ABOUT THE QUALITY AND SUSTAINABLE EDUCATION IN EUROPEAN COUNTRIES: A COMPARATIVE ECONOMETRIC ANALYSIS

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Abstract

This work examines the quality of education in European countries, analyzing its evolution towards the achievement of the Sustainable Development Goals (SDGs), in three different stages of efficiency: levels, patterns and determinants. The SDGs are a call to action for all countries to promote prosperity, while protecting the planet with determinant aspects in an equitable society, such as ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (Goal 4), see [1].

The analysis is made under a non-parametric and deterministic model for measuring efficiency, based on DEA-CCR model, [2], in combination with other mathematical techniques important in the data analysis. In this context, two indicators are defined, one of them to calculate the accumulated effort of the decision units and the other one, to establish the most significant differences between groups with different levels of efficiency. The study is based on the EU's set of indicators to monitor progress towards the UN SDGs: basic education, tertiary education and adult learning. EU's set of indicators involves the participation in early childhood education; achievement in reading, mathematics or science; adult participation in learning; early leavers from education; tertiary education attainment and employment rates of recent graduates.

With the aim of having a broader vision of the European educative performance, are considered two approaches. The approach (A1) considers five Eu set indicators, to examine 31 European countries during eleven years: 2006-2016. The approach (A2) considers the six Eu set indicators to examine 17 European countries during five non-consecutive years (2006, 2009, 2012, 2015, 2018). A comparative econometric analysis is carried out between approaches (A1) and (A2).

This study aims to advance the analysis of strategies that allow us to identify the most efficient European countries in relation to performance factors; highlighting the improvements that could be applied to the less efficient ones, to increase their efficiency and achieve the objectives set for the year of 2030.

Keywords: Efficiency analysis, Quality of education, Sustainable Development Goals-SDGs.

1 INTRODUCTION

One of the main Sustainable Development Goals (SDGs) is ensuring inclusive and equitable quality education; and promote lifelong learning opportunities for all (Goal 4). The global goals are a universal call to action to end poverty, protect the planet, and improve lives and prospects for everyone, everywhere. To this end, all UN member states adopted in 2015, an action plan for people, planet, and prosperity with objectives that cover all dimensions (economic, social and environmental). Thus, the SDGs are a global call to practice strategies to promote inclusion, prosperity and protect the planet. Specifically, the SDGs indicators comprise important aspects in the human being and determinants in an equitable society, see [1].

This paper examines the quality of education, with a view to achieving Goal 4 of the SDGs in European countries. The study involves two approaches (A1 and A2). The approach A1 considers five EU's indicators during eleven years (2006-2016), for examining 31 European countries: Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Iceland (IS), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Macedonia (MK), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH) and Turkey (TR). The approach A2 study six EU's indicators, during seven years (2006, 2009, 2012, 2015, 2018) to examine 17 European countries: BE (Belgium); CZ (Czechia); DK (Denmark); DE (Germany); IE (Ireland); EL (Greece); FR (France); IT (Italy); LV

(Latvia); LU (Luxembourg); HU (Hungary); PL (Poland); PT (Portugal); FI (Finland); SE (Sweden); IS (Iceland) and CH (Switzerland).

This work examines the quality of education in European countries using a model nonparametric deterministic for measuring efficiency based on DEA (Data envelopment Analysis) [2], in combination with other mathematical techniques. In general terms DEA model calculates the amount of inefficiency for every Decision-Making Unit (DMU), according to the best unit, and puts others on the efficiency frontier or under it. DEA is one of the most important approaches to measuring efficiency, with its use for educative performance measurement. There are two DEA models widely used in the literature, the DEA-CCR model [2] and the DEA-BCC model [3]. The first assumes constant returns to scale and the second one variable returns to scale. Some interesting studies in comparative efficiency of public and private high school's higher education institutions, are [4]-[10].

Given the conditions of this study, the model selected for measuring efficiency is the DEA-CCR, in combination with other mathematical techniques. Two significant indicators are calculated: the group efficiency indicator, which allows giving a recommendation of the variables that could be improved to increase the efficiency, and the accumulated effort indicator which allows measuring the effort of the countries to get input resources in a sequence of years. With the study's years considered in this article (seven in approach A1 and eleven in approach A2) it is possible to assess the real difference in the strategies adopted by the countries, before and after the SDGs.

The remainder of the paper is laid out as follows. In the next section, is presented the data of the study and a brief overview of the DEA approach used in this work. Section 3 presents the main results obtained in each approach and, in Section 4, some concluding remarks are formulated.

2 DATA AND METHODOLOGY

2.1 Sources of data and definition of variables

This work examines the quality of education in 31 European countries using a model based on DEA [2], in combination with other mathematical techniques. The variables of study denoted by VI for inputs and VO for outputs, distributed in Table 1, were extracted from the Eurostat database. The study is based on the EU's set of indicators to monitor progress towards the UN SDGs: basic education (VO1, VI1 and VI2), tertiary education (VO2 and VO3) and adult learning (VI3).

Table 1. Variables (EU's indicators).

Inputs		***Outputs***	
VI1	Participation in early childhood education	VO1*	Early leavers from education
VI2	Achievement in reading, mathematic or science	VO2	Tertiary education attainment
VI3	Adult participation in learning	VO3	Employment rates of recent graduates

**Note that, V01 is an undesirable variable in this study, since, efficiency models try to minimize resources (inputs), as production (outputs) increases. Then, we consider the variable complement (CV01) instead of VO1. Complement variable is defined as the maximum value of the output variable in an entire database minus the value of the variable for the unit.*

This study considers two approaches (A1 and A2), under the characteristics exposed in Table 2. The reason the two approaches described above are considered is because until the moment of the study not all the data from the 31 countries were registered in the database and the indicator

VI2 (Achievement in reading, mathematic or science) is only registered every three years.

Table 2. Study's approaches

	Approach (A1)		***Approach (A2)***
Variables	Inputs: VI1, VI3. Outputs: CVO1, VO2, VO3.		Inputs: VI1, VI2, VI3. Outputs: CVO1, VO2, VO3.
Years	2006-2016.		2006, 2009, 2012, 2015, 2018.
Countries	Austria (AT) Belgium (BE) Bukgaria (BG) Croatia (HR) Cyprus (CY) Czech Republic (CZ) Denmark (DK) Estonia (EE) Finland (FI) France (FR) Germany (DE) Greece (EL) Hungary (HU) Iceland (IS) Ireland (IE) Italy (IT)	Latvia (LV) Lithuania (LT) Luxembourg (LU) Macedonia (MK) Malta (MT) Netherlands (NL) Poland (PL) Portugal (PT) Romania (RO) Slovakia (SK) Slovenia (SI) Spain (ES) Sweden (SE) Switzerland (CH) Turkey (TR)	Belgium (BE) Czech Republic (CZ) Denmark (DK) Finland (FI) France (FR) Germany (DE) Greece (EL) Hungary (HU) Iceland (IS) Ireland (IE) Italy (IT) Latvia (LV) Luxembourg (LU) Poland (PL) Portugal (PT) Sweden (SE) Switzerland (CH)

The Table 2 contains the European countries of the study and their two-letter country code.

2.2 Methodology

2.2.1 Data Envelopment Analysis (DEA)

The Data Envelopment Analysis (DEA) is a non-parametric technique that allows to calculate the efficiency and that is sustained in a linear programming between all DMU (decision-making units), introduced in [2] and [3]. DEA needs to run n times for each DMU, using multiple inputs and/or multiple outputs and find the most efficient DMUs, which are then compared to others. In this sense, DEA technique shows an efficiency frontier, where the relationship between outputs and inputs must reach the boundary, to be in an optimal "state" between the quantity produced and its resources.

In the literature are widely used, two DEA models for the efficiency measurement of decision-making units: the DEA-CCR model [2] and the DEA-BCC model [3]. In this study is used the DEA-CCR model, which assumes Constant Returns to Scale (CRS) model. Then, all observed production combinations can be scaled up or down proportionally. DEA-CCR was initially developed with an input orientation model (a variation in the input, will result in a variation in the output, due to the growing returns to scale). Here, we use the model, output oriented CCR model (see (1)-(3)).

In what follows, we give a general description of the model and fix notation.

Let $k\ (c,t) \in N$ be a tuple identifying the country $c \in C$ and year $t \in T$, which we call a country/year tuple, and [m] denotes the set $\{1,\dots,m\}$, for some $m \in$ N. We consider that any given tuple $n \in N$ produces $J \in N$ outputs $yj(n), j \in [J]$, using $I \in N$ inputs $xi(n), i \in [I]$. Then $\mathrm{Z} = \{\mathrm{z(k)}\}_N$ with $z(k) = (x(k), y(k))$, represent the dataset.

Definition (DEA score): For a given dataset $\mathrm{Z} = \{\mathrm{z(k)}\}_{N\ \mathrm{N}}$ with $z(k) = (x(k), y(k))$, the DEA efficiency score of each DMU $k \in N$, is then defined as the value h_k, $0 \leq h_k \leq 1$, such that h_k satisfies (1)-(3):

$$h_k = \min \sum_{i=1}^{n} v_i x_{ik} \qquad (1)$$

Subject to

$$\sum_{r=1}^{m} u_r y_{rj} - \sum_{i=1}^{n} v_i x_{ij} \leq 0 \quad (2)$$

$$\sum_{r=1}^{m} u_r y_{rk} = 1 \quad (3)$$

$$u_r, v_i \geq 0$$

where h_k = efficiency of DMU k, which will be analyzed, u = weights of the outputs; v= weights of inputs; $r = 1, \dots, m$; $i = 1, \dots, n$ and $j = 1, \dots, N$.

Therefore, the efficiency relative of a DMU k can be obtained by solving the program (1)-(3).

Consider the definition above and the set EFF, defined by

$$\text{EFF}: \{\text{k(c, t)} \in C \text{ x } T : 0{,}8 < h_k \leq 1{,}0\}. \quad (4)$$

The countries in the EFF set are called efficient countries; the countries that are not in the EFF will be called not efficient countries ($0{,}0 \leq h_k \leq 0{,}8$).

2.2.2 Group indicator

According to the DEA efficiency scores, two different groups were considered:

$$G1 = \{k(c,t) \in C \text{ x } T: h_k = 1{,}0\}, \qquad G0 = \{k(c,t) \in C \text{ x } T: 0{,}0 \leq h_k \leq 0{,}5\}. \quad (5)$$

The group G_1 corresponding to the most efficient countries and the group G_0 corresponding to the least efficient group (inefficient ones). We defined the following indicator.

To study the differences that can be found between the two groups with different levels of efficiency (groups more and less efficient), we defined the group efficiency indicator. It allows giving a recommendation of the variables that could be improved (in groups with less efficient) to increase the efficiency.

Definition (group indicator): Let G_1 be the most efficient group and G_0 be the least efficient group. The group efficiency indicator, $\text{EG}_{G1.G0}(x_i(n))$ for an input $x_i(n)$, is given by:

$$E\text{G}_{\text{G1.}G0}(x_i(n)) = \frac{m_{G1}(x_i(n)) - m_{G0}(x_i(n))}{m_{G0}(x_i(n))} \quad (6)$$

where $m_{G1}(x_i(n))$ is the mean of the input $x_i(n)$, for G_1 and $m_{G0}(V_i)$ is the mean of $x_i(n)$ for G_0.

The group efficiency indicator represents the relative value of the difference between the groups G_1 and G_0 for each input. Following the same idea $\text{EG}_{G1.G0}(y_j(n))$ can also be defined for each output $y_j(n), j \in [J]$.

2.2.3 Effort Indicator

An indicator to measure the effort of the countries to obtain input resources in a sequence of years, is defined to continue.

Definition (*effort indicator*): Let V be the set of units with DEA efficiency score> 0.9. The effort indicator of the set V of units between the period t_{j-1} and the period t_j, is defined by:

$$\text{EI}_{t_{j-1}t_j}(\text{V}) = -1 + \frac{1}{\bar{\text{I}}} \sum_{\text{i}\in[\bar{\text{I}}]} \frac{\min\{\text{x}_\text{i}(\text{c}, \text{t}_\text{j}): \text{c} \in \text{V}\}}{\min\{\text{x}_\text{i}(\text{c}, \text{t}_{\text{j}-1}): \text{c} \in \text{V}\}}, \quad (7)$$

Where $\bar{\text{I}}$ is the subset of input indices for which both minima are different from zero in the periods t_{j-1} and t_j.

The total effort made by each country in each year is determine by the accumulated effort indicator.

Definition (*accumulated effort*): Let V be the set of units with DEA efficiency score> 0.9. The accumulated effort indicator of the set V of units, is calculated by:

$$\mathrm{AEI}_{t_l}(V) = \sum_{l\epsilon\{1,\dots,m\}} \mathrm{EI}_{t_{j-1}t_j}(V) \quad (8)$$

Where EI is defined as (5).

3 EMPIRICAL RESULTS AND ANALYSIS

This work analyzes the evolution of countries with respect to SDGs at three efficiency stages: levels, patterns, and determinants. The analysis is performed considering three main stages:

- General analysis using DEA efficiency score: comparative analysis Approach (A1) versus Approach (A2) (section 3.1);
- Analysis of groups with different levels of efficiency (section 3.2);
- Analysis of the accumulated effort (section 3.3);

The data processing in this work, is done supported by a software package developed in Python for conducting data envelopment analysis, called pyDEA. The documentation can be found at https://araith.github.io/pyDEA/.

3.1 General analysis using DEA efficiency score: comparative analysis Approach (A1) versus Approach (A2)

The efficiency DEA score was calculated for all countries of the study in the two approaches (A1) and (A2). A ranking of countries by year is established, using the color panel in Table 3.

Table 3: Efficiency Level (color panel).

0≤ h_k ≤0,5	0,5≤ h_k ≤0,6	0,6≤ h_k ≤0,7	0,7≤ h_k ≤0,8	0,8≤ h_k ≤0,9	0,9≤ h_k ≤1

In Table 4 and Table 5, are presented the scores got in approaches (A1) and (A2) respectively. In general terms, we can see in Table 4, less than 50% of the countries in the sample (approach A1) are efficient in each year, except in 2010 (where 54.83% of the countries are efficient). The countries that managed to maintain a high level of efficiency (h_k>0,9) during all the years were: BG, HR, LT, MK and RO. As we can see in Table 4, the countries IE, FI and PL had efficiency maximum ($h_k = 1$) in all study period. On the other hand, IT is the country with the lowest efficiency score ($0{,}58 \leq h_k \leq 0{,}64$) during the study. For a better visualization, in the Fig. 1 the behavior of the DEA score of the countries in each year is represented.

In general terms the countries studied in Table 5 are efficient, the $82{,}3\%$ of the sample is in the set EFF. The countries IE, FI and PL had efficiency maximum ($h_k = 1$) in all study period. On the other hand, IT is the country with the lowest efficiency score for the two approaches during the study. The countries that managed to maintain a high level of efficiency ($h_k > 0{,}9$) during all the years were CH, EL, FI, HU, IE and PL.

Table 4. Ranking countries by year, approach (A1).

2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00	BG	1,00
IE	1,00	IE	1,00	IE	1,00	IE	1,00	HR	1,00	HR	1,00	HR	1,00	EL	1,00	HR	1,00	HR	1,00	HR	1,00
EL	1,00	EL	1,00	HR	1,00	HR	1,00	LT	1,00	LT	1,00	LT	1,00	HR	1,00	LT	1,00	RO	1,00	RO	1,00
HR	1,00	HR	1,00	LT	1,00	MK	1,00	RO	1,00	RO	1,00	RO	1,00	LT	1,00	RO	1,00	MK	1,00	SK	1,00
LT	1,00	RO	1,00	MK	1,00	TR	1,00	FI	1,00	MK	1,00	SK	1,00	PL	1,00	SK	1,00	EL	0,96	MK	1,00
RO	1,00	FI	1,00	TR	1,00	PL	0,99	MK	1,00	TR	1,00	MK	1,00	RO	1,00	MK	1,00	PL	0,95	PL	0,97
FI	1,00	MK	1,00	FI	1,00	LT	0,98	TR	1,00	PL	0,98	TR	1,00	SK	1,00	EL	0,98	SK	0,93	TR	0,97
MK	1,00	TR	1,00	RO	0,99	RO	0,98	SK	0,96	EL	0,97	PL	0,97	MK	1,00	PL	0,97	LT	0,87	LT	0,94
TR	1,00	LT	0,93	PL	0,98	FI	0,97	IE	0,96	IE	0,94	EL	0,97	TR	0,99	TR	0,95	TR	0,85	EL	0,94
CY	0,99	CY	0,90	EL	0,93	SK	0,95	CY	0,95	FR	0,91	CY	0,96	CH	0,94	HU	0,94	CH	0,75	CH	0,86
PL	0,86	PL	0,89	CH	0,88	CH	0,90	PL	0,90	HU	0,89	HU	0,91	HU	0,93	CY	0,90	IE	0,73	IE	0,80
NL	0,81	FR	0,87	SK	0,85	EL	0,87	EL	0,88	CY	0,86	IE	0,89	CY	0,90	CH	0,85	CY	0,73	MT	0,80
SK	0,81	SK	0,84	FR	0,83	FR	0,82	CH	0,88	SK	0,86	FI	0,88	IE	0,88	IE	0,84	MT	0,69	IS	0,79
FR	0,79	BE	0,80	CY	0,82	CY	0,82	FR	0,87	LV	0,80	FR	0,85	MT	0,83	MT	0,82	IS	0,68	CY	0,78
BE	0,78	CH	0,80	BE	0,79	HU	0,79	LU	0,83	BE	0,78	BE	0,82	DE	0,81	LV	0,79	LV	0,67	CZ	0,78
CH	0,77	LU	0,74	HU	0,76	LU	0,77	HU	0,83	MT	0,72	CH	0,78	BE	0,80	DE	0,77	CZ	0,67	LU	0,76
DK	0,74	HU	0,73	DK	0,73	BE	0,76	BE	0,83	DE	0,65	MT	0,76	LV	0,79	CZ	0,74	DE	0,67	DE	0,76
HU	0,73	EE	0,72	SE	0,72	DK	0,73	SE	0,78	FI	0,64	DE	0,75	FI	0,78	AT	0,73	AT	0,66	HU	0,75
SE	0,72	SE	0,70	LU	0,72	SE	0,73	EE	0,77	ES	0,59	LV	0,74	LU	0,76	FI	0,73	FI	0,65	NL	0,75
EE	0,70	CZ	0,70	SI	0,69	IS	0,71	ES	0,75	LU	0,59	LU	0,73	AT	0,74	IS	0,72	LU	0,65	AT	0,75
LU	0,70	DK	0,69	IS	0,69	LV	0,70	MT	0,71	EE	0,56	SE	0,72	SE	0,73	LU	0,72	SE	0,65	SE	0,74
CZ	0,68	SI	0,68	NL	0,68	CZ	0,68	LV	0,70	CH	0,55	AT	0,67	CZ	0,72	BE	0,71	NL	0,65	FI	0,72
ES	0,68	ES	0,67	ES	0,66	NL	0,67	NL	0,70	SE	0,51	CZ	0,67	IS	0,70	SE	0,70	EE	0,63	LV	0,70
SI	0,67	IS	0,64	LV	0,65	MT	0,67	IS	0,70	IT	0,50	ES	0,64	EE	0,68	NL	0,69	HU	0,61	SI	0,69
PT	0,62	NL	0,63	EE	0,64	SI	0,65	DK	0,68	CZ	0,50	DK	0,64	NL	0,67	EE	0,69	BE	0,60	DK	0,69
AT	0,61	LV	0,62	AT	0,63	DE	0,65	PT	0,67	AT	0,49	IS	0,64	SI	0,65	DK	0,66	DK	0,59	BE	0,69
IS	0,61	DE	0,60	MT	0,62	ES	0,64	SI	0,66	IS	0,48	EE	0,63	DK	0,64	SI	0,62	SI	0,58	EE	0,68
DE	0,58	AT	0,59	DE	0,62	EE	0,59	DE	0,65	PT	0,45	SI	0,62	FR	0,64	FR	0,59	PT	0,55	PT	0,65
MT	0,57	PT	0,58	CZ	0,62	PT	0,59	CZ	0,64	SI	0,44	NL	0,62	ES	0,63	ES	0,58	FR	0,54	FR	0,59
LV	0,55	MT	0,56	PT	0,62	AT	0,59	AT	0,59	DK	0,44	PT	0,51	PT	0,58	PT	0,58	ES	0,50	ES	0,57
IT	0,48	IT	0,49	IT	0,49	IT	0,49	IT	0,48	NL	0,43	IT	0,50	IT	0,48	IT	0,39	IT	0,36	IT	0,45

Table 5. Ranking countries by year, approach (A2).

2006		2009		2012		2015		2018	
EL	1,00	CH	1,00	CH	1,00	CH	1,00	CH	1,00
HU	1,00	HU	1,00	CZ	1,00	CZ	1,00	CZ	1,00
IE	1,00	IE	1,00	DE	1,00	DE	1,00	EL	1,00
FI	1,00	FI	1,00	EL	1,00	EL	1,00	FI	1,00
PL	1,00	PL	1,00	FI	1,00	FI	1,00	HU	1,00
PT	1,00	EL	0,99	HU	1,00	IE	1,00	IE	1,00
FR	0,92	FR	0,98	IE	1,00	PL	1,00	PL	1,00
CH	0,92	BE	0,91	PL	1,00	LU	0,97	DE	1,00
BE	0,86	PT	0,88	LU	0,96	LV	0,94	LU	0,96
CZ	0,85	DK	0,85	BE	0,94	IS	0,94	LV	0,96
LU	0,81	DE	0,85	FR	0,91	SE	0,93	BE	0,94
DK	0,80	CZ	0,84	LV	0,89	HU	0,93	SE	0,94
DE	0,79	LU	0,83	SE	0,85	BE	0,92	IS	0,93
IS	0,77	IS	0,81	IS	0,85	DK	0,89	DK	0,92
SE	0,77	SE	0,80	DK	0,80	PT	0,84	PT	0,88
LV	0,75	LV	0,77	PT	0,76	FR	0,80	FR	0,79
IT	0,64	IT	0,58	IT	0,61	IT	0,57	IT	0,64

For comparing the results obtained in the two approaches, we will only consider the 17 countries of approach A2. The Table 6 represent the relation between level of efficiency and approach by year. For all countries, the efficiency level is higher in approach (A2) than in approach (A1). The $57{,}3\%$ of the sample has a high efficiency level ($0{,}9 \leq h_k \leq 1{,}0$) in the approach (A2) and only the $14{,}7\%$ in the approach (A1).

Table 6: Efficiency level by approaches

		A1				A2			
	Efficiency Level	**2006**	**2009**	**2012**	**2015**	**2006**	**2009**	**2012**	**2015**
	$0{,}0 \leq h_k \leq 0{,}5$	1	1	1	2	0	0	0	0
	$0{,}5 < h_k \leq 0{,}6$	3	3	1	5	0	1	0	1
	$0{,}6 < h_k \leq 0{,}7$	8	7	8	12	1	0	1	0
	$0{,}7 < h_k \leq 0{,}8$	6	6	6	3	5	1	2	1
	$0{,}8 < h_k \leq 0{,}9$	3	4	4	2	3	7	3	2
	$0{,}9 < h_k \leq 1$	10	10	11	7	8	8	11	13
	Total	**31**	**31**	**31**	**31**	**17**	**17**	**17**	**17**

In Fig. 1 we can compare the efficiency results, considering the variables in the approach A1 (5 variables) and in the approach A2 (6 variables), during the years 2006, 2009, 2012, 2015 and 2018. The countries that managed to maintain a high level of efficiency ($h_k > 0{,}9$) during all the years were: BG, HR, RO, and MK in (A1), and CH, EL, HU, IE, FI and PL in approach (A2).

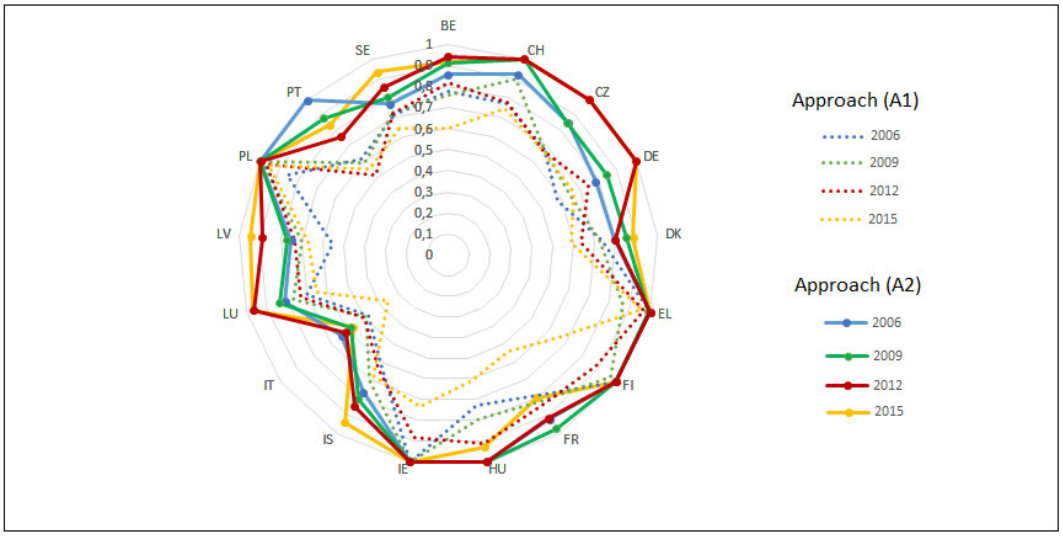


Figure 1. Efficient level of countries by years: approach (A1) versus approach (A2).

An interesting question in efficiency study is to know in what proportion the level of efficiency changes, when a new variable is introduced in the given base.

This question is addressed to continue in this study, considering an additional input.

Fig. 2 shows the results of 17 European countries: BE (Belgium); CZ (Czechia); DK (Denmark); DE (Germany); IE (Ireland); EL (Greece); FR (France); IT (Italy); LV (Latvia); LU (Luxembourg); HU (Hungary); PL (Poland); PT (Portugal); FI (Finland); SE (Sweden); IS (Iceland) and CH (Switzerland). Here are compare 5 variables in approach A1 and 6 variables in approach A2 for the year 2006. As we can see, consider the input VI2 (Achievement in reading, mathematic or science), increased the level of efficiency of all countries in study. Indeed, the Fig 2 show that the blue color is intensified from approach A1 to approach A2, when is increasing the variable VI2.

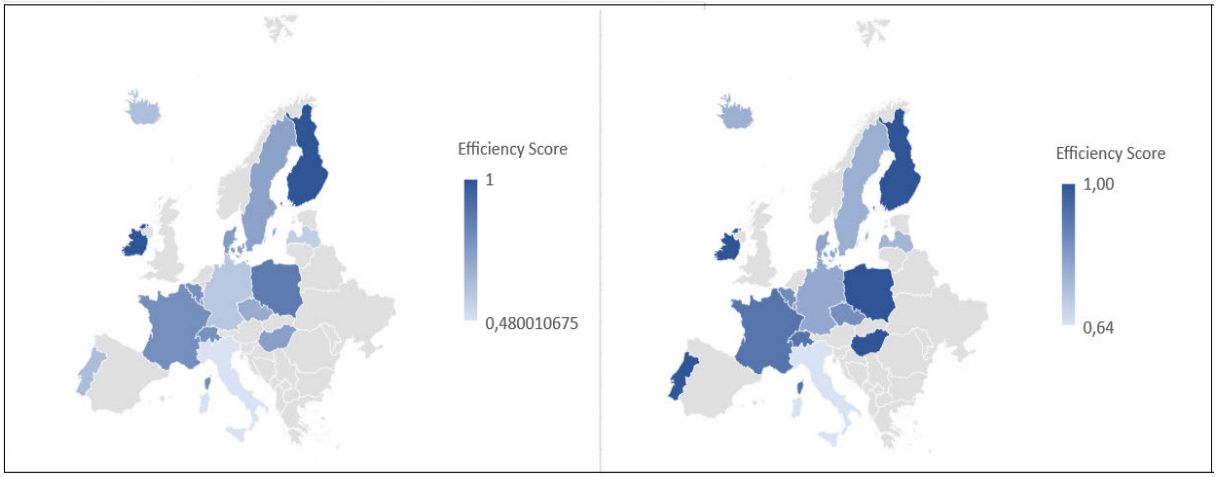


Figure 2. Efficient level of countries in 2006: approach A1 (left side) vs approach A2 (right side)

3.2 Analysis of groups with different levels of efficiency

The group efficiency indicator allows giving a recommendation of the variables that could be improved to increase the efficiency.

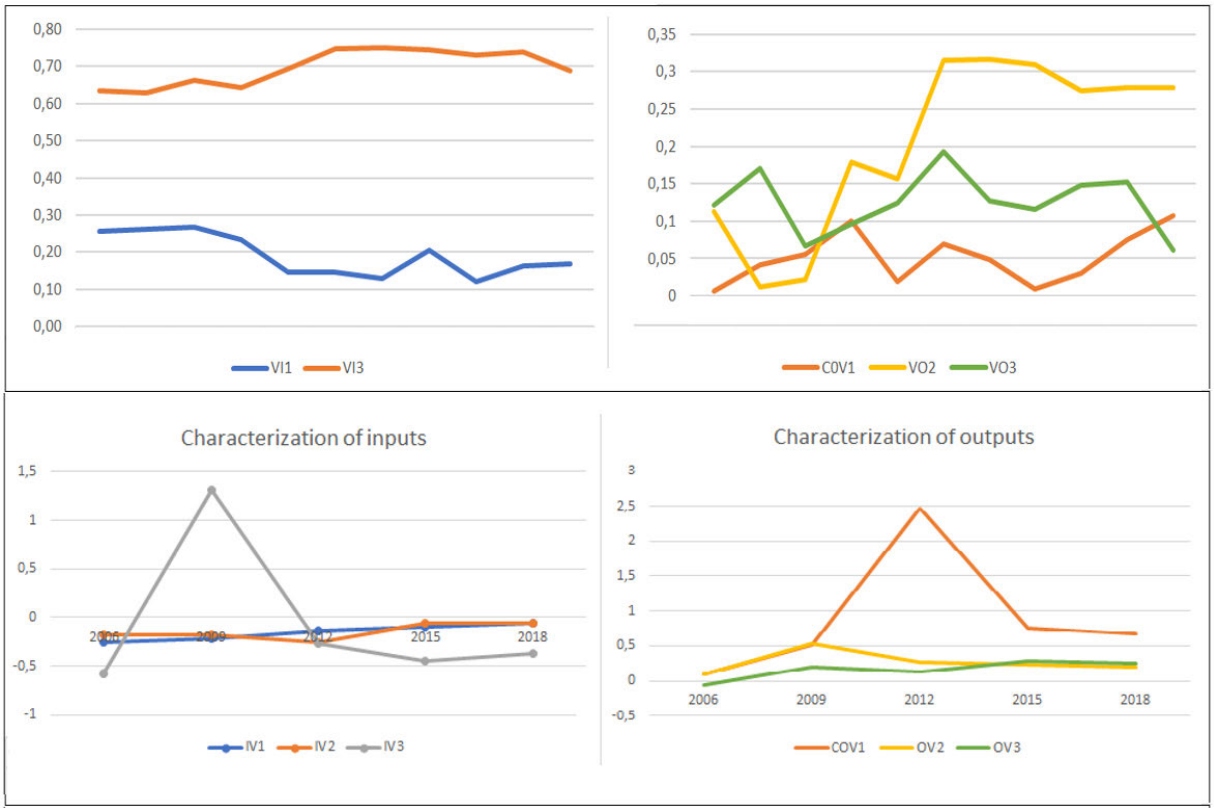


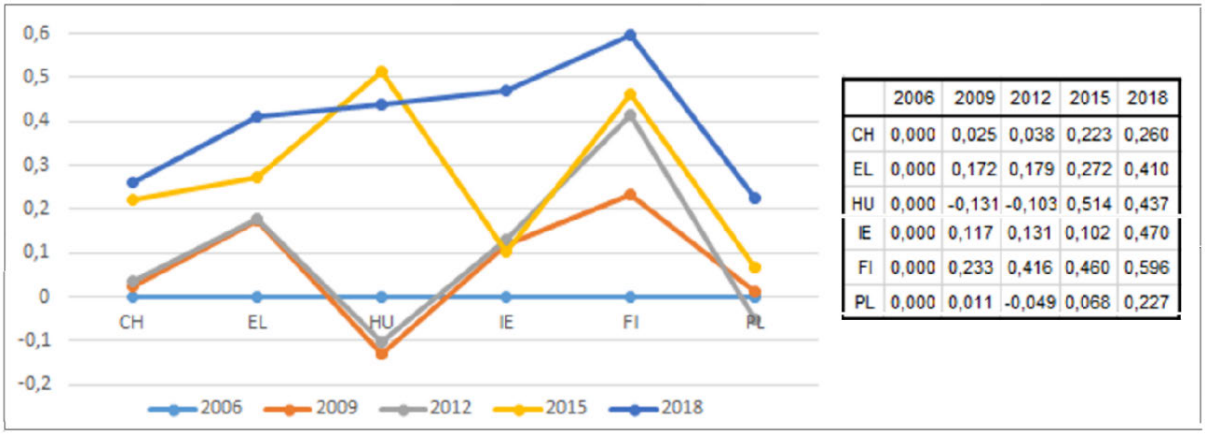
Figure 3. Characterization of variables: A1 (above): outputs (right side), inputs (left side); A2 (down): outputs (right side), inputs (left side)

In order, to calculate the group efficiency indicator, two groups with different DEA efficiency scores were considered, Go and G1. Note that from year to year, the countries that make up each group may be different. Indeed, the Approach (A2), in 2006, G1 group is formed by five countries EL, HU, IE, FI, and PL. Go group by six countries DK, DE, IS, SE, LV, and IT. In 2009, G1 group: CH, HU, IE, FI and PL. Go group: LV and IT. In 2012 G1 group: CH, CZ, DE, EL, FI, HU, IE and PL. Go group: DK, PT, and IT. In 2015 G1 group: CH, CZ, DE, EL, FI, IE and PL. Go group: FR and IT. In 2018 G1 group: CH, CZ, EL, FI, HU, IE and PL. Go group by the countries FR and IT.

Fig. 3, show the Group Efficiency indicators for the two approaches for inputs and outputs. The results in approach (A2), showed that the input that presents less difference between the two groups is IV2 (2015) and the input with the highest index is IV3 (2009). In the output case, the less difference in absolute value is found in 0V3 (2006) and the output with the highest index is COV1 (2012). Comparing the two approaches, in the input case, the most difference in absolute value is found in the variable IV3 in the Approach (A1) for all study period; but in the Approach (A2), IV3 is the more difference only in 2009. Note that the output that presents less difference in absolute value between the two groups is the variable COV1 in Approach (A1); but the input with the highest index (both in natural and absolute value) is COV1 in Approach (A2).

3.3 Analysis of the accumulated effort

In order, to calculate the accumulated effort, we selected the countries with $0{,}9 < h_k \leq 1$, in all years of study. For example, the countries selected in the approach (A1) are BG, HR, RO, and MK. Following the same structure, selected the countries more efficient in Approach (A2): CH, EL, HU, IE, FI and PL. Then, we calculate the accumulated effort. The Fig. 4 show the results for approach (A2) to reach the inputs required to reach the ideal performance (i.e., the one that is able to minimize all the inputs and, at the same time, maximize all the outputs). As we can see, in 2018 nearly all countries had a higher effort. The minimum effort was present for HU in 2009 and 2012.



	2006	2009	2012	2015	2018
CH	0,000	0,025	0,038	0,223	0,260
EL	0,000	0,172	0,179	0,272	0,410
HU	0,000	-0,131	-0,103	0,514	0,437
IE	0,000	0,117	0,131	0,102	0,470
FI	0,000	0,233	0,416	0,460	0,596
PL	0,000	0,011	-0,049	0,068	0,227

Figure 4. Accumulated effort, approach (A2)

4 CONCLUSIONS

This paper examines the progress of European countries made towards quality of education (Goal 4) of the SDGs in the implementation of the 2030 Agenda. The analysis is done using CCRDEA model with other mathematical techniques and following an output-oriented model, involving two approaches (A1 and A2).

The most important findings in this article are as follows:

- The results show that the approach (A1), which considers 31 European countries and five EU's indicators during 2006-2016, is less efficient than the approach (A2), which considers 17 European countries and six EU's indicators, during seven years (2006, 2009, 2012, 2015, 2018).
- In general terms, the level of efficiency is not the same in all countries and every year. According to the results, we found different levels of efficiency, for the two approaches. The countries that managed to maintain a high level of efficiency during all the years were: BG, HR, LT, MK and RO in the approach (A1). The countries CH, EL, FI, HU, IE and PL, in approach (A2).
- The group efficiency indicator allows you to recommend the variables that can be improved to increase efficiency. In the input case, the most difference between the two groups with different levels of efficiency is found in the variable IV3 for the approach (A1) for all study period; but in the approach (A2), IV3 is the more difference only in 2009. In the output case, the less difference is the variable COV1 in approach (A1); but the input with the highest index is COV1 in approach (A2).
- The only inefficient country throughout the study period was IT. Indeed, in approach (A1), IT obtains a DEA score below 0.64 (2006, 2012 and 2018) and below 0.58 (in 2009 and 2015); in approach (A2), IT obtains a DEA score below 0.50in all study period.

- The results reflected that the majority of the countries in the study are working hard to achieve the Goals proposed by the UN. It is important to apply strategies that would improve the performance of countries less efficient, and an interesting way is following the plan used by the more efficient countries, to improve the quality of education not only in Europe; but in all around the world.

ACKNOWLEDGEMENTS

Work supported by The Center for Research and Development in Mathematics and Applications (CIDMA) through the Portuguese Foundation for Science and Technology (FCT-Fundação para a Ciência e a Tecnologia), references UIDB/04106/2020 and UIDP/04106/2020. Murillo is also supported by national funds (OE), through FCT, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the articles 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19.

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