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Efficiency of Environmental Protection Expenditures in EU Countries

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Abstract: Environmental protection policy is a widely discussed issue in scientific works. However, special attention should be also paid to the effectiveness of expenditures on environmental protection, and this is the main goal of this paper. The countries of the European Union were selected for this analysis due to the fact that, in recent years, this region has become an informal world leader with respect to the implementation of policy measures in the field of environmental protection. For that reason, the data envelopment analysis methodology was used, which allows the calculation of input-output efficiency for the years 2005–2015. The analysis shows that, among the 30 analyzed countries, the most effective in environmental protection actions is Finland. The hypothesis that higher environmental protection expenditures does not result in better environmental results has been confirmed. Our analysis confirmed the problem of the deteriorating efficiency of environmental expenditures across the selected European Union Member States, caused by increases in spending. This research may contribute to the discussion on environmental protection policy design and its assessment, as well as environmental policy results measurement.

Keywords: environmental protection expenditures; DEA methodology; relative efficiency; EU environmental policy

1. Introduction

Climate change and pollution are among the most serious challenges facing the world today. Therefore, in March 2007, the EU Heads of State and Government endorsed the European Commission's integrated strategy on climate change and energy, which sets out the EU's proposals for a global and comprehensive agreement to combat climate change after 2012, when the targets under the Kyoto Protocol expire. In Paris in December 2015, 195 countries (practically the whole world) agreed to the first-ever legally binding global deal to tackle climate change. In the EU and around the world, governments, companies and individuals are already working to tackle its causes and adapt to the changes it brings. Environmental protection expenditure are related to preventing, reducing and eliminating pollution and any other degradation of the environment, and in EU-27, they increased from 2006 to 2019 by 34%.

However, environmental protection expenditures used to be neglected as a category of public expenditures in favor of, mainly, education, social security and healthcare. On the other hand, however, environmental protection fits perfectly into the category of public goods due to its shared consumption and gains, as well as its limited spectrum of exceptions, related to, among others, water- or land-based assets [1]. Expenditures on environmental protection address market failures with respect to externalities related to the environment [2], which are considered important determinants of environmental quality [3–8]. Depending on the set of pollutants considered and environmental components, i.e., the water, air or land to be impacted, jurisdiction can be either local, regional or global. Considering the fact that public goods are underprovided in a market economy, as classic public finance theory states, the institution of the state is expected to deliver them, even though that can be inefficient when compared to the provision of public goods by private sector. In fact, in the case of environmental protection expenditures, the role of the private sector is more and more substantial, resulting from the characteristics of environmental regulations that set some standards or enhance the self-regulation of the corporate sector. Importantly, there is a trend toward the privatization of utilities such as water and energy, which enhances the recategorization of some public environmental protection expenditures as private [1]. The empirical evidence of the impact of privatization on environmental protection expenditures is at least ambiguous to date. Recent studies by Xing and Tan [9] indicated that, in the case of high marginal environmental damage, the impact of privatization on social welfare results in the environmental policy of public enterprises, as well as environmental tax rates. An increase in environmental protection expenditures and the improvement of the environment due to privatization proved to be more probable if the public corporate sector is less environmentally conscious. Conversely, with a stronger focus on environmental protection within state-owned enterprises, privatization may reduce environmental protection expenditures and, as a consequence, the quality of the environment. Those results, however, are highly diverse, depending on the level of development of the country and the industry/sector of the economy [10–14].

The main goal of the paper is to evaluate if environmental protection expenditures are used efficiently. Our research fills the gap in the empirical literature studied in Section 2, as we address the efficiency of environmental protection expenditures. Literature review, covering numerous scientific papers, indicates that environmental protection policy and expenditures are widely discussed issues, whereas the efficiency of expenditures on environmental protection has been a niche topic so far. The study presented in this article verifies the hypothesis that higher environmental protection expenditures do not result in better environmental results. The EU countries were selected for this analysis due to the fact that, in recent years, this region has become an informal world leader with respect to the implementation of policy measures in the field of environmental protection laws [15], especially after the withdrawal of former US president Trump from the Paris Agreement [16]. Fortunately, newly elected US president Biden announced a return to this pact in 2021. Environmental conservation and pollution prevention across the Member States fit into the EU's general strategy of green transformation under the European Green Deal, i.e., withdrawal from fossil fuels, which, in turn, translates into a reduction of emissions resulting from fossil fuel combustion and a reduction in dependence on external energy supplies. Energy policy cannot be considered in isolation from the environmental policy of the EU [17]. This complies with Allen et al. [18], who stressed the significant impact of energy policy on environmental protection and expenditures. The environmental policy of the EU, as a sectoral policy that relies on the division of competencies between the EU institutions and member states, has gained a lot of importance in recent years, which has translated into regulatory progress [19] and financial allocations in the field of climate policy, which actually links the environmental and energy policies of the EU. However, the climate and energy policies of the EU have become highly politicized since the global financial crisis 2007–2009 [20]. Among the key legislative initiatives of the EU addressing environmental policy, there were: the Lisbon Strategy (2000), Emission Trading Scheme (2005), Lisbon Treaty (2007), Climate and Energy Package (2009), Europe 2020 Strategy (2010), and European Green Deal (2019). Under the European Green Deal, the EU is expected to achieve carbon neutrality by 2050, which means net-zero greenhouse gases emissions, whereas by 2030 the EU commits itself to reducing those emissions by at least 55%, to increase the shares of renewable energy in gross final energy consumption up to 32% and to increase the ratio of energy efficiency up to 32.5% [17,21–25]. One of the flagship initiatives of the European Green Deal is the New EU Forest Strategy for 2030. Among the key priorities, there is the promotion of sustainable forest bioeconomy, the improvement of the quantity and quality of the EU forests and the re- and afforestation of biodiverse forests. Under this strategy, forests may significantly contribute to the reduction of greenhouse gas emissions by 2030 by 55%—according to estimations, up to 310 million tons of CO_2. The protection of existing forest areas and the planting of new ones (the EU pledges to plant 3 billion new trees) may, therefore, support actions against climate change, as well as several important nature-based economic sectors, i.e., agriculture, construction and food and drink. Forest policy is expected to positively impact the seafood and insurance industries, when considering, for instance, the conservation of marine stocks and the protection of coastal wetlands. The EU Member States are either high- or middle-income countries, more or less experienced with respect to reindustrialization and the resulting reorientation toward environmental-friendly industries, technologies and energy resources [2]. Thus, studies on the efficiency of environmental expenditures enable the formulation of recommendations in the name of the rationalization of the EU- and national-level sectoral policies in this field.

The rest of the paper is organized as follows. Section 2 presents a review of the literature regarding environmental protection expenditures studies. Section 3 describes methodology. Section 4 presents the data, results and discussion. Section 5 concludes this research.

2. Literature Review

The hypothesis of environmental Kuznets curve for environmental protection expenditures states that, at early stage, of economic transition, the quality of the environment tend to deteriorate but improves prospectively due to structural transformation and the rising expectations of the society resulting from the increase in income per capita [26]. Lopez et al. [5], next to income level, stressed the role of scale, composition and technique, with special regard to higher labor efficiency and increased human-capital-intensive activities, as determinants of government expenditures' impact on environmental pollution. Rising public expenditures result in higher redistributive transfers, which translate into increased income equality, then, higher expectations with respect to the quality of the environment [27]. In this regard, government expenditures are necessary to combat inequality if development in itself proves insufficient [28]. On the other hand, market forces do not provide effective solutions to inequality; therefore, there is a need for state activity [29]. This, in turn, translates into policy measures established by the advanced institutions that used to be scarce within the developing world [30–33]. The demand for environmental quality, when treated as luxury public good, can be satisfied through government expenditures when other public goods are already provided [3,4]. Environmental expenditures are expected to decline as the economy reorients itself to more environmentally friendly industries, technologies and energy resources. This, however, might result in the relocation of dirty industries from higher- to lower-income countries [34], while the accumulation of capital in the former group of countries may serve as a trigger for the development of environmental-friendly technologies. A reduction in government size may deteriorate the prosperity of the country [35,36]. Considering the indirect effect of the reduction of government expenditures on environmental protection through its impact on income, the reduction of the government size in developing countries may result in the deterioration of the quality of the environment [6]. Thus, the reduction of government expenditures in developing countries should be accompanied by the introduction of environmental regulations and standards, including the ratification of international environmental treaties. Contrarily, in the case of higher-income countries, i.e., the selected EU Member States, authors verified empirically that cutting government expenditures resulted in an improvement in both income and environmental quality, especially in the long-run [27].

Importantly, empirical studies on the environmental Kuznets curve hypothesis, i.e., [1,16,37–72], have delivered at least ambiguous results with respect to the correlation between the level of income per capita and environmental pollution, especially when considering one of the most important greenhouse gases contributing to climate change, i.e., carbon dioxide. This greenhouse gas accounting for more than 75 percent of total emissions resulting from human activities has been adopted as a measure of environmental degradation in the empirical verification of the environmental Kuznets curve hypothesis [58,64]. Carbon dioxide emissions were proven to increase due to financial development, as pointed out by, i.e., Pata [66] and Shahbaz et al. [73], as well as industrialization and urbanization processes, as analyzed by, i.e., Liu and Bae [74]. The reduction of carbon dioxide can be achieved through the adoption of fiscal expenditures aimed at the development of a low-carbon economy, improvement in energy efficiency and the optimization of energy structure [5,75,76]. From the global perspective, the impact of economic growth and energy structure, as well as population density, on regional and national carbon dioxide emission was studied by, among others, Hubacek et al. [77] and Chen et al. [78]; and from the national perspective, by Zhang et al. [79] and Chen et al. [78]; and from the micro-perspective by Cole et al. [80] and Xu et al. [81]. Whereas Omri et al. [82] and Wang et al. [83] adopted econometric modelling, Rhee et al. [84] and Cansino et al. [85] used input-output methods, and Nag and Parikh [86] and Tan et al. [87] used a factor decomposition approach.

Analyses dedicated to environmental expenditures in the context of carbon dioxide emissions and GDP were conducted for 19 African countries [54], China and India [62], Croatia [60], Malaysia [88], India [64], Turkey [66], Azerbaijan [89] and Eastern European countries [68]. Empirical studies on developed countries addressed the United States [58], Portugal and Spain [61] and the EU countries [44,47,49,50,52,53,56,70,90–93]. Several authors, Panayotou [94], Cole and Elliott [95], Dinda [96] and Tsurumi and Managi [97], analyzed the correlation between carbon dioxide emissions and trade liberalization processes in the context of the environmental Kuznets curve hypothesis. On the other hand, the empirical verification of the impact of renewable energy sources on ecological footprint, which is considered in our analysis next to carbon dioxide with respect to the efficiency of environmental expenditures, were studied across the EU Member States only by a few authors, i.e., Destek et al. [16], Menegaki and Tsagarakis [98].

Maneejuk et al. [70] has confirmed the environmental Kuznets curve hypothesis at the country-level only for 9 of 44 analyzed countries of the EU, OECD and G7 groupings. Interestingly, empirical studies by Pearce and Palmer [1], based on data from 1970s–1990s for OECD countries, pointed at no unambiguous upward trend with respect to the involvement of the private sector in environmental protection expenditures, with highly diversified country-level effects. Whereas several authors, i.e., Freeman [99,100], Hahn [101] and Portney [102], addressed the issue of the relative gains and costs of environmental regulations, there is relatively scarce literature on the budgetary costs of environmental protection in the context of government efficiency.

Ercolano and Romano [2] investigated environmental expenditures across 21 European countries (the selected EU Member States, United Kingdom, Iceland and Norway), using a sigma-convergence approach, followed by principal component and cluster analysis. As indicated by the authors, public environmental protection expenditures, as well as their composition within various initiatives and strategies, differ significantly across the countries. However, not only the level but also the efficiency of environmental expenditures should take into consideration the public spending in this field with environmental outcomes, such as greenhouse gas emissions and renewable energy development [103]. Due to the multidimensional character of public expenditures' impacts, it is useful to adopt composite indicators, such as the environmental performance index (EPI) for the purposes of policy analysis [104]. The fact is that EPI serves as an aggregate measure of the results of policies aimed at the improvement of environmental quality, built on measurable outcomes such as emissions or deforestation, instead of policy inputs, i.e. public expenditures programs. Ercolano and Romano [2] identified no significant bivariate correlation between EPI, public environmental expenditures in terms of GDP and GDP per capita. Authors denied the hypothesis of the convergence of public environmental expenditures across the European countries, with no important changes in the composition of spending in this field. This complied with results obtained by Apergis et al. [105], according to which there is no convergence across the EU Member States, irrespective of several global- and regional-level directives and strategies dedicated to environmental protection, i.e., Sustainable Development Goals, Paris Agreement, Europe 2020 Strategy and the European Green Deal. In fact, a study by Ercolano and Romano [2] proved to be one of the first empirical contributions to the academic debate on the efficiency of environmental expenditures by verifying a correlation between the size and composition of public environmental expenditures and selected environmental performances and results.

Empirical findings by Apergis et al. [105] proved to be in line with analyses by Ferreiro et al. [106,107], which actually pointed at divergence across the EU Member States with respect to the size and composition of environmental expenditures. In fact, there is no single model of fiscal policy that enables the boosting of economic growth, prosperity and social welfare, including environmental quality that impacts people's life assessment from country to country.

Halkos and Paizanos [6] investigated the public environmental expenditures of 77 countries in the years 1980–2000 and their direct and indirect impacts on the income level, as well as the impacts of income level on environmental pollution. Methodology was based on econometric modelling with panel analysis. The authors focused on the emissions of carbon dioxide and sulfur dioxide, indicating that, in the case of carbon dioxide, government spending had an insignificant direct impact on emissions per capita but a negative one with respect to indirect effects. The authors concluded that the reduction of government expenditures in higher-income countries increases both income and environmental quality, as already established environmental regulations and standards would diminish returns from further increases in government size. This, in turn, provides some analogy to the environmental Kuznets curve hypothesis.

Empirical analysis by Ullah et al. [108] considered the asymmetrical effects of fiscal policy on the quality of the environment across the ten Asian countries responsible for the largest carbon emissions, including China and India, as well as Turkey, Iran and Japan, in the years 1981–2018. The authors, using a non-linear autoregressive distributed lag approach, identified the negative impact of a positive shock in government expenditure on environmental quality in the case of, among others, China, India, Turkey and Thailand, while only in the case of Japan did it prove to be positive. On the other hand, only in the case of Japan did the quality of the environment deteriorate in the studied period, because of the reduction in government expenditures. Moreover, due to an increase in governmental income tax revenues, there was an increase in government expenditures, which, in turn, increased carbon emissions everywhere except for Japan, again. As argued by the authors, short-run asymmetric effects translated into long-run effects across most of the Asian countries.

Recently, several analyses dedicated to the impacts of environmental expenditures and their efficiency focused on China, the largest contributor to global carbon dioxide emissions. After nearly three decades of dynamic economic growth, China faces the challenges of structural adjustments and environmental efficiency [109,110]. Zhou and Zhang [111], using a data envelopment analysis (DEA) method, investigated the efficiency of fiscal policies aimed at environmental pollution control across 30 Chinese provinces in the years 2007–2017. Authors empirically proved an improvement in this field since 2014, with special regard to the eastern regions of the country. Analysis confirmed that the efficiency of fiscal policy in the environmental field was negatively impacted by fiscal expenditure decentralization, while in the case of fiscal revenue decentralization, this effect proved to be non-significant. It was recommended to increase public expenditures for environmental pollution control, as well as for the central transfer payment system for environmental protection.

3. Methods and Data

Data envelopment analysis (DEA), created by Farrell [112] and developed by Charnes et al. [113], is the main methodology used in this article. DEA allows the calculation of the maximum performance value for each decision-making unit (DMU) relative to all DMUs in the study. DEA methodology constructs the efficiency production frontier and distance from the frontier at the nearest point for each DMU [114]. It should be noted that DEA measures relative technical efficiency, and, therefore, efficient DMUs are best-practice frontiers rather than production frontiers [115]. Thus, DEA requires the careful interpretation of results. In DEA, variables that may duplicate information should be removed from the model [116].

DEA methodology can be divided into input- and output-oriented models. An input-oriented model assumes a proportional reduction in input, while outputs remain unchanged. By analogy, an output-oriented model undertakes a proportional increase in outputs, while the proportion of inputs remains unchanged [117]. Another division of the DEA methods is based on constant or variable returns to scale (CRS or VRS).

DEA calculates efficiency as the ratio of the weighted sum of outputs to the weighted sum of inputs [118]. The CRS model maximizes this ratio (see Equations (1)–(3)) [119]:

$$\mathrm{Max}\theta_0 = \frac{\sum_{r=1}^{s} u_r\, y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}, \tag{1}$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \tag{2}$$

$$u_r\,,\ v_i \geq 0;\ \forall r = 1, \ldots, s;\ i = 1, \ldots,\ m;\ j = 1, \ldots, n$$

where:

u_r—weight of output
v_i—weight of input
y_{rj}—output
x_{ij}—input

While VRS model use supplementary restriction equation [113]:

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{3}$$

where λ is the corresponding solution vector for the optimization, and n is the number of DMUs.

This linear programming problem can be solved according to two different approaches. In the first, weighted sums of outputs are maximized while keeping inputs constant (output-oriented model). In the second, the weighted sums of inputs are minimized while keeping the outputs constant (input-oriented model). The primary equations for each model, known as the multiplier form, are given below [120].

The CRS input-oriented model equation becomes:

$$\text{Minimize } \theta_k \tag{4}$$

Subject to

$$y_{rk} - \sum_{j=1}^{n} \lambda_j \, y_{rj} \le 0;\ r = 1, \ldots, s \tag{5}$$

$$\theta_k x_{ik} - \sum_{j=1}^{n} \lambda_j \, x_{ij} \ge 0;\ i = 1, \ldots, m \tag{6}$$

$$\lambda_j \ \ge \ 0; \forall j = 1, \ldots, n$$

The VRS input-oriented model equation becomes:

$$\text{Minimize } \theta_k \tag{7}$$

Subject to

$$y_{rk} - \sum_{j=1}^{n} \lambda_j \, y_{rj} \le 0;\ r = 1, \ldots, s \tag{8}$$

$$\theta_k x_{ik} - \sum_{j=1}^{n} \lambda_j \, x_{ij} \ge 0;\ i = 1, \ldots, m \tag{9}$$

$$\sum_{j=1}^{n} \lambda j = 1 \tag{10}$$

$$\lambda_j \ \ge \ 0; \forall j = 1, \ldots, n$$

There are numerous advantages to using DEA methodology. DEA can be used when the relationship between variables does not have a known mathematical function [121]. DEA is a flexible method that can be adapted to the data [122]. Moreover, multiple input and output variables in different units can be analyzed at the same time, without a priori information about the importance of particular variables [123]. Furthermore, the sources of inefficiency for analyzed units can be analyzed [117]. There are also some limitations. DEA does not analyze qualitative variables. The inclusion of a large number of input and output variables would reduce the discriminant power of DEA. Also, DEA is criticized for overestimating efficiency and providing information about dominant DMUs [121]. There is also a noticeable negative correlation between efficiency and the number of DMUs [124].

The presented research has some limitations. Firstly, the selected input and output variables and research periods were limited by the availability of international statistics. There were no available more up-to-date data for environment statistics for all analyzed countries. The available data was mainly until 2017; the latest statistics are missing in generally available databases. Only basic statistics for a selected group of countries is available. Some data, such as water pollution, are incomplete or unavailable for all years and countries, and therefore, they had to be removed from the model. Consequently, the analysis would be more complex if this study analyzed additional indicators, such as the effects of all actions covered by environmental protection expenditures, i.e., the protection of ambient air and climate; wastewater management; waste management; the protection and remediation of soil, groundwater and surface water; noise and vibration abatement; protection of biodiversity and landscapes; protection against radiation; research and development and other environmental protection activities. However, a lack of data in some statistics prevented us from creating a comparable dataset. The possibility of using the model aggregate input variable with specific output variables is one of the main advantages of DEA methodology, which allows us to calculate effectiveness without specifying the mathematical form of the production function. On the other hand, this might be treated as one of the limitations of our study. Introducing to the model all possible combinations of specific inputs and outputs would provide a more general picture of environmental conditions in the analyzed countries; however, simultaneously, it would cause a reduction in the discriminatory power of the DEA. Adding variables to a DEA model will result in higher efficiency scores and an expanded set of efficient DMUs. Therefore, in our analysis, we have followed the principle that the number of variables should be less than one-third of the DMUs. In this research, the DEA assessment was performed for the selected group of 30 countries. Expanding the research objects may cause effective DMUs to become ineffective comparing to the new object group. The analysis of a more extended period could bring more general conclusions and recommendations for environmental policies. An additional challenge is the correctness of the environmental outcomes and the indication of the proper time lag between inputs and outputs. In our study, there were no abrupt changes in spending in the EU countries. If they were increasing, they were increasing proportionally. Thanks to this, we would obtain very similar results if we waited, for example, two or three years for the effects. It is also worth noting that the effects are faster in some countries than in others. Therefore, the authors adopted the principle that they would not use time-lag. Our analysis does not take into account differences in energy demand or the favorability of the conditions and capabilities of countries to invest in renewable energy. On the one hand, northern European countries have better natural conditions for renewable energy production, in particular wind and water power, but on the other hand, due to climate, their demand for energy is higher. Southern European countries have warmer climate, as a consequence, demand less electricity and enjoy better conditions for solar energy production. We need to highlight also that the selected research period includes the subprime crisis, which caused an economic downturn in several EU countries and, consequently, lower funding for environmental protection.

In our research, diagnostic variables were selected based on available data from the Eurostat and World Bank. Input indicators are environmental protection expenditures (as % of GDP), represented by EPE. Expenditure for environmental protection consists of outlays and other transactions related to:

- inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, the consumption of fixed capital);
- capital formation and the buying of land (investment) for environmental protection activities;
- users' outlays for buying environmental protection products;
- transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection, etc.).

More than half of the environmental protection expenditure is incurred by corporations, the rest by the general government, non-profit institutions serving households and households. However, it is worth mentioning that corporations and households environmental expenditures are directly and indirectly derived from government-imposed regulations and rules.

The three output indicators chosen for analysis were as follows: (a) forest area, (b) renewable electricity output, (c) CO_2 emissions. The below principle was followed with respect to the selection of variables [125].

$$n \geq 3(s + m) \quad (11)$$

where:

s—number of inputs
m—number of outputs
n—numbers of DMUs

Table 1 presents a set of variables. In the DEA method, a positive relationship between inputs and outputs is assumed. Therefore, as in our case, the non-desirable output of CO_2 emissions (destimulant) was transformed into desirable (stimulant) with the following transform:

$$X_{ij}^{S} = 1 - \frac{X_{ij}^{D}}{\max_i X_{ij}^{D}}$$

Table 1. Indicators and Sources.

Variable	Indicator Name	Units	Source
Input—EPE	Environmental protection expenditure	(% GDP)	Eurostat, 2021 [126]
Output 1—FA	Forest area	(% of land area)	World Bank, 2021 [127]
Output 2—REO	Renewable electricity output	(% of total electricity output)	World Bank, 2021 [127]
Output 3—COE	CO_2 emissions	(metric tons per capita)	World Bank, 2021 [127]

4. Results and Discussion

Calculations for the purposes of the examination of the relationship between environmental protection expenditures and environmental results were performed in DeaFrontier Software. The research covers 30 European countries and the period from 2005 to 2015. Due to the limitation of article length, authors present only the sample data for the input and output indicators for one year, 2015, in Table 2.

Table 2. Diagnostic set of input and output data—European countries in 2015. Source: World Bank [127], Eurostat [126].

2015	Country/Indicators	EPE	FA	REO	COE
1	AUT	0.40	46.88	76.49	0.56
2	BEL	1.30	22.76	20.80	0.46
3	BGR	0.80	35.22	17.99	0.62
4	CHE	0.60	31.73	62.20	0.73
5	CYP	0.40	18.69	8.78	0.67
6	CZE	1.10	34.54	11.40	0.42
7	DEU	0.60	32.73	29.23	0.45
8	DNK	0.40	14.58	65.51	0.67
9	ESP	0.90	36.86	34.95	0.67
10	EST	0.70	51.35	14.42	0.23
11	FIN	0.20	73.11	44.50	0.52
12	FRA	1.00	31.03	15.86	0.72
13	GBR	0.80	13.00	24.84	0.62
14	GRC	1.50	31.45	28.66	0.63
15	HRV	0.70	34.35	66.83	0.75
16	HUN	1.20	22.85	10.58	0.72
17	IRL	0.40	10.95	27.97	0.53
18	ISL	0.60	0.49	99.98	0.63
19	ITA	0.90	31.61	38.68	0.68
20	LTU	0.50	34.80	39.41	0.72
21	LVA	0.70	53.97	50.17	0.78
22	MLT	1.90	1.09	7.67	0.78
23	NLD	1.40	11.16	12.44	0.37
24	NOR	0.90	33.17	97.71	0.44
25	POL	0.60	30.81	13.80	0.54
26	PRT	0.60	34.74	47.53	0.71
27	ROU	1.00	29.82	39.75	0.78
28	SVK	0.90	40.35	22.68	0.64
29	SVN	1.00	61.96	29.39	0.63
30	SWE	0.40	68.92	63.26	0.76

Note: AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia. EPE—environmental protection expenditure (% GDP), FA—forest area (% of land area), REO—renewable electricity output (% of total electricity output), COE—CO_2 emissions (metric tons per capita).

An input-oriented model is used in the analysis, as most of the environmental protection strategies focus more on inputs than on outputs. The authors used both CRS and VRS models to avoid overestimation. As pointed out by [128,129], using only the VRS model may ignore subsets of proportional inputs and outputs. Therefore the authors used both the CRS and VRS models and then the average efficiency index. The results are presented in Tables 3 and 4.

Table 3. Input-Oriented CRS Efficiency of EPS in 2015. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	Input-Oriented CRS Efficiency	$\sum\lambda$	RTS	Benchmarks	DMU
1	AUT	0.859	1.719	Decreasing	1.719	FIN
2	BEL	0.135	0.878	Increasing	0.878	FIN
3	BGR	0.296	1.182	Decreasing	1.182	FIN
4	CHE	0.469	1.410	Decreasing	1.410	FIN
5	CYP	0.647	1.294	Decreasing	1.294	FIN
6	CZE	0.146	0.800	Increasing	0.800	FIN
7	DEU	0.289	0.867	Increasing	0.867	FIN
8	DNK	0.736	1.472	Decreasing	1.472	FIN
9	ESP	0.285	1.281	Decreasing	1.281	FIN
10	EST	0.201	0.702	Increasing	0.702	FIN
11	FIN	1.000	1.000	Constant	1.000	FIN
12	FRA	0.276	1.378	Decreasing	1.378	FIN
13	GBR	0.296	1.184	Decreasing	1.184	FIN
14	GRC	0.161	1.208	Decreasing	1.208	FIN
15	HRV	0.429	1.502	Decreasing	1.502	FIN
16	HUN	0.231	1.385	Decreasing	1.385	FIN
17	IRL	0.508	1.016	Decreasing	1.016	FIN
18	ISL	0.749	2.247	Decreasing	2.247	FIN
19	ITA	0.288	1.296	Decreasing	1.296	FIN
20	LTU	0.554	1.386	Decreasing	1.386	FIN
21	LVA	0.428	1.500	Decreasing	1.500	FIN
22	MLT	0.157	1.488	Decreasing	1.488	FIN
23	NLD	0.102	0.716	Increasing	0.716	FIN
24	NOR	0.488	2.196	Decreasing	2.196	FIN
25	POL	0.343	1.030	Decreasing	1.030	FIN
26	PRT	0.452	1.357	Decreasing	1.357	FIN
27	ROU	0.298	1.491	Decreasing	1.491	FIN
28	SVK	0.275	1.237	Decreasing	1.237	FIN
29	SVN	0.240	1.201	Decreasing	1.201	FIN
30	SWE	0.729	1.458	Decreasing	1.458	FIN

Note: DMU—decision-making unit, $\sum\lambda$—Lambda sum, Unit, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table 4. Input-Oriented VRS Efficiency of EPS in 2015. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	Input-Oriented VRS Efficiency	Benchmarks	DMU	Lambda	DMU	Lambda	DMU
1	AUT	1.000	1.000	AUT				
2	BEL	0.154	1.000	FIN				
3	BGR	0.349	0.602	FIN	0.398	SWE		
4	CHE	0.640	0.032	AUT	0.079	FIN	0.888	SWE
5	CYP	0.821	0.359	FIN	0.641	SWE		
6	CZE	0.182	1.000	FIN				
7	DEU	0.333	1.000	FIN				
8	DNK	0.941	0.336	AUT	0.117	FIN	0.547	SWE
9	ESP	0.359	0.386	FIN	0.614	SWE		
10	EST	0.286	1.000	FIN				

Table 4. *Cont.*

DMU No.	DMU Name	Input-Oriented VRS Efficiency	Benchmarks	DMU	Lambda	DMU	Lambda	DMU
11	FIN	1.000	1.000	FIN				
12	FRA	0.365	0.175	FIN	0.825	SWE		
13	GBR	0.350	0.599	FIN	0.401	SWE		
14	GRC	0.194	0.545	FIN	0.455	SWE		
15	HRV	0.598	0.007	AUT	0.095	ISL	0.898	SWE
16	HUN	0.307	0.159	FIN	0.841	SWE		
17	IRL	0.518	0.964	FIN	0.036	SWE		
18	ISL	1.000	1.000	ISL				
19	ITA	0.366	0.354	FIN	0.646	SWE		
20	LTU	0.737	0.157	FIN	0.843	SWE		
21	LVA	1.000	1.000	LVA				
22	MLT	0.324	0.722	LVA	0.278	SWE		
23	NLD	0.143	1.000	FIN				
24	NOR	1.000	1.000	-				
25	POL	0.355	0.934	FIN	0.066	SWE		
26	PRT	0.593	0.222	FIN	0.778	SWE		
27	ROU	0.636	0.786	LVA	0.214	SWE		
28	SVK	0.337	0.482	FIN	0.518	SWE		
29	SVN	0.288	0.561	FIN	0.439	SWE		
30	SWE	1.000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

The authors also calculated the efficiency of spending on environmental protection expenditure for an additional ten years (2005–2015). A similar technique was carried out separately for each year. The results of this analysis are presented in Tables 5–7 and in Appendix A from Tables A1–A20.

Table 5. Input-Oriented CRS Efficiency of Environmental Protection Expenditure in 2005–2015. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	Avr
1	FIN	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	0.99
2	ISL	0.75	1.00	1.00	0.82	1.00	0.91	0.52	1.00	1.00	0.89	0.88	0.89
3	CYP	0.65	1.00	1.00	0.85	0.92	0.83	0.51	1.00	1.00	1.00	0.86	0.87
4	AUT	0.86	1.00	1.00	0.73	0.79	0.60	0.45	0.93	0.98	0.88	0.87	0.83
5	SWE	0.73	1.00	0.78	0.58	0.85	0.87	0.51	0.89	0.98	0.93	0.82	0.81
6	NOR	0.49	0.74	0.62	0.60	0.73	0.65	0.38	1.00	1.00	1.00	1.00	0.75
7	LVA	0.43	0.60	0.57	0.47	0.48	1.00	1.00	0.62	0.60	0.72	0.72	0.65
8	CHE	0.47	0.69	0.62	0.49	0.55	0.52	0.29	0.90	0.83	0.64	0.58	0.60
9	HRV	0.43	0.82	0.58	0.48	0.52	0.57	0.26	0.72	0.72	0.75	0.67	0.59
10	DNK	0.74	0.77	0.61	0.62	0.65	0.56	0.37	0.66	0.65	0.48	0.40	0.59
11	ROU	0.30	0.50	0.39	0.36	0.36	0.37	0.32	0.82	1.00	1.00	1.00	0.58
12	PRT	0.45	0.71	0.54	0.48	0.45	0.41	0.30	0.58	0.69	0.57	0.49	0.52
13	LTU	0.55	0.63	0.62	0.35	0.45	0.22	0.16	0.47	0.42	0.47	0.52	0.44
14	HUN	0.23	0.28	0.25	0.40	0.44	0.47	0.31	0.60	0.58	0.49	0.47	0.41
15	DEU	0.29	0.41	0.35	0.33	0.38	0.35	0.23	0.58	0.59	0.48	0.41	0.40
16	POL	0.34	0.44	0.33	0.37	0.35	0.32	0.21	0.44	0.51	0.43	0.44	0.38
17	SVN	0.24	0.35	0.43	0.29	0.32	0.42	0.26	0.41	0.45	0.45	0.39	0.37
18	ITA	0.29	0.40	0.33	0.28	0.30	0.31	0.20	0.42	0.47	0.46	0.32	0.34
19	EST	0.20	0.30	0.30	0.16	0.72	0.75	0.25	0.22	0.27	0.35	0.27	0.34
20	BGR	0.30	0.44	0.27	0.36	0.39	0.38	0.16	0.48	0.28	0.29	0.41	0.34

Table 5. *Cont.*

DMU No.	DMU Name	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	Avr
21	SVK	0.27	0.40	0.28	0.28	0.35	0.28	0.18	0.43	0.51	0.34	0.26	0.33
22	FRA	0.28	0.33	0.24	0.27	0.30	0.27	0.18	0.41	0.40	0.39	0.31	0.31
23	IRL	0.51	0.47	0.36	0.28	0.32	0.22	0.12	0.26	0.27	0.30	0.24	0.30
24	ESP	0.28	0.40	0.34	0.26	0.29	0.24	0.15	0.35	0.34	0.33	0.30	0.30
25	GBR	0.30	0.36	0.25	0.29	0.30	0.23	0.15	0.33	0.32	0.31	0.17	0.27
26	GRC	0.16	0.20	0.15	0.21	0.29	0.30	0.16	0.33	0.37	0.38	0.41	0.27
27	BEL	0.14	0.17	0.12	0.13	0.15	0.16	0.13	0.27	0.34	0.33	0.27	0.20
28	CZE	0.15	0.21	0.19	0.14	0.16	0.19	0.18	0.28	0.25	0.23	0.20	0.20
29	MLT	0.16	0.20	0.14	0.18	0.22	0.14	0.11	0.22	0.20	0.21	0.19	0.18
30	NLD	0.10	0.14	0.10	0.12	0.12	0.11	0.07	0.17	0.17	0.17	0.13	0.13

Note: DMU—decision-making unit, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table 6. Input-Oriented VRS Efficiency of Environmental Protection Expenditure in 2005–2015. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	Average
1	FIN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	ISL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	LVA	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	NOR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	SWE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	CYP	0.82	1.00	1.00	1.00	1.00	1.00	0.67	1.00	1.00	1.00	1.00	0.95
7	AUT	1.00	1.00	1.00	1.00	0.85	0.69	0.63	0.98	1.00	0.89	0.87	0.90
8	ROU	0.64	0.87	0.86	0.76	0.66	0.38	0.33	1.00	1.00	1.00	1.00	0.77
9	HRV	0.60	1.00	0.91	0.98	0.88	0.59	0.29	0.82	0.72	0.85	0.73	0.76
10	CHE	0.64	0.74	0.77	0.88	0.87	0.52	0.33	1.00	0.96	0.69	0.62	0.73
11	DNK	0.94	0.79	0.62	0.94	0.80	0.75	0.50	0.68	0.67	0.52	0.50	0.70
12	PRT	0.59	0.79	0.81	0.94	0.79	0.43	0.33	0.68	0.70	0.58	0.50	0.65
13	LTU	0.74	0.72	0.96	0.65	0.78	0.23	0.17	0.65	0.55	0.66	0.69	0.62
14	HUN	0.31	0.41	0.53	0.76	0.70	0.50	0.33	0.75	0.63	0.53	0.50	0.54
15	DEU	0.33	0.50	0.42	0.33	0.39	0.50	0.33	0.60	0.61	0.50	0.50	0.46
16	EST	0.29	0.43	0.37	0.22	1.00	1.00	0.25	0.27	0.33	0.37	0.33	0.44
17	POL	0.36	0.50	0.37	0.40	0.37	0.43	0.29	0.44	0.52	0.43	0.50	0.42
18	SVN	0.29	0.35	0.50	0.40	0.39	0.43	0.27	0.45	0.49	0.50	0.44	0.41
19	ITA	0.37	0.41	0.35	0.39	0.36	0.38	0.25	0.44	0.47	0.47	0.38	0.39
20	BGR	0.35	0.44	0.30	0.48	0.45	0.43	0.18	0.55	0.30	0.31	0.43	0.38
21	FRA	0.37	0.39	0.27	0.46	0.46	0.30	0.20	0.49	0.42	0.41	0.33	0.37
22	SVK	0.34	0.41	0.30	0.39	0.41	0.33	0.22	0.47	0.53	0.36	0.27	0.37
23	IRL	0.52	0.50	0.40	0.31	0.35	0.30	0.18	0.27	0.30	0.33	0.33	0.34
24	ESP	0.36	0.40	0.40	0.38	0.37	0.27	0.18	0.37	0.34	0.34	0.33	0.34
25	GBR	0.35	0.38	0.28	0.32	0.32	0.30	0.20	0.33	0.33	0.33	0.21	0.31
26	GRC	0.19	0.21	0.15	0.24	0.32	0.38	0.22	0.33	0.38	0.39	0.50	0.30
27	CZE	0.18	0.27	0.23	0.15	0.16	0.30	0.29	0.33	0.30	0.27	0.27	0.25
28	BEL	0.15	0.21	0.15	0.14	0.16	0.25	0.20	0.30	0.37	0.37	0.38	0.24
29	MLT	0.32	0.20	0.14	0.21	0.26	0.16	0.13	0.27	0.21	0.23	0.21	0.21
30	NLD	0.14	0.21	0.14	0.13	0.13	0.19	0.12	0.20	0.20	0.20	0.20	0.17

Note: DMU—decision-making unit, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table 7. Efficiency Ranking for European Countries. Source: Authors' calculations in DEAFrontier; European Commission [130].

DMU Name	CRS Average	VRS Average	CRS Rank	VRS Rank	AVG Effectiveness Index	Rank	EU Funds Absorption (%)
FIN	0.991	1.000	1	1	1.00	1	94.98
ISL	0.888	1.000	2	1	0.94	2	-
CYP	0.874	0.953	3	6	0.91	3	91.93
SWE	0.813	1.000	5	1	0.91	4	94.71
NOR	0.747	1.000	6	1	0.87	5	-
AUT	0.827	0.901	4	7	0.86	6	89.08
LVA	0.654	1.000	7	1	0.83	7	95.00
ROU	0.583	0.772	11	8	0.68	8	70.87
HRV	0.592	0.761	9	9	0.68	9	58.57
CHE	0.597	0.730	8	10	0.66	10	-
DNK	0.592	0.701	10	11	0.65	11	95.00
PRT	0.516	0.648	12	12	0.58	12	94.98
LTU	0.442	0.619	13	13	0.53	13	94.93
HUN	0.410	0.541	14	14	0.48	14	88.37
DEU	0.400	0.456	15	15	0.43	15	91.80
POL	0.380	0.418	16	17	0.40	16	94.86
EST	0.344	0.443	19	16	0.39	17	95.00
SVN	0.365	0.410	17	18	0.39	18	95.00
ITA	0.344	0.387	18	19	0.37	19	78.97
BGR	0.341	0.383	20	20	0.36	20	85.24
SVK	0.328	0.368	21	22	0.35	21	84.36
FRA	0.308	0.373	22	21	0.34	22	92.12
IRL	0.303	0.345	23	23	0.32	23	89.96
ESP	0.299	0.341	24	24	0.32	24	84.07
GBR	0.274	0.306	25	25	0.29	25	88.01
GRC	0.270	0.301	26	26	0.29	26	98.09
CZE	0.197	0.251	28	27	0.22	27	84.13
BEL	0.201	0.244	27	28	0.22	28	93.06
MLT	0.179	0.214	29	29	0.20	29	81.61
NLD	0.127	0.169	30	30	0.15	30	86.54

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, CRS—Constant Returns to Scale, AVG—Average, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Among the analyzed European economies, only Finland was efficient in the CRS model in 2015. Other countries may improve their efficiency by decreasing their environmental protection expenditures. In 2015, the Netherlands achieved the worst results (0.102), and, to become effective, it should receive the same results with inputs that are lower by 88.8% (1–0.102). Moreover, DEA methodology point out benchmarks (BDMUs), whose environmental strategies, policies and best practices may be a good pattern for ineffective DMUs, to improve their efficiency results. Finland is a benchmark for all other countries, which requires a closer look at the strategies and programs of environmental protection applied in that country. DEA, also, allows to recognize character of return to scale. In our case, most of the countries have decreasing returns to scale. Constant—optimal returns-to-scale (RTS) are seen only in Finland. Belgium, the Czech Republic, the Netherlands, Spain and Germany, which all have an increasing RTS.

Six countries are efficient under the VRS model: Austria, Finland, Iceland, Latvia, Norway and Sweden—mainly Nordic countries. Similarly to the CRS model, the Netherlands obtained the worst result (0.143). In general, more economies are efficient under the VRS than the CRS methodology.

The final efficiency index was calculated as the average of the CRS and VRS efficiency based on data from Tables 5 and 6. The ranking of the most efficient countries is presented in Table 7. According to the presented ranking, Finland is the most efficient country.

Finland was an efficient DMU in both the CRS and VRS models for the whole analyzed period. Iceland, Norway, Sweden and Latvia (1.00) are efficiency frontiers in the VRS model. Twelve out of thirty economies gained a score higher than average 0.52 in average innovation efficiency index, while the remaining eighteen economies gained scores lower. The Netherland's low place in the ranking may be surprising as this country spends on environmental protection a relatively higher percentage of GDP than other countries in the Europe on environmental protection. The hypothesis about the non-proportional relation between higher environmental protection expenditures and environmental outputs has not been confirmed. From the interpretation of the results, it is essential to emphasize that the DEA methodology calculates relative efficiency, in the study group of countries, and investigates the degree to which environmental protection funds have been converted into environmental outputs.

Some spikes in CRS and VRS efficiencies were caused by unforeseen events. In 2013, one of Belgium's lime plants operated without oxygen and, as a result, in the following year, the efficiency of spending on environmental protection expenditure in Belgium increased from 0.12 to 0.17 (CRS) and from 0.15 to 0.21 (VRS), which was partly due to the elimination of a problem from a previous year, rather than an actual improvement caused by the efficient spending of available funds.

As can be observed in the case of Bulgaria and Romania, two EU Member States since 2007, a sudden increase in funds for environmental purposes may result in their inefficient use. Romania spent the available funds efficiently in the years before its accession to the EU (VRS and CRS equal to 1), only to experience a decline in subsequent years to 0.82 in 2008 and 0.32 in 2009 (Table 5). In the case of VRS, the change is noticeable starting from 2009. In 2013, Croatia joined the European Union, and, in the second year after joining, a significant decrease in CRS (2013—0.58; 2014—0.82; 2015—0.43) and VRS (2013—0.91; 2014—1; 2015—0.6) values was observed.

A comparison of the ranking of countries in Table 7 and data on the absorption of EU funds in 2015 provides interesting insights. The absorption rate of the EU Cohesion Policy Funds (European Regional Development Fund, Cohesion Fund and European Social Fund) show the percentage paid to each Member State compared to the total available budget. Countries that have absorbed less than 90% of the funds available to them are: Ireland (rank 23), Hungary (rank 14), UK (rank 25), Netherlands (rank 30), Bulgaria (rank 20), Slovakia (rank 21), Czech Republic (rank 27), Spain (rank 24), Malta (rank 29) and Italy (rank 19). Two cases in particular are worth mentioning. Romania (place 8) has the second-worst absorption rate in the whole EU (less than 71%; the third-worst belongs to Italy, with almost 79%). Such a high ranking with such a low absorption rate is caused by taking into account data from before Romania's accession to the EU. At the opposite end of the spectrum is Greece (rank 26), which has the highest absorption rate (over 98%, 3% higher than the second-best country). This may indicate that inefficiency can be caused not only by the low absorption of funds but also by the fact that the rush to absorb funds can lead to the insufficient consideration of value for money, poor quality of governance and the selection of projects for funding.

Further study of the impact of accession on the efficiency of environmental protection expenditure by comparing the values of CRS and VRS one and two years after the accession of 10 new countries in 2004 to the values of these measures in 2015 reveals that:

- CRS values in 2015 decreased compared to 2005 in 8 of the 10 countries and for VRS in 6 of the 10 countries,
- CRS values in 2015 decreased compared to 2006 in 9 of 10 countries and for VRS in 7 of 10 countries

The thirteen EU countries that joined the EU in 2004, 2007 and 2013 were ranked below the EU average with respect to GDP per capita. However, environmental protection investment in those countries proved to be less efficient than in the case of higher-income Member States, irrespective of the significance of those expenditures for the improvement of environmental quality, life expectancy and related indicators of socioeconomic development, for instance, in Central and Eastern Europe (CEE). CEE countries are heavily affected by the impacts of climate changes, as well as air and noise pollution, on environmental quality and human health when compared to Western Europe. Countries like Poland and Czech Republic are characterized by a concentration of heavy industries and the coal-based energy sector. Both economic development and enforcement have impeded environmental protection investment in CEE [131]. These observations cause one to wonder whether simply comparing the planned budget with its execution is sufficient to assess the performance of individual countries. Our findings are in line with the environmental Kuznets curve, which suggests that economic development initially leads to deterioration in environmental quality, but, after reaching a certain level of economic growth and development, environmental degradation decreases. As argued by Berg et al. [132], in the case of lower income and developing countries, the so-called marginal efficiency, resulting from an increase in public investment, including environmental protection expenditures, generate relatively smaller output multipliers (lower than 1) due to general capital scarcity and historical inefficiencies. The latter involves, among others, lower institutional capacity, governance quality and infrastructure and supply bottlenecks, as well as corruption [133]. Annual reports published by the European Anti-Fraud Office (OLAF) [134] confirm that the problem of fraud of the EU structural funds is more and more significant, with rising number of investigations conducted every year, mostly addressing CEE countries and Italy. The other problems related to the issue, especially in the CEE region are: the selection of contractors under government procurement, budgetary constraints to satisfy national contribution to the project and a heavy reliance on public funds in environmental spending in general.

5. Conclusions

Our analysis confirmed the problem of the deteriorating efficiency of environmental expenditures across the selected EU Member States, caused by an increase in spending, whereas Halkos and Paizanos [27] suggested that the reduction of environmental expenditures in higher-income countries, such as the countries of the EU, led to an improvement in environmental quality and an increase in income. This, in turn, supports the argument that, after reaching a given level of income and economic development, environmental quality improves due to rising social pressure to boost spending in this field; however, an increase in environmental expenditures doesn't have to translate into proportional results in terms of their efficiency from country to country, year after year. In other words, continuous increases in government size provide diminishing returns [6]. Therefore, environmental expenditures have to be confronted with environmental outcome to consider efficiency, not only the level of spending on this sectoral policy [103]. The European Green Deal requires dedicated environmental expenditures to achieve the far-reaching goal of carbon neutrality [6,75,76]. The problem of carbon dioxide emissions within the single market of the EU, complies with studies by Panayotou [94], Cole and Elliott [95], Dinda [96] and Tsurumi and Managi [97] with respect to the positive correlation between emissions and the degree of trade liberalization, which, in turn, translates into trade creation and diversion effects. Similar to the case of analysis of the EU countries [16,42,44,46,47,49–52,56,57,70], the environmental Kuznets curve hypothesis can be confirmed at the region-level; however, across the selected Member States, results were diversified. For instance, higher-income EU countries relocated dirty industries to lower-income countries, increasing the income and degree of industrialization without the deterioration of environmental quality, as the aforementioned hypothesis assumed. The diversity of environmental outcomes and the efficiency of expenditures proved to vary among the EU Member States due to the diversified approaches and strategies of environmental protection and pollution reduction, which confirms conclusions by Ercolano and Romano [2], based on studies of selected EU Member States. Our research indicated the lack of convergence of public environmental expenditures across the EU Member States, which complies with results achieved by Ercolano and Romano [2], Apergis et al. [105] and Ferreiro et al. [106,107]. The recognition of the positive impact of an increase of shares of renewables in final energy consumption supports the empirical findings by Destek et al. [16] that environmental degradation requires a reorientation from fossil-fuels-based growth policies across the Member States. Therefore, EU policymakers are expected to introduce legislative measures to enhance the production of renewable energy, while discouraging non-renewable sources, including dedicated subsidization and tax schemes.

The European Union, when assessing environmental protection expenditures, should focus on the merits of such investments, with particular emphasis on the expected environmental effects. This would result in reports comparing the ratio of expected to achieved environmental effects. Such data would provide more valuable information and conclusions than a simple comparison of planned budget with its execution. The distribution of European funds should depend more on the efficiency of use of those funds, as opposed to the current situation. Inefficient countries should not be punished, but the period of time dedicated to the use of funds should be extended and divided into smaller sub-periods, to avoid motivating politicians in these countries to absorb funds quickly (inefficiently) to serve propaganda purposes. The re-examination of environmental expenditures with a goal of potentially finding and eliminating those expenditures whose classification in that group is not justified due to negligible or no impact at all on the quality of the environment in terms of its protection and the protection of human health. The limitation of the funds allocated for environmental protection might enhance competition among ideas for environmental expenditures.

Our research has some limitations, and they were discussed in the Section 3.

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Appendix A

Table A1. Input-Oriented CRS Efficiency of EPS in 2014. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	1.00000	1.000	Constant	1.000	AUT				
2	BEL	0.17364	0.730	Increasing	0.487	CYP	0.242	SWE		
3	BGR	0.44212	1.032	Decreasing	0.742	CYP	0.290	FIN		
4	CHE	0.68649	1.014	Decreasing	0.032	ISL	0.982	SWE		
5	CYP	1.00000	1.000	Constant	1.000	CYP				
6	CZE	0.21137	0.775	Increasing	0.407	CYP	0.368	FIN		
7	DEU	0.40879	0.672	Increasing	0.234	CYP	0.437	SWE		
8	DNK	0.77316	0.907	Increasing	0.119	ISL	0.787	SWE		
9	ESP	0.40058	0.975	Increasing	0.295	CYP	0.680	SWE		
10	EST	0.30104	0.702	Increasing	0.702	FIN				
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.33406	1.072	Decreasing	0.864	CYP	0.083	FIN	0.124	SWE
13	GBR	0.36340	0.881	Increasing	0.616	CYP	0.265	SWE		
14	GRC	0.20405	0.899	Increasing	0.536	CYP	0.363	SWE		
15	HRV	0.82231	1.077	Decreasing	0.313	ISL	0.763	SWE		
16	HUN	0.27595	1.085	Decreasing	1.028	CYP	0.057	SWE		
17	IRL	0.46811	0.807	Increasing	0.418	CYP	0.389	SWE		
18	ISL	1.00000	1.000	Constant	1.000	ISL				
19	ITA	0.40045	0.951	Increasing	0.200	CYP	0.751	SWE		
20	LTU	0.62864	1.029	Decreasing	0.344	CYP	0.685	SWE		
21	LVA	0.60262	1.086	Decreasing	0.126	CYP	0.960	SWE		
22	MLT	0.19769	0.988	Increasing	0.988	CYP				
23	NLD	0.13844	0.598	Increasing	0.455	CYP	0.143	SWE		
24	NOR	0.74448	1.110	Decreasing	0.704	AUT	0.406	ISL		
25	POL	0.44305	0.886	Increasing	0.626	CYP	0.261	FIN		
26	PRT	0.70971	1.025	Decreasing	0.080	ISL	0.945	SWE		
27	ROU	0.49965	1.102	Decreasing	0.410	CYP	0.692	SWE		
28	SVK	0.40421	1.022	Decreasing	0.619	CYP	0.236	FIN	0.167	SWE
29	SVN	0.34685	1.046	Decreasing	0.241	CYP	0.474	FIN	0.331	SWE
30	SWE	1.00000	1.000	Constant	1.000	SWE				

Note: DMU—decisio-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A2. Input-Oriented VRS Efficiency of EPS in 2014. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	1.00000	1.000	AUT				
2	BEL	0.21429	0.687	CYP	0.313	FIN		
3	BGR	0.44393	0.691	CYP	0.201	FIN	0.108	SWE
4	CHE	0.74066	0.125	HRV	0.065	LVA	0.810	SWE
5	CYP	1.00000	1.000	CYP				

Table A2. *Cont.*

DMU No	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
6	CZE	0.27273	0.709	CYP	0.291	FIN		
7	DEU	0.50000	0.398	CYP	0.602	FIN		
8	DNK	0.78547	0.165	AUT	0.238	FIN	0.597	SWE
9	ESP	0.40295	0.297	CYP	0.077	FIN	0.627	SWE
10	EST	0.42857	1.000	FIN				
11	FIN	1.00000	1.000	FIN				
12	FRA	0.38855	0.115	CYP	0.885	SWE		
13	GBR	0.37623	0.623	CYP	0.367	FIN	0.010	SWE
14	GRC	0.20984	0.541	CYP	0.311	FIN	0.148	SWE
15	HRV	1.00000	1.000	HRV				
16	HUN	0.40620	0.291	LVA	0.709	SWE		
17	IRL	0.50000	0.442	CYP	0.558	FIN		
18	ISL	1.00000	1.000	ISL				
19	ITA	0.40514	0.203	CYP	0.151	FIN	0.646	SWE
20	LTU	0.71938	0.105	LVA	0.895	SWE		
21	LVA	1.00000	1.000	LVA				
22	MLT	0.20000	1.000	CYP				
23	NLD	0.21429	0.871	CYP	0.129	FIN		
24	NOR	1.00000	1.000	NOR				
25	POL	0.50000	0.779	CYP	0.221	FIN		
26	PRT	0.78536	0.274	HRV	0.054	LVA	0.671	SWE
27	ROU	0.86903	0.984	LVA	0.016	SWE		
28	SVK	0.40532	0.583	CYP	0.174	FIN	0.243	SWE
29	SVN	0.34868	0.168	CYP	0.346	FIN	0.487	SWE
30	SWE	1.00000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A3. Input-Oriented CRS Efficiency of EPS in 2013. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	1.00000	1.000	Constant	1.000	AUT				
2	BEL	0.12063	0.776	Increasing	0.072	AUT	0.589	CYP	0.115	FIN
3	BGR	0.26565	1.054	Decreasing	0.002	AUT	0.774	CYP	0.278	FIN
4	CHE	0.61691	1.133	Decreasing	0.718	AUT	0.414	CYP		
5	CYP	1.00000	1.000	Constant	1.000	CYP				
6	CZE	0.18907	0.759	Increasing	0.386	CYP	0.373	FIN		
7	DEU	0.35291	0.776	Increasing	0.156	AUT	0.366	CYP	0.254	FIN
8	DNK	0.61121	0.981	Increasing	0.547	AUT	0.435	CYP		
9	ESP	0.34435	1.098	Decreasing	0.409	AUT	0.603	CYP	0.085	FIN
10	EST	0.30109	0.703	Increasing	0.703	FIN				
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.24134	1.064	Decreasing	0.060	AUT	0.837	CYP	0.166	FIN
13	GBR	0.24844	0.876	Increasing	0.118	AUT	0.758	CYP		
14	GRC	0.14637	0.981	Increasing	0.198	AUT	0.653	CYP	0.130	FIN
15	HRV	0.57892	1.213	Decreasing	0.813	AUT	0.400	CYP		
16	HUN	0.24552	1.082	Decreasing	1.035	CYP	0.047	FIN		
17	IRL	0.35975	0.860	Increasing	0.219	AUT	0.640	CYP		
18	ISL	1.00000	1.000	Constant	1.000	ISL				
19	ITA	0.32730	1.032	Decreasing	0.441	AUT	0.591	CYP		
20	LTU	0.61595	1.144	Decreasing	0.369	AUT	0.721	CYP	0.054	FIN
21	LVA	0.56580	1.286	Decreasing	0.566	AUT	0.463	CYP	0.257	FIN
22	MLT	0.13953	0.977	Increasing	0.977	CYP				
23	NLD	0.09767	0.631	Increasing	0.102	AUT	0.529	CYP		
24	NOR	0.61940	1.132	Decreasing	0.704	AUT	0.428	ISL		
25	POL	0.33222	0.863	Increasing	0.596	CYP	0.267	FIN		

Table A3. *Cont.*

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
26	PRT	0.53704	1.179	Decreasing	0.701	AUT	0.478	CYP		
27	ROU	0.38597	1.183	Decreasing	0.361	AUT	0.822	CYP		
28	SVK	0.28286	1.034	Decreasing	0.062	AUT	0.618	CYP	0.354	FIN
29	SVN	0.42832	1.085	Decreasing	0.042	AUT	0.299	CYP	0.744	FIN
30	SWE	0.78390	1.267	Decreasing	0.373	AUT	0.256	CYP	0.638	FIN

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A4. Input-Oriented VRS Efficiency of EPS in 2013. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
1	AUT	1.00000	1.000	AUT						
2	BEL	0.14624	0.080	AUT	0.886	CYP	0.033	FIN		
3	BGR	0.30371	0.686	CYP	0.104	FIN	0.210	SWE		
4	CHE	0.77437	0.233	CYP	0.337	ISL	0.173	LVA	0.257	SWE
5	CYP	1.00000	1.000	CYP						
6	CZE	0.22902	0.710	CYP	0.290	FIN				
7	DEU	0.41683	0.164	AUT	0.663	CYP	0.173	FIN		
8	DNK	0.61782	0.545	AUT	0.455	CYP				
9	ESP	0.40496	0.003	AUT	0.451	CYP	0.139	ISL	0.407	SWE
10	EST	0.37148	0.400	CYP	0.600	FIN				
11	FIN	1.00000	1.000	FIN						
12	FRA	0.27389	0.760	CYP	0.009	LVA	0.231	SWE		
13	GBR	0.27616	0.105	AUT	0.895	CYP				
14	GRC	0.14830	0.199	AUT	0.678	CYP	0.123	FIN		
15	HRV	0.91378	0.022	CYP	0.247	ISL	0.731	LVA		
16	HUN	0.52732	0.451	CYP	0.549	LVA				
17	IRL	0.40143	0.204	AUT	0.796	CYP				
18	ISL	1.00000	1.000	ISL						
19	ITA	0.34942	0.254	AUT	0.534	CYP	0.077	ISL	0.135	SWE
20	LTU	0.96359	0.431	CYP	0.013	ISL	0.556	LVA		
21	LVA	1.00000	1.000	LVA						
22	MLT	0.14286	1.000	CYP						
23	NLD	0.14158	0.062	AUT	0.938	CYP				
24	NOR	1.00000	1.000	NOR						
25	POL	0.37002	0.780	CYP	0.220	FIN				
26	PRT	0.81216	0.171	CYP	0.229	ISL	0.600	LVA		
27	ROU	0.86313	0.019	CYP	0.981	LVA				
28	SVK	0.29808	0.015	AUT	0.585	CYP	0.273	FIN	0.127	SWE
29	SVN	0.49593	0.180	CYP	0.494	FIN	0.326	SWE		
30	SWE	1.00000	1.000	SWE						

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A5. Input-Oriented VRS Efficiency of EPS in 2012. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU
1	AUT	0.73497	1.837	Decreasing	1.837	FIN
2	BEL	0.13060	1.045	Decreasing	1.045	FIN
3	BGR	0.36206	1.267	Decreasing	1.267	FIN
4	CHE	0.48876	1.466	Decreasing	1.466	FIN
5	CYP	0.84751	1.271	Decreasing	1.271	FIN

Table A5. *Cont.*

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU
6	CZE	0.14284	0.928	Increasing	0.928	FIN
7	DEU	0.32952	0.989	Increasing	0.989	FIN
8	DNK	0.61644	1.233	Decreasing	1.233	FIN
9	ESP	0.26224	1.311	Decreasing	1.311	FIN
10	EST	0.16013	0.721	Increasing	0.721	FIN
11	FIN	1.00000	1.000	Constant	1.000	FIN
12	FRA	0.27299	1.365	Decreasing	1.365	FIN
13	GBR	0.28904	1.156	Decreasing	1.156	FIN
14	GRC	0.21193	1.166	Decreasing	1.166	FIN
15	HRV	0.48088	1.443	Decreasing	1.443	FIN
16	HUN	0.40357	1.412	Decreasing	1.412	FIN
17	IRL	0.28018	1.121	Decreasing	1.121	FIN
18	ISL	0.82165	2.465	Decreasing	2.465	FIN
19	ITA	0.28028	1.261	Decreasing	1.261	FIN
20	LTU	0.35146	1.406	Decreasing	1.406	FIN
21	LVA	0.46933	1.643	Decreasing	1.643	FIN
22	MLT	0.17787	1.245	Decreasing	1.245	FIN
23	NLD	0.11867	0.890	Increasing	0.890	FIN
24	NOR	0.60374	2.415	Decreasing	2.415	FIN
25	POL	0.36922	1.108	Decreasing	1.108	FIN
26	PRT	0.47636	1.429	Decreasing	1.429	FIN
27	ROU	0.36419	1.457	Decreasing	1.457	FIN
28	SVK	0.28311	1.274	Decreasing	1.274	FIN
29	SVN	0.29402	1.176	Decreasing	1.176	FIN
30	SWE	0.58250	1.456	Decreasing	1.456	FIN

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A6. Input-Oriented VRS Efficiency of EPS in 2012. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	1.00000	1.000	AUT				
2	BEL	0.13531	0.165	CYP	0.835	FIN		
3	BGR	0.47544	0.689	CYP	0.098	FIN	0.213	SWE
4	CHE	0.87962	0.014	CYP	0.153	LVA	0.833	SWE
5	CYP	1.00000	1.000	CYP				
6	CZE	0.15385	1.000	FIN				
7	DEU	0.33333	1.000	FIN				
8	DNK	0.94122	0.076	CYP	0.361	FIN	0.563	SWE
9	ESP	0.38480	0.542	CYP	0.023	FIN	0.435	SWE
10	EST	0.22222	1.000	FIN				
11	FIN	1.00000	1.000	FIN				
12	FRA	0.45565	0.611	CYP	0.389	LVA		
13	GBR	0.32196	0.576	CYP	0.424	FIN		
14	GRC	0.23733	0.611	CYP	0.389	FIN		
15	HRV	0.97548	0.274	CYP	0.700	LVA	0.026	SWE
16	HUN	0.76372	0.413	CYP	0.587	LVA		
17	IRL	0.30562	0.445	CYP	0.555	FIN		
18	ISL	1.00000	1.000	ISL				
19	ITA	0.39373	0.462	CYP	0.178	FIN	0.361	SWE
20	LTU	0.65444	0.441	CYP	0.559	LVA		
21	LVA	1.00000	1.000	LVA				
22	MLT	0.20739	0.903	CYP	0.097	FIN		
23	NLD	0.13333	1.000	FIN				
24	NOR	1.00000	1.000	NOR				

Table A6. *Cont.*

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
25	POL	0.39948	0.397	CYP	0.603	FIN		
26	PRT	0.93697	0.345	CYP	0.655	LVA		
27	ROU	0.76021	0.230	CYP	0.770	LVA		
28	SVK	0.38997	0.579	CYP	0.111	FIN	0.310	SWE
29	SVN	0.39908	0.180	CYP	0.483	FIN	0.338	SWE
30	SWE	1.00000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A7. Input-Oriented CRS Efficiency of EPS in 2011. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU
1	AUT	0.79102	1.084	Decreasing	0.637	FIN	0.447	ISL
2	BEL	0.15186	1.139	Decreasing	1.139	FIN		
3	BGR	0.38908	1.362	Decreasing	1.362	FIN		
4	CHE	0.54745	1.529	Decreasing	1.472	FIN	0.057	ISL
5	CYP	0.91514	1.373	Decreasing	1.373	FIN		
6	CZE	0.15717	1.022	Decreasing	1.022	FIN		
7	DEU	0.37855	1.136	Decreasing	1.136	FIN		
8	DNK	0.65318	1.306	Decreasing	1.306	FIN		
9	ESP	0.29004	1.450	Decreasing	1.450	FIN		
10	EST	0.72070	0.721	Increasing	0.721	FIN		
11	FIN	1.00000	1.000	Constant	1.000	FIN		
12	FRA	0.30356	1.518	Decreasing	1.518	FIN		
13	GBR	0.29507	1.328	Decreasing	1.328	FIN		
14	GRC	0.29260	1.317	Decreasing	1.317	FIN		
15	HRV	0.51943	1.558	Decreasing	1.558	FIN		
16	HUN	0.43924	1.537	Decreasing	1.537	FIN		
17	IRL	0.31511	1.260	Decreasing	1.260	FIN		
18	ISL	1.00000	1.000	Constant	1.000	ISL		
19	ITA	0.30291	1.363	Decreasing	1.363	FIN		
20	LTU	0.44793	1.568	Decreasing	1.568	FIN		
21	LVA	0.47546	1.664	Decreasing	1.664	FIN		
22	MLT	0.21821	1.418	Decreasing	1.418	FIN		
23	NLD	0.12488	0.999	Increasing	0.999	FIN		
24	NOR	0.72527	1.266	Decreasing	0.448	FIN	0.818	ISL
25	POL	0.34520	1.208	Decreasing	1.208	FIN		
26	PRT	0.44908	1.572	Decreasing	1.572	FIN		
27	ROU	0.35518	1.598	Decreasing	1.598	FIN		
28	SVK	0.34809	1.392	Decreasing	1.392	FIN		
29	SVN	0.32454	1.298	Decreasing	1.298	FIN		
30	SWE	0.84770	1.419	Decreasing	1.281	FIN	0.138	ISL

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A8. Input-Oriented VRS Efficiency of EPS in 2011. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.84669	0.217	FIN	0.333	ISL	0.450	SWE
2	BEL	0.15819	0.373	CYP	0.627	FIN		
3	BGR	0.44661	0.689	CYP	0.092	FIN	0.218	SWE
4	CHE	0.87065	0.008	ISL	0.403	LVA	0.589	SWE
5	CYP	1.00000	1.000	CYP				
6	CZE	0.15831	0.058	CYP	0.942	FIN		
7	DEU	0.39399	0.364	CYP	0.636	FIN		
8	DNK	0.79760	0.156	CYP	0.327	FIN	0.517	SWE
9	ESP	0.37221	0.278	CYP	0.722	SWE		
10	EST	1.00000	1.000	EST				
11	FIN	1.00000	1.000	FIN				
12	FRA	0.46159	0.205	LVA	0.795	SWE		
13	GBR	0.32301	0.830	CYP	0.132	FIN	0.039	SWE
14	GRC	0.32413	0.728	CYP	0.178	FIN	0.095	SWE
15	HRV	0.87932	0.425	LVA	0.575	SWE		
16	HUN	0.70493	0.312	LVA	0.688	SWE		
17	IRL	0.34839	0.539	CYP	0.337	FIN	0.124	SWE
18	ISL	1.00000	1.000	ISL				
19	ITA	0.36072	0.482	CYP	0.136	FIN	0.382	SWE
20	LTU	0.77568	0.477	LVA	0.523	SWE		
21	LVA	1.00000	1.000	LVA				
22	MLT	0.26349	0.575	CYP	0.425	SWE		
23	NLD	0.12500	0.003	EST	0.997	FIN		
24	NOR	1.00000	1.000	NOR				
25	POL	0.36552	0.559	CYP	0.441	FIN		
26	PRT	0.78510	0.499	LVA	0.501	SWE		
27	ROU	0.65865	0.643	LVA	0.357	SWE		
28	SVK	0.41493	0.570	CYP	0.055	FIN	0.375	SWE
29	SVN	0.39401	0.163	CYP	0.342	FIN	0.494	SWE
30	SWE	1.00000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A9. Input-Oriented CRS Efficiency of EPS in 2010. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU
1	AUT	0.60355	1.207	Decreasing	1.207	LVA		
2	BEL	0.16187	0.647	Increasing	0.647	LVA		
3	BGR	0.37760	0.881	Increasing	0.881	LVA		
4	CHE	0.51712	1.034	Decreasing	1.034	LVA		
5	CYP	0.82692	0.827	Increasing	0.827	LVA		
6	CZE	0.18783	0.626	Increasing	0.034	FIN	0.592	LVA
7	DEU	0.34768	0.695	Increasing	0.695	LVA		
8	DNK	0.56408	0.752	Increasing	0.752	LVA		
9	ESP	0.24257	0.889	Increasing	0.889	LVA		
10	EST	0.74646	0.746	Increasing	0.649	FIN	0.097	LVA
11	FIN	1.00000	1.000	Constant	1.000	FIN		
12	FRA	0.27336	0.911	Increasing	0.911	LVA		
13	GBR	0.23253	0.775	Increasing	0.775	LVA		
14	GRC	0.29719	0.792	Increasing	0.792	LVA		
15	HRV	0.57283	1.146	Decreasing	1.146	LVA		
16	HUN	0.46703	0.934	Increasing	0.934	LVA		
17	IRL	0.21676	0.723	Increasing	0.723	LVA		
18	ISL	0.91145	1.823	Decreasing	1.823	LVA		
19	ITA	0.31198	0.832	Increasing	0.832	LVA		
20	LTU	0.22429	0.972	Increasing	0.972	LVA		

Table A9. *Cont.*

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU
21	LVA	1.00000	1.000	Constant	1.000	LVA		
22	MLT	0.13725	0.869	Increasing	0.869	LVA		
23	NLD	0.11048	0.589	Increasing	0.589	LVA		
24	NOR	0.65449	1.745	Decreasing	1.745	LVA		
25	POL	0.32101	0.749	Increasing	0.749	LVA		
26	PRT	0.41260	0.963	Increasing	0.963	LVA		
27	ROU	0.37347	0.996	Increasing	0.996	LVA		
28	SVK	0.27950	0.838	Increasing	0.838	LVA		
29	SVN	0.42390	0.989	Increasing	0.447	FIN	0.542	LVA
30	SWE	0.86584	1.154	Decreasing	0.323	FIN	0.832	LVA

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A10. Input-Oriented VRS Efficiency of EPS in 2010. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.69363	0.247	ISL	0.333	LVA	0.419	SWE
2	BEL	0.25000	0.891	CYP	0.012	FIN	0.097	LVA
3	BGR	0.42857	0.553	CYP	0.447	LVA		
4	CHE	0.52081	0.042	ISL	0.958	LVA		
5	CYP	1.00000	1.000	CYP				
6	CZE	0.30000	0.712	CYP	0.288	FIN		
7	DEU	0.50000	0.662	CYP	0.110	FIN	0.228	LVA
8	DNK	0.75000	0.198	CYP	0.494	FIN	0.308	LVA
9	ESP	0.27273	0.413	CYP	0.587	LVA		
10	EST	1.00000	0.375	CYP	0.625	FIN		
11	FIN	1.00000	1.000	FIN				
12	FRA	0.30000	0.513	CYP	0.487	LVA		
13	GBR	0.30000	0.898	CYP	0.102	LVA		
14	GRC	0.37500	0.677	CYP	0.012	FIN	0.311	LVA
15	HRV	0.58851	0.177	ISL	0.823	LVA		
16	HUN	0.50000	1.000	LVA				
17	IRL	0.30000	0.590	CYP	0.405	FIN	0.005	LVA
18	ISL	1.00000	1.000	ISL				
19	ITA	0.37500	0.446	CYP	0.210	FIN	0.344	LVA
20	LTU	0.23077	1.000	LVA				
21	LVA	1.00000	1.000	LVA				
22	MLT	0.15789	0.755	CYP	0.245	LVA		
23	NLD	0.18750	0.720	CYP	0.280	FIN		
24	NOR	1.00000	1.000	NOR				
25	POL	0.42857	0.784	CYP	0.216	FIN		
26	PRT	0.42857	0.038	CYP	0.962	LVA		
27	ROU	0.37500	1.000	LVA				
28	SVK	0.33333	0.484	CYP	0.180	FIN	0.336	LVA
29	SVN	0.42857	0.025	CYP	0.462	FIN	0.513	LVA
30	SWE	1.00000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A11. Input-Oriented CRS Efficiency of EPS in 2009. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU
1	AUT	0.44564	1.114	Decreasing	1.114	LVA
2	BEL	0.13347	0.667	Increasing	0.667	LVA
3	BGR	0.15735	0.865	Increasing	0.865	LVA
4	CHE	0.29491	0.885	Increasing	0.885	LVA
5	CYP	0.51390	0.771	Increasing	0.771	LVA
6	CZE	0.18267	0.639	Increasing	0.639	LVA
7	DEU	0.23008	0.690	Increasing	0.690	LVA
8	DNK	0.36634	0.733	Increasing	0.733	LVA
9	ESP	0.15231	0.838	Increasing	0.838	LVA
10	EST	0.24549	0.982	Increasing	0.982	LVA
11	FIN	0.90606	1.359	Decreasing	1.359	LVA
12	FRA	0.17644	0.882	Increasing	0.882	LVA
13	GBR	0.15208	0.760	Increasing	0.760	LVA
14	GRC	0.15998	0.720	Increasing	0.720	LVA
15	HRV	0.26057	0.912	Increasing	0.912	LVA
16	HUN	0.30546	0.916	Increasing	0.916	LVA
17	IRL	0.12417	0.683	Increasing	0.683	LVA
18	ISL	0.52197	1.566	Decreasing	1.566	LVA
19	ITA	0.20116	0.805	Increasing	0.805	LVA
20	LTU	0.16113	0.967	Increasing	0.967	LVA
21	LVA	1.00000	1.000	Constant	1.000	LVA
22	MLT	0.11327	0.850	Increasing	0.850	LVA
23	NLD	0.06958	0.591	Increasing	0.591	LVA
24	NOR	0.37809	1.512	Decreasing	1.512	LVA
25	POL	0.21348	0.747	Increasing	0.747	LVA
26	PRT	0.30000	0.900	Increasing	0.900	LVA
27	ROU	0.32136	0.964	Increasing	0.964	LVA
28	SVK	0.18486	0.832	Increasing	0.832	LVA
29	SVN	0.25572	1.151	Decreasing	1.151	LVA
30	SWE	0.50959	1.274	Decreasing	1.274	LVA

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A12. Input-Oriented VRS Efficiency of EPS in 2009. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.62528	0.080	ISL	0.786	LVA	0.134	NOR
2	BEL	0.20000	1.000	LVA				
3	BGR	0.18182	1.000	LVA				
4	CHE	0.33333	1.000	LVA				
5	CYP	0.66667	1.000	LVA				
6	CZE	0.28571	1.000	LVA				
7	DEU	0.33333	1.000	LVA				
8	DNK	0.50000	1.000	LVA				
9	ESP	0.18182	1.000	LVA				
10	EST	0.25000	1.000	LVA				
11	FIN	1.00000	1.000	FIN				
12	FRA	0.20000	1.000	LVA				
13	GBR	0.20000	1.000	LVA				
14	GRC	0.22222	1.000	LVA				
15	HRV	0.28571	1.000	LVA				
16	HUN	0.33333	1.000	LVA				
17	IRL	0.18182	1.000	LVA				
18	ISL	1.00000	1.000	ISL				

Table A12. *Cont.*

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU
19	ITA	0.25000	1.000	LVA				
20	LTU	0.16667	1.000	LVA				
21	LVA	1.00000	1.000	LVA				
22	MLT	0.13333	1.000	LVA				
23	NLD	0.11765	1.000	LVA				
24	NOR	1.00000	1.000	NOR				
25	POL	0.28571	1.000	LVA				
26	PRT	0.33333	1.000	LVA				
27	ROU	0.33333	1.000	LVA				
28	SVK	0.22222	1.000	LVA				
29	SVN	0.26886	0.420	FIN	0.580	LVA		
30	SWE	1.00000	1.000	SWE				

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A13. Input-Oriented CRS Efficiency of EPS in 2008. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.93336	1.079	Decreasing	0.602	FIN	0.398	ISL	0.079	NOR
2	BEL	0.27036	0.901	Increasing	0.760	CYP	0.141	FIN		
3	BGR	0.48275	1.126	Decreasing	0.887	CYP	0.240	FIN		
4	CHE	0.90267	1.444	Decreasing	1.384	FIN	0.060	ISL		
5	CYP	1.00000	1.000	Constant	1.000	CYP				
6	CZE	0.27916	0.837	Increasing	0.494	CYP	0.344	FIN		
7	DEU	0.58215	0.970	Increasing	0.565	CYP	0.405	FIN		
8	DNK	0.65958	1.099	Decreasing	0.334	CYP	0.766	FIN		
9	ESP	0.34784	1.159	Decreasing	0.608	CYP	0.552	FIN		
10	EST	0.21892	0.803	Increasing	0.106	CYP	0.697	FIN		
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.40781	1.223	Decreasing	0.869	CYP	0.355	FIN		
13	GBR	0.33132	0.994	Increasing	0.843	CYP	0.151	FIN		
14	GRC	0.33244	0.997	Increasing	0.749	CYP	0.249	FIN		
15	HRV	0.71585	1.432	Decreasing	0.159	CYP	1.273	FIN		
16	HUN	0.60053	1.201	Decreasing	1.046	CYP	0.156	FIN		
17	IRL	0.25863	0.948	Increasing	0.619	CYP	0.329	FIN		
18	ISL	1.00000	1.000	Constant	1.000	ISL				
19	ITA	0.42060	1.122	Decreasing	0.610	CYP	0.512	FIN		
20	LTU	0.47325	1.262	Decreasing	1.065	CYP	0.197	FIN		
21	LVA	0.61823	1.586	Decreasing	1.524	FIN	0.062	ISL		
22	MLT	0.22322	1.116	Decreasing	1.116	CYP				
23	NLD	0.16963	0.848	Increasing	0.606	CYP	0.242	FIN		
24	NOR	1.00000	1.000	Constant	1.000	NOR				
25	POL	0.43601	1.017	Decreasing	0.810	CYP	0.207	FIN		
26	PRT	0.58144	1.357	Decreasing	0.463	CYP	0.894	FIN		
27	ROU	0.81943	1.366	Decreasing	0.632	CYP	0.734	FIN		
28	SVK	0.43046	1.148	Decreasing	0.712	CYP	0.436	FIN		
29	SVN	0.41294	1.101	Decreasing	0.342	CYP	0.759	FIN		
30	SWE	0.89140	1.450	Decreasing	1.414	FIN	0.036	ISL		

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A14. Input-Oriented VRS Efficiency of EPS in 2008. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
1	AUT	0.98456	0.255	FIN	0.235	ISL	0.197	NOR	0.314	SWE
2	BEL	0.30000	0.860	CYP	0.140	FIN				
3	BGR	0.54671	0.587	CYP	0.129	ROU	0.284	SWE		
4	CHE	1.00000	1.000	CHE						
5	CYP	1.00000	1.000	CYP						
6	CZE	0.33333	0.712	CYP	0.288	FIN				
7	DEU	0.60000	0.595	CYP	0.405	FIN				
8	DNK	0.68242	0.206	CHE	0.348	CYP	0.446	FIN		
9	ESP	0.36732	0.050	CHE	0.623	CYP	0.040	FIN	0.287	SWE
10	EST	0.27273	0.371	CYP	0.629	FIN				
11	FIN	1.00000	1.000	FIN						
12	FRA	0.49154	0.288	CYP	0.609	ROU	0.103	SWE		
13	GBR	0.33333	0.849	CYP	0.151	FIN				
14	GRC	0.33333	0.751	CYP	0.249	FIN				
15	HRV	0.82054	0.582	CHE	0.038	CYP	0.264	ROU	0.117	SWE
16	HUN	0.75449	0.237	CYP	0.763	ROU				
17	IRL	0.27273	0.403	CYP	0.597	FIN				
18	ISL	1.00000	1.000	ISL						
19	ITA	0.43833	0.202	CHE	0.626	CYP	0.121	FIN	0.052	SWE
20	LTU	0.64974	0.066	LVA	0.823	ROU	0.112	SWE		
21	LVA	1.00000	1.000	LVA						
22	MLT	0.26909	0.482	CYP	0.518	ROU				
23	NLD	0.20000	1.000	FIN						
24	NOR	1.00000	1.000	NOR						
25	POL	0.44337	0.782	CYP	0.166	FIN	0.052	SWE		
26	PRT	0.68058	0.104	CHE	0.118	CYP	0.571	ROU	0.206	SWE
27	ROU	1.00000	1.000	ROU						
28	SVK	0.47314	0.571	CYP	0.036	FIN	0.393	SWE		
29	SVN	0.45050	0.181	CYP	0.517	FIN	0.302	SWE		
30	SWE	1.00000	1.000	SWE						

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A15. Input-Oriented CRS Efficiency of EPS in 2007. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.97636	1.129	Decreasing	0.631	FIN	0.483	ISL	0.015	NOR
2	BEL	0.33746	0.889	Increasing	0.754	CYP	0.104	FIN	0.032	ROU
3	BGR	0.27985	1.119	Decreasing	0.880	CYP	0.240	FIN		
4	CHE	0.82510	1.118	Decreasing	0.201	FIN	0.339	ISL	0.579	ROU
5	CYP	1.00000	1.000	Constant	1.000	CYP				
6	CZE	0.24602	0.820	Increasing	0.470	CYP	0.350	FIN		
7	DEU	0.59422	0.907	Increasing	0.408	CYP	0.247	FIN	0.251	ROU
8	DNK	0.65133	0.773	Increasing	0.083	ISL	0.689	ROU		
9	ESP	0.33710	0.968	Increasing	0.261	CYP	0.239	FIN	0.468	ROU
10	EST	0.26885	0.807	Increasing	0.108	CYP	0.699	FIN		
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.40205	1.098	Decreasing	0.665	CYP	0.107	FIN	0.325	ROU
13	GBR	0.32291	0.905	Increasing	0.714	CYP	0.191	ROU		
14	GRC	0.37007	0.971	Increasing	0.722	CYP	0.202	FIN	0.047	ROU
15	HRV	0.71689	1.055	Decreasing	0.182	FIN	0.131	ISL	0.742	ROU
16	HUN	0.58349	1.107	Decreasing	0.928	CYP	0.001	FIN	0.179	ROU
17	IRL	0.26997	0.771	Increasing	0.386	CYP	0.386	ROU		
18	ISL	1.00000	1.000	Constant	1.000	ISL				

Table A15. *Cont.*

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
19	ITA	0.46820	0.954	Increasing	0.382	CYP	0.155	FIN	0.416	ROU
20	LTU	0.41789	1.254	Decreasing	1.056	CYP	0.197	FIN		
21	LVA	0.59505	1.323	Decreasing	0.552	FIN	0.307	ISL	0.464	ROU
22	MLT	0.19987	1.066	Decreasing	1.066	CYP				
23	NLD	0.16726	0.744	Increasing	0.467	CYP	0.277	ROU		
24	NOR	1.00000	1.000	Constant	1.000	NOR				
25	POL	0.51142	1.023	Decreasing	0.819	CYP	0.204	FIN		
26	PRT	0.69437	1.047	Decreasing	0.199	FIN	0.090	ISL	0.758	ROU
27	ROU	1.00000	1.000	Constant	1.000	ROU				
28	SVK	0.51139	1.086	Decreasing	0.454	CYP	0.312	FIN	0.321	ROU
29	SVN	0.44574	1.181	Decreasing	0.428	CYP	0.728	FIN	0.024	ROU
30	SWE	0.97809	1.331	Decreasing	0.817	FIN	0.192	ISL	0.322	ROU

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A16. Input-Oriented VRS Efficiency of EPS in 2007. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
1	AUT	0.99916	0.231	FIN	0.203	ISL	0.255	NOR	0.310	SWE
2	BEL	0.37500	0.528	CYP	0.472	FIN				
3	BGR	0.29688	0.253	CYP	0.184	FIN	0.563	ROU		
4	CHE	0.96330	0.032	ISL	0.187	LVA	0.781	SWE		
5	CYP	1.00000	1.000	CYP						
6	CZE	0.30000	0.019	CYP	0.981	FIN				
7	DEU	0.60692	0.531	CYP	0.435	FIN	0.035	ROU		
8	DNK	0.66983	0.078	CYP	0.573	FIN	0.349	ROU		
9	ESP	0.33930	0.303	CYP	0.304	FIN	0.393	ROU		
10	EST	0.33333	1.000	FIN						
11	FIN	1.00000	1.000	FIN						
12	FRA	0.42064	0.152	CYP	0.062	FIN	0.786	ROU		
13	GBR	0.33333	0.790	CYP	0.210	FIN				
14	GRC	0.37500	0.727	CYP	0.273	FIN				
15	HRV	0.71995	0.045	FIN	0.099	ISL	0.688	ROU	0.168	SWE
16	HUN	0.62681	0.239	CYP	0.761	ROU				
17	IRL	0.30000	0.666	CYP	0.334	FIN				
18	ISL	1,00000	1.000	ISL						
19	ITA	0.47269	0.443	CYP	0.248	FIN	0.309	ROU		
20	LTU	0.55402	0.191	LVA	0.777	ROU	0.032	SWE		
21	LVA	1.00000	1.000	LVA						
22	MLT	0,20988	0.642	CYP	0.358	ROU				
23	NLD	0.20000	0.761	CYP	0.239	FIN				
24	NOR	1.00000	1.000	NOR						
25	POL	0.51793	0.699	CYP	0.194	FIN	0.108	ROU		
26	PRT	0.69694	0.084	FIN	0.062	ISL	0.713	ROU	0.141	SWE
27	ROU	1.00000	1.000	ROU						
28	SVK	0.53250	0.000	CYP	0.272	FIN	0.727	ROU		
29	SVN	0.49278	0.422	FIN	0.213	ROU	0.365	SWE		
30	SWE	1.00000	1.000	SWE						

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A17. Input-Oriented CRS Efficiency of EPS in 2006. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.87772	1.052	Decreasing	0.326	FIN	0.505	NOR	0.222	ROU
2	BEL	0.32736	0.868	Increasing	0.742	CYP	0.113	FIN	0.014	ROU
3	BGR	0.28699	1.110	Decreasing	0.776	CYP	0.221	FIN	0.113	ROU
4	CHE	0.63569	1.038	Decreasing	0.008	FIN	0.305	NOR	0.726	ROU
5	CYP	1.00000	1.000	Constant	1.000	CYP				
6	CZE	0.22767	0.835	Increasing	0.490	CYP	0.345	FIN		
7	DEU	0.47831	0.910	Increasing	0.506	CYP	0.265	FIN	0.139	ROU
8	DNK	0.48072	0.732	Increasing	0.043	CYP	0.689	ROU		
9	ESP	0.33430	0.989	Increasing	0.370	CYP	0.241	FIN	0.377	ROU
10	EST	0.34704	0.925	Increasing	0.266	CYP	0.660	FIN		
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.39199	1.088	Decreasing	0.707	CYP	0.118	FIN	0.263	ROU
13	GBR	0.31346	0.888	Increasing	0.732	CYP	0.157	ROU		
14	GRC	0.38195	0.928	Increasing	0.481	CYP	0.175	FIN	0.272	ROU
15	HRV	0.75373	1.073	Decreasing	0.058	FIN	0.287	NOR	0.728	ROU
16	HUN	0.48546	1.090	Decreasing	0.947	CYP	0.013	FIN	0.129	ROU
17	IRL	0.29855	0.792	Increasing	0.481	CYP	0.311	ROU		
18	ISL	0.89068	1.093	Decreasing	0.970	NOR	0.123	ROU		
19	ITA	0.46457	0.945	Increasing	0.373	CYP	0.156	FIN	0.416	ROU
20	LTU	0.46807	1.248	Decreasing	1.052	CYP	0.197	FIN		
21	LVA	0.72053	1.278	Decreasing	0.357	FIN	0.289	NOR	0.632	ROU
22	MLT	0.21329	1.066	Decreasing	1.065	CYP	0.001	ROU		
23	NLD	0.16672	0.741	Increasing	0.463	CYP	0.278	ROU		
24	NOR	1.00000	1.000	Constant	1.000	NOR				
25	POL	0.43208	1.008	Decreasing	0.800	CYP	0.208	FIN		
26	PRT	0.57072	1.029	Decreasing	0.156	FIN	0.036	NOR	0.836	ROU
27	ROU	1.00000	1.000	Constant	1.000	ROU				
28	SVK	0.34496	1.079	Decreasing	0.532	CYP	0.333	FIN	0.214	ROU
29	SVN	0.45326	1.152	Decreasing	0.267	CYP	0.714	FIN	0.171	ROU
30	SWE	0.93231	1.294	Decreasing	0.703	FIN	0.187	NOR	0.404	ROU

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A18. Input-Oriented VRS Efficiency of EPS in 2006. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
1	AUT	0.88979	0.201	FIN	0.471	NOR	0.150	ROU	0.178	SWE
2	BEL	0.37500	0.462	CYP	0.538	FIN				
3	BGR	0.30848	0.139	CYP	0.159	FIN	0.702	ROU		
4	CHE	0.68601	0.242	ISL	0.034	LVA	0.508	ROU	0.216	SWE
5	CYP	1.00000	1.000	CYP						
6	CZE	0.27273	0.112	CYP	0.888	FIN				
7	DEU	0.50000	0.511	CYP	0.489	FIN				
8	DNK	0.52157	0.432	CYP	0.503	FIN	0.065	NOR		
9	ESP	0.33529	0.421	CYP	0.243	FIN	0.017	NOR	0.320	ROU
10	EST	0.37500	0.095	CYP	0.905	FIN				
11	FIN	1.00000	1.000	FIN						
12	FRA	0.41492	0.197	CYP	0.069	FIN	0.734	ROU		
13	GBR	0.33333	0.713	CYP	0.287	FIN				
14	GRC	0.38997	0.691	CYP	0.249	FIN	0.060	NOR		
15	HRV	0.85356	0.192	ISL	0.192	LVA	0.455	ROU	0.161	SWE
16	HUN	0.52583	0.319	CYP	0.681	ROU				
17	IRL	0.33333	0.666	CYP	0.334	FIN				
18	ISL	1.00000	1.000	ISL						

Table A18. *Cont.*

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
19	ITA	0.47131	0.617	CYP	0.163	FIN	0.079	NOR	0.140	ROU
20	LTU	0.66208	0.432	LVA	0.568	ROU				
21	LVA	1.00000	1.000	LVA						
22	MLT	0.22846	0.573	CYP	0.427	ROU				
23	NLD	0.20000	0.702	CYP	0.298	FIN				
24	NOR	1.00000	1.000	NOR						
25	POL	0.43481	0.753	CYP	0.203	FIN	0.044	ROU		
26	PRT	0.57543	0.088	FIN	0.018	NOR	0.797	ROU	0.097	SWE
27	ROU	1.00000	1.000	ROU						
28	SVK	0.36334	0.077	CYP	0.289	FIN	0.633	ROU		
29	SVN	0.50067	0.392	FIN	0.210	ROU	0.398	SWE		
30	SWE	1.00000	1.000	SWE						

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A19. Input-Oriented CRS Efficiency of EPS in 2005. Source: Authors' calculations in DEAFrontier.

DMU No	DMU Name	CRS Efficiency	Sl	RTS	Benchmarks	DMU	λ	DMU	λ	DMU
1	AUT	0.87226	0.994	Increasing	0.369	FIN	0.460	NOR	0.165	ROU
2	BEL	0.27260	0.727	Increasing	0.049	FIN	0.678	ROU		
3	BGR	0.41130	0.960	Increasing	0.154	FIN	0.805	ROU		
4	CHE	0.57691	1.026	Decreasing	0.013	FIN	0.320	NOR	0.692	ROU
5	CYP	0.86323	0.863	Increasing	0.863	ROU				
6	CZE	0.20007	0.734	Increasing	0.309	FIN	0.425	ROU		
7	DEU	0.40590	0.812	Increasing	0.225	FIN	0.587	ROU		
8	DNK	0.39772	0.795	Increasing	0.000	NOR	0.795	ROU		
9	ESP	0.29617	0.888	Increasing	0.221	FIN	0.667	ROU		
10	EST	0.27067	0.812	Increasing	0.680	FIN	0.132	ROU		
11	FIN	1.00000	1.000	Constant	1.000	FIN				
12	FRA	0.31358	0.941	Increasing	0.063	FIN	0.878	ROU		
13	GBR	0.16722	0.780	Increasing	0.780	ROU				
14	GRC	0.41063	0.821	Increasing	0.140	FIN	0.681	ROU		
15	HRV	0.66575	1.051	Decreasing	0.074	FIN	0.281	NOR	0.696	ROU
16	HUN	0.46977	0.940	Increasing	0.940	ROU				
17	IRL	0.23606	0.708	Increasing	0.708	ROU				
18	ISL	0.87562	1.075	Decreasing	0.968	NOR	0.106	ROU		
19	ITA	0.32211	0.859	Increasing	0.132	FIN	0.727	ROU		
20	LTU	0.52373	1.047	Decreasing	0.105	FIN	0.942	ROU		
21	LVA	0.71594	1.256	Decreasing	0.354	FIN	0.415	NOR	0.487	ROU
22	MLT	0.19150	0.894	Increasing	0.894	ROU				
23	NLD	0.13475	0.674	Increasing	0.674	ROU				
24	NOR	1.00000	1.000	Constant	1.000	NOR				
25	POL	0.43517	0.870	Increasing	0.130	FIN	0.740	ROU		
26	PRT	0.48739	0.975	Increasing	0.199	FIN	0.776	ROU		
27	ROU	1.00000	1.000	Constant	1.000	ROU				
28	SVK	0.25941	0.951	Increasing	0.306	FIN	0.645	ROU		
29	SVN	0.39164	1.044	Decreasing	0.728	FIN	0.316	ROU		
30	SWE	0.82238	1.203	Decreasing	0.767	FIN	0.167	NOR	0.269	ROU

Note: DMU—decision-making unit, CRS—Constant Returns to Scale, RTS—Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

Table A20. Input-Oriented VRS Efficiency of EPS in 2005. Source: Authors' calculations in DEAFrontier.

DMU No.	DMU Name	VRS Efficiency	Benchmarks	DMU	λ	DMU	λ	DMU	λ	DMU
1	AUT	0.87399	0.366	FIN	0.457	NOR	0.178	ROU		
2	BEL	0.37500	0.927	CYP	0.068	FIN	0.005	ROU		
3	BGR	0.42857	0.130	FIN	0.870	ROU				
4	CHE	0.61707	0.042	ISL	0.117	LVA	0.228	NOR	0.613	ROU
5	CYP	1.00000	1.000	CYP						
6	CZE	0.27273	0.712	CYP	0.288	FIN				
7	DEU	0.50000	0.696	CYP	0.249	FIN	0.055	ROU		
8	DNK	0.50000	1.000	ROU						
9	ESP	0.33333	0.152	FIN	0.848	ROU				
10	EST	0.33333	0.363	CYP	0.637	FIN				
11	FIN	1.00000	1.000	FIN						
12	FRA	0.33333	0.026	FIN	0.974	ROU				
13	GBR	0.21429	0.872	CYP	0.128	FIN				
14	GRC	0.50000	0.680	CYP	0.167	FIN	0.153	ROU		
15	HRV	0.73035	0.191	LVA	0.200	NOR	0.600	ROU	0.008	SWE
16	HUN	0.50000	0.442	CYP	0.558	ROU				
17	IRL	0.33333	0.786	CYP	0.214	ROU				
18	ISL	1.00000	1.000	ISL						
19	ITA	0.37500	0.044	FIN	0.956	ROU				
20	LTU	0.69364	0.290	LVA	0.710	ROU				
21	LVA	1.00000	1.000	LVA						
22	MLT	0.21429	1.000	ROU						
23	NLD	0.20000	0.782	CYP	0.218	ROU				
24	NOR	1.00000	1.000	NOR						
25	POL	0.50000	0.050	FIN	0.950	ROU				
26	PRT	0.50000	0.184	FIN	0.816	ROU				
27	ROU	1.00000	1.000	ROU						
28	SVK	0.27273	0.276	FIN	0.724	ROU				
29	SVN	0.43808	0.525	FIN	0.222	ROU	0.252	SWE		
30	SWE	1.00000	1.000	SWE						

Note: DMU—decision-making unit, VRS—Variable Returns to Scale, AUT—Austria, BEL—Belgium, BGR—Bulgaria, CHE—Switzerland, CYP—Cyprus, CZE—The Czech Republic, DEU—Germany, DNK—Denmark, ESP—Spain, EST—Estonia, FIN—Finland, FRA—ZZZ, GBR—United Kingdom, BEL—Belgium, GRC—Greece, HRV—Croatia, HUN—Hungary, IRL—Ireland, ISL—Iceland, ITA—Italy, LTU—Lithuania, LVA—Latvia, MLT—Malta, NLD—Netherlands, NOR—Norway, POL—Poland, PRT—Portugal, ROU—Romania, SVK—Slovak Republic, SVN—Slovenia.

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