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How Does Ukraine Deal with the Efficiency of Public Spending on Education Compared to European Union Countries?

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Abstract:

Purpose: *Every human has a right to education. The states are required to provide educational services to every citizen, as it is an essential tool for creating and enhancing the knowledge and skills of a given society. The aim of this study is to investigate how Ukraine deals with the efficiency of public spending on education, as compared to the other EU countries.*

Design/Methodology/Approach: *As a quantitative tool, a non-parametric Data Envelopment Analysis (DEA) has been applied. The DEA evaluates the technical efficiency and aims at estimating the relationship between the inputs and outputs of homogeneous objects. It is a powerful, non-parametric method for evaluating the relative efficiency when there are multiple inputs and outputs. The variant of the super-efficiency and non-oriented, slack-based DEA model, under the assumption of variable returns to scale has been used in this study.*

Findings: *The DEA computations showed that Ukraine fared very well, as compared to 22 EU countries, taking second place in the DEA super efficiency ranking ($\delta = 1.18$). This result confirmed that in terms of the technical efficiency of public spending on education, Ukraine was doing much better than many EU member states. It does not mean that the Ukrainian education system should be considered a model one, but only that with relatively low expenditure on education, Ukraine achieves above-average results.*

Practical Implications: *The results of the study help to identify areas of state activity in which Ukraine meets the standards of the European Union countries and justify the need to introduce appropriate aid to support Ukraine in its pursuit of the EU membership.*

Originality/Value: *The study complements the existing knowledge in the literature with evidence-based discussion on the opportunities and threats of Ukraine joining the EU.*

Keywords: *Education system, efficiency, DEA, EU countries.*

JEL Classification: *H43, H52, I22.*

Paper Type: *Research article.*

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1. Introduction

Few things in life are more important than having an education. Education is considered to be a human right and plays a crucial role in human, social, and economic development. Education promotes gender equality, promotes peace, and increases a person's chances of having more opportunities in life. There is no doubt that for many countries, the modern educational system is one of the key paths that can lead to reduction of the gap in civilization, in relation to the most developed economies (for more on the economic and social impact of education see Wößmannand and Schütz, 2006; Schuller *et al.,* 2004).

The states are required to provide educational services, which are the essential tools for creating knowledge and skills to a given society. Education is the essential component of human resource, which is the most important factor in determining a country's future development and welfare. Although there are many sources that analyze and evaluate the performance of education systems around the world there is no definitive list of countries that offer the best ones — it all depends on the criteria adopted for evaluation[2].

This study is focused on comparing the efficiency of education systems on a cross-country level. The EU member states and Ukraine, as a country aspiring to gain membership, have been taken into account.

Ukraine deserves special attention, because after 30 years of independence, on the way to European integration, it seems to be the biggest loser among all post-communist countries. After the collapse of the Soviet Union, Ukraine, like other post-Soviet countries, needs a major economic transformation.

Unfortunately, compared to other countries in Eastern Europe, Ukraine has faced difficulties in building a new independent and democratic state. Many of these difficulties still exist and decrease the vision of Ukraine's membership in the EU, despite the declaration that we can read on an official website of the European Commission (Facts and Figures about EU-Ukraine Relations), which states that Ukraine is a priority partner in the European Union, and the EU supports Ukraine in

[2]*For example a prestigious Best Countries for Education ranking provided by U.S. News & World Report (which assesses national education systems on a perception-based global survey, and uses a compilation of scores from three equally weighted country attributes: having a well-developed public education system, whether people would consider attending university there and if that country provides a top quality education) placed the USA on the top of the ranking (No. 1), both in 2020 and 2021. At the same time as reported by Library Journal (Rea, 2020), according to the National Center for Educational Statistics, 21 percent of adults in the United States (about 43 million) fall into the illiterate/functionally illiterate category. Nearly two-thirds of fourth graders read below grade level, and the same number graduate from high school, still reading below grade level.*

ensuring a stable, prosperous, and democratic future for its citizens and is unwavering in its support for Ukraine's independence, territorial integrity, and sovereignty.

Unfortunately, the reality does not seem to be optimistic, because after three decades Ukraine still needs reforms including the fight against corruption, reform of the judiciary, constitutional and electoral reforms, improvement of the business climate and energy efficiency, as well as reform of public administration and decentralization. For mismatched expectations, which are straining the EU-Ukraine relations, see Gherasimov and Litra (2020).

This difficult geopolitical and economic situation of Ukraine in its efforts to join the EU, was a reason to look at its achievements in building its human resource, a key factor in the economic growth and development of a mature democratic state. As a research area, "The assessment of the Ukrainian education system compared to those present in the EU member states," has been chosen. Precisely speaking, the aim of this study is to investigate how Ukraine deals with the efficiency of public spending on education compared to that in the EU countries.

The statistics commonly used for describing educational systems show that Ukraine does not differ significantly from the prevailing pattern of financing education in the EU countries. Here are some frequently used indicators:

- In the EU countries, education is financed mainly from public funds. According to *Education at a Glance* (OECD, 2020), public funds cover from 80% (the Netherlands) up to 98% (Denmark) of the total expenditure on education in the EU member states. The exception was the United Kingdom (which left the EU in 2020), where the share of public sources in financing education was much lower, that is, around 66%. In the case of Ukraine, this indicator amounts to approximately 83% (Stadny, 2015).
- As the World Bank reports, the EU countries allocate approximately 8%-16% of their total general government expenses to education. In this respect, Ukraine is close to the EU average (12%) and apportions 13% of its public funds to education.
- In relation to the GDP, public expenditure on education reaches the lowest share in Romania (3%) and the highest in Denmark (8%). Public funds allocated to education by Ukraine account for about 6% of the GDP, which is slightly above the EU average (5%).

Does the above picture of the Ukrainian education system (which does not differ from the EU "average") confirmed in terms of efficiency? In other words, how successfully does Ukraine, compare to the economies of the EU in transforming a given amount of public expenditure into specific educational outputs. This is the research question of this study.

In order to estimate the efficiency, the DEA approach will be applied. This quantitative tool, the so-called "super efficient" variant, will rank the examined samples of the countries by DEA scores, as well as deliver the projections of input–output measures, which will been identified as sources of inefficiency or over-efficiency.

The study is organized as follows: Section two describes a conceptual framework for assessing the efficiency of public expenditure on education in the chosen sample of countries. Section three presents a brief outline of the DEA methodology. Section four shows the statistical description of the input–output indicators used for the DEA calculations. Section five focuses on the results of the DEA-efficiency scores, and Section six delivers the concluding remarks.

2. Empirical Framework

Education is a complex process — it is one of the assimilations of scientific knowledge, its use, and proliferation. The effects of an education system on society have very specific characteristics, which are visible for a long period and are realized through different levels of education. This is why it is very complicated to measure and evaluate the level of knowledge and skills of a given society, and even more difficult to link them to specific expenses (Kozuń-Cieślak, 2013).

A massive amount of literature has been devoted to the subject of education systems functioning all over the world. From the perspective of this article's topic, particular attention has been paid to publications in which researchers investigate the efficiency of educational systems on a cross-country level. It is particularly interesting to see how researchers express the input and output measures. Many interesting approaches can be found in Afonso and Aubyn (2005), Sutherland *et al.* (2007), Gimenez *et al.* (2007), Eugene (2010), Mihaiu-Cindea (2010), Agasisti (2011), and Aristovnik (2011). The literature review confirms that the "production of education" is a very complex issue and there are no universal or comprehensive set of input and output indicators.

These studies also show that the issue of efficiency of education systems attracts researchers from all over the world and still leaves space for further investigations aimed at cross-country comparisons.

This study examines the achievements of the Ukrainian Education System in comparison to those occurring in the 22 member states of the European Union, that is, Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, and Sweden.

Due to the lack of data, five countries have been removed from the analysis (Belgium, Croatia, France, Greece, and the Netherlands). Moreover the United

Kingdom has been omitted because of two reasons. First, the education system in the UK differs from other EU countries and shows a relatively low share of public expenditure on education in the total educational expenses, and second, the UK is no longer a member of the EU.

The study covers a ten-year period, from 2010-2019, however, not all indicators used in the study are available as a complete time series. The following Table 1 provides a list of input–output variables used for the DEA efficiency estimation, including details about the data sources and scope.

Table 1. *Study Variables*

INPUT INDICATORS	ABBREVIATION	DATA SOURCE AND SCOPE
Government expenditure on primary education per student (PPP $)	GE-P/ps	UNESCO — *online data* The arithmetic mean of data available for at least 5 years from the period 2010–2017
Government expenditure on secondary education per student (PPP $)	GE-S/ps	UNESCO — *online data* The arithmetic mean of data available for at least 5 years from the period 2010–2017
OUTPUT INDICATORS	ABBREVIATION	DATA SOURCE AND SCOPE
Gross secondary enrollment rate	GSE	WORLD BANK — *online data* The arithmetic mean of GSE rates for the period 2010–2018 (Ukraine data available only for years 2010–2014)
PISA scores	PISA	OECD — *online data* The arithmetic mean of reading, mathematical, and scientific literacy scores expressed as the average from the surveys of 2012, 2015, 2018 (Ukraine data available only for 2018)
Critical thinking in teaching	CTT	WORLD ECONOMIC FORUM — *The Global Competitiveness Report (GCR)* The arithmetic mean of indices available for two years, 2018 and 2019

Source: *Own study.*

The government expenditure on education, per student (in the purchasing power parity, that allows to minimize the differences in the cost of living when comparing national economies), at the primary and secondary levels of education, were used as the input indicators.

As measures reflecting the results of a given education system, three indicators were used, reflecting both the knowledge and skills of the direct beneficiaries of the educational system, as well as the general assessment of the quality of the system, as per public opinion. The following is a brief description of the output measures that justify their use in the research.

Gross secondary enrollment rate (GSE) — according to UNESCO, the definition of GSE is, the ratio of the total enrollment seen, regardless of age, to the population of the age group that accurately corresponds to the level of education. Secondary education completes the provision of basic education that begins at the primary level, and aims at laying the foundation for lifelong learning and human development, by offering more subject- and skill-oriented instruction, through the use of highly specialized teachers. The education and training that children receive in the secondary school, equip them with skills that are necessary to fully participate in a society.

PISA scores — reflect findings of the OECD Program for International Student Assessment. Every three years, PISA assesses how far students who are close to the end of their compulsory education (15-year-olds) have acquired knowledge and skills that will be needed for full participation in society. In every cycle, the topic of reading, mathematical, and scientific literacy are covered not merely in terms of mastery of the school curriculum, but in terms of the vital knowledge and skills needed in adult life.

- Reading literacy — involves reading, interpretation, and reflection, and the ability to use reading to fulfill one's goals in life. The focus of PISA is on reading to learn rather than learning to read, and hence, students are not assessed for basic reading skills.
- Mathematical literacy is related to a wider, functional use of mathematics, which includes the ability to recognize and formulate mathematical problems in various situations.
- Scientific literacy requires an understanding of scientific concepts, as well as the ability to apply a scientific perspective and to think critically about the evidence.

Critical thinking in teaching (CTT) — this indicator shows how the educational system is responsible for preparing young people to create a future both for themselves as well as for future generations. This index is derived from a survey in which respondents rate the mentioned aspect of education on a scale of 1 to 7. The response to the survey question, "In your country, how do you assess the style of teaching?" When rated at 1 it means frontal, teacher-based, and focused on memorizing and when rated at 7 it means that it encourages creative and critical individual thinking. The data on the above-mentioned input and output indicators used to calculate the DEA-efficiency have been listed in the Appendix, Table A1.

3. Data Envelopment Analysis Approach

The method of Data Envelopment Analysis (DEA) was applied as a quantitative tool in this study. The DEA was introduced by Charnes, Cooper, and Rhodes (CCR), in 1978 (Charnes *et al.,* 1978), who on the basis of a study by Farrell (1957) proposed a basic DEA model — the radial CCR model (with the assumption of constant returns to scale (CRS). The CCR model was extended to account for technologies that showed variable returns to scale (VRS) by Banker, Charnes, and Cooper in 1984 (Banker *et al.,* 1984).

This is a non-parametric method that assumes the existence of a convex production frontier. The production frontier in the DEA approach is constructed using linear programming techniques. The DEA identifies a *frontier* on which the relative performance of all decision-making units (DMUs) in the sample can be compared — the DEA benchmarks analyzed a DMU only against the best ones, which form the frontier of efficiency. A DMU is recognized as 100% efficient (DEA efficiency measure $\delta = 1$) when comparisons with other DMUs in a sample do not provide evidence of that means it is inefficient — its distance from the frontier determines the level of inefficiency, and the DEA efficiency measure is $\delta < 1$ (for the mathematical foundations of the DEA computations see Cooper *et al.,* 2007).

Since 1978, there has been a rapid and continuous growth in the field of the DEA and a considerable amount of research has been published, which has focused on DEA efficiency computations in both public and private sector activities (Emrouznejad and Yang, 2017).

Over the years, the group of DEA models has been enriched by non-radial models, that is, they measure distances from the efficiency frontier using techniques other than the radial technique. The non-radial approach has this advantage, where it allows avoidance of the so-called Farrell's weak efficiency (apparent efficiency). These DEA models are known as slacks-based measures (SBM).

Another modification of the DEA models is the super-efficiency (SE) approach, which allows avoiding the redundancy of the efficient leaders. The super-efficiency model is identical to the standard model, except that the DMU under evaluation is excluded from the reference set. The super-efficiency DEA models rank the efficient DMUs, and the efficiency indicators may be greater than 1 (suggesting "over-efficiency").

Under the assumption of variable returns to scale (and this assumption is made in this study) the SE DEA model may not be feasible for some efficient DMUs. This problem can be solved by using the generalized orientation of the SE DEA model (Cheng *et al.,* 2011).

In this study the super-efficient and non-oriented DEA slacks-based model (DEA SE-NO-SBM) will be applied. Its mathematical form is as follows (Cooper *et al.*, 2007; Domagała, 2013; Guzik, 2009):

$$\delta^{DEA-SE-NO-SBM} = \min_{\phi,\psi,\lambda} \frac{1+\frac{1}{m}\sum_{i=1}^{m}\varphi_{io}}{1-\frac{1}{s}\sum_{r=1}^{s}\psi_{ro}} \tag{1}$$

subject to:

$$\sum_{\substack{j=1 \\ j\neq o}}^{n} x_{ij}\lambda_{jo} - x_{io}\varphi_{io} \leq x_{io} \quad (i=1,\ldots, m),$$

$$\sum_{\substack{j=1 \\ j\neq o}}^{n} y_{rj}\lambda_{jo} - y_{ro}\psi_{ro} \geq y_{ro} \quad (r=1,\ldots, s),$$

$$\varphi_{io}, \psi_{ro}, \lambda_{jo} \geq 0$$

where:

$\delta^{DEA-SE-NO-SBM}$ — efficiency score of the DMU*o* ($o = 1,\ldots,n$).

x_{ij} — amount of the *i-th* input of the DMU*j* ($i = 1,\ldots,m$).

y_{rj} — amount of the *r-th* output of the DMU*j* ($r = 1,\ldots, s$).

λ_{jo} — the intensity factor associated with the DMU*j* and designated for the analyzed DMU*o* ($j = 1,\ldots, n$).

The weighted (by lambda coefficients) sum of inputs (outputs) of the DMUs that are reference objects for the DMU*o* show the recommended value of inputs (outputs) of the DMU*o* at which it becomes efficient.

φ_{io} — indicates the required percentage reduction of the *i-th* input.

ψ_{ro} — indicates the required percentage increase of the *r-th* output.

The DEA, thanks to its many advantages, and only a few limitations (Kozuń-Cieślak, 2011), is a commonly used quantitative method, appropriate for assessing the relative efficiency of the public sector performance.

In this study the DEA SE-NO-SBM model will provide a ranking of the relative efficiencies of multiple systems (here, 22 EU countries plus Ukraine) at consuming two inputs (here, GE-P/ps and GE-S/ps) in order to produce multiple outputs (here, GSE, PISA, CTT).

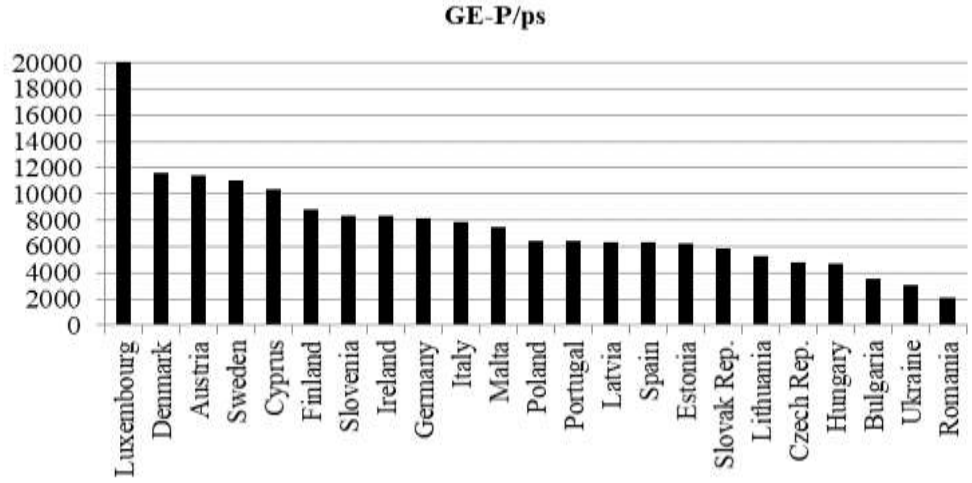
4. Education Input and Output Indicators — Statistical Description

The DEA model formulated in this study assumes the assessment of the efficiency of 23 decision-making units, using two input indicators expressed in monetary terms and three non-monetary output measures. Thus, the model meets the DEA technical requirement, due to the required relationship between the total number of input and output variables and the size of study sample [number of DMUs ≥ 3 (number of inputs + number of outputs) +1].

The data of education input and output indicators used to calculate the DEA-efficiency of 23 states, along with the basic measures of descriptive statistics, are presented in Table A1.

Figures 1 and 2 present data on the DEA inputs, that is, government expenditure on education at both primary (GE-P/PS) and secondary (GE-S/PS) levels. The descriptive analyses of the GE-P/PS and GE-S/PS indicators show the moderately strong differentiation (coefficient of variation equals 48% and 45%, respectively).

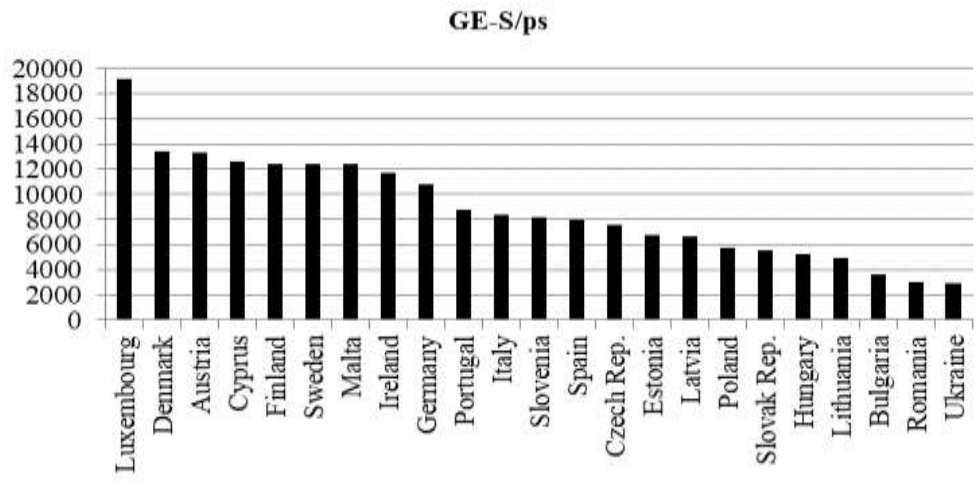
Figure 1. *Government expenditure on primary education (average of 2010–2017)*



Source: *Own work on UNESCO online data.*

The range of GE-P/ps dataset equals 17 950 PPP$. In practice, this means that the maximal value of public expenditure on students in primary school belonging to Luxembourg (2026 PPP$) is nearly 10 times higher than the minimum value noted in Romania (2076 PPP$). Above the GE-P/ps upper quartile (Q3) are also Austria, Sweden, Cyprus, and Finland. On the other hand, apart from Romania, Lithuania, the Czech Republic, Bulgaria, and Ukraine are below the GE-P/ps lower quartile (Q1).

Figure 2. *Government expenditure on secondary education (average of 2010–2017)*



Source: *Own work on UNESCO on-line data.*

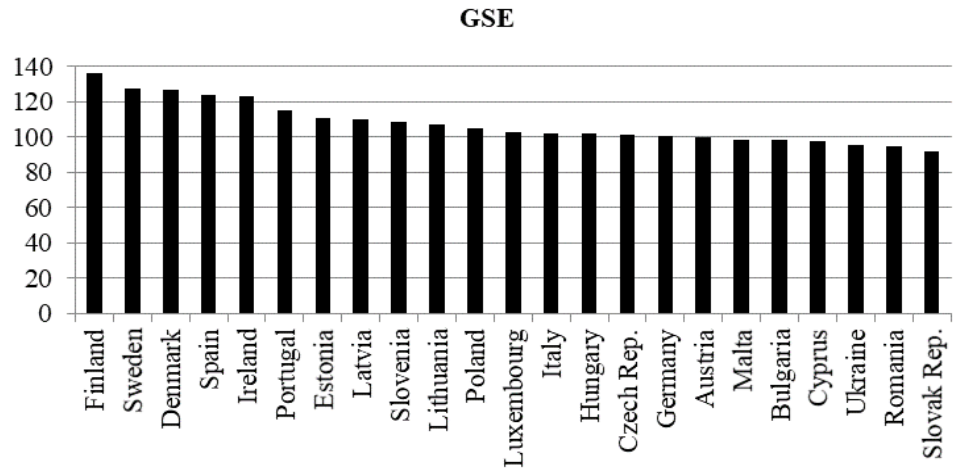
The GE-S/ps dataset shows a slightly lower range (16 206 PPP$), but still the maximal value of government expenditure on students in secondary school noted in Luxembourg (19 168 PPP$) is more than six times higher than that recorded in Ukraine (2 962 PPP$). Above the GE-S/ps upper quartile are the same countries as in case of the GE-P/ps indicator. In turn, below the GE-S/ps lower quartile, apart from Ukraine, are also Slovakia, Hungary, Lithuania, Bulgaria, and Romania.

Both input indicators show positive weak or moderate Pearson Correlation Coefficients (PCC) with all output indicators. The lack of a very strong correlation between variables of inputs and outputs is favorable for the DEA method. In contrast to the econometric methods, a very strong correlation between inputs and outputs leads to the degeneracy of the standard DEA CCR model (Guzik, 2009). Similarly, the lack of a very strong correlation between the output indicators avoids over-representation of the result variables.

It is also worth noting the fairly large differences between the coefficients of variation for the input indicators compared to the coefficients of variation for the output datasets. For the PISA indicator CV equals 5%, which means a very weak differentiation of this variable among the examined countries. For the GSE and CIT datasets, the coefficients of variation are slightly higher and amount to 11% and 20%, respectively.

The following Figures 3-5 show data on the DEA output indicators , that is, the gross secondary enrollment rate (GSE), critical thinking in teaching index (CTT), and scores of knowledge and skills in reading, mathematics, and scientific literacy (PISA).

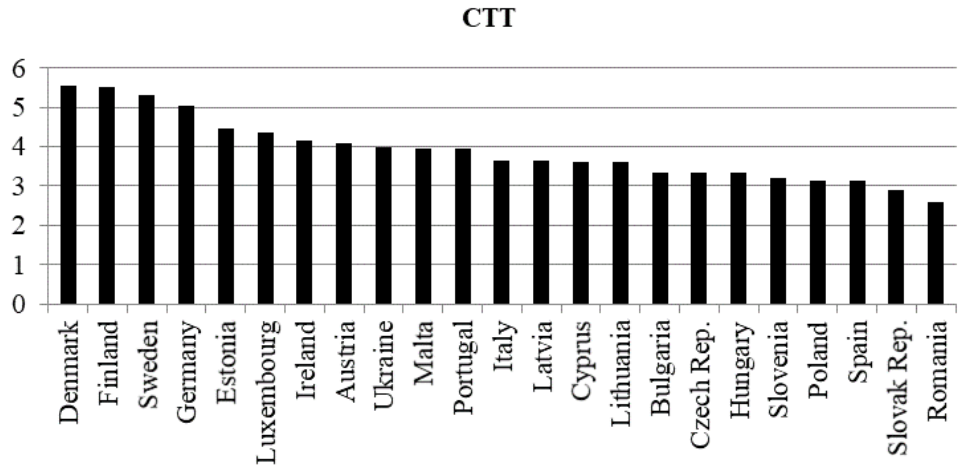
Figure 3. *Gross secondary enrollment rate (average of 2010–2018, for Ukraine 2010–2014)*



Source: *Own work on World Bank on-line data.*

The highest value of gross secondary enrollment (136%) has been noted in Finland, while the lowest in Slovakia (92%). Above the GSE upper quartile are also Denmark, Sweden, Spain, Ireland, and Portugal. On the other hand, apart from Slovakia, below the GSE lower quartile are Bulgaria, Cyprus, Ukraine, and Romania.

Figure 4. *Critical thinking in teaching index (average of 2018– 2019)*

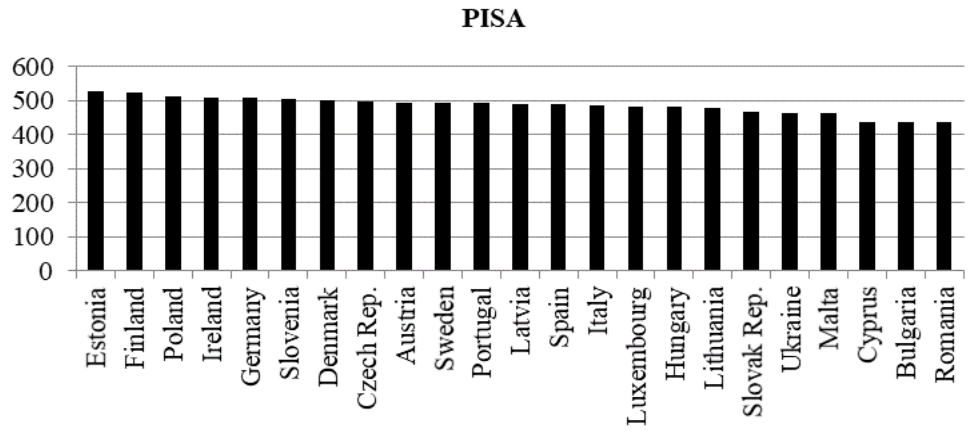


Source: *Own work on data from The Global Competitiveness Report 2018, 2019.*

As Figure 5 shows the critical thinking in teaching has been rated the highest in Denmark (5,6) while the lowest in Romania (2,6). Above the CTT upper quartile are

also Sweden, Finland, Germany, Estonia, and Luxembourg. On the other hand, apart from Romania, the Czech Republic, Bulgaria, Hungary, Poland, Spain, Slovenia, and Slovakia are below the CTT lower quartile.

Figure 5. *PISA scores (knowledge and skills in reading, mathematics, and scientific literacy, average of 2012, 2015, 2018; for Ukraine 2018)*



Source: *Own work on OECD on-line data.*

The highest PISA scores of knowledge and skills in reading, mathematics, and scientific literacy have been recorded in Estonia (525) while the lowest in Romania (435). Above the PISA upper quartile are also Finland, Poland, Ireland, Germany and Slovenia. On the other hand, apart from Romania, Bulgaria, Cyprus, Malta, Slovakia, and Ukraine are below the PISA lower quartile.

The above analysis creates a peculiar portrait of the chosen sample of European countries, which shows that the examined education systems are not as similar as they appear to be, based on the data presented in Section 1, but differ from each other, mainly in the amount of financial outlays supplied to them, which are only partially reflected in the results. Hence, it is worth taking a closer look at the "productivity" of these education systems using the Data Envelopment Analysis approach.

5. DEA Computation Results

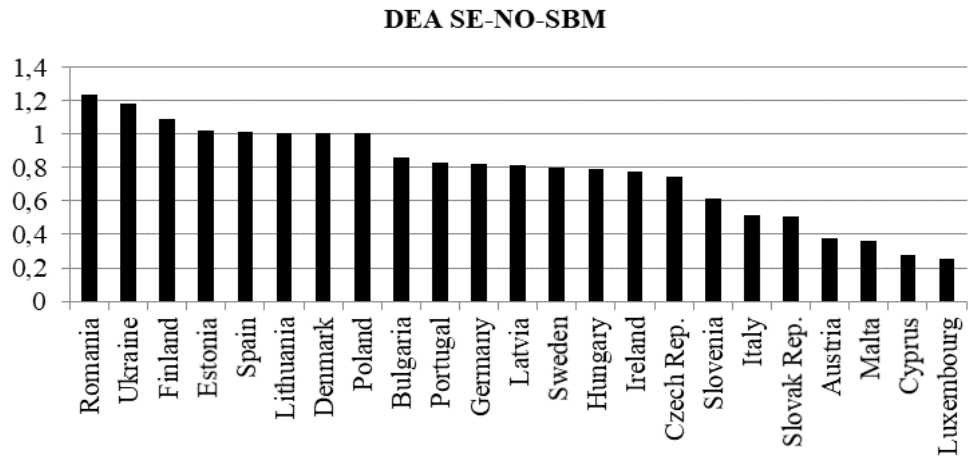
Figure 6 presents the DEA super-efficiency scores for the non-oriented, slacks-based model, with the assumption of variable returns to scale (DEA SE-NO-SBM). On the basis of the DEA calculations, eight economies have been identified as leaders, of which six even show the so-called over-efficiency at the level of 1% to 24%. The leaders' group includes: Ukraine, four post-communist EU member states , that is, Romania, Estonia, Lithuania, and Poland, and three "old" EU members, namely Finland, Spain, and Denmark.

Romania is at the top of this ranking with the DEA-SE score amounting to 1,24. Ukraine came second and Finland third with over-efficiency at 18% and 9%, respectively. In the case of Estonia, Spain, and Lithuania, over-efficiency was practically insignificant (1%–2%).

The country with the lowest efficiency gap of 14% is Bulgaria. This means that Bulgaria "produces" educational outputs about 14% more costly than if it were efficient. Similarly, we can interpret the results for other countries that are assessed as relatively inefficient.

Dramatic low efficiency scores that ranged from 50% to 25% were seen in six countries, among which Luxembourg fared the worst. Luxembourg should reach the current level of educational results by lowering the cost by 75%.

Figure 6. *DEA efficiency scores — non-oriented super efficiency slacks-based model with variable returns to scale (DEA SE-NO-SBM).*



Source: *Own work on data from Appendix, Table A2.*

Luxembourg (just like Cyprus, Malta, Austria, Slovakia, and Italy) represents the case of a huge over-investment in the education system accompanied by inadequate results. This means that the unusually high expenditure on education is not reflected in the corresponding outcomes. As "the production of education" is not exempt from the Law of Diminishing Returns, therefore, Luxembourg and other lowest-rated countries should consider bold changes to the allocation of public expenditure, in order to improve educational outputs.

The case of Ukraine is radically different. Dramatically low expenditure per student is accompanied by very satisfying results. An increase in expenditure in the Ukrainian education system is expected to result in increasing returns to scale.

6. Concluding Remarks

It is crucial to emphasize that the assessment of DEA efficiency is merely an analysis of the relationship between results (outputs) and efforts (inputs), and it does not necessarily express searching for the most desirable or best target solution. Hence, DEA-efficiency indicators do not indicate the economies with the best educational systems or the best educated society, but the states that have obtained the best results within the determined level of input or states that have obtained the determined level of output with the lowest input of employment.

Therefore, a very high DEA score obtained by Ukraine does not mean that the Ukrainian education system should be considered a model one, but only that with relatively low expenditure on education, amounting to about 70% of the EU average, Ukraine achieves results of about 90%–95% of the EU average in case of the gross secondary enrollment rate and PISA indicator (showing reading, mathematical, and science literacy) and even 106% of the EU average in case of critical thinking in the teaching index.

Despite significant differences in the level of socio-economic development of EU Member States, among the countries assessed as DEA-efficient, there are both highly developed (Finland, Denmark, Spain) and much poorer ones (Romania, Lithuania, Poland). The same applies to countries rated as DEA-inefficient. Therefore, there is no relationship between the country's level of wealth and the technical efficiency of the education system (as expressed by the set of indicators used in this study).

Ukraine fared very well compared to 22 EU countries, taking second place in the DEA super efficiency ranking ($\delta = 1.18$). This result confirms that in terms of technical efficiency of public spending on education, Ukraine is doing much better than many EU member states. To obtain a more complete picture of the Ukrainian education system, in a further research, it would also be worth assessing the efficiency of public spending on tertiary education.

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Appendix:

Table A1. *DEA input - output data, statistical description*

DMU	Inputs		Outputs		
	GE-P/ps	GE-S/ps	GSE	CTT	PISA
Austria	11465	13337	99	4,1	495
Bulgaria	3537	3672	98	3,4	436
Cyprus	10380	12631	97	3,6	438
Czech Republic	4836	7559	101	3,4	495
Denmark	11646	13417	127	5,6	501
Estonia	6238	6730	111	4,5	525
Finland	8803	12356	136	5,5	523
Germany	8130	10752	100	5,1	508
Hungary	4701	5190	102	3,4	480
Ireland	8306	11699	123	4,2	510
Italy	7882	8336	102	3,7	484
Latvia	6366	6632	110	3,7	489
Lithuania	5249	4896	107	3,6	480
Luxembourg	20026	19168	102	4,4	483
Malta	7515	12353	98	4,0	461
Poland	6426	5746	105	3,2	512
Portugal	6411	8798	115	4,0	492
Romania	2076	3041	94	2,6	435
Slovak Republic	5834	5545	92	2,9	468
Slovenia	8383	8144	108	3,2	504
Spain	6364	7947	124	3,2	489
Sweden	11016	12356	127	5,3	493
Ukraine	3070	2962	96	4,0	463
Statistical description					
	Inputs		Outputs		
	GE-P/ps	GE-S/ps	GSE	CTT	PISA
Max	20026	19168	136	5,6	525
Min	2076	2962	92	2,6	435
Average	7594	8838	108	3,9	485
Median	6426	8144	103	3,7	489
Q 1	5541	5646	99	3,4	474
Q 3	8593	12354	113	4,3	503
CV	0,48	0,45	0,11	0,20	0,05
	Pearson correlation coefficients				
	GE-P/ps	GE-S/ps	GSE	CTT	PISA
GE-P/ps	1	0,93	0,26	0,52	0,27
GE-S/ps		1	0,36	0,62	0,29
GSE			1	0,62	0,62
CTT				1	0,51
PISA					1

Source: *Own work.*

Table A2. *DEA SE-NO-SBM computations*

DMU		DEA SE-NO-SBM		DMU		DEA SE-NO-SBM	
		Score δ	Rank			Score δ	Rank
1	Austria	0,38	20	**13**	**Lithuania**	**1,01**	6
2	Bulgaria	0,86	9	14	Luxembourg	0,25	23
3	Cyprus	0,27	22	15	Malta	0,36	21
4	Czech Republic	0,74	16	**16**	**Poland**	**1,00**	8
5	**Denmark**	**1,00**	7	17	Portugal	0,83	10
6	**Estonia**	**1,02**	4	**18**	**Romania**	**1,24**	1
7	**Finland**	**1,09**	3	19	Slovak Republic	0,51	19
8	Germany	0,82	11	20	Slovenia	0,62	17
9	Hungary	0,79	14	**21**	**Spain**	**1,01**	5
10	Ireland	0,77	15	22	Sweden	0,80	13
11	Italy	0,52	18	**23**	**Ukraine**	**1,18**	2
12	Latvia	0,82	12				

Source: *Own computations performed with the use of DEA solver, Springer Science+the Business Media, LLC, ©2008 (in bold efficient DMUs).*