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RESEARCH ARTICLE

Assessment of the Logistics Performance Index of OPEC Countries with ENTROPY, CRITIC and LOPCOW-based EDAS Methods

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ABSTRACT

The aim of this study is to examine the Logistics Performance Index (LPI) of the Organization of the Petroleum Exporting Countries (OPEC) using the ENTROPY, CRITIC, and LOPCOW-based EDAS method. Data were obtained from the "2018 report of LPI" issued by the World Bank (WB). To evaluate the logistics performance of the selected countries, six key dimensions—customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness—were utilized. The weight of the criteria was calculated using three different weighting methods: ENTROPY, CRITIC, and LOPCOW. Subsequently, the countries were ranked using the EDAS method. The results from ENTROPY, CRITIC, and LOPCOW indicated that the most significant criteria were infrastructure, international shipments, and timeliness, respectively. The outcomes of the EDAS method revealed that the United Arab Emirates (UAE) and Angola exhibited the highest and lowest logistics performance, respectively. Additionally, the robustness and validity of the results were confirmed through comparative analysis.

Keywords: LPI, OPEC, ENTROPY, CRITIC, LOPCOW, EDAS

1. Introduction

The OPEC was founded in Baghdad in 1960. The member countries of OPEC are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the UAE, and Venezuela. The main goal of OPEC is to provide an efficient, economic, and regular supply of petroleum to consuming nations (OPEC, 2010). In particular, OPEC plays a critical role in the sustainability of the economy, energy, and environment. In this context, a large amount of research has been carried out on the OPEC. Existing literature on the OPEC countries has been largely focused on economic growth (Ftiti et al., 2016; Onoh et al., 2018; Ostic et al., 2022), energy consumption (Dabachi et al., 2020; Onifade et al., 2021; Iorember et al., 2022), carbon emissions (Acar et al., 2018; Nazlioglu et al., 2021). However, a limited number of studies have examined the OPEC countries within the scope of logistics.

The role of logistics in the world economy is becoming increasingly important. The logistics industry contributes significantly to facilitating trade, decreasing transportation costs, and promoting economic growth. Additionally, sustainable growth and trade efficiency depend on the quality and efficiency of logistics services (Devlin and Yee, 2005; Bugarčić et al., 2020). As stated by Rashidi and Cullinane (2019), effective logistics operations in international trade have a significant role in the development of the reliability of the supply chain and improvement of trade relations between countries. On the contrary, inefficient logistics operations could damage the balance of foreign trade and cause interruptions in the functioning of all economic sectors (Isik et al., 2020, p.549-550). Accordingly, it is important to analyse the logistics performance of nations. The WB has been publishing the LPI report since 2007. In this report, logistics performance across more than 160 countries is measured by six main indicators, which are customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing and timeliness. The LPI plays a vital role in global initiatives aimed at enhancing the understanding of logistics performance amid increasingly intricate supply chains. It is derived from a comprehensive worldwide survey targeting on-the-ground operators, including global freight forwarders and express carriers, who provide insights into the logistics "friendliness" of the nations in which they operate and those with which they engage in trade. It incorporates both qualitative and quantitative metrics, facilitating the development of logistics friendliness profiles for these nations. It assesses performance throughout the logistics supply chain within a country, offering both international and domestic viewpoints. It has been released every two years from 2010 to 2018, with the most recent edition published in 2018 (Arvis et al., 2018). In the preparation of this report, over 1,000 experts involved in international logistics

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operations from various countries contributed significantly. In this regard, LPI is considered as a Multi-Criteria Decision Making (MCDM) problem (Yıldırım and Mercangöz, 2020, p.28).

MCDM is one of the most accurate decision-making methods (Aruldoss et al., 2013). Since the 1950s, a variety of empirical and theoretical researchers have concentrated on MCDM methods to investigate their mathematical modeling potential. Their objective has been to create a framework that facilitates the organization of decision-making challenges and the formulation of preferences from a range of alternatives (Hajduk,2021; Taherdoost and Madanchian, 2023). Accordingly, this paper investigates the logistics performance of OPEC countries using the integrated MCDM methods. In this study, three objective weighting methods, namely ENTROPY, CRITIC and LOPCOW are used for determining the criteria weights. Logistics performance of countries is evaluated by EDAS method. Since each weighting method has its own unique formulation and approach, multiple weighting methods are employed in this study. This approach aimed to examine the impact of different weighting methods on the ranking results. Accordingly, it can be stated that the combination of ENTROPY, CRITIC, and LOPCOW with EDAS offers a novel approach that merges the advantages of these weighting techniques with the efficient distance-based assessment of EDAS. This integration has the potential to establish a stronger and more reliable decision-making process. For instance, the ENTROPY method quantifies information content per criterion to minimize bias in weighting, the CRITIC method leverages criteria correlation, and the LOPCOW method provides a structured approach for managing criteria hierarchy, resulting in increased consistent and reliable in outcomes (Diakoulaki et al., 1995; Alinezhad and Khalili, 2019; Ecer & Pamucar, 2022). The EDAS method assesses alternatives by measuring their proximity to the average solution, taking into account both favorable and unfavorable deviations (Keshavarz Ghorabaee et al., 2015).

The current study contributes to existing literature in two ways. First, this study allows the comparison of three types of objective method for determining criteria weights and their implementation to analyze the logistics performance of OPEC countries. Second, so far there has been little discussion about the logistics performance of OPEC countries with MCDM methods. Previous research is largely focused on other economic organizations such as The Organization for Economic Co-operation and Development (OECD) and the European Union (EU). Therefore, the current study is designed to address these research gaps and research question is formulated as follows:

Research Question: What is the logistics performance of OPEC countries and does their performance ranking differ according to MCDM methods?

The remaining part of the research proceeds as follows: Section 2 presents the studies related to logistics performance evaluation. Section 3 describes the integrated MCDM methodology. Section 4 illustrates the weights of the criteria and logistics performance ranking of countries. Section 5 explains conclusions, limitations, and recommendations for further study. Additionally, the editing and proofreading of the manuscript is completed by Artificial Intelligence tool (ChatGPT).

2. Literature Review

This section provides an overview of previous research conducted on logistics performance. There has been a notable increase in research aimed at evaluating the logistics performance of countries in recent years. Table 1 presents a brief summary of the relevant literature in this field.

Table 1. Previous research

Author(s)	Year	Methods	Topic
Cakir	2017	CRITIC-SAW-Peter's Fuzzy Regression	Measuring the LPI of OECD countries via fuzzy linear regression
Marti et al.	2017	DEA	Examine the logistics performance of the countries using DEA method
Rezaei et al.	2018	BWM	Evaluate the relative importance of LPI indicators with BWM method
Gök Kısa & Ayçin	2019	SWARA-EDAS	Analysis the LPI of OECD countries with SWARA-based EDAS methods
Karaköy & Ölmez	2019	ENTROPY-OCRA	Investigate the LPI of Balkan countries using Entropy-OCRA methods
Ulutaş & Karaköy	2019	CRITIC-SWARA-PIV	Examine the LPI of European Union (EU) countries by integrated MCDM methods
Mešić et al.	2020	CRITIC-MARCOS	Assessment of the LPI of Western Balkan countries using CRITIC-MARCOS methods
Isik et al.	2020	SV-MABAC	Evaluate the LPI of CEE countries with SV-MABAC methods
Yalcin & Ayvaz	2020	FAHP-FTOPSIS	Analyze the LPI of selected countries by Fuzzy AHP-Fuzzy TOPSIS methods
Adıgüzel Mercangöz et al.	2020	COPRAS-G	Investigate the LPI of EU and candidate EU countries based COPRAS-G method
Ulutaş & Karaköy	2021	Grey SWARA-Grey MOORA	Assessment of the LPI of Transition Economies countries with grey MCDM methods
Miškić et al.	2023	MEREC-MARCOS	Examine the LPI of EU countries using MEREC-MARCOS methods
Oğuz	2023	EDAS-TOPSIS	Measuring of Customs, Infrastructure and Logistics Service performance for selected countries with EDAS-TOPSIS methods
Pehlivan et al.	2024	TOPSIS-Clustering Analysis	Analysis the logistics performance of G20 countries using decision-making methods
Akbulut et al.	2024	SD-PSI-MEREC-MARA	Measuring the LPI of G20 countries based on integrated MCDM methods
Kale & Tilki	2024	ENTROPY-TOPSIS	Comparison the LPI of World countries with Entropy-TOPSIS methods

As depicted above, a considerable amount of literature has published that analyze the LPI of countries such as EU, OECD or Balkan countries using various MCDM methods. Despite the extensive research conducted utilizing hybrid MCDM methodologies, no single study has been identified that assesses the LPI of OPEC countries with Entropy, CRITIC, LOPCOW-based EDAS methods. Therefore, this study seeks to fill this gap by proposing a new MCDM model.

3. Methodology

3.1. ENTROPY

The concept of Entropy was introduced by the German physicist R. Clausius in 1865. The Entropy method is employed to assess the relative significance of various attributes and their capacity to convey decision-making information. In information theory, it primarily utilizes the Entropy value to quantify the uncertainty associated with information. As the weight of the evaluated information criterion increases, the Entropy associated with that criterion diminishes (Chen, 2021, p.9). The procedure for applying the Entropy method is outlined as follows (Alinezhad and Khalili, 2019):

Step 1. In the initial decision matrix, "*m*" number of alternatives and "n" number of criteria will be set, as shown by Eq. (1).

$$x = \begin{bmatrix} X11 & X\ 12 & \dots & X1n \\ X\ 21 & X\ 22 & \dots & X\ 2n \\ . & . & \dots & . \\ . & . & . & . \\ . & . & . & . \\ X\ m1 & X\ m2 & . & X\ mn \end{bmatrix} \tag{1}$$

Step 2. Based on Eq. (2), the normalized decision matrix is formed.

$$r_{ij}^{-} = \frac{r_{ij}}{\Sigma_{i=0}^{n} r_{ij}}; \qquad j = 1, \dots\dots\dots, n \tag{2}$$

Step 3. The degree of entropy (e_j) is determined using Eq. (3), the divergence degree (d_j) of the entropy value is generated by Eq. (4) and the entropy weight (w_j) is computed by Eq. (5).

$$E_j = -\frac{1}{lnn} \sum_{i=1}^{n} \bar{r}_{ij} * ln\bar{r}_{ij}; \qquad j = 1, \dots\dots\dots\dots.., n, 0 \leq E_j \leq 1 \tag{3}$$

$$d_j = 1 - E_j; j = 1, \dots\dots\dots\dots.., n \tag{4}$$

$$w_j = \frac{d_j}{\Sigma_{j=1}^{n} d_j} \tag{5}$$

3.2. CRITIC

In 1995, Diakoulaki, Mavrotas, and Papayannakin introduced the Criteria Importance Through Intercriteria Correlation (CRITIC) method. This approach is primarily employed to determine the weights of various attributes and is recognized as an objective weighting technique. The attributes considered in this method are non-conflicting, and the decision matrix serves as the basis for calculating these weights. The steps of the CRITIC method is outlined as follows (Diakoulaki et al., 1995; Alinezhad and Khalili, 2019):

Step 1. Eqs. (6) and (7) are used to normalize the positive and negative attributes of decision matrix, respectively.

$$x_{ij} = \frac{r_{ij} - r_i^{-}}{r_i^{t} - r_i^{-}}; \qquad i = 1, \dots\dots., m \ \ j = 1, \dots\dots., n \tag{6}$$

$$x_{ij} = \frac{r_{ij} - r_i^{+}}{r_i^{-} - r_i^{+}}; \qquad i = 1, \dots\dots., m \ \ j = 1, \dots\dots., n \tag{7}$$

Step 2. Eq. (8) is used to determine the correlation coefficient among attributes.

$$\rho_{jk} = \Sigma_{i=1}^{m}(x_{ij} - \bar{x}_j)(x_{ik} - \bar{x}_k) / \sqrt{\Sigma_{i=1}^{m}(x_{ij} - \bar{x}_j)^2 \Sigma_{i=1}^{m}(x_{ik} - \bar{x}_k)^2} \tag{8}$$

$\bar{x}_j$ is calculated from Eq. (9).

$$\bar{x}_j = \frac{1}{n}\sum_{j=1}^{n} x_{ij}; \qquad i = 1, \ldots\ldots\ldots\ldots\ldots\ldots, m \tag{9}$$

Step 3. The standard deviation of each attribute is estimated by Eq. (10)

$$\sigma_j = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_{ij} - \bar{x}_j)^2}; \qquad i = 1, \ldots\ldots\ldots\ldots\ldots\ldots, m \tag{10}$$

Eq. (11) is used to calculate the index (C)

$$C_J = \sigma_j \sum_{k=1}^{n}(1 - \rho_{jk}); \qquad j = 1, \ldots\ldots\ldots\ldots\ldots\ldots.., n \tag{11}$$

Step 4. Eq. (12) is utilized to determine the weights of attributes.

$$w_j = \frac{C_j}{\Sigma_{j=1}^{n} C_j}; \qquad j = 1, \ldots\ldots\ldots\ldots\ldots\ldots., n \tag{12}$$

For the final ranking, the attribute weights are ranked in descending order.

3.3. LOPCOW

The Logarithmic Percentage Change-driven Objective Weighting (LOPCOW) method was introduced by Ecer and Pamucar in 2022. It has emerged as a novel approach to objective weighting. The steps for implementing the LOPCOW method are outlined as follows (Ecer & Pamucar, 2022):

Step 1. The decision matrix is formed.

Step 2. According to Eqs. (13-14), the decision matrix is normalized.

$$r_{ij} = \frac{x_{max} - x_{ij}}{x_{max} - x_{min}}, \text{if } j \text{ is a cost criterion} \tag{13}$$

$$r_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}}, \text{if } j \text{ is a benefit criterion} \tag{14}$$

Step 3. Percentage values (PV) of each criterion is determined based on Eq. (15).

$$PV_{ij} = \left| ln\left(\frac{\sqrt{\frac{\Sigma_{i=1}^{m} r_{ij}^2}{m}}}{\sigma} \right).100 \right| \tag{15}$$

Step 4. Calculate the weights of the criteria using Eq. (16).

$$w_j = \frac{PV_{ij}}{\Sigma_{i=1}^{n} PV_{ij}} \tag{16}$$

3.4. EDAS

In 2015, Keshavarz Ghorabaee, Zavadskas, Olfat, and Turskis developed the Evaluation based on Distance from Average Solution (EDAS) method. This method proves to be highly effective in scenarios characterized by conflicting attributes, allowing for the selection of the most suitable alternative by calculating the distance of each option from the optimal value. The steps of the EDAS method is outlined as follows (Keshavarz Ghorabaee et al., 2015; 2017; Alinezhad and Khalili, 2019):

Step 1. Eq. (17) is used to calculate each attribute's average solution.

$$AV_J = \frac{\sum_{i=1}^{m} r_{ij}}{m}; j = 1, ..., n \tag{17}$$

Step 2. Eqs. (18) and (19) are used to determine the positive distances from average (PDA) and negative distances from average (NDA) of the positive attributes based on the positive and negative types of attributes.

$$PDA_{IJ} = \frac{max(0, (r_{ij} - AV_j))}{AV_j}; \qquad i = 1, ...m, j = 1, ..., n \tag{18}$$

$$NDA_{IJ} = \frac{max(0, (AV_j - r_{ij}))}{AV_j}; \qquad i = 1, ...m, j = 1, ..., n \tag{19}$$

Additionally, Eqs. (20) and (21) are used to calculate the PDA and NDA values of the negative attributes.

$$PDA_{IJ} = \frac{max(0, (AV_j - r_{ij}))}{AV_j}; \qquad i = 1, ...m, j = 1, ..., n \tag{20}$$

$$NDA_{IJ} = \frac{max(0, (r_{ij} - AV_j))}{AV_j}; \qquad i = 1, ...m, j = 1, ..., n \tag{21}$$

Step 3. Eqs. (22) and (23) are used to calculate the weighted PDA and weighted NDA values for each alternative, considering the weight of attributes.

$$SP_I = \sum_{j=1}^{n} PDA_{IJ}.w_j; \qquad i = 1, ..., m \tag{22}$$

$$SN_I = \sum_{j=1}^{n} NDA_{IJ}.w_j; \qquad i = 1, ..., m \tag{23}$$

Step 4. The values of weighted PDA and weighted NDA are normalized using Eqs. (24) and (25), respectively.

$$NSP_I = \frac{SP_i}{\max\limits_i(SP_i)}; \qquad i = 1, ..., m \tag{24}$$

$$NSN_I = \frac{SN_i}{\max\limits_i(SN_i)}; \qquad i = 1, ..., m \tag{25}$$

Step 5. Eq. (26) is used to compute each alternative's appraisal score.

$$AS_i = \frac{1}{2}(NSP_i + NSN_i); \qquad i = 1, ..., m \tag{26}$$

The appraisal scores of the alternatives are ranked in descending order to determine the final ranking of the alternatives.

4. Results

In this section, the results of the ENTROPY, CRITIC and LOPCOW-based EDAS methods are presented. Initially, the weight of the criteria was calculated with the ENTROPY, CRITIC and LOPCOW methods, separately. Once the determination of the criteria weight, logistics performance of the alternatives was ranked using the EDAS method. In the current study, the six criteria,

which are customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing and timeliness, were used to evaluate the logistics performance of OPEC countries. All criteria were considered beneficial. The 2018 LPI data for OPEC countries were retrieved from the WB. Table 2 and 3 demonstrates the description of the criteria and initial decision matrix, respectively (Arvis et al., 2018, p.8).

Table 2. Summary of the Criteria

Criterion	Code	Definition	Source
Customs	C1	The efficiency of customs and borders	World Bank (LPI-2018)
Infrastructure	C2	The quality of trade and transport infrastructure	
International Shipments	C3	The ease of arranging competitively priced shipments	
Logistics Quality & Competence	C4	The competence and quality of logistics services	
Tracking & Tracing	C5	The ability to track and trace consignments	
Timeliness	C6	The frequency with which shipments reach consignees within scheduled or expected delivery times	

Table 3. The Decision Matrix of OPEC Countries

Country	C1	C2	C3	C4	C5	C6
Algeria	2,13	2,42	2,39	2,39	2,60	2,76
Angola	1,57	1,86	2,20	2,00	2,00	2,59
Congo	2,27	2,07	2,87	2,28	2,38	2,95
Equatorial Guinea	1,91	1,88	2,88	2,25	2,13	2,75
Gabon	1,96	2,09	2,10	2,07	2,07	2,67
Iran	2,63	2,77	2,76	2,84	2,77	3,36
Iraq	1,84	2,03	2,32	1,91	2,19	2,72
Kuwait	2,73	3,02	2,63	2,80	2,66	3,37
Libya	1,95	2,25	1,99	2,05	1,64	2,77
Nigeria	1,97	2,56	2,52	2,40	2,68	3,07
Saudi Arabia	2,66	3,11	2,99	2,86	3,17	3,30
United Arab Emirates	3,63	4,02	3,85	3,92	3,96	4,38
Venezuela	1,79	2,10	2,38	2,21	2,29	2,58

4.1. Results of the ENTROPY Method

The normalized values of the decision matrix were computed using Eq. (2) and shown in Table 4.

Table 4. The Normalized Decision Matrix

Criteria	C1	C2	C3	C4	C5	C6
Algeria	0,0734	0,0753	0,0705	0,0748	0,0800	0,0703
Angola	0,0541	0,0577	0,0650	0,0627	0,0616	0,0661
Congo	0,0783	0,0642	0,0846	0,0713	0,0731	0,0751
Equatorial Guinea	0,0658	0,0583	0,0849	0,0704	0,0653	0,0700
Gabon	0,0674	0,0650	0,0620	0,0649	0,0635	0,0681
Iran	0,0904	0,0860	0,0814	0,0888	0,0850	0,0855
Iraq	0,0634	0,0632	0,0687	0,0597	0,0673	0,0693
Kuwait	0,0939	0,0939	0,0776	0,0875	0,0817	0,0858
Libya	0,0673	0,0699	0,0587	0,0640	0,0503	0,0705
Nigeria	0,0677	0,0796	0,0745	0,0750	0,0825	0,0781
Saudi Arabia	0,0916	0,0966	0,0882	0,0894	0,0975	0,0840
United Arab Emirates	0,1251	0,1250	0,1136	0,1226	0,1217	0,1114
Venezuela	0,0616	0,0652	0,0703	0,0690	0,0705	0,0657

According to Eqs. (3), (4) and (5), the entropy value (ej), divergence degree (d_j) and the final weights (w_j) for all criterions were generated. The final weights obtained from the Entropy method should be in the range of 0 and 1, and the sum of the resulting weights should give the value 1. In this case, number of alternatives n = 13. Therefore, $K = 1/\ln(n) = 1/\ln(13) = 0.3899$. The results obtained from all calculation is presented in Table 5 and 6.

Table 5. The Degree of Entropy

Criteria	C1	C2	C3	C4	C5	C6
Algeria	-0,1917	-0,1947	-0,1870	-0,1939	-0,2021	-0,1867
Angola	-0,1579	-0,1647	-0,1777	-0,1736	-0,1717	-0,1795
Congo	-0,1994	-0,1763	-0,2090	-0,1884	-0,1912	-0,1944
Equatorial Guinea	-0,1791	-0,1657	-0,2094	-0,1868	-0,1782	-0,1862
Gabon	-0,1817	-0,1777	-0,1724	-0,1775	-0,1751	-0,1829
Iran	-0,2173	-0,2110	-0,2042	-0,2150	-0,2096	-0,2102
Iraq	-0,1748	-0,1746	-0,1839	-0,1682	-0,1817	-0,1849
Kuwait	-0,2221	-0,2222	-0,1983	-0,2131	-0,2046	-0,2107
Libya	-0,1816	-0,1860	-0,1665	-0,1759	-0,1503	-0,1870
Nigeria	-0,1824	-0,2014	-0,1935	-0,1943	-0,2058	-0,1992
Saudi Arabia	-0,2190	-0,2258	-0,2141	-0,2159	-0,2269	-0,2081
United Arab Emirates	-0,2600	-0,2599	-0,2471	-0,2573	-0,2563	-0,2445
Venezuela	-0,1716	-0,1780	-0,1866	-0,1845	-0,1870	-0,1790

Table 6. The Entropy Weight

Criteria	C1	C2	C3	C4	C5	C6
Entropy (e_j)	0,9897	0,9895	0,9941	0,9920	0,9905	0,9955
Divergence degree (d_j)	0,0103	0,0105	0,0059	0,0080	0,0095	0,0045
Weights (w_j)	0,2101	0,2158	0,1218	0,1646	0,1954	0,0923
rank	2	1	5	4	3	6

The ENTROPY results showed that infrastructure (C2) and timeliness (C6) are the most and least important criteria, respectively. The general ranking of criteria is as follows: C2 > C1 > C5 > C4 > C3 > C6.

4.2. Results of the CRITIC Method

According to Eq. (6), the decision matrix was normalized and presented in Table 7.

Table 7. The Normalized Decision Matrix

Criteria	C1	C2	C3	C4	C5	C6
Algeria	0,2713	0,2607	0,2144	0,2401	0,4169	0,1000
Angola	0,0000	0,0000	0,1147	0,0477	0,1585	0,0074
Congo	0,3404	0,0966	0,4719	0,1855	0,3193	0,2049
Equatorial Guinea	0,1645	0,0083	0,4767	0,1699	0,2104	0,0938
Gabon	0,1865	0,1085	0,0590	0,0827	0,1857	0,0504
Iran	0,5114	0,4203	0,4131	0,4623	0,4865	0,4313
Iraq	0,1301	0,0815	0,1806	0,0000	0,2391	0,0770
Kuwait	0,5602	0,5382	0,3434	0,4416	0,4399	0,4381
Libya	0,1855	0,1809	0,0000	0,0681	0,0000	0,1049
Nigeria	0,1919	0,3246	0,2869	0,2438	0,4512	0,2711
Saudi Arabia	0,5287	0,5775	0,5359	0,4732	0,6607	0,4003
United Arab Emirates	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Venezuela	0,1048	0,1108	0,2101	0,1484	0,2832	0,0000

Based on Eqs. (8) and (9), the mean values of each attribute were computed and shown in Table 8.

Table 8. The Correlation Coefficient

Criteria	C1	C2	C3	C4	C5	C6
C1	1,0000	0,9457	0,8460	0,9631	0,8845	0,9670
C2	0,9457	1,0000	0,7578	0,9561	0,9105	0,9538
C3	0,8460	0,7578	1,0000	0,8832	0,8774	0,8637
C4	0,9631	0,9561	0,8832	1,0000	0,9380	0,9703
C5	0,8845	0,9105	0,8774	0,9380	1,0000	0,9001
C6	0,9670	0,9538	0,8637	0,9703	0,9001	1,0000

The standard deviation of each attribute was calculated by using Eqs. (10) and (11). The index for all attributes presented in Table 9.

Table 9. The Index (C)

Criteria	C1	C2	C3	C4	C5	C6
C1	0,0000	0,0543	0,1540	0,0369	0,1155	0,0330
C2	0,0543	0,0000	0,2422	0,0439	0,0895	0,0462
C3	0,1540	0,2422	0,0000	0,1168	0,1226	0,1363
C4	0,0369	0,0439	0,1168	0,0000	0,0620	0,0297
C5	0,1155	0,0895	0,1226	0,0620	0,0000	0,0999
C6	0,0330	0,0462	0,1363	0,0297	0,0999	0,0000

By using Eq. (12), the weight of the criteria was calculated and shown in Table 10.

Table 10. The Weight of Criteria

	C1	C2	C3	C4	C5	C6
W_j	0,1424	0,1842	0,2721	0,1051	0,1679	0,1284
rank	4	2	1	6	3	5

The CRITIC results showed that international shipments (C3) and logistics quality and competence (C4) are the most and least important criteria, respectively. The general ranking of criteria is as follows: C3 > C2 > C5 > C1 > C6 > C4.

4.3. Results of the LOPCOW Method

Based on Eq. (14), the decision matrix was normalized and shown in Table 11. Then, *PV* of each criterion and weight of criteria was determined using Eqs. (15-16), respectively. The results of the LOPCOW method are presented in Table 12.

Table 11. The normalized decision matrix

Country	C1	C2	C3	C4	C5	C6
Algeria	0,2718	0,4126	0,3981	0,3981	0,5000	0,5777
Angola	0,0000	0,1408	0,3058	0,2087	0,2087	0,4951
Congo	0,3398	0,2427	0,6311	0,3447	0,3932	0,6699
Equatorial Guinea	0,1650	0,1505	0,6359	0,3301	0,2718	0,5728
Gabon	0,1893	0,2524	0,2573	0,2427	0,2427	0,5340
Iran	0,5146	0,5825	0,5777	0,6165	0,5825	0,8689
Iraq	0,1311	0,2233	0,3641	0,1650	0,3010	0,5583
Kuwait	0,5631	0,7039	0,5146	0,5971	0,5291	0,8738
Libya	0,1845	0,3301	0,2039	0,2330	0,0340	0,5825
Nigeria	0,1942	0,4806	0,4612	0,4029	0,5388	0,7282
Saudi Arabia	0,5291	0,7476	0,6893	0,6262	0,7767	0,8398
United Arab Emirates	1,0000	1,1893	1,1068	1,1408	1,1602	1,3641
Venezuela	0,1068	0,2573	0,3932	0,3107	0,3495	0,4903

Table 12. The results of LOPCOW

Criteria	C1	C2	C3	C4	C5	C6
Mean Square	0,3223	0,4395	0,5030	0,4320	0,4529	0,7043
σ	0,2684	0,3012	0,2366	0,2634	0,2868	0,2414
PV	18,2801	37,8042	75,4080	49,4789	45,7160	107,0689
W_j	0,0548	0,1133	0,2259	0,1482	0,1370	0,3208
rank	6	5	2	3	4	1

The LOPCOW results showed that timeliness (C6) and customs (C1) are the most and least important criteria, respectively. The general ranking of criteria is as follows: C6>C3>C4>C5>C2>C1.

4.4. Results of the ENTROPY-based EDAS Method

The average solution of each attribute was obtained using Eq. (17) and shown in Table 13.

Table 13. The Average Solution

Country	C1	C2	C3	C4	C5	C6
Algeria	2,13	2,42	2,39	2,39	2,60	2,76
Angola	1,57	1,86	2,20	2,00	2,00	2,59
Congo	2,27	2,07	2,87	2,28	2,38	2,95
Equatorial Guinea	1,91	1,88	2,88	2,25	2,13	2,75
Gabon	1,96	2,09	2,10	2,07	2,07	2,67
Iran	2,63	2,77	2,76	2,84	2,77	3,36
Iraq	1,84	2,03	2,32	1,91	2,19	2,72
Kuwait	2,73	3,02	2,63	2,80	2,66	3,37
Libya	1,95	2,25	1,99	2,05	1,64	2,77
Nigeria	1,97	2,56	2,52	2,40	2,68	3,07
Saudi Arabia	2,66	3,11	2,99	2,86	3,17	3,30
United Arab Emirates	3,63	4,02	3,85	3,92	3,96	4,38
Venezuela	1,79	2,10	2,38	2,21	2,29	2,58
Average	2,2331	2,4744	2,6047	2,4596	2,5033	3,0206
w_j	0,2101	0,2158	0,1218	0,1646	0,1954	0,0923

The values of the PDA and NDA solution for each alternative was calculated by Eqs. (18-21), and shown in Table 14 and 15, respectively.

Table 14. Values of the PDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0000	0,0000	0,0000	0,0000	0,0406	0,0000
Angola	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Congo	0,0178	0,0000	0,1003	0,0000	0,0000	0,0000
Equatorial Guinea	0,0000	0,0000	0,1038	0,0000	0,0000	0,0000
Gabon	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iran	0,1755	0,1181	0,0584	0,1539	0,1052	0,1110
Iraq	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Kuwait	0,2205	0,2212	0,0086	0,1370	0,0620	0,1150
Libya	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Nigeria	0,0000	0,0345	0,0000	0,0000	0,0725	0,0158
Saudi Arabia	0,1914	0,2557	0,1460	0,1628	0,2670	0,0925
United Arab Emirates	0,6262	0,6252	0,4771	0,5935	0,5820	0,4488
Venezuela	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Table 15. Values of the NDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0460	0,0214	0,0834	0,0278	0,0000	0,0859
Angola	0,2963	0,2495	0,1545	0,1851	0,1993	0,1409
Congo	0,0000	0,1650	0,0000	0,0725	0,0501	0,0236
Equatorial Guinea	0,1446	0,2422	0,0000	0,0852	0,1511	0,0896
Gabon	0,1243	0,1546	0,1943	0,1565	0,1741	0,1153
Iran	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iraq	0,1763	0,1782	0,1075	0,2241	0,1245	0,0995
Kuwait	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Libya	0,1251	0,0912	0,2363	0,1684	0,3465	0,0829
Nigeria	0,1193	0,0000	0,0317	0,0248	0,0000	0,0000
Saudi Arabia	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
United Arab Emirates	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Venezuela	0,1996	0,1525	0,0865	0,1027	0,0836	0,1453

The values of the weighted PDA and weighted NDA of each alternative were obtained using Eqs. (22) and (23), and the results are presented in Table 16.

Table 16. Values of the SP and SN

Country	SP	SN
Algeria	0,0079	0,0370
Angola	0,0000	0,2173
Congo	0,0160	0,0595
Equatorial Guinea	0,0126	0,1345
Gabon	0,0000	0,1536
Iran	0,1256	0,0000
Iraq	0,0000	0,1590
Kuwait	0,1404	0,0000
Libya	0,0000	0,1779
Nigeria	0,0231	0,0330
Saudi Arabia	0,2007	0,0000
United Arab Emirates	0,5774	0,0000
Venezuela	0,0000	0,1320

Eqs. (24) and (25) was used to normalize the values of the weighted PDA and weighted NDA, respectively and shown in Table 17.

Table 17. Values of the NSP and NSN

Country	NSP	NSN
Algeria	0,0137	0,8299
Angola	0,0000	0,0000
Congo	0,0276	0,7262
Equatorial Guinea	0,0219	0,3812
Gabon	0,0000	0,2934
Iran	0,2175	1,0000
Iraq	0,0000	0,2684
Kuwait	0,2431	1,0000
Libya	0,0000	0,1816
Nigeria	0,0399	0,8482
Saudi Arabia	0,3475	1,0000
United Arab Emirates	1,0000	1,0000
Venezuela	0,0000	0,3925

Based on Eq. (26), the AS for each alternative was computed and the AS of alternatives were arranged in a descending order. Table 18 presents the final ranking of the alternatives.

Table 18. Values of the AS and Final Ranking

Country	AS	Rank
Algeria	0,4218	6
Angola	0,0000	13
Congo	0,3769	7
Equatorial Guinea	0,2016	8
Gabon	0,1467	10
Iran	0,6088	4
Iraq	0,1342	11
Kuwait	0,6216	3
Libya	0,0908	12
Nigeria	0,4440	5
Saudi Arabia	0,6738	2
United Arab Emirates	1,0000	1
Venezuela	0,1962	9

According to results obtained by the ENTROPY-based EDAS methods, the UAE has the highest logistics performance, followed by Saudi Arabia and Kuwait. On the other hand, Angola has the lowest logistics performance, followed by Libya and Iraq.

4.5. Results of the CRITIC-based EDAS Method

The average solution of each attribute was obtained using Eq. (17) and presented in Table 19.

Table 19. The Average Solution

Country	C1	C2	C3	C4	C5	C6
Algeria	2,13	2,42	2,39	2,39	2,60	2,76
Angola	1,57	1,86	2,20	2,00	2,00	2,59
Congo	2,27	2,07	2,87	2,28	2,38	2,95
Equatorial Guinea	1,91	1,88	2,88	2,25	2,13	2,75
Gabon	1,96	2,09	2,10	2,07	2,07	2,67
Iran	2,63	2,77	2,76	2,84	2,77	3,36
Iraq	1,84	2,03	2,32	1,91	2,19	2,72
Kuwait	2,73	3,02	2,63	2,80	2,66	3,37
Libya	1,95	2,25	1,99	2,05	1,64	2,77
Nigeria	1,97	2,56	2,52	2,40	2,68	3,07
Saudi Arabia	2,66	3,11	2,99	2,86	3,17	3,30
United Arab Emirates	3,63	4,02	3,85	3,92	3,96	4,38
Venezuela	1,79	2,10	2,38	2,21	2,29	2,58
Average	2,2331	2,4744	2,6047	2,4596	2,5033	3,0206
w_j	0,1424	0,1842	0,2721	0,1051	0,1679	0,1284

Eqs. (18-21) were used to determine the positive distance from average (PDA) and negative distance from average (NDA) values for each alternative, and the results are displayed in Tables 20 and 21, respectively.

Table 20. Values of the PDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0000	0,0000	0,0000	0,0000	0,0406	0,0000
Angola	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Congo	0,0178	0,0000	0,1003	0,0000	0,0000	0,0000
Equatorial Guinea	0,0000	0,0000	0,1038	0,0000	0,0000	0,0000
Gabon	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iran	0,1755	0,1181	0,0584	0,1539	0,1052	0,1110
Iraq	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Kuwait	0,2205	0,2212	0,0086	0,1370	0,0620	0,1150
Libya	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Nigeria	0,0000	0,0345	0,0000	0,0000	0,0725	0,0158
Saudi Arabia	0,1914	0,2557	0,1460	0,1628	0,2670	0,0925
United Arab Emirates	0,6262	0,6252	0,4771	0,5935	0,5820	0,4488
Venezuela	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Table 21. Values of the NDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0460	0,0214	0,0834	0,0278	0,0000	0,0859
Angola	0,2963	0,2495	0,1545	0,1851	0,1993	0,1409
Congo	0,0000	0,1650	0,0000	0,0725	0,0501	0,0236
Equatorial Guinea	0,1446	0,2422	0,0000	0,0852	0,1511	0,0896
Gabon	0,1243	0,1546	0,1943	0,1565	0,1741	0,1153
Iran	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iraq	0,1763	0,1782	0,1075	0,2241	0,1245	0,0995
Kuwait	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Libya	0,1251	0,0912	0,2363	0,1684	0,3465	0,0829
Nigeria	0,1193	0,0000	0,0317	0,0248	0,0000	0,0000
Saudi Arabia	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
United Arab Emirates	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Venezuela	0,1996	0,1525	0,0865	0,1027	0,0836	0,1453

The values of the weighted PDA and weighted NDA of each alternative were obtained using Eqs. (22) and (23), and the results are presented in Table 22.

Table 22. Values of the SP and SN

Country	SP	SN
Algeria	0,0068	0,0471
Angola	0,0000	0,2012
Congo	0,0298	0,0494
Equatorial Guinea	0,0282	0,1110
Gabon	0,0000	0,1595
Iran	0,1107	0,0000
Iraq	0,0000	0,1444
Kuwait	0,1141	0,0000
Libya	0,0000	0,1854
Nigeria	0,0205	0,0282
Saudi Arabia	0,1879	0,0000
United Arab Emirates	0,5518	0,0000
Venezuela	0,0000	0,1235

Eqs. (24) and (25) was used to normalize the values of the weighted PDA and weighted NDA, respectively and the results are shown in Table 23.

Table 23. Values of the NSP and NSN

Country	NSP	NSN
Algeria	0,0123	0,7657
Angola	0,0000	0,0000
Congo	0,0541	0,7543
Equatorial Guinea	0,0512	0,4481
Gabon	0,0000	0,2071
Iran	0,2006	1,0000
Iraq	0,0000	0,2823
Kuwait	0,2067	1,0000
Libya	0,0000	0,0782
Nigeria	0,0372	0,8598
Saudi Arabia	0,3405	1,0000
United Arab Emirates	1,0000	1,0000
Venezuela	0,0000	0,3861

Based on Eq. (26), the appraisal score (AS) for each alternative was computed and the AS of alternatives were arranged in a descending order. Table 24 illustrates the final ranking of the alternatives.

Table 24. Values of the AS and Final Ranking

Country	AS	Rank
Algeria	0,3890	7
Angola	0,0000	13
Congo	0,4042	6
Equatorial Guinea	0,2496	8
Gabon	0,1036	11
Iran	0,6003	4
Iraq	0,1411	10
Kuwait	0,6034	3
Libya	0,0391	12
Nigeria	0,4485	5
Saudi Arabia	0,6702	2
United Arab Emirates	1,0000	1
Venezuela	0,1930	9

According to results obtained by CRITIC-based EDAS method, UAE has the highest logistics performance, followed by Saudi Arabia and Kuwait. On the other hand, Angola has the lowest logistics performance, followed by Libya and Gabon.

4.6. Results of the LOPCOW-based EDAS Method

The average solution of each attribute was obtained using Eq. (17) and presented in Table 25.

Table 25. The Average Solution

Country	C1	C2	C3	C4	C5	C6
Algeria	2,13	2,42	2,39	2,39	2,60	2,76
Angola	1,57	1,86	2,20	2,00	2,00	2,59
Congo	2,27	2,07	2,87	2,28	2,38	2,95
Equatorial Guinea	1,91	1,88	2,88	2,25	2,13	2,75
Gabon	1,96	2,09	2,10	2,07	2,07	2,67
Iran	2,63	2,77	2,76	2,84	2,77	3,36
Iraq	1,84	2,03	2,32	1,91	2,19	2,72
Kuwait	2,73	3,02	2,63	2,80	2,66	3,37
Libya	1,95	2,25	1,99	2,05	1,64	2,77
Nigeria	1,97	2,56	2,52	2,40	2,68	3,07
Saudi Arabia	2,66	3,11	2,99	2,86	3,17	3,30
United Arab Emirates	3,63	4,02	3,85	3,92	3,96	4,38
Venezuela	1,79	2,10	2,38	2,21	2,29	2,58
Average	2,2331	2,4744	2,6047	2,4596	2,5033	3,0206
w_j	0,1424	0,1842	0,2721	0,1051	0,1679	0,1284

Eqs. (18-21) were used to determine the positive distance from average (PDA) and negative distance from average (NDA) values for each alternative, and the results are displayed in Table 26 and 27, respectively.

Table 26. Values of the PDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0000	0,0000	0,0000	0,0000	0,0387	0,0000
Angola	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Congo	0,0162	0,0000	0,1012	0,0000	0,0000	0,0000
Equatorial Guinea	0,0000	0,0000	0,1051	0,0000	0,0000	0,0000
Gabon	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iran	0,1773	0,1190	0,0590	0,1545	0,1066	0,1123
Iraq	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Kuwait	0,2221	0,2200	0,0091	0,1382	0,0627	0,1156
Libya	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Nigeria	0,0000	0,0342	0,0000	0,0000	0,0707	0,0163
Saudi Arabia	0,1908	0,2564	0,1473	0,1626	0,2664	0,0924
United Arab Emirates	0,6250	0,6240	0,4773	0,5935	0,5821	0,4500
Venezuela	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Table 27. Values of the NDA

Country	C1	C2	C3	C4	C5	C6
Algeria	0,0465	0,0224	0,0829	0,0285	0,0000	0,0863
Angola	0,2972	0,2486	0,1558	0,1870	0,2010	0,1426
Congo	0,0000	0,1638	0,0000	0,0732	0,0492	0,0234
Equatorial Guinea	0,1450	0,2405	0,0000	0,0854	0,1490	0,0896
Gabon	0,1226	0,1557	0,1942	0,1585	0,1730	0,1161
Iran	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Iraq	0,1763	0,1799	0,1098	0,2236	0,1251	0,0996
Kuwait	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Libya	0,1271	0,0911	0,2364	0,1667	0,3448	0,0830
Nigeria	0,1181	0,0000	0,0331	0,0244	0,0000	0,0000
Saudi Arabia	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
United Arab Emirates	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Venezuela	0,1987	0,1516	0,0868	0,1016	0,0851	0,1459

The values of the weighted PDA and weighted NDA of each alternative were obtained using Eqs. (22) and (23), and the results are presented in Table 28.

Table 28. Values of the SP and SN

Country	SP	SN
Algeria	0,0053	0,0557
Angola	0,0000	0,1807
Congo	0,0238	0,0437
Equatorial Guinea	0,0237	0,0970
Gabon	0,0000	0,1527
Iran	0,1101	0,0000
Iraq	0,0000	0,1371
Kuwait	0,1053	0,0000
Libya	0,0000	0,1693
Nigeria	0,0188	0,0176
Saudi Arabia	0,1630	0,0000
United Arab Emirates	0,5248	0,0000
Venezuela	0,0000	0,1212

Eqs. (24) and (25) was used to normalize the values of the weighted PDA and weighted NDA, respectively and the results are shown in Table 29.

Table 29. Values of the NSP and NSN

Country	NSP	NSN
Algeria	0,0101	0,6915
Angola	0,0000	0,0000
Congo	0,0453	0,7584
Equatorial Guinea	0,0452	0,4629
Gabon	0,0000	0,1548
Iran	0,2097	1,0000
Iraq	0,0000	0,2413
Kuwait	0,2007	1,0000
Libya	0,0000	0,0631
Nigeria	0,0358	0,9028
Saudi Arabia	0,3106	1,0000
United Arab Emirates	1,0000	1,0000
Venezuela	0,0000	0,3291

Based on Eq. (26), the appraisal score (AS) for each alternative was computed and the AS of alternatives were arranged in a descending order. Table 30 demonstrates the final ranking of the alternatives.

Table 30. Values of the AS and Final Ranking

Country	AS	Rank
Algeria	0,3508	7
Angola	0,0000	13
Congo	0,4018	6
Equatorial Guinea	0,2541	8
Gabon	0,0774	11
Iran	0,6049	3
Iraq	0,1206	10
Kuwait	0,6003	4
Libya	0,0315	12
Nigeria	0,4693	5
Saudi Arabia	0,6553	2
United Arab Emirates	1,0000	1
Venezuela	0,1645	9

According to results obtained by LOPCOW-based EDAS method, the UAE has the highest logistics performance, followed by Saudi Arabia and Iran. On the other hand, Angola has the lowest logistics performance, followed by Libya and Gabon. Additionally, a comparison of ranking results with different weighting methods is presented in Figure 1. Based on the comparison of ranking results obtained by ENTROPY, CRITIC and LOPCOW-based EDAS method, the logistics performance of the top five countries is the same in all approaches. The UAE is the best ranked in LPI, followed by Saudi Arabia, Kuwait, Iran, and Nigeria. However, some differences have been observed in the rest of the ranking. For instance, the logistics performance rankings of Algeria, Congo, Gabon, and Iraq are relatively different, as illustrated in Figure 1.

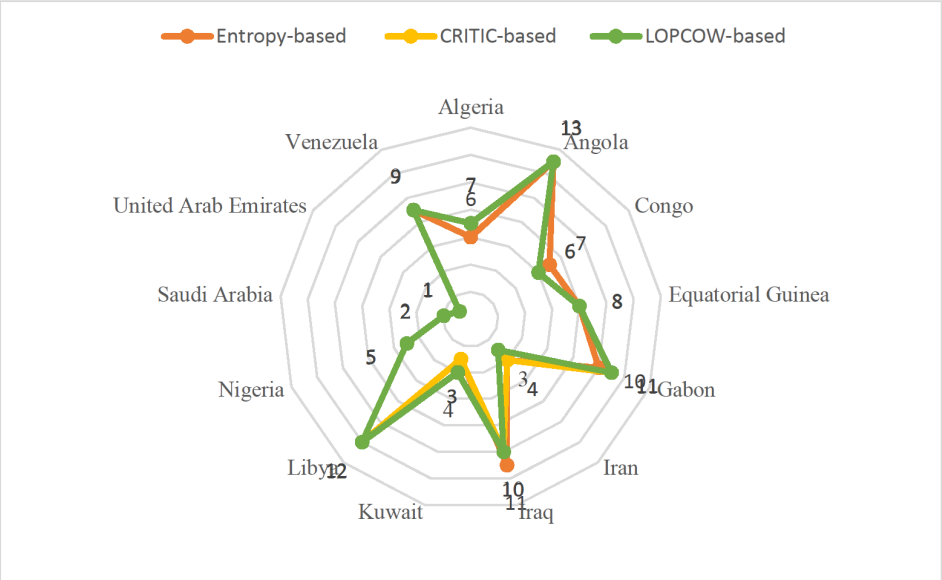

Figure 1. Comparison of ranking results

5. Comparative Analysis

Mešić et al. (2022) pointed out that it's important to carried out consistency analysis of results based on the changes of methods. In this study, a comparative analysis was conducted to assess the robustness of the results obtained from the proposed model. Initially, the geometric mean of the criteria weights was calculated. Subsequently, the outcomes obtained from the proposed model were compared with those obtained by applying other MCDM methods, including ARAS, TOPSIS, COPRAS, MAIRCA, WASPAS, and CoCoSo. These methods were selected due to their distinct calculations and approaches. Table 31 and Figure 2 presents the results obtained by different MCDM methods, respectively.

Table 31. Comparative Analysis Results

Country	EDAS	ARAS	TOPSIS	COPRAS	MAIRCA	WASPAS	CoCoSo
Algeria	7	7	7	9	7	7	7
Angola	13	13	13	13	13	13	13
Congo	6	6	6	5	6	6	6
Equatorial Guinea	8	8	8	6	8	8	8
Gabon	11	11	11	11	11	11	10
Iran	3	4	4	4	4	4	4
Iraq	10	10	10	12	10	10	11
Kuwait	4	3	3	3	3	3	3
Libya	12	12	12	7	12	12	12
Nigeria	5	5	5	8	5	5	5
Saudi Arabia	2	2	2	2	2	2	2
United Arab Emirates	1	1	1	1	1	1	1
Venezuela	9	9	9	10	9	9	9

The comparative analysis results showed that the ranking obtained from the EDAS method is almost the same as in the ranking order obtained from the ARAS, TOPSIS, MAIRCA, WASPAS and CoCoSo methods. However, the ranking differs in relation to COPRAS method. The comparative analysis showed that the UAE and Angola have the best and worst logistics performance, respectively. It can be concluded that the countries with the highest and lowest logistics performance are constant for all methods. The overall ranking of countries obtained by the comparative analysis is presented in Figure 2.

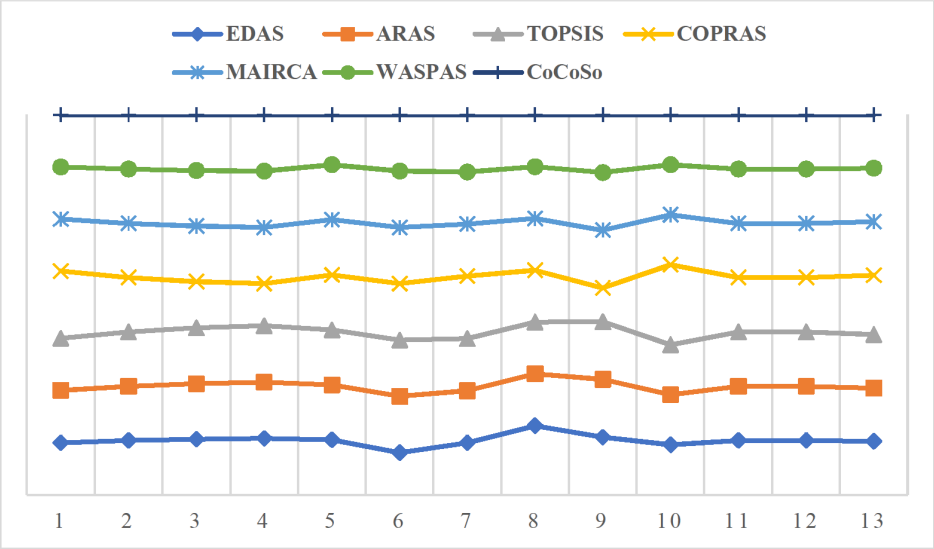

Figure 2. Comparison of ranking results

6. Discussion and Conclusions

The logistics is one of the important industries in facilitating trade, decreasing transportation costs, and stimulating economic growth. Logistics services are crucial in terms of sustainable growth and trade efficiency. In addition, it has a positive effect on economies of scale, production activities, and distribution of goods (Bugarčić et al., 2020). Therefore, measuring the logistics performance of countries is quite important. In this context, the WB has been publishing LPI reports since 2007. LPI is an interactive benchmarking tool created to help countries identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance (WB, 2023). Parallel to this, a large and growing body of literature has investigated the logistics performance of nations with various MCDM methods. For instance, the logistics performance of OECD (Çakır, 2017; Gök Kısa & Ayçin, 2019; Yıldırım & Adıgüzel Mercangöz., 2020; Arıkan Kargı, 2022; Çalık et al., 2023), the logistics performance of EU (Ulutaş & Karaköy, 2019a; Isik et al., 2020; Adıgüzel Mercangöz et al., 2020), the logistics performance of Balkans countries (Bugarčić et al., 2020; Mešić et al., 2022), the logistics performance of G20 members (Ulutaş & Karaköy, 2019b and the logistics performance of Gulf Cooperation Council (GCC) (Stojanović & Puška, 2021) has been reviewed by many researchers. However, there has been a limited number of studies on the logistics performance of GCC and OPEC members in relevant literature. Accordingly, this study examines the logistics performance of OPEC countries using the ENTROPY, CRITIC and LOPCOW-based EDAS method.

The findings obtained by the ENTROPY, CRITIC and LOPCOW methods showed that the most important criteria were infrastructure, international shipments and timeliness, respectively. The findings of the current study are consistent with those of Ulutaş & Karaköy (2019, 2021), Yıldırım & Adıgüzel Mercan (2020), Isik et al. (2020), Arıkan Kargı (2022), Miškić et al. (2023) who determined the infrastructure, international shipments and timeliness as a most critical criterion. Once the weight of criteria was calculated, the logistics performance of OPEC countries was ranked using the EDAS method. According to results obtained by the ENTROPY, CRITIC and LOPCOW-based EDAS method revealed that the UAE has the highest logistics performance, followed by Saudi Arabia, Iran, Kuwait and Nigeria. These findings seem to be consistent with another research which found that the UAE has the best logistics performance among GCC. However, the logistics performance of Saudi Arabia and Kuwait is relatively low among GCC (Stojanović & Puška, 2021). On the other hand, Angola and Libya have the worst logistics performance, followed by Iraq and Gabon. A possible explanation for these results may be the lack of adequate political and economic stability. In such regions, economic development is relatively low and military administration is more dominant. Based on the LPI Report published by the WB in 2018, the UAE is among the top 20 countries (11^{th} rank), whereas Saudi Arabia and Kuwait are among the top 75 countries (55^{th} and 63^{rd}, respectively). Additionally, Iraq, Gabon, Libya, and Angola are in last place on LPI (147^{th}, 150^{th}, 154^{th} and 159^{th}, respectively).

Overall, the findings from this study make several contributions to the current literature. To the best of the author's knowledge, this is the first study examining the logistics performance of OPEC countries using the ENTROPY, CRITIC and LOPCOW-based EDAS methods. This study also enables a comparison of ranking results with different MCDM methods, such as ARAS, TOPSIS, COPRAS, MAIRCA, WASPAS and CoCoSo. It is anticipated that the results derived from this study will offer valuable insights to policymakers, investors, and businesses operating within OPEC countries concerning logistics performance. Furthermore, this

research has identified priority countries for managers of logistics firms operating within or considering investment in OPEC countries, along with key criteria for market entry. Additionally, several managerial recommendations have been proposed to enhance the logistics performance of these countries: (I) oil and subterranean resources are important sources of revenue for the OPEC countries. To improve connectivity and facilitate effective movement of goods, it would be beneficial to allocate part of their income from transport and logistics infrastructure such as ports, roads, railways or airports. (II) in order to reduce bureaucratic barriers and improve efficiency in their customs and trade activities, OPEC countries can further strengthen contacts with the other countries particularly Europe and Africa. (III) in order to simplify supply chain operations, reduce transaction costs and increase transparency in the logistics network, technological advances such as digitalization, automation, big data, blockchain, artificial intelligence can be adopted. (IV) in order to contribute to environmental preservation and long-term sustainability, while improving overall logistics performance, it is possible to integrate sustainability principles into operations such as the adoption of green logistics practices, optimization of transport routes or reducing carbon emissions. Several limitations of this study need to be acknowledged. For instance, one of the limitations is the observed period and the number of countries. Future research could investigate the logistics performance of other regions, such as Asia, South America, and Africa, over several years and compare the results. Moreover, future research in this field might use different subjective and objective methods, or methods involving fuzzy approaches. It would be interesting to compare the results obtained by fuzzy and gray approaches.

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