Environmental Performance Assessment of the Transport Sector in the European Union

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Abstract. The European Union (EU) has been promoting diverse initiatives towards sustainable development and environment protection. One of these initiatives is the reduction of the greenhouse gas (GHG) emissions in 60% below their 1990 level, by 2050. As the transport sector is responsible for more than 22% of those emissions some strategies need to be taken towards a more sustainable mobility, as the ones proposed in 2011 White Paper on transport. Under this context, this study aims to evaluate the environmental performance of the transport sector in the 28 EU countries towards these goals, from 2015 to 2017. The transport environmental performance is measured through the composite indicator derived from the Benefit of the Doubt (BoD) model. The country transport environmental performance is assessed through the aggregation of multiple sub-indicators using the composite indicator derived from the Data Envelopment Analysis (DEA) model. The results indicate that the EU countries slightly improved their transport environmental performance, on average 2.8%. The areas where the inefficient countries need more improvement were also identified: reducing the GHG emissions from fossil fuels, increasing the share of transport energy from renewable sources and improving the public transport share of the total passenger transport.

Keywords: Transport environmental performance · Data Envelopment Analysis · Sustainable development

1 Introduction

Transportation is an important sector in the European economy, it employs more than 11 million people and accounts for about 5% of Europe's Gross Domestic

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Product (GDP). Between 2010 and 2050, passenger transport activity is expected to grow by 42% and freight transport activity by 60% [1]. However, GHG emissions of the transport sector, in opposition to other sectors such as industry or energy related industries, have increased in the last 25 years and reached 22% of the total European GHG emissions in 2015 [2]. Under this scenario, the European Commission's, 2011, White Paper on transport - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system [3], proposed strategies for deep changes in the European transport sector aiming a more sustainable and efficient system. Some of the targets addressed in the white paper include: achieving a 60% reduction in CO_2 emissions by 2050 with respect to 1990, phasing out conventionally fuelled cars from cities by the same year and improvement of the road safety.

The United Nations' Sustainable Development Goals (SDG) aim to achieve a more sustainable future for everyone. These goals address global challenges in several areas such as poverty, inequality and climate change, in a total of 17 goals [4]. The SDG targets related to transport sustainability are highlighted in [5] being some of them directly related to the transport sector and others to areas where transport has an important impact, such as energy consumption and emissions. The United Nations emphasizes the interconnection of all goals and the importance of achieving them by 2030 [4].

Therefore, it is important to be able to measure and assess the sustainability of present and future transport policies concerning EU Countries. In order to fulfil this objective, this study aims to evaluate the environmental performance of the transport sector in the EU countries, from 2015 till 2017, towards a more sustainable mobility. The methodology used in this paper to evaluate the environmental performance is based on the Composite Indicator (CI) derived from the DEA model, as proposed by Cherchye in [6], the Benefit of the Doubt model. This CI allows to summarize, compare and track the performance of the countries for complex or multi-dimensional issues [7]. The use of CI is increasingly being recognised as a useful tool in policy analysis and public communication, as it can provide simple comparisons that can be used to illustrate complex and sometimes elusive issues in wide-ranging fields, e.g. environment, economy, society or technological development [8]. In a general level the CI consists in a weighted average of sub-indicators. There are different methods for weighting and aggregating the data of the sub-indicators, being some of them presented in this work.

This paper is organized as follows: the second section presents the literature review about composite indicator usefulness and its construction. Section 3 explains the DEA method and the sub-indicators selected to compose the CI. Section 4 presents the data used and the results obtained. Finally, the conclusions from this work are presented in Sect. 5.

2 Literature Review

Composite Indicators have been proven useful for benchmarking countries performance and are becoming a recognized tool for policy analysis, decision makers

and public communication as they provide a big picture often making it easier for the general public to interpret CI rather than identifying common trends across many indicators. However, CI must be considered a means to facilitate a discussion and to stimulate public interest, since their "big picture" results often lead users to draw simplistic analytical or policy conclusions [8].

In [9], four main reasons for the usefulness of indicators are identified: they allow the synthesis of masses of data, show the current position in relation to desirable states, demonstrate progress towards goals and objectives and, finally, they communicate current status to stakeholders leading to effective management decisions towards the established targets.

A Composite Indicator comprises several individual indicators compiled into a single index on the basis of an underlying model and much like mathematical and computational models. Moreover, CI construction owes more to the craftsmanship of the modeller than to universally accepted rules [8].

Different aggregation and weighting techniques have been used in the literature for the assessment of the transport environmental impact.

In [5], the Sustainable Urban Transport Index was developed for cities in the Asian-Pacific region. The sub-indicators were chosen based on the literature while incorporating the Sustainable Development Goals related to urban transport planning. Equal weight of 0.10 was given to the ten selected sub-indicators and the index was calculated by applying the geometric mean for the normalized sub-indicators values.

In [7], a comparison among 33 different combinations regarding normalization, weighting and aggregation techniques for the development of a Composite Indicator was made. A set of 16 sub-indicators was selected to estimate the composite indicator of sustainable urban mobility for Italian provincial towns.

The work performed in [10] evaluates the sustainable transport system in 23 Spanish cities, using a three dimensional CI (economic, social and environmental). The sub-indicators i were normalized using the standardized values method and then aggregated into composite indicators related to the dimensions of sustainability using weights. The signs of the different weights are dependent on the meaning of the sub-indicator, being positive for indicators in which an increase in their values contributes to a more sustainable transport system and negative for those contributing conversely.

A composite indicator for transport sustainability in Melbourne local areas is developed in [11]. Nine sub-indicators were chosen and normalized by the min-max method. The sub-indicators were first aggregated into environmental, social and economic sub-indices using the Principal Component Analysis/Factor Analysis (PCA/FA) and then combined into a single CI.

In [12], a standardized set of transport performance indicators is selected to build the Normalized Transport Sustainability Index. The sub-indicators were normalized in a range between 0 and 1 using the max-min method and the index was calculated using the Euclidean distance between the city evaluated and an hypothetical *worst city*. This hypothetical *worst city* assumes the value one or zero when the effect of the indicator is negative or positive, respectively.

An alternative method to compute the CI is using the DEA method. In [13], an index to assess the performance of 112 countries in green transportation and logistics practices is constructed. The composite indicator combines the logistic performance index, CO_2 emissions and oil consumption using the DEA for weighting and aggregation.

Following the DEA approach, this study proposes the measurement of the transport environmental performance of EU countries through their composite indicator. The CI is calculated through the aggregation of multiple sub-indicators using the BoD model. The selection of the sub-indicators should reflect the targets defined by the EU's White Paper and the SDG goals related to transport. The weight attributed to each sub-indicator is derived endogenously from the DEA model.

3 Methodology

3.1 Data Envelopment Analysis

The DEA is a linear programming method that assesses the efficiency score of multiple decision making units in using multiple inputs to produce multiple outputs [14]. The DEA enables to measure the efficiency in terms of Pareto-Koopmans concept which is attained when an increase in any output (or a decrease in any input) requires a decrease in at least another output (or an increase in at least another input; e.g., [15]).

The CI is derived from the DEA model proposed by [6], named the Benefit of the Doubt model which is equivalent to the original DEA input oriented model, with all indicators considered as outputs and a single dummy input equal to one for all countries. The dummy input can be understood intuitively by regarding the model as a tool for aggregating several sub-indicators of performance, without referencing the inputs that are used to obtain this performance [16]. As the BoD model only includes outputs (the indicators), this DEA model measures the performance rather than the efficiency.

One of the best features of DEA is that it does not require any prior knowledge of weight factors as the model optimizes them endogenously. The weights can vary among countries and are determined in a way to show each of them in the best possible way, i.e., maximizing their performance [16]. Thus, DEA is a popular method in the CI literature as it can solve the problem of subjectivity in the weighting procedure. Another well-known property of the original DEA model is its unit invariance. This is very interesting for the construction of CI as its final value is independent of the measurement units of the sub-indicators which in turn makes the normalization stage redundant [17].

As stated before, the objective is to aggregate the individuals sub-indicators (the outputs) for each country into a single composite indicator defined as the weighted average of the m sub-indicators. Given a cross-section of m sub-indicators and n countries, with y_{ij} being the value of sub-indicator (or output) i for the country j, and w_i the weight attributed to the i-th sub-indicator, which is endogenously defined to maximize the CI value for the country under assessment

[17], without *a priori* expert information. The CI is computed for each country j_o, through the BoD model which has the linear programming formulation (1):

$$CI_{j_o} = max \sum_{i=1}^{m} w_i y_{ij_o} \tag{1}$$

subject to:

$$\sum_{i=1}^{m} w_i y_{ij} \leq 1 \qquad \forall j = 1, ..., n$$

$$w_i \geq 0 \qquad \forall i = 1, ..., m$$

Analyzing the objective function, it can be observed that the problem chooses the w_i that maximizes the resulting CI_{j_o} value. This implies that the highest relative weights are assigned to those dimensions in which the country has the best relative performance when compared to the other countries [17]. The core idea is as follows: if a sub-indicator has a good relative performance it suggests that this country views this policy dimension as relatively important, so it deserves a higher weight. The opposite is also valid, i.e., a sub-indicator with a low relative performance indicates a lower importance attached by the country in that context, therefore it receives a lower weight [6].

The formulation above has only two kinds of restrictions: it is imposed that no country can have a CI value greater than one, ensuring an intuitive interpretation of the indicator; also, each weight should be non-negative, which implies that the CI is a non-decreasing function of the sub-indicators. Consequently, the CI value obtained varies between zero and one for each assessed country j_o, where higher values indicate a better relative performance [17].

The BoD model (1) allows the weights to be freely estimated in order to maximize the relative performance of the country. Thus, in some situations. A country may obtain a higher relative performance by assigning zero weights to some indicators which have worst scores. This means that each sub-indicator associated with the zero weight has no influence in the composite indicator value. This situation should be avoided, since the sub-indicators were carefully selected and therefore they are all important in computing the CI [18]. To accomplish these goals, the model (1) should incorporate additional restrictions for each sub-indicator contribution, by adding virtual proportional weight restrictions, as proposed by [19]. Thus, each sub-indicator is required to have a minimum percentage of contribution (α) in the assessed composite indicator given by (2).

$$\frac{w_i y_{ij_o}}{\sum_{i=1}^{m} w_i y_{ij_o}} \geq \alpha \qquad \forall i = 1, ..., m \tag{2}$$

Another issue that is not considered in the original BoD model is the presence of undesirable sub-indicators, i.e. sub-indicators where the increase of their value is not beneficial, as the percentage of GHG emissions, for example. One possible approach to deal with these undesirable indicators is the use of data

transformation techniques. Some of these techniques can be the inversion of the value of the undesirable indicator, the subtraction the undesirable factor from a sufficient large number, or the use of the max-min method. Some of these techniques are presented and compared in [18]. After the data transformation, the transformed undesirable sub-indicators are included in the conventional BoD model and treated as the desirable sub-indicators [20].

3.2 Data and Variables

Three pillars are usually mentioned as defining a sustainable transport system: the economic, the environmental, and the social one [7]. The proposed composite indicator has been developed aiming to achieve a balance between what is necessary to support sustainable transport assessment and the available data for EU countries.

As previously stated, the CI consists in the aggregation of several sub-indicators, being of crucial importance the selection of the indicators to compute the overall performance. Some issues were considered in the sub-indicators selection process: they should reflect the Roadmap targets [3] and other sustainability topics of relevance for transport; and finally, each sub-indicator must measure a specific area of the performance, ensuring the minimum number of sub-indicators; each sub-indicator must be of easy interpretation and should be available for all countries in the time span selected.

Several sub-indicators were considered to incorporate important topics related to the Roadmap and SDG targets. Taken into account these topics and the literature review of previous works with similar concepts on sustainable transport and conceptual framework, the CI is constructed based on the following five sub-indicators: share of buses and trains in total passengers transport, people dead in road accidents, share of energy from renewable sources in transport, GHG emissions by fuel combustion in transport and average CO_2 emissions per kilometer from new passengers cars. These sub-indicators are described hereinafter.

The share of buses and trains in total passengers transport (y_1) reflects the SDG goal related to industry, innovation and infrastructure, which requires building resilient and sustainable infrastructure. On the other hand, the SDG involving sustainable cities and communities, aims to renew and plan cities so they offer access to basic services for all. Future mobility should optimise the use of transport, including car sharing and the integration between different modes of collective transports. Also, the necessity to improve the transport quality, accessibility and reliability is one of the subjects discussed in the Roadmap. Capturing these goals, this indicator measures the share of collective transport in total inland transport. Collective transport refers to buses (including coaches and trolley-buses) and trains, while the total inland transport includes this modes and passenger cars. Trams and metros are not included due to the lack of harmonised data.

The people dead in road accidents (y_2) measures the number of fatalities in road accidents per hundred thousand inhabitants. The average population of the

reference year (used as denominator) is calculated as the arithmetic mean of the population on 1st January of two consecutive years. The European Commission aims to make EU a world leader in safety and security of all modes of transport. With initiatives in the areas of technology, enforcement and education, EU aims to reduce fatalities close to zero by 2050. This indicator is also aligned with two SDG, aiming at safer cities and health and well-being status.

The share of energy from renewable sources in transport (y_3) contributes to a significant reduction in the greenhouse gas emissions and also reduces the oil dependence, as well as the local air and noise pollution. The Renewable Energy Directive [21] sets a 10% target for renewable energy in transport for 2020. The Roadmap also suggests a regular phase out of conventionally-fuelled vehicles from urban environments by halving their number in 2030 and phasing them out of the cities by 2050. This indicator shows how extensive is the use of renewable energy and how much it has replacing the fossil fuels.

The GHG emissions by fuel combustion in transport (y_4) measures the transport's fuel combustion contribution in the total greenhouse gas emissions. The value is originally given in thousand tonnes and was normalized using the country's population on 1st January of each year, to consider the dimension of the country. Its unit of measure is thousand tonnes per hundred thousand inhabitants.

The average carbon dioxide (CO_2) emissions per kilometer from new passengers cars (y_5) is defined as the average CO_2 emissions per kilometer in a given year for new passenger cars. The Roadmap highlights the importance of the research and innovation on vehicle propulsion technologies and the improvement of energy efficiency performance of vehicles across all modes. The EU sets a mandatory target for emission reduction for new cars of 95 g of CO_2 per kilometer in 2021. This is a target for the average of the manufacturer's overall fleet, meaning that cars above the limit are allowed as long as they are offset by the production of lighter cars.

These five sub-indicators are used to assess the transport environmental performance of EU countries, as presented in the next section.

4 Results and Discussion

4.1 Descriptive Analysis of the Variables

The transport environmental performance was calculated for the 28 EU countries, from 2015 to 2017. Therefore, data was collected for Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and United Kingdom. It was chosen to use the United Kingdom data, since during the time span of the assessment the country still integrated the European Union. All the data used in this work was gathered from the Eurostat database [22].

Table 1 shows two descriptive statistics for the sub-indicators under analysis across countries for each year. Besides the mean, the dispersion coefficient

(DC), given by the ratio between the standard deviation and the mean, was also calculated in order to facilitate the comparison between sub-indicators.

Table 1. Mean and DC of the indicators data used in the construction of the CI.

	2015		2016		2017	
Indicator	Mean	DC	Mean	DC	Mean	DC
Public transport (y_1)	18.175	0.241	18.011	0.238	17.768	0.246
Deaths road accidents (y_2)	5.800	0.366	5.625	0.325	5.325	0.358
Renewable energy (y_3)	6.544	0.795	6.191	0.746	6.884	0.733
GHG emissions (y_4)	208.670	0.771	211.493	0.714	213.696	0.696
New cars emissions (y_5)	120.946	0.078	118.757	0.066	119.168	0.064

Analysing Table 1, it can be seen that the share of public transport in total passenger transport (y_1) has constantly decreased in the time span under study, by 2017 it was more than 2% lower compared to 2015 levels. The mean of deaths in road accidents (y_2) for all countries has decreased more than 9% from 2015 to 2017. The share of energy from renewable sources in transport (y_3) decreased in 2016 but during 2017 it increased more than 5%, when compared with the 2015 value. The mean of GHG emissions (y_4) for all countries has increased more than 2.4% during the time span studied. The mean of CO_2 emissions per kilometer from new passengers cars (y_5) has increased from 2016 to 2017 but still remained 1.5% below 2015 levels.

The highest difference among countries data is observed in the GHG emissions (y_4) and the share of energy from renewable sources in transport (y_3), as some countries are ahead in utilizing renewable energy, such as Sweden with 26.8% in 2017 and Finland with 24.8% in 2015.

The higher scores of variability relative to the mean are observed for the share of energy from renewable sources in transport (y_3) followed by the GHG emissions from fuel combustion (y_4), although both have been decreasing during the time span studied. These outputs translate the differences among countries in available renewable resources and/or different policies for reducing GHG emissions. The lowest variability relative to the mean is observed for the CO_2 emissions per kilometer from new passengers cars (y_5) showing a higher homogeneity in the energy efficiency performance of vehicles between countries.

4.2 Performance Assessment of the Models

The relative transport environmental performance for each country in a given year is computed by aggregating the sub-indicators y_1, y_2, y_3, y_4 and y_5 through the BoD model given by (1), by computing the CI. To avoid using zero weights in the performance assessment of a given country, the previous model should incorporate proportional virtual weights restrictions, as proposed by (2), imposing α

equal to 5% for each sub-indicator share. The relative transport environmental performance for each country in a given year is assessed by comparison to the best practices observed during the period analysed, i.e., from 2015 until 2017. The obtained results are presented in Table 2, where the Model 1 refers to BoD model defined by (1), and Model 2 refers to the previous one but considering restrictions (2).

Table 2. Transport environmental performance results.

	2015		2016		2017	
Country	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Belgium	0.918	0.748	0.924	0.831	0.926	0.847
Bulgaria	0.881	0.799	0.901	0.815	0.889	0.810
Czechia	0.944	0.898	0.974	0.924	0.965	0.929
Denmark	**1.000**	0.929	0.999	0.920	0.999	0.927
Germany	0.932	0.803	0.842	0.821	0.841	0.821
Estonia	0.851	0.234	0.847	0.240	0.879	0.242
Ireland	0.924	0.861	0.936	0.834	0.955	0.909
Greece	**1.000**	0.459	0.996	0.563	0.977	0.782
Spain	0.943	0.476	0.941	0.848	0.908	0.851
France	0.965	0.909	0.968	0.915	0.972	0.920
Croatia	0.946	0.743	0.951	0.494	0.935	0.468
Italy	0.944	0.863	0.958	0.887	0.955	0.865
Cyprus	0.872	0.654	0.883	0.677	0.894	0.668
Latvia	0.835	0.716	0.865	0.666	0.852	0.640
Lithuania	0.812	0.695	0.821	0.681	0.807	0.696
Luxembourg	0.852	0.635	0.853	0.651	0.854	0.666
Hungary	**1.000**	**1.000**	**1.000**	**1.000**	0.992	0.983
Malta	**1.000**	0.871	0.978	0.872	0.985	0.926
Netherlands	**1.000**	0.923	0.970	0.874	0.959	0.902
Austria	0.951	0.902	0.965	0.917	0.958	0.909
Poland	0.914	0.856	0.914	0.782	0.894	0.781
Portugal	0.995	0.902	0.999	0.916	0.997	0.915
Romania	**1.000**	**1.000**	**1.000**	0.970	0.996	0.941
Slovenia	0.866	0.612	0.866	0.530	0.861	0.646
Slovakia	0.946	0.929	0.959	0.939	0.951	0.927
Finland	0.980	0.927	0.911	0.877	0.970	0.936
Sweden	0.975	0.965	0.993	0.987	**1.000**	**1.000**
UK	0.918	0.791	0.925	0.814	0.920	0.804
Mean	0.931	0.789	0.933	0.794	0.932	0.811
Std Dev	0.059	0.178	0.054	0.172	0.054	0.165

The mean of the Model 2 presented in Table 2, shows that the transport environmental performance has increased, on average, 2.8% between 2015 and 2017. These results imply that, overall, the countries are slowly improving towards the sustainable goals and if the results for the GHG emissions and the public transport share in passenger transport were better, the overall performance would be higher.

Considering the Model 1, eight units were efficient: Denmark (in 2015), Greece (in 2015), Hungary (in 2015 and 2016), Malta (in 2015), Netherlands (in 2015), Romania (in 2015 and 2016) and Sweden (in 2017). When the proportional virtual weights restrictions are imposed (Model 2), only four units remain efficient: Hungary (in 2015 and 2016), Romania (in 2015) and Sweden (in 2017) taken into account the five sub-indicators. The countries that are efficient only in the BoD model and become inefficient in the BoD model with restrictions (Denmark, Greece, Malta and Netherlands in 2015 and Romania in 2016) probably had a better result in some sub-indicators but a lower performance in overall sub-indicators. Thus, when restrictions are imposed and all sub-indicators are required to contribute to the final CI score, those countries become inefficient. Hereinafter, it is fair to consider the Model 2, i.e., the Model 1 with restrictions (2), to assess the transport environmental performance of EU countries.

Under this methodology, from 2015 to 2017, most of the countries followed a small improvement in the mean of the overall performance. However, Spain, Greece and Belgium showed a higher improvement in their final score, increasing in 2017 by 79%, 70% and 13% above 2015 levels, respectively. Estonia was the most inefficient country in this analysis with an average CI of 24% and it had almost no improvement in the considered years. Croatia, Poland, Latvia, Romania and Hungary decreased their performance during the time period of analysis, with Romania being efficient in 2015 and Hungary in 2015 and 2016. Finland, Slovenia and the Netherlands decreased their performance in 2016, but by 2017 they managed to improve the environmental performance above 2015 levels.

Analysing Table 2 it is possible to notice that, in all three years, the variability in the results presented in Model 2 was higher compared to the variability presented for the results obtained with Model 1. The highest standard deviation value was observed in the CI from 2015 with Model 2 and the lowest was presented by the CI from 2016 and 2017 using Model 1.

Regarding the transport environmental performance computed by the adopted methodology, this study also compares the benchmark countries with the inefficient ones. This analysis is implemented considering as benchmarks the best performing countries, which obtained a CI score above 0.95, i.e., Hungary (in 2015, 2016 and 2017), Sweden (in 2015, 2016 and 2017) and Romania (in 2015 and 2016). The other countries are considered inefficient. The mean for each sub-indicator is calculated for both groups (benchmarks and inefficient countries), using the original data for the undesirable sub-indicators (GHG emissions, deaths in road accidents and new cars emissions), i.e., without transformation. Figure 1

shows a comparison for each sub-indicator between the benchmark countries and the remaining, considered inefficient.

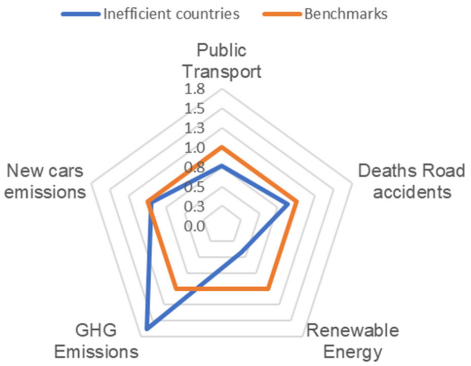

Fig. 1. Comparison between benchmarks and inefficient countries.

Analysing Fig. 1, it is possible to notice that inefficient countries have less than 50% of the share of transport energy from renewable sources observed in the benchmark countries and the GHG emissions from fuel combustion engines are more than 60% higher than the benchmarks. The average CO_2 emissions from new passenger cars is almost the same for both groups. The average share of public transport in the inefficient countries is almost reaching the same level as the benchmark countries. Regarding the number of deaths on road accidents, however, the inefficient countries are slightly better than the benchmarks. This analysis enables to identify the areas where the inefficient countries need to improve by setting out policies and/or redefine output standards, for instance. Most of this work need to be done in drastically reducing the GHG emissions from fossil fuel, increasing the share of transport energy from renewable sources and improving the public transport access and quality to allow a larger share of the total passenger transport.

5 Conclusions

This study assesses the environmental performance of the transport sector in the 28 countries of the European Union towards the targets set in the Roadmap and SDG, from the year 2015 until 2017. The assessment of the transport environmental performance is implemented through the composite indicator derived from the BoD model with virtual proportional weights restrictions. Based on the results achieved, it is possible to conclude that EU countries slightly improved their transport environmental performance, on average 2.8%. This implies that EU countries should develop more efforts to follow the transport environment targets.

Spain, Greece and Belgium showed the highest improvement in their final score during the time frame analysed. Estonia was the most inefficient country and showed almost no improvement over the years. Croatia, Poland, Latvia, Romania and Hungary decreased their performance during this time period. Finland, Slovenia and the Netherlands decreased their performance initially in 2016, but by 2017 they were able to improve above 2015 levels. These results suggest that inefficient countries should improve their practices by emulating the best practices observed on benchmarks.

By using as benchmark units the ones that obtained a performance above 95%, the comparison with the remaining units, considered inefficient, allowed the identification of the areas where policies should greatly impact: the reduction of GHG emissions from fuel combustion engines and the increase of the share of public transport in total passenger transport.

Future works should explore other models for treating undesirable indicators in order to allow results comparison among those different models. Furthermore, some other sub-indicators can be taken into account, to calculate the composite indicator for each country.

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