

**ASSESSING THE SUSTAINABILITY PERFORMANCE OF ROAD TRANSPORT:
ANALYSIS OF EUROPEAN UNION COUNTRIES**

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Abstract

Road transport plays a crucial role in the European Union's transition toward climate-neutral mobility; however, significant differences persist among Member States in terms of sustainability performance. This study evaluates the sustainability performance of road transport systems in 26 EU countries to understand their comparative positions in this transformation process. Using a comprehensive dataset from 2021, an integrated Multi-Criteria Decision-Making (MCDM) approach was employed, combining the Entropy method for objective criteria weighting and the EDAS method for performance ranking. The analysis reveals that Traffic Accidents, GDP, and Vehicle Usage are the most influential factors driving sustainability scores. Among the evaluated nations, France, Czechia, and Denmark achieved the highest performance rankings. The original contribution of this study lies in its application of an entropy–EDAS multi-criteria framework to evaluate the 2021 sustainability performance of road transport systems in 26 EU countries, providing a systematic, data-driven basis for comparing Member States' performance.

Keywords: Road transport,, European Union Countries, Sustainability, Entropy, EDAS

JEL Codes

Introduction

The twentieth century witnessed an exponential rise in global population, which drove up demand for transportation and placed a significant strain on the petroleum and transportation industries (Wang et al., 2022b). Due to the heavy reliance on fossil fuels, the transportation industry is responsible for 27% of the world's greenhouse gas emissions, significantly contributing to smog and air pollution (Wang et al., 2020). This challenge is particularly acute in the European Union, where transportation is a vital economic sector that employed 10.2 million people and generated a net turnover of €1.5 trillion in 2021 (Eurostat, 2024a). However, this expansion has come at a significant cost in terms of energy consumption and safety, positioning transport as one of the key challenges in the EU's sustainable development strategy (Shen et al., 2011). Consequently, road transport, which accounts for nearly one-fifth of total EU greenhouse gas (GHG) emissions, has been prioritized for climate action and identified as a crucial component of the European Green Deal (Tamba et al., 2022).

Despite a significant shift towards electric vehicles, the majority of the European Union (EU) fleet continues to rely on fossil fuels, creating an urgent need for structural transformation to mitigate climate change. The transport sector accounts for approximately one-quarter of the EU's total greenhouse gas emissions, with road transport being the primary contributor. To address this, the European Green Deal and the Sustainable and Smart Mobility Strategy serve as crucial frameworks, setting an ambitious goal of reducing transport-related emissions by 90%, by 2050 (European Environment Agency, 2024b). The current landscape of carbon dioxide emissions, which highlights the starting point of this transformation, is presented in Figure 1."

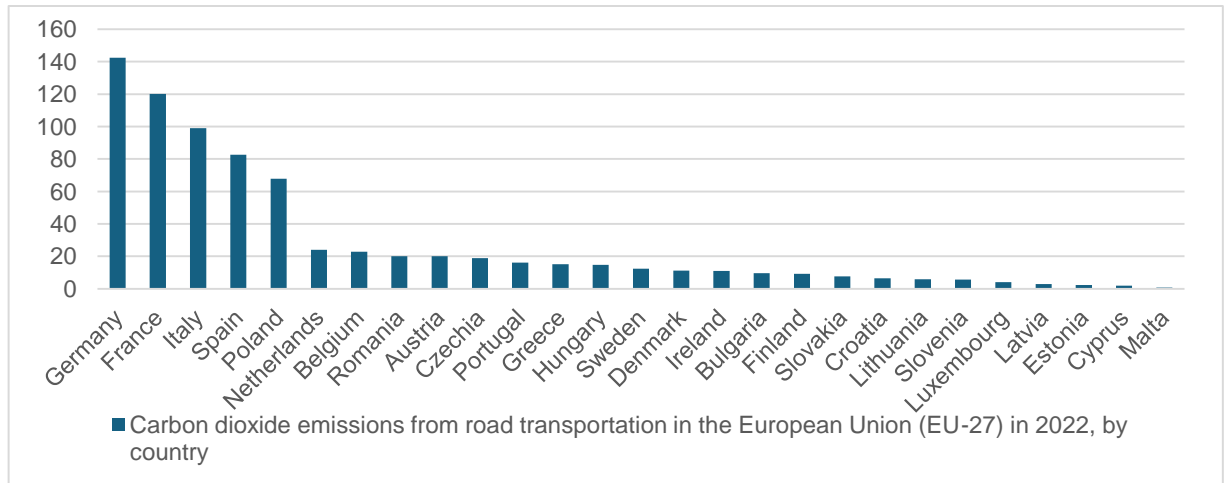


Figure 1: Carbon dioxide emissions from road transportation in the European Union (EU-27) in 2022, by country (in million metric tons)

Source: European Environment Agency

According to the data presented in Figure 1, the five countries with the highest carbon dioxide emissions from road transport are Germany (142.45 Mt), France (120.06 Mt), Italy (99.1 Mt), Spain (67.9 Mt), and Poland (67.9 Mt). These countries are the most significant contributors to carbon dioxide emissions from road transport within the European Union. Conversely, the countries with the lowest carbon dioxide emission rates from road transport are Malta (0.66 Mt), Cyprus (2 Mt), Estonia (2.35 Mt), Latvia (3.02 Mt), and Luxembourg (4.16 Mt). These nations have a minimal impact on the environmental effects of road transport in the European Union, contributing only marginally to overall emissions. In this context, accelerating the reduction of emissions is not merely an environmental goal but a critical prerequisite for the successful transformation of the EU transport sector (European Environment Agency, 2024a). Consequently, this study addresses the following primary research question: To what extent do EU countries differ in their road transport sustainability performance during this transition, and which specific factors drive these differences?"

To address this inquiry, this study aims to evaluate the sustainability performance of road transportation systems in European Union countries for 2021. In the existing literature,

sustainability assessments of road transportation have predominantly focused on Organization for Economic Co-operation and Development (OECD) countries (Wang et al., 2022a; Wang et al., 2022b; Senir & Büyükkeklik, 2023; Gökgöz & Yalçın, 2023). Consequently, there appears to be a gap in research specifically addressing European Union countries (26 countries), underscoring the potential contribution of this study to academic research. This research could provide valuable insights for policymakers, professionals, and researchers in transportation and sustainability. Additionally, this study is expected to enrich existing literature by integrating multi-criteria decision-making methods such as entropy and EDAS.

The remainder of this paper is structured as follows: Section 2 provides a thematic literature review, emphasizing existing sustainability assessments and methodological approaches. Section 3 details the data sources and the integrated Entropy-EDAS methodology. Section 4 presents and interprets the key findings, including the country rankings and sensitivity analysis. Finally, Section 5 offers conclusions, policy recommendations tailored to the countries' performance levels, and outlines avenues for future research."

Literature review

Environmental concerns associated with different transportation modes have led to an expanding academic discussion, highlighting the need to evaluate their impacts and identify effective mitigation strategies. An effectively planned strategy that harmonizes socio-economic development with environmental preservation is essential to address the current societal demands and the fundamental needs of future generations (Dündar & Kolay, 2021). In line with these concerns, the integration of logistics and sustainability has become an

important and steadily growing focus within academic research (McKinnon, 2007; Oberhofer & Dieplinger, 2014; Senir & Büyükkeklik, 2023).

Transport mode-based sustainability findings within the European Union highlight substantial performance differences across rail, maritime, and road systems. Petrovic et al. (2024) reveal that rail transport emerges as the most sustainable mode of transport within the European Union, while road transport ranks as the least sustainable. The study employed the RAWEC method alongside entropy, FANMA, and standard deviation techniques to assess sustainability based on various economic, environmental, and social indicators. The results consistently highlighted rail transport's superior sustainability performance, underscoring the importance of strategic policy adjustments to enhance the sustainability of other transport modes.

Aydın and Atak (2020) utilized Picture Fuzzy Numbers (PFN) and the EDAS methods to determine the optimal mode of freight transport between Istanbul and the Netherlands, evaluating rail, maritime, and road transport options. The study concluded that maritime transport is the most suitable mode for this route. Furthermore, the research underscores the effectiveness of MCDM methods in selecting the appropriate transport mode.

In the European Union context, studies examining road transport sustainability employ efficiency-based approaches to assess performance across countries. Within this line of research, Shen, Bao, and Hermans (2020) offer a comprehensive evaluation of EU road transport systems through a Data Envelopment Analysis (DEA) framework that incorporates both desirable outputs (e.g., revenue) and undesirable outputs (e.g., greenhouse gas emissions, road fatalities). Their findings revealed that Sweden was the only country to achieve optimal efficiency across all factors, highlighting the need for a comprehensive approach to transport sustainability. These results emphasize the importance of considering

both positive and negative aspects for effective policymaking and sustainable transport planning.

Wang et al. (2022a) analyzed the sustainable performance of road transport across 25 OECD countries over the period 2015-2019, utilizing a DEA framework that incorporated infrastructure investment and maintenance, route length, labour, and energy consumption as key inputs. The findings revealed that Australia, Switzerland, Spain, France, Italy, Japan, Korea, Lithuania, the Netherlands, Poland, Sweden, and the USA consistently achieved the highest efficiency rankings across all five consecutive years, indicating their superior sustainable performance in road transport within the OECD. Complementing this analysis, Wang et al. (2022b) employed an entropy–CoCoSo multi-criteria decision-making model for 28 OECD countries, identifying Japan, Germany, and France as leading performers, while Iceland, the United States, and Latvia fell behind. Across both studies, fuel consumption emerged as a particularly influential factor, followed by indicators such as road accidents and air pollution emissions.

In addition to DEA- and entropy-based analyses, other OECD-oriented research applies alternative multi-criteria frameworks to capture the multidimensional nature of road transport sustainability. Senir and Büyükkelik (2022) analyzed the sustainable performance of road transport in 18 countries using the Entropy method to determine criteria weights and the WASPAS method for ranking performance. Their results identified Iceland, Turkey, and Lithuania as the highest-performing countries, while New Zealand, Austria, and the Czech Republic ranked lowest. In a related OECD-based assessment, Gökgöz and Yalçın (2023) employed the Proximity-Indexed Value (PIV) method within an integrated MCDM framework and identified Germany, The United Kingdom, and France as the leading performers in road transport sustainability. According to the authors, the strong performance of these countries may be linked to advanced technological innovations, robust economic

growth, and substantial infrastructure investments. Conversely, Luxembourg, Austria, Belgium, and Greece exhibit lower sustainability levels.

Dataset and Methodology

The analysis utilizes the most recent data, sourced from OECD statistics, Eurostat, the International Road Federation, and the World Bank, all corresponding to 2021. However, Malta, a member of the European Union, was excluded from the study due to the unavailability of sufficient data for this country.

Entropy Method

Entropy determines the objective weighting of criteria in decision-making processes. It measures the disorder or uncertainty associated with each criterion, where lower entropy indicates more informative data. The method begins by normalizing the data, followed by the calculation of entropy for each criterion, and then the determination of weighting based on the inverse of these entropy values. This ensures that criteria with more significant informational contributions receive higher weighting (Zou et al., 2006). According to Chen (2020:23), the properties of the entropy weighting method are described as follows:

a. When all the values within a column are identical, the entropy reaches its maximum value of 1, and the corresponding entropy weighting becomes 0. This means that if the data for each evaluation criterion is the same, the criterion does not provide any meaningful information.

b. The larger the variation between the values in a column, the lower the entropy value and the higher the corresponding entropy weighting. This suggests that the criterion carries valuable information. Conversely, a higher entropy value indicates a smaller entropy weighting, signifying that the criterion is less important.

The key strength of the entropy method lies in its objectivity. Unlike subjective weighting methods, it relies purely on the data to assign importance to each criterion, thus

reducing bias. This objectivity is particularly useful in multi-criteria decision-making scenarios where the consistency and reliability of the criteria weighting are crucial for accurate outcomes. Wu et al. (2018) describe the calculation steps of the entropy method as demonstrated in Table 1.

Values used for calculation:

p_{ij} : Normalized value of X_{ij} used in the entropy calculation

E_j : Entropy value of criterion j

d_j : Degree of diversification for criterion j

$k = \frac{1}{\ln(m)}$: Entropy constant

w_j : Final weight of criterion j calculated by the entropy method

$i = 1, 2, \dots, m$: Alternatives

$j = 1, 2, \dots, n$: Criteria

Table 1: Phases of the entropy method

1st Step: Construct the Decision Matrix	$\begin{matrix} X_{11} & X_{12} & \dots & X_{1n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ \dots & \dots & \dots & \dots \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{matrix}$ <p>where $i=1, 2, \dots, m$ (alternatives), $j=1, 2, \dots, n$ (criteria)</p>
2nd Step: Normalize the Decision Matrix	$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}}$
3rd Step: Calculate the Entropy for Each Criterion	$E_j = -k \sum_{i=1}^m p_{ij} \ln p_{ij}$ <p>Where $k = \frac{1}{\ln(m)}$</p>
4th Step: Determine the Degree of Diversification (d_j) for Each Criterion	$d_j = 1 - E_j, \forall j$
5th Step: Calculate the Entropy Weighting for Each Criterion	$W_i = \frac{1 - e_i}{\sum_{i=1}^m (1 - e_i)}$

Source: Wu et al. (2018: 7).

EDAS Method

EDAS (Evaluation based on Distance from Average Solution) is one of the recently developed methods with great applicability in various complex decision-making problems. Developed by Ghorabae et al. in 2015, EDAS is a multi-criteria decision-making method based on distance from average (Torkayesh et al., 2023). The EDAS method involves several systematic steps to evaluate alternatives in multi-criteria decision-making scenarios. Initially, a decision matrix is constructed, followed by the computation of the average values for each criterion. The next step involves creating positive and negative distance matrices based on the deviation of each alternative from these average values. The weighted sums of these distances are then calculated, and the results are normalized. Finally, an evaluation score is computed for each alternative, with the alternatives ranked according to these scores, where the highest score indicates the optimal choice (Ghorabae et al., 2016: 360). Values used in the calculation:

- AV_j :Average value of criterion j
- PDA_{ij} :Positive Distance from Average for alternative i
- NDA_{ij} :Negative Distance from Average for alternative i
- SP_i :Weighted sum of PDA_{ij} values for alternative i
- SN_i :Weighted sum of NDA_{ij} values for alternative i
- NSP_i :Normalized SP_i
- NSN_i :Normalized SN_i
- AS_i :Final appraisal score of alternative i
- w_j :Weight of criterion j (obtained from Entropy method)
- $i = 1,2, \dots, m$:Alternatives
- $j = 1,2, \dots, n$:Criteria

Table 2: Phases of the EDAS method

1. Creating the Decision Matrix ($X=x_{ij}$)	$ \begin{matrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} \dots & & a_{mn} \end{matrix} $ <p>Where Decision matrix X containing a_n criteria and x_m alternatives</p>
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2. Creation of Average Values Matrix	$AV_j = \frac{\sum_{i=1}^n x_{ij}}{n}$
3. Creation of Positive and Negative Distance Matrices from the Mean	$PDA = [PDA_{ij}]_{n \times m}$ $NDA = [NDA_{ij}]_{n \times m}$ If criterion j is benefit If criterion j is cost
4. Calculation of Weighted Total Values	$SP_i = \sum_{j=1}^m w_j x PDA_{ij}$ $SN_i = \sum_{j=1}^m w_j x NDA_{ij}$
5. Normalisation of Total Weighted Distance	$NSP_i = \frac{SP_i}{\max_i(SP_i)}$ $NSN_i = 1 - \frac{SP_i}{\max_i(SN_i)}$

Source: Özaydın ve Karakul, 2021: 6-7

Results

The sustainability assessment framework in this study is structured around four fundamental criteria commonly applied in transport literature. Table 4 provides a comprehensive overview of these criteria, their corresponding indicators, benefit/cost types, and supporting literature from previous research.

In the majority of studies evaluating the sustainability performance of transport modes, the assessment has been conducted based on four fundamental criteria. The benefit-cost aspects of these criteria are detailed in Table 4.

Table 4: Criteria used in the study and their definitions

Main Criteria	Criteria	Description	References
System Effectiveness	Roadway Length (Benefit)	The total length of the roadway of the countries- (km)	Wang et al., 2022a; Sayyadi & Awasthi, 2020; Camargo Pérez et al., 2015

	Vehicle in Use (Benefit)	Number of registered passenger cars in Europe (<i>in 1,000 units</i>)	Ecer et al., 2019; Camargo Pérez et al., 2015; Rao, 2021
	Freight Volume (Benefit)	The total movement of goods by means of road transport (Million Tone)	Wang et al., 2022a; Rao, 2021; Miller et al., 2016)
Economic	Infrastructure Maintenance (Cost)	Transport infrastructure investment and maintenance spending on roads (Millions USD)	Osorio-Tejada, 2017; Shiau et al., 2015
	GDP (Benefit)	In 2021, GDP of European Union Countries (Millions USD)	Camargo Pérez et al., 2015
Social	Number of employees (Benefit)	Countries total number of employees (Thousands of people)	(Wang et al., 2022b; Goulart et al., 2024; Stefaniec et al., 2021)
	Road Accidents (Cost)	countries' total number of road accidents (Number of accidents)	(Wang et al., 2022b; Goulart et al., 2024; Stefaniec et al., 2021)
Environmental	Fuel Consumption (Cost)	Energy consumption by road transport (Thousand tons)	Ecer et al., 2019; Osorio-Tejada et al., 2017; Shiau et al., 2015
	CO2 Emissions (Cost)	Gross direct emissions from fuel combustion (Million tons)	Sayyadi & Awasthi, 2020; Rao, 2021; Miller et al., 2016
	Air Pollution Emissions (Cost)	The amount of air pollutants emitted into the atmosphere including emissions of (sulfur oxides, nitrogen oxides, and carbon monoxide) (Thousand tons)	Wang et al., 2022a; Rao, 2021; Osorio-Tejada et al., 2017; Shiau et al., 2015

The criteria used to assess road transport performance and compare country-level alternatives were obtained from OECD Statistics, Eurostat, the International Road Federation,

and the World Bank. Based on these indicators, a 2021 decision matrix was constructed and is presented in Table 5.

Table 5: Construction of Decision-making Matrix

Country	Road Length	Vehicles in Use	Freight	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO₂	Air Pollution emissions
Austria	126357	5133	403502	480	479295	4688653	52774	7585	66,01	669
Bulgaria	19925	2830	157376	152	84041	3268751	6080	3328	43,64	368
Croatia	26411	1795	84968	537	69602	1724579	9246	2054	18	279
Cyprus	13226	592	27670	27	29481	667244	326	659	6,75	30
Czechia	130756	6088	500288	1817	281791	52799722	18156	6522	97,69	1341
Denmark	74948	2787	171555	239	405687	3070703	2402	3695	27,29	293
Estonia	58846	825	28894	281	36864	702984	1538	841,4	14,91	143
Finland	77906	2755	250023	1662	296470	2799859	3243	3790	98,99	450
France	1104743	37880	1648948	1020	2959355	31271173	53540	40071	302,33	3514
Germany	642401	48540	3107981	1605	4278503	43386527	258987	47388	665,88	3802
Greece	117899	5604	270994	681	214667	4571642	10454	4781	53,37	693
Hungary	216509	4020	219919	1894	182109	4920977	14233	4712	50,69	459
Ireland	102078	2250	153466	525	513391	2551560	4913	3535	35,01	231
Italy	236401	39822	987085	6185	2154875	25087249	151815	32687	319,67	2714
Latvia	57461	758	81562	201	39443	956869	3399	1071	7,21	137
Lithuania	84893	1611	113135	434	66798	1468048	2784	2056	13,82	172
Luxembourg	2914	433	48225	224	85584	333257	926	1754	8,45	31

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Netherlands	186817	8827	701990	7080	1029678	9620091	18449	8787	146,87	624
Poland	429816	25869	1580517	7563	681346	5190888	22826	23537	320,77	3420
Portugal	14325	5632	147065	93	255536	18519217	30691	5262	38,68	435
Romania	118174	7611	306805	442	285810	8200518	26805	6544	78,75	1231
Slovakia	57824	2493	98910	1003	118563	2773127	4541	2469	37,48	762
Slovenia	38840	2189	154828	611	61832	1045561	5330	1681	14,17	124
Spain	538451	24940	1626362	3780	1445651	23384158	89862	27303	231,91	2293
Sweden	215690	4986	492496	4140	639714	5638697	12625	6412	38,92	411
Belgium	154000	5927	36199	1137	600904	5259744	34660	8215	95,92	437
Total	4847611	252197	13400763	43813	17296990	263901798	840605	256739,4	2833,18	25063

The entropy method was applied to assess the significance levels of ten criteria. These levels are detailed in Table 6 and depicted in Figure 2. The criteria with the highest significance are Road Accidents, GDP, Vehicle Utilization, Freight Volume, Number of Employees, and CO2 Emissions.

Table 6: The criteria weighting calculated employing the Entropy Method

Criteria	Road Length	Vehicles in Use	Freight Volume	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO2	Air Pollution emissions
Wj	0,0867	0,1029	0,1008	0,0946	0,1115	0,1010	0,1330	0,0903	0,0951	0,0836

Source: Calculated by the authors.

The main criteria within the sustainability dimensions were ranked as follows: system effectiveness (0.223) was the highest, followed by the environment (0.213), social factors (0.1625), and the economy (0.150). Within these criteria, vehicle usage emerged as the most significant factor for system effectiveness, GDP for the economy, road accidents for the social criterion, and CO2 emissions for the environment.

The sustainability performance of countries in road transportation was evaluated using the EDAS method, and the resulting rankings are displayed in Table 7. The top five countries with the highest sustainability performance in road transportation are France (0.693812), Czechia (0.584464), Denmark (0.518459), Ireland (0.516127), and Portugal (0.514184). Conversely, countries with the lowest sustainability performance in road transportation are Belgium (0.470832), Austria (0.470048), the Netherlands (0.460035), Poland (0.404827), and Italy (0.38057). The significance levels of these criteria align with previous research on road-transport sustainability-particularly studies emphasizing accident indicators and confirming France's strong performance in this field (Wang et al., 2022b; Senir and Büyükkeklik, 2023).

Table 7: Ranking of European Union countries using the EDAS Method

Country	AS_i	Ranking
France	0,693812	1
Czechia	0,584464	2
Denmark	0,518459	3
Ireland	0,516127	4
Portugal	0,514184	5
Spain	0,511095	6
Lithuania	0,501589	7
Greece	0,501072	8
Germany	0,50000	9
Latvia	0,499109	10
Cyprus	0,498511	11
Sweden	0,497092	12
Estonia	0,495685	13
Slovenia	0,495388	14
Luxembourg	0,493338	15

Bulgaria	0,491946	16
Hungary	0,490544	17
Romania	0,48631	18
Croatia	0,483768	19
Finland	0,478522	20
Slovakia	0,477783	21
Belgium	0,470832	22
Austria	0,470048	23
Netherlands	0,460035	24
Poland	0,404827	25
Italy	0,38057	26

Source: Calculated by the authors.

A sensitivity analysis was conducted to test the reliability of the index results obtained regarding the efficiency of road transport. For this purpose, changes of $\pm 1\%$, $\pm 5\%$, $\pm 10\%$ and $\pm 20\%$ were applied to the criterion weighting, and the resulting rank shifts were examined. The sensitivity tests demonstrate that the rankings are largely stable. France remained in first place in every scenario, while the Czech Republic and Denmark also maintained their positions at the top of the rankings. Spain, Portugal, and Ireland continued to rank in the upper-middle range with similar scores. This stability demonstrates the reliability of the method and that the results are not affected by random weighting changes. However, small fluctuations are observed in some countries. In particular, the scores of countries such as Poland and Italy, which are in the lower ranks, decreased more significantly in the $\pm 20\%$ scenario? However, these changes did not disrupt the overall ranking structure but rather affected the score values relatively (Table 8).

Table 8: Sensitivity Analysis

Country	+1%	R	-1%	R	+ 5%	R	-5%	R
France	0,70075	1	0,68687	1	0,728503	1	0,65912	1
Czechia	0,590309	2	0,57862	2	0,613687	2	0,55524	2
Denmark	0,523644	3	0,51327	3	0,544382	3	0,49254	3

Ireland	0,521288	4	0,51097	4	0,541933	4	0,49032	4
Portugal	0,519326	5	0,50904	5	0,539893	5	0,48847	5
Spain	0,516206	6	-0,50598	6	0,53665	6	0,48554	6
Lithuania	0,506605	7	0,49657	7	0,526668	7	0,47651	7
Greece	0,506083	8	-0,49606	8	0,526126	8	-0,47602	8
Germany	0,505	9	-0,495	9	0,525	9	-0,475	9
Latvia	0,5041	10	0,49412	10	0,524064	10	0,47415	10
Cyprus	0,503496	11	0,49353	11	0,523437	11	0,47359	11
Sweden	0,502063	12	0,49212	12	0,521947	12	0,47224	12
Estonia	0,500642	13	0,49073	13	0,520469	13	0,4709	13
Slovenia	0,500342	14	0,49043	14	0,520157	14	0,47062	14
Luxembourg	0,498271	15	-0,4884	15	0,518005	15	0,46867	15
Bulgaria	0,496865	16	0,48703	16	0,516543	16	0,46735	16
Hungary	0,495449	17	0,48564	17	0,515071	17	0,46602	17
Romania	0,491173	18	0,48145	18	0,510626	18	0,46199	18
Croatia	0,488606	19	0,47893	19	0,507956	19	-0,45958	19
Finland	0,483307	20	0,47374	20	0,502448	20	0,4546	20
Slovakia	0,482561	21	0,47301	21	0,501672	21	0,45389	21
Belgium	0,47554	22	0,46612	22	0,494374	22	0,44729	22
Austria	0,474748	23	0,46535	23	0,49355	23	0,44655	23
Netherlands	0,464635	24	0,45543	24	0,483037	24	0,43703	24
Poland	0,408875	25	0,40078	25	0,425068	25	0,38459	25
Italy	0,384376	26	0,37676	26	0,399599	26	0,36154	26
France	0,763193	1	0,62443	1	0,832574	1	0,55505	1

Czechia	0,64291	2	0,52602	2	0,701357	2	0,46757	2
Denmark	0,570305	3	0,46661	3	0,622151	3	0,41477	3
Ireland	0,56774	4	0,46451	4	0,619352	4	0,4129	4
Portugal	0,565602	5	0,46277	5	0,617021	5	0,41135	5
Spain	0,562205	6	0,45999	6	0,613314	6	0,40888	6
Lithuania	0,551748	7	0,45143	7	0,601907	7	0,40127	7
Greece	0,551179	8	0,45096	8	0,601286	8	0,40086	8
Germany	0,55	9	0,45	9	0,6	9	0,4	9
Latvia	0,54902	10	0,4492	10	0,598931	10	0,39929	10
Cyprus	0,548362	11	0,44866	11	0,598213	11	0,39881	11
Sweden	0,546801	12	0,44738	12	0,59651	12	0,39767	12
Estonia	0,545254	13	-0,44612	13	0,594822	13	0,39655	13
Slovenia	0,544927	14	0,44585	14	0,594466	14	0,39631	14
Luxembourg	0,542672	15	0,444	15	0,592006	15	0,39467	15
Bulgaria	0,541141	16	0,44275	16	0,590335	16	0,39356	16
Hungary	0,539598	17	-0,44149	17	0,588653	17	0,39244	17
Romania	0,534941	18	0,43768	18	0,583572	18	0,38905	18
Croatia	0,532145	19	0,43539	19	0,580522	19	0,38701	19
Finland	0,526374	20	0,43067	20	0,574226	20	0,38282	20
Slovakia	0,525561	21	0,43	21	0,57334	21	0,38223	21
Belgium	0,517915	22	0,42375	22	0,564998	22	0,37667	22
Austria	0,517053	23	0,42304	23	0,564058	23	0,37604	23
Netherlands	0,506039	24	0,41403	24	0,552042	24	0,36803	24
Poland	0,44531	25	0,36434	25	0,485792	25	0,32386	25

Italy	0,418627	26	0,34251	26	0,456684	26	0,30446	26
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Source: Calculated by the authors.

Conclusion and Recommendations

The final rankings indicate a clear performance gap among EU member states, with France, Czechia, and Denmark emerging as having the most sustainable road transport systems in the sample. The strong performance of France, the Czech Republic, and Denmark in the sustainability rankings can be explained by their comprehensive national strategies, long-term policy commitments, and structural investments that collectively support low-emission and safe road transport systems. Their transport policies are closely tied to broader climate objectives, which help improve the environmental and safety indicators that are most influential in the index.

In France, the transport sector accounts for around 30% of total greenhouse gas emissions, and the country aims to reduce emissions from road transport by around 40% compared to 2015 levels by 2030 (Roure et al., 2025). Enacted in 2019, the Mobility Orientation Law (Loi d'orientation des mobilités) has strengthened the framework for sustainable mobility at the national level by institutionalizing measures such as expanding low-emission zones (ZFE), improving public transport accessibility, developing micromobility solutions, and making long-term investments in bicycle infrastructure. The law is also a key policy instrument for encouraging the adoption of electric vehicles and facilitating the transition from road to lower-carbon modes of transport, such as rail and sea (Ministry for Ecological Transition, 2023). These comprehensive regulations contribute to limiting per capita emissions and negative traffic-related impacts, particularly by reducing motor vehicle traffic in large metropolitan areas.

Czechia and Denmark's high sustainability scores likewise reflect transport-sector policies and structural investments that underpin their rankings. The Czech Republic has advanced sustainable mobility through the adoption of electric and hydrogen vehicles, expansion of charging infrastructure, and promotion of alternative fuels, supported by the updated National Energy and Climate Plan aimed at cutting emissions by at least 14.5% by 2030 (European Commission, 2023; Ministry of Industry and Trade of the Czech Republic, 2024). Local government implementation of low-emission transport, smart city technologies, and environmental planning further strengthens its performance, alongside extensive rail infrastructure and combined transport investments that reduce emissions relative to road-only systems (Ministry of the Environment of the Czech Republic, 2024; UIC & UIRR, 2024). Denmark follows a similar approach, supported by comprehensive transport-sector strategies, including kilometer-based tariffs linked to carbon performance, tax reforms, alternative fuels, and strong electric vehicle incentives (Kany et al., 2022; European Parliament, 2024). Examples from Copenhagen, including dense bicycle infrastructure, a metro system, bicycle–public transport integration, and high user satisfaction, enhanced urban mobility efficiency and safety, reducing reliance on motor vehicles for short and medium-distance trips (Vierø et al., 2025; Tuganbayev, 2025).

While the top-performing countries show what can be achieved with coherent, long-term transport strategies, there is still substantial room for improvement among lower-scoring states. Accelerating the shift toward low-emission mobility—especially through incentives for electric and other alternative-fuel vehicles—would help alleviate environmental pressure from road transport. Improving access to public transport, supporting micromobility options, and investing in safe, well-integrated urban transport networks can further reduce dependence on private motor vehicles. In practical terms, expanding charging and refueling infrastructure, tightening traffic-safety regulations, and introducing targeted programmes to reduce accident

rates could all support sustainability goals. Finally, reinforcing data collection systems so that emissions, safety indicators, and infrastructure performance are constantly monitored would enable more informed policy design and evaluation.

This research is subject to several limitations. First, it assesses the sustainable performance of road transport in European countries for the year 2021. However, due to incomplete and insufficient data for 2022, 2023, and 2024, these years were not included in the analysis. Second, despite being a member of the European Union, Malta was excluded from the study due to the lack of complete data. Third, the results are constrained by the selected set of criteria and their operationalization within the entropy–EDAS framework; alternative indicators or weighting schemes might lead to partially different country rankings. Future research could extend the analysis to other country groups, such as OPEC members, and conduct longitudinal assessments to track changes in sustainability performance over time, providing valuable insights into the effectiveness of policies and identifying areas requiring further intervention. Comparative research between EU and non-EU countries could also help identify best practices and highlight areas where EU countries can improve, contributing to a broader understanding of global road transport sustainability.

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Appendix:

Table 1: Normalized Values in the Context of Entropy Method

Country	Roadway Length	Vehicle in Use	Freight Volume	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO₂	Air Pollution emissions
Austria	0,026065829	0,02035314	0,030110375	0,010955652	0,027709734	0,017766658	0,062780973	0,029543576	0,023299	0,026692734
Bulgaria	0,004110272	0,01122139	0,011743809	0,00346929	0,004858707	0,01238624	0,007232886	0,01296256	0,015403	0,014682999
Croatia	0,005448251	0,00711745	0,006340534	0,012256636	0,004023937	0,006534927	0,010999221	0,00800033	0,006353	0,011131947
Cyprus	0,002728354	0,00234737	0,002064808	0,000616255	0,001704401	0,00252838	0,000387816	0,002566805	0,002382	0,001196984
Czechia	0,026973286	0,02413986	0,0373328	0,041471709	0,016291332	0,20007337	0,021598729	0,025403191	0,034481	0,053505167
Denmark	0,015460812	0,01105088	0,012801883	0,005455002	0,023454196	0,011635779	0,002857466	0,014392026	0,009632	0,01169054
Estonia	0,012139175	0,00327125	0,002156146	0,006413622	0,002131238	0,002663809	0,001829635	0,003277253	0,005263	0,005705622
Finland	0,016071009	0,010924	0,01865737	0,037933947	0,017139976	0,010609473	0,003857936	0,014762051	0,03494	0,017954754
France	0,227894317	0,15020004	0,123048814	0,023280761	0,17109075	0,118495491	0,063692222	0,156076551	0,10671	0,140206679
Germany	0,13251909	0,19246859	0,231925675	0,036632963	0,247355349	0,16440406	0,308095955	0,184576267	0,235029	0,151697722
Greece	0,024321052	0,02222072	0,020222281	0,015543332	0,012410656	0,01732327	0,012436281	0,018621996	0,018837	0,027650321
Hungary	0,044663031	0,01593992	0,016410931	0,043229179	0,010528364	0,018647001	0,016931853	0,018353241	0,017892	0,018313849
Ireland	0,021057383	0,0089216	0,011452034	0,011982745	0,029680944	0,009668596	0,0058446	0,013768826	0,012357	0,009216774
Italy	0,048	0,157	0,073	0,1411	0,124	0,095	0,180	0,1273	0,11	0,108

	76649 5	9003 7	65886 6	68146	58092 4	06282	60206 6	1587	283 1	28711 6
Latvia	0,011 85346 8	0,003 0055 9	0,006 08637	0,0045 87679	0,002 28033 9	0,003 62585 3	0,004 04351 6	0,0041 71545	0,00 254 5	0,005 46622 5
Lithuania	0,017 51233 8	0,006 3878 6	0,008 44243	0,0099 05736	0,003 86182 8	0,005 56285 7	0,003 3119	0,0080 0812	0,00 487 8	0,006 86270 6
Luxembourg	0,000 60112 1	0,001 7169 1	0,003 59867 6	0,0051 12638	0,004 94791 3	0,001 26280 7	0,001 10158 8	0,0068 3183	0,00 298 3	0,001 23688 3
Netherlands	0,038 53795 2	0,035 0004 2	0,052 38433 1	0,1615 95873	0,059 52931 7	0,036 45329 8	0,021 94728 8	0,0342 25366	0,05 183 9	0,024 89725 9
Poland	0,088 66553	0,102 5745 7	0,117 94231 4	0,1726 19999	0,039 39101 5	0,019 66977 1	0,027 15425 2	0,0916 76618	0,11 321 9	0,136 45613 1
Portugal	0,002 95506 4	0,022 3317 5	0,010 97437 5	0,0021 22658	0,014 77343 7	0,070 17465 3	0,036 51060 8	0,0204 95491	0,01 365 3	0,017 35626 2
Romania	0,024 37778 1	0,030 1787 9	0,022 89459 2	0,0100 8833	0,016 52368 4	0,031 07412 7	0,031 88774 8	0,0254 88881	0,02 779 6	0,049 11622 7
Slovakia	0,011 92835	0,009 8851 3	0,007 38092 3	0,0228 92749	0,006 85454 5	0,010 50817 8	0,005 40206 2	0,0096 16755	0,01 322 9	0,030 40338 3
Slovenia	0,008 01219 4	0,008 6797 2	0,011 55367	0,0139 45633	0,003 57472 6	0,003 96193 2	0,006 34067 1	0,0065 47495	0,00 500 1	0,004 94753 2
Spain	0,111 07553 8	0,098 8909 5	0,121 36338 8	0,0862 75763	0,083 57818 3	0,088 60931 7	0,106 90157 7	0,1063 45189	0,08 185 5	0,091 48944 7
Sweden	0,044 49408 2	0,019 7702 6	0,036 75134	0,0944 92502	0,036 98412 3	0,021 36664 9	0,015 01894 5	0,0249 74741	0,01 373 7	0,016 39867 5
Belgium	0,031 76822 6	0,023 5014 7	0,002 70126 4	0,0259 51202	0,034 74038	0,019 93068 6	0,041 23220 8	0,0319 97426	0,03 385 6	0,017 43606 1

Table 2: Weighted Values in the Context of Entropy Method

Country	Roadway Length	Vehicle in Use	Freight Volume	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO ₂	Air Pollution emissions
Austria	- 0,095 06546	- 0,079 2657	- 0,105 47319	- 0,0494 52717	- 0,099 36631	- 0,071 60730	- 0,173 7842	- 0,1040 49194	- 0,0 875	- 0,096 71748

	9		6		8	2	1		9	9
Bulgaria	- 0,022 58292 8	- 0,050 3832 8	- 0,052 19452 6	- 0,0196 49383	- 0,025 88224 8	- 0,054 39007 4	- 0,035 6517 4	- 0,0563 3127	- 0,0 642 8	- 0,061 97789 2
Croatia	- 0,028 39879 3	- 0,035 1972 6	- 0,032 08812 8	- 0,0539 49885	- 0,022 19400 3	- 0,032 87456 5	- 0,049 6057 3	- 0,0386 27774	- 0,0 321 4	- 0,050 07078 9
Cyprus	- 0,016 10835 8	- 0,014 2120 6	- 0,012 76612 5	- 0,0045 55267	- 0,010 86477 3	- 0,015 12015 8	- 0,003 0462 9	- 0,0153 11232	- 0,0 143 9	- 0,008 05324 6
Czechia	- 0,097 45201	- 0,089 8942	- 0,122 74587 7	- 0,1319 93825	- 0,067 07340 2	- 0,321 93228 3	- 0,082 8337 4	- 0,0933 02884	- 0,1 161 1	- 0,156 66190 1
Denmark	- 0,064 46303	- 0,049 7869 4	- 0,055 79269 3	- 0,0284 27228	- 0,088 0167	- 0,051 82192 6	- 0,016 7385 2	- 0,0610 37746	- 0,0 447 2	- 0,052 01092 3
Estonia	- 0,053 54975 6	- 0,018 7200 1	- 0,013 23751 3	- 0,0323 84499	- 0,013 10935 6	- 0,015 79105 5	- 0,011 5333 6	- 0,0187 48345	- 0,0 276 1	- 0,029 47697 3
Finland	- 0,066 38513 3	- 0,049 3414 5	- 0,074 28458 2	- 0,1241 16417	- 0,069 69700 1	- 0,048 23074 9	- 0,021 4409 5	- 0,0622 32311	- 0,1 171 9	- 0,072 17632 2
France	- 0,337 02681 6	- 0,284 7473 3	- 0,257 80869 4	- 0,0875 38642	- 0,302 07118 4	- 0,252 73670 6	- 0,175 3888 1	- 0,2898 9794	- 0,2 387 8	- 0,275 45532 3
Germany	- 0,267 82486 7	- 0,317 1540 3	- 0,338 92187 7	- 0,1211 38131	- 0,345 53793 9	- 0,296 81971	- 0,362 7349 2	- 0,3118 77139	- 0,3 403 3	- 0,286 08148 6
Greece	- 0,090 38707 3	- 0,084 5883	- 0,078 88651 8	- 0,0647 24354	- 0,054 47285 1	- 0,070 25806 5	- 0,054 5596 7	- 0,0741 79078	- 0,0 748 2	- 0,099 21261 3
Hungary	- 0,138 83990 7	- 0,065 9741 9	- 0,067 44577	- 0,1357 93207	- 0,047 94282 4	- 0,074 25366 1	- 0,069 0575 5	- 0,0733 75322	- 0,0 719 9	- 0,073 25718 6
Ireland	- 0,081 29211 1	- 0,042 1035 2	- 0,051 18587 5	- 0,0530 15109	- 0,104 39530 3	- 0,044 85138 3	- 0,030 0543 2	- 0,0590 04212	- 0,0 542 9	- 0,043 19653 2

Italy	- 0,147 30952 7	- 0,291 4510 9	- 0,192 12521 2	- 0,2763 79501	- 0,259 47712 2	- 0,223 70347 6	- 0,309 0930 7	- 0,2624 08717	- 0,2 461 8	- 0,240 71891 3
Latvia	- 0,052 57172 7	- 0,017 4542 9	- 0,031 05085 4	- 0,0247 01814	- 0,013 87228 5	- 0,020 37608	- 0,022 2823 6	- 0,0228 57851	- 0,0 152	- 0,028 47448
Lithuania	- 0,070 83477 2	- 0,032 2801 4	- 0,040 30825 5	- 0,0457 11417	- 0,021 45869	- 0,028 88037 1	- 0,018 9117 2	- 0,0386 57593	- 0,0 259 7	- 0,034 18762 3
Luxembourg	- 0,004 45834 2	- 0,010 9319 7	- 0,020 25043	- 0,0269 74481	- 0,026 26742 8	- 0,008 42850 1	- 0,007 5029 2	- 0,0340 64617	- 0,0 173 4	- 0,008 28113 1
Netherlands	- 0,125 48387 9	- 0,117 3352 3	- 0,154 48913 2	- 0,2945 33796	- 0,167 94925	- 0,120 72323 9	- 0,083 8191 4	- 0,1155 03362	- 0,1 534 2	- 0,091 94551 7
Poland	- 0,214 82630 1	- 0,233 5792 5	- 0,252 10873	- 0,3032 35103	- 0,127 39911 2	- 0,077 27608 5	- 0,097 9242 5	- 0,2190 60171	- 0,2 466 4	- 0,271 78678 5
Portugal	- 0,017 21098 6	- 0,084 8996 3	- 0,049 51849	- 0,0130 65141	- 0,062 26892 3	- 0,186 43777 9	- 0,120 8556 8	- 0,0796 77253	- 0,0 586 2	- 0,070 35884 9
Romania	- 0,090 54110 7	- 0,105 6443 5	- 0,086 46954 4	- 0,0463 69757	- 0,067 79602 4	- 0,107 87009 5	- 0,109 8703	- 0,0935 31779	- 0,0 995 9	- 0,148 01498 3
Slovakia	- 0,052 82872 2	- 0,045 6369 1	- 0,036 23189 2	- 0,0864 64425	- 0,034 15512 5	- 0,047 87107	- 0,028 2040 3	- 0,0446 626	- 0,0 572 2	- 0,106 20514 1
Slovenia	- 0,038 67318 3	- 0,041 2006 1	- 0,051 53806	- 0,0595 83955	- 0,020 13953	- 0,021 91353 9	- 0,032 0886 8	- 0,0329 25211	- 0,0 265	- 0,026 26578 7
Spain	- 0,244 09346 9	- 0,228 8077	- 0,255 95126 2	- 0,2113 93441	- 0,207 43877 4	- 0,214 74629 8	- 0,239 0155 4	- 0,2383 26478	- 0,2 048 7	- 0,218 79990 7
Sweden	- 0,138 48334	- 0,077 5701 2	- 0,121 41101 4	- 0,2229 29999	- 0,121 94651 2	- 0,082 17450 8	- 0,063 0561 8	- 0,0921 54055	- 0,0 589	- 0,067 40765 2
Belgi	-	-	-	-	-	-	-	-	-	-

um	0,109 57778 1	0,088 1467 8	0,015 97537 2	0,0947 61783	0,116 72255 5	0,078 03849 7	0,131 4703 6	0,1101 38335	0,1 146 2	0,070 60235 6
total	- 2,666 26938 8	- 2,556 3063 6	- 2,570 25962	- 2,6128 43277	- 2,497 51522 9	- 2,569 12717 7	- 2,350 5240 5	- 2,6419 42472	- 2,6 093 2	- 2,687 3978

Table 3: Entropy Values (ej), Differentiation (dj) and Significance (wj) of Components

	Road way Lengt h	Vehic le in Use	Freigh t Volum e	Infrast ructur e mainte nance	GDP	Numb er of Empl oyees	Road Accid ents	Fuel Consu mption	CO2	Air Polluti on emissi ons
e j	0,8183 51868	0,784 60117	0,7888 83813	0,80195 3916	0,7665 56546	0,7885 36235	0,7214 40886	0,8108 85264	0,80 0871	0,8248 36762
d j	0,1816 48132	0,215 39883	0,2111 16187	0,19804 6084	0,2334 43454	0,2114 63765	0,2785 59114	0,1891 14736	0,19 9129	0,1751 63238
w j	0,0867 85003	0,102 90988	0,1008 6379	0,09461 936	0,1115 30962	0,1010 2985	0,1330 85616	0,0903 52281	0,09 5137	0,0836 86752

Table 4 : Mean positive matrices created for the EDAS method

Count ry	Road way Lengt h	Vehic le in Use	Freigh t Volu me	Infrast ructur e mainte nance	GDP	Num ber of Empl oyees	Road Acci dents	Fuel Consu mption	CO2	Air Polluti on emissi ons
Austri a	0	0	0	0,7151 53817	0	0	0	0,2318 6684	0,394 23694 6	0,305 9878
Bulga ria	0	0	0	0,9097 98709	0	0	0,811 9449 6	0,6629 7335	0,599 52280 4	0,618 24142 1
Croati a	0	0	0	0,6813 28333	0	0	0,714 0202 5	0,7919 9136	0,834 81692 2	0,710 56890 3
Cypru s	0	0	0	0,9839 77402	0	0	0,989 9167 9	0,9332 6305	0,938 05634 6	0,968 87837 7
Czech ia	0	0	0	0	0	4,201 90761 5	0,438 4330 1	0,3395 1688	0,103 51472 9	0
Denm ark	0	0	0	0,8581 70338	0	0	0,925 7058 9	0,6258 0725	0,749 5641	0,696 04547 9

Estonia	0	0	0	0,8332 46297	0	0	0,952 4295	0,9147 914	0,863 17335	0,851 65359 6
Finland	0	0	0	0,0137 20091	0	0	0,899 6936 7	0,6161 866	0,091 58484	0,533 17565
France	4,925 25215 5	2,905 20295 1	2,199 2691 9	0,3947 01861	3,448 3594 9	2,080 88275 4	0	0	0	0
Germany	2,445 49629 2	4,004 18561 9	5,030 0675 6	0,0475 45575	5,431 2390 4	3,274 50555 8	0	0	0	0
Greece	0	0	0	0,5958 74478	0	0	0,676 6566 8	0,5158 28	0,510 23217 4	0,281 09050 2
Hungary	0,161 23878 5	0	0	0	0	0	0,559 7718 1	0,5228 1563	0,534 82609 9	0,523 83916 3
Ireland	0	0	0	0,6884 49487	0	0	0,848 0403 9	0,6420 1045	0,678 71891 3	0,760 36350 1
Italy	0,267 92886 2	3,105 41161 3	0,915 1305 1	0	2,239 1040 1	1,471 63330 9	0	0	0	0
Latvia	0	0	0	0,8807 20661	0	0	0,894 8685 7	0,8915 398	0,933 835	0,857 87792
Lithuania	0	0	0	0,7424 51576	0	0	0,913 8905 9	0,7917 8882	0,873 17610 4	0,821 56936
Luxembourg	0	0	0	0,8670 71781	0	0	0,971 3587 2	0,8223 7237	0,922 45572 2	0,967 84098 9
Netherlands	0,001 98673 5	0	0,361 9926	0	0,547 7622 3	0	0,429 3704 9	0,1101 4027	0	0,352 67023 5
Poland	1,305 30375	1,666 94021	2,066 5001 8	0	0,024 1664	0	0,293 9894 1	0	0	0
Portugal	0	0	0	0,9448 11052	0	0,824 54096 9	0,050 7241 4	0,4671 1712	0,645 03991 9	0,548 73646 2
Romania	0	0	0	0,7377 0414	0	0	0,170 9185 3	0,3372 8894	0,277 32403 4	0
Slavakia	0	0	0	0,4047 90163	0	0	0,859 5463 9	0,7499 643	0,656 05212 4	0,209 51076 8
Slovenia	0	0	0	0,6374	0	0	0,835	0,8297	0,869	0,871

nia				14546			14254	6508	96421	363957
Spain	1,887963941	1,571165829	2,1554481	0	1,17303275	1,303842235	0	0	0	0
Sweden	0,156846106	0	0	0	0	0	0,60950742	0,35065658	0,642837478	0,573633761
Belgium	0	0	0	0,325270604	0	0	0	0,16806672	0,119757731	0,546661687

Table 5 : Mean negative matrices created for the EDAS method

Country	Roadway Length	Vehicle in Use	Freight Volume	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO2	Air Pollution emissions
Austria	0,322288454	0,470818196	0,21713025	0	0,27954691	0,538066891	0,63230538	0	0	0
Bulgaria	0,893132928	0,708243813	0,69466097	0	0,87367363	0,677957761	0	0	0	0
Croatia	0,858345484	0,814946164	0,8351461	0	0,89537764	0,830091896	0	0	0	0
Cyprus	0,929062791	0,938968317	0,946315	0	0,95568558	0,934262123	0	0	0	0
Czechia	0,298694564	0,372363369	0,02934721	0,078261489	0,57642538	0	0	0	0	0,391136562
Denmark	0,598018907	0,712676858	0,66715104	0	0,3901909	0,697469746	0	0	0	0
Estonia	0,684381446	0,914947401	0,94394021	0	0,94458782	0,930740964	0	0	0	0
Finland	0,582153773	0,715975868	0,51490837	0	0,55436062	0,724153702	0	0	0	0
France	0	0	0	0	0	0	0,65599784	3,05799127	1,77443333	2,645379476
Germany	0	0	0	0	0	0	7,0104952	3,79898406	5,110672662	2,94414706

Greece	0,367 65265 4	0,422 26089 4	0,474 2206 8	0	0,677 3229 3	0,549 59499	0	0	0	0
Hungary	0	0,585 56188 3	0,573 3157 9	0,1239 55564	0,726 2625 5	0,515 17798 3	0	0	0	0
Ireland	0,452 50805 9	0,768 03836 7	0,702 2471	0	0,228 2954 5	0,748 61649 1	0	0	0	0
Italy	0	0	0	2,6703 61755	0	0	3,695 6539 5	2,3102 1339	1,933 55969 5	1,815 46952 2
Latvia	0,691 80984 7	0,921 85470 3	0,841 7543 8	0	0,940 7111 9	0,905 72783 4	0	0	0	0
Lithuania	0,544 67923 2	0,833 91547 1	0,780 4968 3	0	0,899 5924 7	0,855 36571 4	0	0	0	0
Luxembourg	0,984 37085 8	0,955 36027 2	0,906 4344 3	0	0,871 3542 7	0,967 16702 2	0	0	0	0
Netherlands	0	0,089 98874 2	0	3,2014 812	0	0,052 21424	0	0	0,347 80214 7	0
Poland	0	0	0	3,4881 07672	0	0,488 58594 7	0	1,3835 9264	1,943 65421 7	2,547 86505 7
Portugal	0,923 16834 1	0,419 37426	0,714 6662 5	0	0,615 8906 3	0	0	0	0	0
Romania	0,366 17770 1	0,215 35111 8	0,404 7406 1	0	0,570 3842 1	0,192 07269 6	0	0	0	0,277 02394 3
Slavakia	0,689 86290 9	0,742 98651 1	0,808 096	0	0,821 7818 3	0,726 78737 9	0	0	0	0
Slovenia	0,791 68295 8	0,774 32710 5	0,699 6045 7	0	0,907 0571 2	0,896 98976 6	0	0	0	0
Spain	0	0	0	1,2431 63692	0	0	1,779 4411 3	1,7649 7556	1,128 20042 2	1,378 72940 8
Sweden	0	0,485 97302 2	0,044 4651 5	1,4567 98329	0,038 4128 2	0,444 46713 4	0	0	0	0
Belgium	0,174 02614 7	0,388 96151 3	0,929 7671 3	0	0,096 7501 3	0,481 80215 1	0,072 0374 5	0	0	0

Table 6 : Weighted positive distance matrices for the EDAS method

Country	Roadway Length	Vehicle in Use	Freight Volume	Infrastructure maintenance	GDP	Number of Employees	Road Accidents	Fuel Consumption	CO2	Air Pollution emissions
Austria	0	0	0	0,067224	0	0	0	0,020868	0,037453	0,025397
Bulgaria	0	0	0	0,085521	0	0	0,107989	0,059668	0,056955	0,051314
Croatia	0	0	0	0,064045	0	0	0,094965	0,071279	0,079308	0,058977
Cyprus	0	0	0	0,092494	0	0	0,131659	0,083994	0,089115	0,080417
Czechia	0	0	0	0	0	0,424393	0,058312	0,030557	0,009834	0
Denmark	0	0	0	0,080668	0	0	0,123119	0,056323	0,071209	0,057772
Estonia	0	0	0	0,078325	0	0	0,126673	0,082331	0,082001	0,070687
Finland	0	0	0	0,00129	0	0	0,119659	0,055457	0,008701	0,044254
France	0,423572	0,296331	0,219927	0,037102	0,382768	0,210169	0	0	0	0
Germany	0,210313	0,408427	0,503007	0,004469	0,602868	0,330725	0	0	0	0
Greece	0	0	0	0,056012	0	0	0,089995	0,046425	0,048472	0,023331
Hungary	0,013867	0	0	0	0	0	0,07445	0,047053	0,050808	0,043479
Ireland	0	0	0	0,064714	0	0	0,112789	0,057781	0,064478	0,06311
Italy	0,023042	0,316752	0,091513	0	0,248541	0,148635	0	0	0	0
Latvia	0	0	0	0,082788	0	0	0,119018	0,080239	0,088714	0,071204
Lithuania	0	0	0	0,06979	0	0	0,121547	0,071261	0,082952	0,06819
Luxembourg	0	0	0	0,081505	0	0	0,129191	0,074014	0,087633	0,080331
Netherlands	0,000171	0	0,036199	0	0,060802	0	0,057106	0,009913	0	0,029272
Poland	0,112256	0,170028	0,20665	0	0,002682	0	0,039101	0	0	0
Portugal	0	0	0	0,088812	0	0,083279	0,006746	0,042041	0,061279	0,045545
Romania	0	0	0	0,069344	0	0	0,022732	0,030356	0,026346	0

Slavaki a	0	0	0	0,03805	0	0	0,114 32	0,06749 7	0,06 2325	0,017 389
Sloven ia	0	0	0	0,05991 7	0	0	0,111 074	0,07467 9	0,08 2647	0,072 323
Spain	0,162 365	0,16 0259	0,21 5545	0	0,13 0207	0,131 688	0	0	0	0
Swede n	0,013 489	0	0	0	0	0	0,081 064	0,03155 9	0,06 107	0,047 612
Belgiu m	0	0	0	0,03057 5	0	0	0	0,01512 6	0,01 1377	0,045 373
	0,086	0,10 2	0,1	0,094	0,111	0,101	0,133	0,09	0,09 5	0,083

Table 7: Weighted negative distance matrices for EDAS method

Country	Road way Leng th	Vehi cle in Use	Frei ght Volu me	Infrastr ucture mainten ance	GDP	Numb er of Empl oyees	Road Acci dents	Fuel Consu mption	CO2	Air Pollu tion emiss ions
Austria	0,027 717	0,04 8023	0,02 1713	0	0,03 103	0,054 345	0,084 097	0	0	0
Bulgari a	0,076 809	0,07 2241	0,06 9466	0	0,09 6978	0,068 474	0	0	0	0
Croatia	0,073 818	0,08 3125	0,08 3515	0	0,09 9387	0,083 839	0	0	0	0
Cyprus	0,079 899	0,09 5775	0,09 4631	0	0,10 6081	0,094 36	0	0	0	0
Czechi a	0,025 688	0,03 7981	0,00 2935	0,00735 7	0,06 3983	0	0	0	0	0,032 464
Denma rk	0,051 43	0,07 2693	0,06 6715	0	0,04 3311	0,070 444	0	0	0	0
Estonia	0,058 857	0,09 3325	0,09 4394	0	0,10 4849	0,094 005	0	0	0	0
Finlan d	0,050 065	0,07 303	0,05 1491	0	0,06 1534	0,073 14	0	0	0	0
France	0	0	0	0	0	0	0,087 248	0,27521 9	0,16 8571	0,219 566
Germa ny	0	0	0	0	0	0	0,932 396	0,34190 9	0,48 5514	0,244 364
Greece	0,031 618	0,04 3071	0,04 7422	0	0,07 5183	0,055 509	0	0	0	0
Hungar y	0	0,05 9727	0,05 7332	0,01165 2	0,08 0615	0,052 033	0	0	0	0
Ireland	0,038 916	0,07 834	0,07 0225	0	0,02 5341	0,075 61	0	0	0	0
Italy	0	0	0	0,25101 4	0	0	0,491 522	0,20791 9	0,18 3688	0,150 684
Latvia	0,059	0,09	0,08	0	0,10	0,091	0	0	0	0

	496	4029	4175		4419	479				
Lithuania	0,046842	0,085059	0,07805	0	0,099855	0,086392	0	0	0	0
Luxembourg	0,084656	0,097447	0,090643	0	0,09672	0,097684	0	0	0	0
Netherlands	0	0,009179	0	0,300939	0	0,005274	0	0	0,033041	0
Poland	0	0	0	0,327882	0	0,049347	0	0,124523	0,184647	0,211473
Portugal	0,079392	0,042776	0,071467	0	0,068364	0	0	0	0	0
Romania	0,031491	0,021966	0,040474	0	0,063313	0,019399	0	0	0	0,022993
Slavakia	0,059328	0,075785	0,08081	0	0,091218	0,073406	0	0	0	0
Slovenia	0,068085	0,078981	0,06996	0	0,100683	0,090596	0	0	0	0
Spain	0	0	0	0,116857	0	0	0,236666	0,158848	0,107179	0,114435
Sweden	0	0,049569	0,004447	0,136939	0,004264	0,044891	0	0	0	0
Belgium	0,014966	0,039674	0,092977	0	0,010739	0,048662	0,009581	0	0	0

Table 8: Performance Ranking of European Union Countries

Country	SP	SN	Nor. SP	Nor. SN.	average of normalized values	Ranking
Austria	0,150942	0,266924	0,07328	0,866816	0,470048	23
Bulgaria	0,361446	0,383968	0,175476	0,808417	0,491946	16
Croatia	0,368574	0,423683	0,178936	0,788601	0,483768	19
Cyprus	0,477679	0,470747	0,231904	0,765118	0,498511	11
Czechia	0,523095	0,170408	0,253953	0,914974	0,584464	2
Denmark	0,38909	0,304593	0,188896	0,848021	0,518459	3
Estonia	0,440018	0,44543	0,213621	0,77775	0,495685	13
Finland	0,22936	0,309259	0,11135	0,845693	0,478522	20
France	1,569868	0,750605	0,762143	0,625481	0,693812	1
Germany	2,059808	2,004183	1	0	0,5	9
Greece	0,264235	0,252803	0,128281	0,873862	0,501072	8
Hungary	0,229657	0,261359	0,111494	0,869593	0,490544	17
Ireland	0,362873	0,288431	0,176168	0,856085	0,516127	4
Italy	0,828482	1,284827	0,402213	0,358927	0,38057	26
Latvia	0,441962	0,433598	0,214565	0,783654	0,499109	10
Lithuania	0,413741	0,396198	0,200864	0,802314	0,501589	7
Luxembourg	0,452673	0,46715	0,219765	0,766912	0,493338	15
Netherlands	0,193462	0,348433	0,093922	0,826147	0,460035	24
Poland	0,530717	0,897873	0,257654	0,552001	0,404827	25

Portugal	0,327702	0,261999	0,159093	0,869274	0,514184	5
Romania	0,148778	0,199636	0,072229	0,90039	0,48631	18
Slavakia	0,299581	0,380546	0,145441	0,810124	0,477783	21
Slovenia	0,40064	0,408306	0,194503	0,796273	0,495388	14
Spain	0,800063	0,733984	0,388416	0,633774	0,511095	6
Sweden	0,234794	0,24011	0,113988	0,880196	0,497092	12
Belgium	0,102451	0,216599	0,049738	0,891926	0,470832	22