses the BCC model (Banker, Charnes & Cooper, 1984) which is based on variable returns. This approach allows for constant, increasing, and decreasing returns to scale. When measuring efficiency in this model, the final calculation provides a comparison of European countries, i.e., our decision-making units, where the efficiency limit is a convex curve (due to variable returns). As previously stated, the advantage of the BCC model is its flexibility and more realistic representation of DMUs operating at different scales. As argued by Agasisti (2011), the assumption of constant returns to scale is restrictive, because the number of students, amounts of resources, etc., may considerably affect the calculation of efficiency. Another important factor in DEA is model orientation. There are two distinct options available, input and output orientation. Input-oriented models are used in analyses focused on minimizing input(s) to attain a desired level of output(s). In a similar vein, output-oriented models are focused on maximizing output(s) given the input(s). Therefore, an additional specification in this research is output orientation, i.e., it shows how much it is possible to increase output (SDG 4) with current inputs (government expenditure per tertiary education student and the total number of students in tertiary education – ISCED levels 5-8). This is a frequent assumption when analyzing HE efficiency (e.g., in Agasisti and Dal Bianco, 2009; Johnes 2006b). Data Envelopment Analysis is performed in Stata. The higher education sector offers a highly suitable context for evaluating technical efficiency due to the non-profit nature of its institutions, multiple inputs and outputs, and the absence of clear output and input pricing mechanisms.

The coefficient of technical efficiency is determined in the range from 0 to 1, where 1 represents the most efficient country, i.e., decision-making unit, in the observed research. These results are presented in Table 3.

Table 1

List of variables

	Variable name	Definition	Source
Input	Total number of students	Students enrolled in tertiary education (number), last year available	Eurostat, 2021
Input	Government expenditure per student	Government expenditure per student, tertiary (% of GDP per capita)	UNESCO (uis.unesco.org), Data as of February 2020
Output	SDG4 score	Score for ensuring inclusive and equitable quality education and promoting life-long learning opportunities for all (worst 0-100 best)	Online database for the Sustainable Development Report 2022, Sachs et al. (2022)

Table 2

Summary statistics for variables used in the final estimation

Variable	Obs	Mean	Std. Dev.	Min	Max
Total number of students	40	703 270.9	1010609	7444	4200000
Government expenditure per student	40	28.13	8.72	11.2	44.4
SDG4 score	40	93.69	8.44	64.1	99.9

The average technical efficiency of the countries in the sample is relatively high and equal to 0.94. Nine countries emerge as fully efficient with a coefficient equal to 1 in achieving SDG 4 (Quality Education) – these are Albania, Cyprus, Greece, Iceland, Ireland, Latvia, Lithuania, Luxemburg, and Sweden. The worst performing countries are Bosnia and Herzegovina (rank 40) an efficiency coefficient equal to 0.65, followed by Bulgaria (efficiency score 0.69 and rank 39) and North Macedonia (efficiency score 0.77 and rank 38). Bulgaria and Bosnia are also the countries with the smallest SDG4 score so this result is in line with expectations. In the investigation of the scientific impact of HE lecturers in seven Central Eastern European countries (Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, Serbia, and Slovenia), Sajter (2021) found significant differences among countries and their HEIs, with Slovenian and Croatian HEIs having the highest ranks. That situation in the HE systems in CEE countries can be, to some extent, linked to the findings in this research. The worst-performing countries in Table 3 are followed by Ukraine, Slovak Republic, and Romania, which have a score between 0.80-0.84.

Six of the largest European higher education systems with over 17 million students account for 60% of students in the sample. These are Russian, German, French, British, Spanish, and Italian HE systems. They all achieve high-efficiency scores of 0.94 or higher. The results of the Pearson correlation indicate that there is a significant large positive relationship between the SDG 4 score and the achieved technical efficiency result. This would be in line with expectations as the high SDG 4 score indicates that a country is successful in ensuring inclusive and equitable education and promoting learning opportunities for all. There is a non-significant small positive relationship between government expenditure per student and efficiency score.

The results in Table 3 suggest that in terms of achieving SDG 4, most of the European countries are achieving high efficiency. There is room for improvement in the six worst-performing countries, where Bosnia, Bulgaria, and North Macedonia need to make the largest effort. More research in these countries is necessary to examine the sources of inefficiency.

Table 3

Technical efficiency results and ranks

Country	Technical Efficiency Score	Rank
Albania	1	1
Austria	0.98323	16
Belarus	0.97988	19
Belgium	0.94532	29
Bosnia and Herzegovina	0.64947	40
Bulgaria	0.68656	39
Croatia	0.97422	23
Cyprus	1	1
Czech Republic	0.92469	33
Denmark	0.97864	20
Estonia	0.96661	26
Finland	0.9827	17
France	0.99842	11
Germany	0.97431	22
Greece	1	1
Hungary	0.92164	34
Iceland	1	1
Ireland	1	1
Italy	0.94259	31
Latvia	1	1
Lithuania	1	8

Country	Technical Efficiency Score	Rank
Luxembourg	1	1
Malta	0.98977	13
Moldova	0.99952	10
Montenegro	0.92583	32
Netherlands	0.98425	15
North Macedonia	0.77074	38
Norway	0.9777	21
Poland	0.98963	14
Portugal	0.95151	28
Romania	0.83535	35
Russian Federation	0.9728	24
Serbia	0.94387	30
Slovak Republic	0.8341	36
Slovenia	0.96781	25
Spain	0.9577	27
Sweden	1	9
Switzerland	0.98159	18
Ukraine	0.80306	37
United Kingdom	0.99318	12

Source: Own research

Table 4
Technical efficiency results and ranks with SDG index score as output variable

Country	Technical Efficiency Score	Rank
Albania	1	40
Austria	0.951445	39
Belarus	0.884822	38
Belgium	0.927131	38
Bosnia and Herzegovina	0.884822	37
Bulgaria	0.917782	36
Croatia	0.951522	35
Cyprus	0.921935	34
Czech Republic	0.979163	33
Denmark	0.989595	32
Estonia	1	31
Finland	1	30
France	0.946663	29
Germany	0.951329	28
Greece	1	26
Hungary	0.942489	25
Iceland	1	24
Ireland	1	23
Italy	0.938018	22
Latvia	1	21
Lithuania	0.935855	20
Luxembourg	1	19
Malta	0.972052	18
Moldova	0.899525	17
Montenegro	0.861322	16
Netherlands	0.923699	15
North Macedonia	0.901288	14
Norway	0.951932	13
Poland	0.960384	12
Portugal	0.939574	11
Romania	0.924545	10
Russian Federation	0.903048	9
Serbia	0.893609	1
Slovak Republic	0.95434	1
Slovenia	0.989937	1
Spain	0.966308	1
Sweden	0.984971	1
Switzerland	0.934104	1
Ukraine	0.872832	1
United Kingdom	0.931792	1

Source: Own research

Different model specifications were also used to check the robustness of results and these are in the Appendix. Briefly, when the overall SDG index score is used as the output variable (Table 4), some of the results slightly change. Estonia and Finland join the best-performing countries while Sweden achieves a score of 0.985 instead of its previous score equal to 1. Montenegro and Belarus join the worst-performing countries. The average technical efficiency of the countries in the sample remains relatively high and equal to 0.94 (as previously).

Future Research Directions

The database for the Sustainable Development Report (Sachs et al., 2022) used in this research only recently became available. It represents overall SDG results for all countries in the world, including index score, goal dashboard, and trend dashboard for all indicators and goals. The database has also led to the choice of variables used in this investigation. While it would have been useful to have the 2021 data for government expenditures for tertiary students (input variable), that data was not available for this estimation of technical efficiency. When new data becomes available, it would be useful to examine whether there are differences in efficiency scores. During the second quarter of 2020, a period still overshadowed by COVID-19 containment measures across the majority of Member States, Eurostat, released a preliminary estimate indicating a decline in seasonally adjusted GDP. The Euro area experienced a decrease of 12.1%, while the EU observed a reduction of 11.9% in GDP compared to the previous quarter. In light of these circumstances, numerous European universities will encounter fluctuations in their funding, in both the short and long run. The impact of the COVID-19 pandemic on higher education systems throughout Europe will vary, depending on the salient features of each country's HE system. Most European higher education systems rely on public funding. It may be argued that the variable on government expenditures per student does not change considerably on an annual level to influence the results. In the research by Estermann et al. (2020) of the aftermath of the 2008 financial crisis only a limited number of HE systems, including Iceland, the Baltic States, and Greece, implemented significant reductions in public funding. This leads authors to conclude that it is likely a comparable scenario will unfold after the pandemic, affecting systems to varying degrees and at different times.

Within SDG 4 ("ensure inclusive and equitable quality education and promote life-long learning opportunities for all"), Target 4.7 is the most interesting. However, due to data limitations and the lack of good indicators, it is difficult to assess more precisely the contribution of higher education.

In terms of the worst-performing countries identified in this research, more analysis is necessary to inform education policy-makers. Possible extensions of research for those countries may include a more detailed efficiency analysis of their education system, even at the level of individual higher education institutions, if data is available.

When more data becomes available, this research could also be expanded by examining the results for the selected European countries using their sub-regions (as classified by the UN). This would allow for better comparison of neighboring countries that often have similar educational traditions.

Finally, due to data limitations, this research could not directly examine the effect of the COVID-19 pandemic on the chosen sample of countries. During the pandemic, the worldwide closures of educational institutions have affected about 70% of the student population (UNESCO, 2020). At the same time, distant learning technology is speculated to have a positive impact on SDG 4 shortly. In terms of SDG 4, the cost of attaining this goal has been increasing before the pandemic, and now, due to the disruptions brought on by the pandemic, it has escalated further (UNESCO Digital Library, 2020). The estimates until the year 2030 narrow this cost to approximately US$335 billion. These funds are required to address various education sector challenges such are re-enrolment efforts, infrastructural needs, and second chance programs. When additional data becomes available, it would be interesting to calculate new technical efficiency scores for European countries and compare them to the ones in this research.

Conclusion

Higher education assists in the implementation of various SDGs, especially the ones with social and economic components (in Leal Filho et al., 2023) such as SDG1 (no poverty), SDG2 (zero hunger), SDG3 (health), SDG5 (gender equality), SDG7 (energy), SDG8 (decent work), SDG9 (industry and innovation), SDG 11 (sustainable cities), SDG12 (responsible consumption). To some extent, HE also plays a role in SDG 13 (climate change) and SDG 16 (peace and justice). Fonseca et al. (2020) find the existence of strong positive correlations between SDG 4 (Quality education) and several other SDGs. This suggests the need for equitable education that can foster the implementation of SDGs.

The goal of this research was to examine and calculate technical efficiency in achieving Sustainable Development Goals from the higher education perspective. For that purpose, overall, 2022 SDG index score and SDG 4 score were used. If inputs are used inefficiently, they will fail to improve educational outcomes and, consequentially, an economy may stagnate. This is an important issue, especially for the non-EU member countries examined in this research.

Only a few studies contributed to this field of research, as presented in the literature review, and there is a need for more research in this area. This particularly relates to the situation in non-EU countries, which are rarely examined in this context. There is less than a decade left to achieve the Sustainable Development Goals and higher education institutions should more than ever take part in fostering sustainable development. This involves promoting sustainability through education, conducting relevant research, actively engaging with local communities, and integrating sustainability principles into their fundamental operations. More data, examples from the practice, and research are necessary.

In the final model, the inputs used in this research are the total number of students enrolled in tertiary education and government expenditure per student in tertiary education. The output is the SDG 4 score. For the 40 European countries used in this research, the results suggest that the technical efficiency in attaining SDG 4 (Quality Education) is high (average 0.94). For a small number of countries, there is still a need for improvement. The four largest higher education systems (Russian, French, German, and British) achieved above-average efficiency scores higher than 0.97. Different model specifications were also used to check the robustness of technical efficiency scores. As previously stated, SDG 4 is not strictly related to higher education. However, due to data limitations, it was not possible to use a more precise measure. Given these data limitations and relative efficiency scores being calculated by DEA, the results should be interpreted with caution.

DEA only provides relative efficiency scores and it is a non-stochastic method hence statistical inference cannot be used to examine possible bias.

Generally, this research found that there is a pressing need for more examination of the implementation of sustainable development and achievement of SDGs and, in particular, the investigation of the role of higher education within it.

References

Agasisti, T., & Dal Bianco, A. (2009). Reforming the university sector: Effects on teaching efficiency. Evidence from Italy. *Higher Education, 57*(4), 477-498. Retrieved from https://ssrn.com/abstract=942733

Agasisti, T., & Dal Bianco, A. (2009). Reforming the university sector: Effects on teaching efficiency. Evidence from Italy. *Higher Education, 57*(4), 477-498.

Aghion, P., & Howitt, P. (2009). *The Economics of Growth*. Cambridge, MA: MIT Press.

ICSD (2022). *Lecture Notes in Networks and Systems, 529*. Springer, Cham. DOI: 10.1007/978-3-031-17767-5_5

Allen C., Metternicht G., & Wiedmann, T. (2019). Prioritizing SDG targets: assessing baselines, gaps, and interlinkages. *Sustainability Science, 14*(2), 421–438. DOI: 10.1007/s11625-018-0596-8.

Bali, S., & Yang-Wallentin, F. (2020). Achieving sustainable development goals: predicaments and strategies, *International Journal of Sustainable Development & World Ecology, 27*(2), 96-106. DOI:10.1080/13504509.2019.1692316

Banker, R.D., Charnes, A., & Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9), 1078–1092. DOI: 10.1287/mnsc.30.9.1078

Blanc, D.L. (2015). Towards integration at last? The sustainable development goals as a network of targets. Sustainable Development, 23(3), 176–187. DOI: 10.1002/sd.1582.

Chankseliani, M., & McCowan, T. (2021). Higher education and the sustainable development goals. *Higher Education, 81*(1), 1–8. DOI: 10.1007/s10734-020-00652-w.

Coleman, J.S., Campbell, E.Q., Hobson, C.J., McPartland, F., Mood, A.M., Weinfeld, G.D., & York. R.L. (1966). *Equality of Educational Opportunity*. Washington, DC: U.S. Government Printing Office.

Deprins, D., L. Simar, & Tulkens, H. (1984). Measuring labor efficiency in post offices. In Marchand M., Pestieau P. and Tulkens H. (Eds), *The Performance of Public Enterprises: Concepts and Measurement* (pp. 243-267). Amsterdam: Elsevier.

De Witte, K., & López-Torres, L. (2017). Efficiency in education: A review of the literature and a way forward. *Journal of the Operational Research Society, 68*(4), 339-363. DOI: 10.1057/jors.2015.92

Emrouznejad, A., & Yang, G. (2018). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978 – 2016, *Socio-Economic Planning Sciences, 61*, 4-8. DOI: 10.1016/j.seps.2017.01.008

Emrouznejad, A., Yang, G. L., Khoveyni, M., & Michali, M. (2022). Data Envelopment Analysis: Recent Developments and Challenges. In Salhi, S., Boylan, J. (Eds.) *The Palgrave Handbook of Operations Research* (pp. 307-350). Palgrave Macmillan, Cham.

Estermann, T., Pruvot, E. B., Kupriyanova, V., & Stoyanova, H. (2020). *The Impact of the Covid-19 Crisis on University Funding in Europe: Lessons Learnt from the 2008 Global Financial Crisis*. European University Association. Retrieved from https://eua.eu/downloads/publications/eua%20briefing_the%20impact%20of%20the%20covid-19%20crisis%20on%20university%20funding%20in%20europe.pdf

Eurostat (2021). *Tertiary education statistics*. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tertiary_education_statistics#Participation_by_level

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society, 120*, 253-290.

Grochová, L., & Litzman, M. (2021). The efficiency in meeting measurable sustainable development goals, *International Journal of Sustainable Development & World Ecology, 28*(8), 709-719. DOI: 10.1080/13504509.2021.1882606

Greene, W. H. (1980). On the estimation of a flexible frontier production model, *Journal of Econometrics, 13*, 101-115.

Hallinger, P., & Chatpinyakoop, C. (2019). A bibliometric review of research on higher education for sustainable development, 1998–2018. *Sustainability, 11*(8), 2401. DOI: 10.3390/su11082401.

Hanushek, E. A. (1989). The Impact of Differential Expenditures on School Performance. *Educational Researcher, 18*(4), 45–62.

Hanushek, E. A. (1991). When School Finance 'Reform' May Not Be Good Policy. *Harvard Journal on Legislation, 28*(2), 423-456.

Hanushek, E. A., & Woessmann, L. (2020). A quantitative look at the economic impact of the European Union's educational goals. *Education Economics, 28*(3), 225-244. DOI: 10.1080/09645292.2020.1719980

Johnes, J. (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review, 25*(3), 273-288. DOI: 10.1016/j.econedurev.2005.02.005

Johnes, J. (2006b): Measuring Teaching Efficiency in Higher Education: An Application of Dana Envelopment Analysis to Economics Graduates from UK Universities 1993, *European Journal of Operational Research, 174*(1), 443-456. DOI:10.1016/j.ejor.2005.02.044

Johnes, J., & Yu, L. (2008): Measuring the Research Performance of Chinese Higher Education Institutions Using Data Envelopment Analysis, *China Economic Review, 19*(4), 679-696. DOI:10.1016/j.chieco.2008.08.004

Knoeppel, R. C., Verstegen, D. A., & Rinehart, J. S. (2007). What Is the Relationship Between Resources and Student Achievement? A Canonical Analysis. *Journal of Education Finance, 33*(2), 183–202. Retrieved from https://www.jstor.org/stable/pdf/40704323.pdf?casa_token=8TDHIr9IE1MAAAAA:0tx5LfmM8RtvBSk8ooM1j4Ls1m46gdLavtk3RAdgKRndF4decN85dYyvvqkyPrZ7DLkaVN-lZ-9Z7I4A0RQxdZyTHOBbW32dB6KylzT68iDeUJXorVxTM

Leal Filho, W., Salvia, A. L., & Pires Eustachio, J. H. (2023). An overview of the engagement of higher education institutions in the imple¬mentation of the UN Sustainable Development Goals. *Journal of Cleaner Production, 386*(16), 135694. DOI: 10.1016/j.jclepro.2022.135694.

Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F. J., Waas, T., Lambrechts, W., Lukman, R., & Hugé, J. (2015). A review of commitment and implementation of sustainable development in higher education: Results from a worldwide survey. *Journal of Cleaner Production, 108*, 1–18. DOI: 10.1016/j.jclepro.2014.09.048

Malešević Perović, L., & Mihaljević Kosor, M. (2020). The efficiency of universities in achieving Sustainable Development Goals. *Amfiteatru Economic, 22*(54), 516-532. Retrieved from https://ideas.repec.org/a/aes/amfeco/v22y2020i54p516.html

Mihaljević Kosor M. (2013). Efficiency measurement in higher education: Concepts, methods, and perspective. *Procedia - Social and Behavioral Sciences, 106*, 1031- 1038. DOI: 10.1016/j.sbspro.2013.12.117

OECD (2019). Why does the Sustainable Development Goal on Education (SDG 4) matter for OECD countries? *Education Indicators in Focus*, No. 67, OECD Publishing, Paris. DOI: 10.1787/cdc2482b-en.

OECD (2022). *Education at a Glance 2022: OECD Indicators*. Paris: OECD Publishing.

Sachs, J., Lafortune, G., Kroll, C., Fuller, G., & Woelm, F. (2022). *From Crisis to Sustainable Development: The SDGs as Roadmap to 2030 and Beyond. Sustainable Development Report 2022*. Cambridge: Cambridge University Press.

Salvia, A. L., Leal Filho, W., Brandli, L. L., & Griebeler, J. S. (2019). Assessing research trends related to Sustainable Development Goals: Local and global issues. *Journal of Cleaner Production, 208*, 841-849. DOI: 10.1016/j.jclepro.2018.09.242.

Sajter, D. (2021). Scientific Impact of Central and Eastern European Higher Education Lecturers. *Naše gospodarstvo/Our Economy, 67*(3), 17-28. DOI: 10.2478/ngoe-2021-0014.

Schmidt-Traub, G., Kroll, C., Teksoz, K., Durand-Delacre, D., & Sachs, J.D. (2017). National baselines for the sustainable development goals are assessed in the SDG index and dashboards. *Nature Geoscience, 10*(8), 547–555. DOI: doi:10.1038/ngeo2985.

SDSN. (2020). *Accelerating Education for the SDGs in Universities: A Guide for Universities, Colleges, and Tertiary and Higher Education Institutions*. Retrieved from https://resources.unsdsn.org/accelerating-education-for-the-sdgs-in-universities-a-guide-for-universities-colleges-and-tertiary-and-higher-education-institutions

Tilbury, D. (2011). *Higher education for sustainability: A global overview of commitment and progress. Higher Education's Commitment to Sustainability: From Understanding to Action*. 18-28. Retrieved from https://www.guninetwork.org/files/8_i.2_he_for_sustainability_-_tilbury.pdf

Thore, S., Golany, B., Tarverdyan, R., Adler, N. & Yazhemsky, E. (2014). *Measuring the SDGs' Progress with DEA*. Brief for GSDR 2015. Retrieved from https://sustainabledevelopment.un.org/content/documents/6729140-Thore-Measuring%20the%20SDGs%20Progress%20with%20DEA.pdf)

UNESCO (2020). COVID-19 *Educational Disruption and Response*. Retrieved from https://en.unesco.org/covid19/educationresponse

UNESCO Institute for Statistics (2022). *Data for the Sustainable Development Goals*. Retrieved from uis.unesco.org.

United Nations (2021). *The Sustainable Development Goals Report 2021*. Retrieved from https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf.

van Zanten, J. A., & van Tulder, R. (2020). Towards nexus-based governance: defining interactions between economic activities and Sustainable Development Goals (SDGs). *International Journal of Sustainable Development & World Ecology. 28*(3), 210-226. DOI: 10.1080/13504509.2020.1768452.

Verstegen, D. A., & King, R. A. (1998). The Relationship Between School Spending and Student Achievement: A Review and Analysis of 35 Years of Production Function Research. *Journal of Education Finance, 24*, 241-262.

Wolszczak-Derlacz, J. (2017). An evaluation and explanation of (in)efficiency in higher education institutions in Europe and the U.S. with the application of two-stage semi-parametric DEA, *Research Policy, 46*(9), 1595-1605. DOI: 10.1016/j.respol.2017.07.010

Wolszczak-Derlacz, J., & Parteka, A. (2011) Efficiency of European public higher education institutions: a two-stage multicountry approach, *Scientometrics, 89*(3), 887-917. DOI: 10.1007/s11192-011-0484-9

World Bank (2022). *World Bank development indicators*. Retrieved from https://data.worldbank.org/indicator/.

Zotti, R., & Barra, C. (2014). Human capital development, knowledge spillovers, and local growth: Is there a quality effect of university efficiency? *MPRA Paper*, No. 60065. University Library of Munich, Germany.

Cilji trajnostnega razvoja in visoko šolstvo: analiza učinkovitosti

Izvleček

Visokošolsko izobraževanje (VŠ) je pomemben dejavnik ekonomske blaginje države in ima ključno vlogo pri reševanju vprašanj trajnosti in dejavnem spodbujanju trajnostnega razvoja. Medtem ko imajo številne države članice EU dobro razvite izobraževalne sisteme v smislu uvrstitev in doseganja ciljev trajnostnega razvoja, je o napredku drugih evropskih držav znanega malo. Cilj te raziskave je oceniti učinkovitost visokega šolstva pri doseganju ciljev trajnostnega razvoja v 40 evropskih državah. Metoda, uporabljena za oceno učinkovitosti, je analiza ovojnice podatkov (DEA) z izhodno usmerjenostjo in pristopom variabilnih donosov obsega. V končni specifikaciji modela sta uporabljeni dve vhodni spremenljivki in ena izhodna spremenljivka. Rezultati kažejo, da je povprečna tehnična učinkovitost 40 evropskih držav razmeroma visoka in znaša 0,94. Devet držav je popolnoma učinkovitih pri doseganju četrtega cilja trajnostnega razvoja s koeficientom, ki je enak 1. Štirje največji visokošolski sistemi so dosegli nadpovprečno stopnjo učinkovitosti, ki znaša 0,97 ali več. Šest držav je prepoznanih kot najmanj učinkovitih. Vendar je treba opraviti več analiz, da bi preučili vire neučinkovitosti v državah z najslabšimi rezultati. Zaradi specifičnih podatkovnih omejitev, navedenih v tej raziskavi, ostaja izziv oceniti natančen učinek visokega šolstva in njegov prispevek k ciljem trajnostnega razvoja.

Ključne besede: cilji trajnostnega razvoja (SDGs), visokošolsko izobraževanje, analiza ovojnice podatkov (DEA), SDG 4, evropske države