Do the European Countries Perform Road Transport Efficiency?

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Abstract

The transportation industry uses around one-third of all energy used globally, with inland transit alone accounting for half of all petroleum use. Focusing on realistic targets is crucial given the growth of motorization in countries that have recently entered the industrial age. Sustainable transportation is a mode of transportation that promotes the social and economic development of people, lessens adverse environmental effects, and assures the flow of people and products. The transportation industry might be able to help resolve current problems if it receives international support to transform and reduce its harmful externalities, such as traffic accidents that put people's lives and health in danger, air and noise pollution, lost time spent in vehicles, and greenhouse gas emissions that cause climate change. However, recent advancements in transportation technology and infrastructure frequently pose significant hazards to sustainability. As a result, the advantages of more mobility must be balanced against the drawbacks in the social, environmental, and financial spheres. To demonstrate the efficacy of the presented methodology, an empirical application evaluating road transport sustainability taking into account safety concerns in selected EU countries is carried out by slack-based DEA technique, which is able to consider undesirable outputs that need to be included in transportation sustainability measurement. As per analysis results, France, Romania, and Finland are found to be efficient.

Keywords: Slack Based-Data Envelopment Analysis, European Union, Road, Transport

1. Introduction

The environment and safety are the cornerstones of sustainable transportation. The transportation industry contributes significantly to the production of air pollution and accidents that are dangerous to human health. According to the World Health Organization, traffic has a substantial role in both fatal and injury accidents. Performance evaluation is a crucial step in addressing the issues of environmental impact and safety in transportation because it provides a framework for decision-making (Wang, 2019). One of the largest social and health problems we currently confront is traffic accidents. In developing countries, road traffic accidents pose a severe threat to public health and annually consume a sizeable amount of GDP. To fully comprehend how this issue relates to the existing policies, the governments must conduct a thorough safety evaluation of regional accident reduction efforts (Seyedalizadeh Ganji and Rassafi, 2019).

Young individuals die most frequently from traffic accidents worldwide and they also cause a 3% GDP reduction (Ganji et al. 2019). The leading cause of young age-related mortality, they are predicted to be the ninth most prevalent cause of death worldwide (Fancello et al. 2020). Road safety management is crucial for lowering the number of deadly traffic accidents as well as other detrimental effects of traffic. Determining the present level of traffic safety is the first stage in regulating road safety, and decision-makers usually struggle with this. Additionally, comparing and measuring the level of road traffic safety between various areas is one of the most challenging components of traffic safety research (Antić et al. 2020). Evaluation of road safety is a crucial problem for legislators. Data envelopment analysis (DEA) is one of the most crucial techniques for evaluating traffic safety. In this study, we use slack-based DEA, a particular kind of DEA approach, to assess road transport sustainability with safety issues in a few selected EU nations. The rest of our paper is organized in that way. The second part details the papers about road transport sustainability. The third part explains the analysis method used in the study. Then empirical results are evaluated. The last section presents the conclusions.

2. Literature Review

Several studies analyze the sustainability of road transportation while taking environmental and safety considerations into account. These studies are summarized in certain cases as follows:

Wang (2019) used DEA for assessing units with several inputs and numerous outputs, to produce a single performance measure for road transport sustainability. This approach employs the slacks-based DEA including safety problems like accident deaths and injuries as well as environmental consequences. They use the model to look at how driving affects safety and the environment for a set of OECD nations between 2000 and 2014. They demonstrate how a combined evaluation's unified measure and a separate assessment of the environment and safety may differ significantly.

Ganji et al. (2019) present a DEA-based decision strategy in order to help practitioners in urban road safety management determine which roadways most urgently need safety improvement. For an Italian network of urban roadways, the technique is used to rank problematic road locations according to safety criteria. The traffic volume and average number of locations at crossings are used as inputs, and the only indicator of the outcome is the societal cost of accidents. Both the input- and output-oriented traditional DEA models are employed. The findings demonstrate that the employed methods produce a more thorough and realistic evaluation.

Omrani et al. (2020) combine the DEA road safety model with the group best-worst method (BWM) in this study to solve the weight flexibility restriction of the DEA-RS model and include decision-makers preferences in the process. It is advised to use a group BWM to take preferences into consideration. The recommended technique is used to determine how efficient the provinces of Iran have been in enhancing traffic safety. The results show that Tehran and other developed areas of Iran have the safest roads in the world. On the other side, driving in poor road infrastructure provinces is found to be risky.

Seyedalizadeh Ganji and Rassafi (2019) evaluate Iranian provinces' safety efficiencies and are analyzed concurrently using the double frontier DEA. Using the Evidential Reasoning (ER) approach, the obtained efficiency numbers are then aggregated. Data from 2014-2016 was used to rank these provinces. Finally, the overall safety performance of Iranian roadways is employed over time using a Malmquist productivity index (MPI).

Stefaniec et al. (2021) employ the Shannon entropy to aggregate the outcomes of DEA models to provide a sole sustainability value. The approach was employed to analyze road traffic in EU countries. The empirical part examines the profiles of each individual EU nation, contrasts the two clusters of EU members, and evaluates the evolution of social sustainability. As a result, their method prevents the rankings of more developed economies from being artificially inflated. The results also highlight the issue of automobile dependence, which is related to high rates of motorization in the wealthier EU-15 countries.

Lo Storto and Evangelista (2023) aim to use the DEA approach to evaluate the effectiveness of each of the logistics networks associated with land in each of the EU member states between 2010 and 2017. There is a comparison of the environmental impact, infrastructural efficacy, and logistical quality of several national logistics systems. The efficiency, norms, and environmental effects of land logistics networks in EU member states were examined in this study. When comparing different efficiency metrics, it becomes clear that logistics systems' competitiveness might not be guaranteed or maintained solely by the service component due to insufficiently high infrastructure efficiency.

Baran and Górecka (2019) apply the DEA technique in order to evaluate the efficiency of road and rail freight transport in both new and existing EU members. To do this, the authors present an overview of the corpus of work that represents the research on the importance of transportation and how it has developed in relation to economic and environmental challenges. The empirical part consists of the DEA data presentation and the connection between transport efficiency, GDP, and CO2 emissions outcomes.

Domagała and Kadłubek (2022) consider all three social, economic, and environmental problems while managing transportation sustainably. This article's goal is to provide a thorough study of the 27 road freight transport sectors in the EU's energy, economic, and environmental performance in 2019. The Slacks-Based Measure (SBM) DEA model was utilized. The degree of environmental efficiency in the road freight transport sector varies throughout EU member states. There are effective networks for road freight transportation in ten members. It was found that there was a weak but positive correlation between the economic growth of EU member states and the eco-efficiency of the transport industry.

Shen et al. (2020) assess environmentally efficient road transportation among the EU members. Besides, the fundamental concept of DEA is extended to include the assessment of the intended results as well as the undesired expenses for benchmarking purposes. A total score for the sustainability of road transport is determined for each of the EU member countries. It is therefore possible to calculate the efficiency scores for both good and poor attributes using this score. Furthermore, after employing a clustering approach that allocates nations according to core similarities in their behavior.

3. Research Methodology

3.1 Slack-Based DEA Technique

A non-parametric comprehensive assessment method called DEA may be employed to compare the efficiency of several decision-making units (DMUs). This technique establishes the quantity and reasons for inefficient DMUs by using efficient DMUs as a reference benchmark. Numerous DEA models have been proposed for various reasons. However, these models disregard the lack of indications and instead, assume that changes in variables are proportionate. The non-radial SBM-DEA model, on the other hand, is more appropriate for assessing units with equivocal connectivity inputs. Additionally, DMU input surpluses and output deficits are taken into account, in addition, a distinct objective improvement value is assigned to each ineffective DMU's input and output. (Cheng et al. 2020). Despite the advantages of traditional DEA, the analysis results have been proven to not be practically reliable. One explanation for this could be that the typical DEA ignores input and output slacks because it is a radial model.

Tone (2001) suggested a measuring method based on slack to address the slack of input waste and output scarcity (Keskin, 2021). Take into account that there are n DMUs, m inputs, and s inputs. The slack-based DEA technique is presented below (Park et al. 2018).

$$\min p = \frac{1-\frac{1}{m}\sum_{i=1}^{m} S_i^{-}/x_{io}}{1+\frac{1}{s}\sum_{i=1}^{s} S_i^{+}/y_{io}}$$

(1)

$$X\lambda + s^{-} = x_0$$

(2)

$$Y\lambda - s^{+} = y_0$$

(3)

$$\lambda, s^{-}, s^{+} \geq 0$$

(4)

where X and Y represent the quantity of input and output, respectively, and s- and s+ represent input and output slacks. λ denotes the weight that is not negative.

4. Empirical Results

In our analysis, we aim to assess road transport sustainability considering road safety in selected EU countries by the slack-based DEA technique that can include undesirable outputs as well. Initially, we present the variables used in our empirical analysis in Table 1.

Table 1. Road Transport Sustainability Variables of the Slack-Based DEA

Variable Type	Variables
Inputs	Total Employment in Road Transport Total Energy Consumption Total Length of Road Network
Desirable Output	Total Road Passenger Volume
Undesirable Outputs	GHG Emissions Total Road Accidents

Table 2 presents the slack-based DEA analysis results of road transport sustainability by considering safety concerns in selected European countries. We analyze a selected group of EU members

Table 2. The Slack-Based DEA Results of the Transport Sustainability in Selected European Countries.

EU Countries	Efficiency Scores (2018)	Efficiency Scores (2019)
Bulgaria	0,142	0,152
Czechia	0,433	0,455
Spain	0,322	0,352
France	1,000	1,000
Croatia	0,425	0,419
Italy	0,128	0,146
Hungary	0,369	0,384
Netherlands	0,765	0,773
Romania	1,000	1,000
Finland	1,000	1,000
Sweden	0,584	0,624
Average Efficiency Level	0,560	0,573

Source: Authors' Calculations.

France, Romania, and Finland are determined to be efficient, as shown in Table 2, over the 2018-2019 period. Moreover, the average efficiency level is determined to be 56-57%, indicating that there is still room for efficiency development in terms of road transport sustainability from the standpoint of road safety of 43-44% for selected European members. Significant efficiency disparities exist between analyzed European countries in terms of road transport sustainability.

5. Conclusions

Approximately 25% of the CO2 emissions in the EU come from traffic, with 88% of it coming from road traffic. Transportation is the largest energy consumer in the EU, accounting for about 30% of total energy consumption. The majority of the road transportation sector runs mostly on fossil fuels, which has negative consequences on both climate change and energy security. The need for low-carbon transportation system solutions is being driven by the depletion of less expensive energy extraction sources, the rise in demand for non-renewable energy sources, and the worsening environmental conditions (Domagała and Kadłubek, 2022). The ecology and human habitat are seriously destroyed by newly industrialized nations in order to make rapid economic growth. The expansion of motorization in developed countries is currently at a turning point because of the increase in transportation. Though their efficacy varies, energy conservation initiatives have been a primary priority for all EU members in the transportation sector. Therefore, examining a country's road transport sustainability is noteworthy. We use the slack-based DEA in our empirical research to assess the road transport sustainability of European members, which can include undesirable outputs. As per the analysis, three countries namely France, Romania, and Finland set a benchmark for inefficient countries. The more developed areas have higher rates of road transport efficiency. This might be explained by the fact that economically developed countries have higher levels technological innovation, which helps develop their transport systems. The number of people transported on the current road network and the number of accidents in relation to the length of roads greatly outperform the data of efficient EU countries throughout the whole research period. Road infrastructure should be developed in inefficient countries. The high price of private vehicles is a factor that renders traffic problems more difficult in developed countries. Therefore, public transport networks should be developed to increase road transport sustainability. Cities in industrialized countries have policies managing land use and transportation to reduce dependency on vehicles. Low-ranking nations should step up their efforts to promote sustainable transportation. We also conclude that more prosperous countries are not necessarily at the top of road transport sustainability rankings. The evaluation's findings could also aid in setting sustainability objectives for policymakers. An inefficient country may seek improvement from other countries with higher rankings in sustainability. For instance, urging the adoption of modern technologies and industry standards across the board in the transportation sector, and reducing energy usage and its impact on the environment by utilizing alternative energy sources are energy-efficient transportation solutions for inefficient countries to enhance their efficiency. Investing in renewable energy decreases the need to import fossil fuels and power, hence increasing road transport inside the European Union. However, the efficacy of renewable energy varies since every EU nation has its own energy strategy and employs distinct tactics to promote RE. Specifically, Electric Vehicles (EVs) should be adopted to minimize the detrimental effects of road transportation. In this regard, tax exemptions and purchase incentives are very significant breakthroughs for the spread of EVs in the EU. In conclusion, we may state that efficiency methodologies can yield important empirical conclusions when analyzing levels of transport and energy efficiency.

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