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Evaluating the Logistics Performance of One Belt One Road Project Countries with Multi Criteria Decision Making Methods

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Abstract

Logistics is significant for national governments to evaluate the activities, functions and elements of the existing country-level logistics system to develop competitive advantage. The Logistics Performance Index (LPI) is one of the most reliable reports used to evaluate logistics performance at the country level. In this study, a new hybrid model using the SIWEC, CRITIC, LOPCOW and MACONT methods from the Multi-Criteria Decision Making (MCDM) methods is proposed to measure the logistics performance of the countries located in the northern, southern and central corridors of the One Belt, One Road Project (OBORP) connecting Asia to Europe. SIWEC, CRITIC, and LOPCOW methods were used to calculate the objective weights of the criteria for each corridor. The MACONT method was employed to rank the countries based on their logistics performance for each corridor. According to the combined criteria weights, the most important criterion in the northern corridor was international shipping, while the least crucial criterion was customs. The most crucial criterion in the southern corridor was customs, while the least crucial criterion was tracking and tracing. In the middle corridor, the most crucial criterion was tracking and tracing, while the least crucial criterion was logistics quality and competence. Owing to the analysis made with the MACONT method, Germany was the country that showed the best logistics performance in all three corridors. The results obtained for each corridor using the decision-making approach offered in the study were compared with other alternative assessment methods such as MARA, ARAS, COPRAS, GIA, EDAS and OCRA to ensure the validity and robustness of the findings. Based on the comparison, it was observed that the results obtained for each corridor were quite similar, and the proposed approach gave consistent results.

Keywords: ***Logistics Performance Index (LPI), Multi Criteria Decision Making (MCDM), SIWEC, CRITIC, LOPCOW, MACONT***

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1. INTRODUCTION

Globalization and increasing global economic integrations have increased the trade volumes of countries and businesses (Gürler et al., 2024). Before the globalization phenomenon, countries generally contended with countries in their regions. With globalization, the scope of competition has expanded to encompass the entire world. This has made logistics a fundamental element of international trade and a cornerstone of economic growth and development (Martí et al., 2014; Rezaei et al., 2018).

Logistics has multiple activities, functions and elements. Thus, being competitive in the global market and increasing the number of persistent customers by ensuring customer satisfaction is a challenge (Mešić et al., 2022). To develop logistics competitive advantage, it is crucial for national governments to appraise the activities, functions and elements of the existing country-level logistics system. Due to the assessment outcomes, it is obligatory to decide which infrastructures should be most appropriately utilized, developed, created, or completely removed through policies and initiatives (Beysenbaev & Dus, 2020; Jhawar et al., 2017).

The logistics sector plays a significant role in a country's achievement of its sustainable development aims. Hence, it is of high priority for country governments and industry leaders to understand how their logistics performance compares to other countries. This is notably true for global logistics suppliers. This essential comparison of national logistics performances not only lets countries to identify their competitive position relative to international logistics service providers but also eases benchmarking with market leaders to advance and cultivate national logistics performance (Rashidi & Cullinane, 2019).

There are not many tools for assessing logistics efficiency at the country level. This is because research is generally conducted at the micro-logistics level rather than at the global logistics level (Beysenbaev & Dus, 2020). One of the most reliable reports used to analyze the efficiency of logistics systems at the country level is the Logistics Performance Index (LPI), composed by the World Bank in 2007 and brought out every two years. The World Bank evaluates the logistics competitiveness of countries by utilizing the LPI. The LPI is a benchmarking tool utilized by directors and decision makers in the logistics industry to identify potential challenges and opportunities that countries may face in their trade logistics performance (Rezaei et al., 2018). LPI is estimated by considering six main criteria of logistics performance for each country (Arvis et al., 2010; Rashidi & Cullinane, 2019):

- Customs and border management: It covers the efficiency of customs clearance procedures, such as speed, ease and predictability of procedures and laws.
- Infrastructure: The qualification of infrastructure related to trade and transportation such as railways, information technology, ports and roads.
- Shipping arrangements: The ease of arranging shipments to markets at competitive prices.

- Quality of logistics services: All levels of competence and qualification of key logistics service providers, such as freight forwarders, transport operators, customs and border agents, distributors, and shippers.
- Track and trace: The ability to track shipments during transportation to market.
- Timeliness: Shipments arrive at their destination on time within the planned or expected delivery time.

Since One Belt, One Road Project (OBORP) creates an uninterrupted supply chain network from Asia to Europe, the logistics performance of the countries where the project is implemented is of great importance. This situation increases interest in this huge project with high geographical and commercial importance. Recently, decision-making in complex environments has become a global focus. The objective of this study is to analyze the logistics performance of the countries located in the Northern, Southern and Central corridors of the OBORP railway line connecting Asia and Europe using MCDM methods. The data in the study were compiled from the LPI documentation presented by the World Bank (2023). The weights of the evaluation factors were determined by applying three multi criteria decision making (MCDM) methods (SIWEC, CRITIC and LOPCOW). The MACONT method was utilized to rank the alternatives using the criteria weights. There is no study in the literature that integrates the four methods used in the study in terms of both weighting and ranking. In addition, the SIWEC method is a relatively new method in the literature. The number of studies applying this method (Puška et al., 2024) is quite low. The study aims to fill these gaps in the literature in terms of methods.

The study is composed of five chapters. In the next chapter, LPI studies using MCDM methods in the literature will be reviewed. In the third chapter, the MCDM methods utilized in the study will be detailed. In the fourth chapter, the logistics performances of the countries in the North, South and Central corridors of the OBORP in line with the data extracted from the LPI report announced by the World Bank in 2023 will be analyzed by integrating the identified MCDM methods. In the fifth chapter, which is the last section, a discussion section will be included in line with the analysis results.

2. LITERATURE REVIEW

In this chapter, LPI studies using MCDM approaches in the literature are reviewed. Some of the logistics performance index studies conducted in the literature by utilizing MCDM methods are given in Table 1. Google Scholar database was utilized during the literature review. The keywords "Logistics Performance Index" and “MCDM” were used as keywords.

Table 1. LPI Studies Using MCDM Methods

Author(s)	Aim	Method(s)	Findings
Mercangoz et al. (2020)	Analyzing the logistics performance of 28 EU countries and 5 candidate countries.	COPRAS-G	The ranking of the F-AHP method criteria weights is as follows: infrastructure>timeliness>customs=logistics quality and competence>international shipping>tracking and tracing. Consequently, according to the SAW method, the country with the highest LPI score was “Germany”, while “Albania” was in the last place.
Işık et al. (2020)	Evaluation of LPI of 11 CEECs using 2018 LPI data.	SV and MABAC	The ranking of the F-AHP method criteria weights is as follows: timeliness>international shipping>customs>logistics quality and competence>tracking and tracing>infrastructure. Consequently, according to the MABAC approach, the country with the highest LPI score was “Czechia”, while “Latvia” was in the last place.
Yıldırım and Mercangoz (2020)	Evaluation of LPI of OECD countries in the period 2010-2018	Fuzzy AHP and Grey ARAS	The ranking of the F-AHP method criteria weights is as follows: infrastructure> timeliness> customs> logistics quality and competence> international shipping > tracking and tracing. Consequently, according to the Grey ARAS technique, the country with the highest LPI score was “Germany”, while “Latvia” was in the last place.
Senir (2021)	Comparison of domestic logistics performance of Türkiye and EU countries using 2018 LPI data.	CRITIC and COPRAS	Using the CRITIC approach, the most significance criteria was defined as the customs clearance period sub-criterion "without physical examination". According to the COPRAS method results, the country with the best domestic logistics performance was "Netherlands", while "Latvia" was in the last place.
Stojanović and Puška (2021)	Measuring the logistics performance of the Gulf Cooperation Council countries.	CRITIC and MABAC	The ranking of the CRITIC method criteria weights is as follows: logistics quality and competence>tracking and tracing>international shipping>infrastructure>customs> timeliness. As a result of the MABAC approach, the country with the most LPI score was “United Arab Emirates”, while “Kuwait” was in the last place.
Özdağoğlu et al. (2022)	They evaluated all 160 countries included in the LPI report together.	MAUT, TOPSIS, MOORA, MAIRCA, MABAC, WSM, WPM, Borda Method	Consequently, the ranking of the top 10 countries is as follows: Germany > Sweden > Belgium > Japan > Austria > Netherlands > Singapore > Denmark > United Kingdom > Finland.
Stević et al. (2022)	Evaluation of logistics performance of Balkan countries in the period 2007-2018.	CRITIC and MARCOS	The ranking of the CRITIC method criteria weights is as follows: timeliness>international shipping>tracking and tracing>infrastructure>logistics quality and competence>customs. As a result of the MARCOS, the country with the highest LPI score was “Slovenia”, while “Albania” was in the last place.

(Table 1 cont.)

Author(s)	Aim	Method(s)	Findings
Oğuz (2023)	2023 evaluation of LPI of the top 10 countries in the LPI report	EDAS and TOPSIS	The ranking of the criteria weights is as follows: logistics quality and competence> tracking and tracing= infrastructure> customs> timeliness>international shipping. Consequently, the TOPSIS, the country with the most LPI score was "Finland", while "Canada" was in the last place. Consequently, the EDAS, the country with the most LPI was "Singapore", while "Austria" was in the last place.
Kara et al. (2024)	Evaluating 78 countries' supply chain performance and logistics performance.	MPSI and ARLON	The ranking of the MPSI method criteria weights is as follows: mean delivery time for postal activities> maritime connectivity> aviation connectivity> postal connectivity>mean consolidated import dwell time> mean turnaround time at ports> mean consolidated export dwell time> mean port export dwell time>mean port import dwell time> mean aviation import dwell time. As a result of the ARLON, the country with the most LPI score was "Netherlands", while "Sudan" was in the last place.
Pehlivan et al. (2024)	Evaluation of logistics performance of G20 countries.	TOPSIS and Cluster Analysis	All criteria weights were taken as equal (0.167). Consequently, the TOPSIS, the country with the most LPI score was "Germany", while "Russia" was in the last place.
Ju et al. (2024)	Evaluating the logistics performance of European countries.	CRITIC, MEREC, ENTROPY and Fuzzy ROV	According to CRITIC, MEREC, ENTROPY and Fuzzy ROV integrated model results, Finland was the country with the highest LPI, while Cyprus was in the last place.
Akbulut et al. (2024)	Evaluation of logistics performance of G20 countries.	SD, PSI, MEREC and MARA	According to SD, PSI, MEREC and MARA integrated model results, Germany was the country with the highest LPI, while Russia was in the last place.

2.1. Research Gap Analysis

Literature reviews show that there are many studies examining the logistics performance of different countries or economic integrations. However, the logistics performance indices of the countries located in the three corridors (north, south and central) of the OBORP railway route connecting Asia to Europe have not been evaluated comprehensively with MCDM methods before. The study contributes to literature in this respect.

In this study, various criteria weighting methods were applied. Therefore, the criterion weights obtained in this study are considered to be more precise and robust.

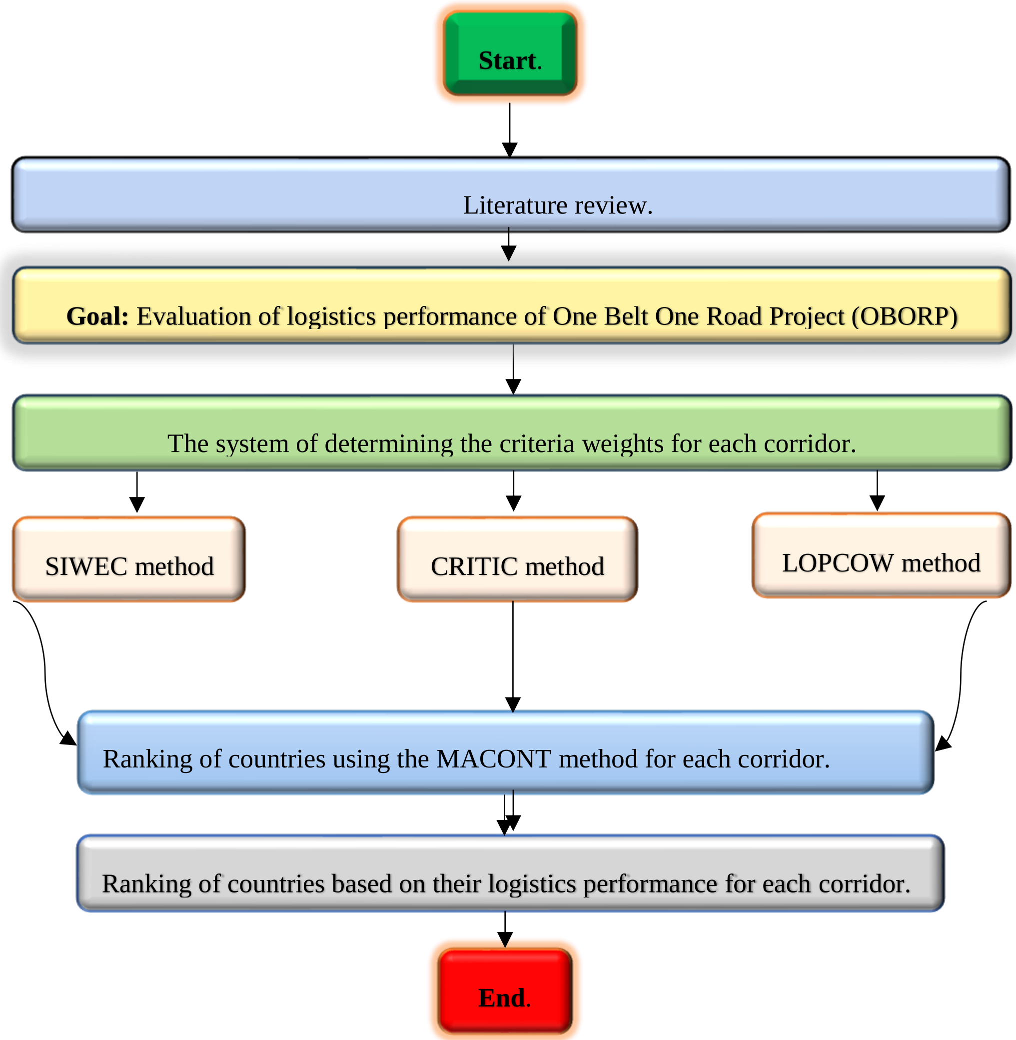
The second gap is the absence of studies in the literature that combine the SIWEC, CRITIC, LOPCOW, and MACONT methods to assess the logistics performance of countries. Therefore, it is targeted to complete this research gap in the literature by designing a performance measurement basis that combines the beneficial aspects of these four methods and provides more comprehensive and practical evaluations of countries. In addition, the SIWEC method is a relatively new method in the literature. The number of studies applying this method (Puška et al., 2024) is quite low, and there is a void in the literature in this branch.

Hence, in order to fill all these gaps detected in the literature, the effectiveness of the proposed integrated method in evaluating the LPIs of countries located in the north, south and center corridors of the OBORP railway route was tested.

3. METHODOLOGY

This section introduces the SIWEC, CRITIC, LOPCOW and MACONT methods employed to assess the logistics performance of countries located in the northern, southern and central corridors of the OBORP railway route. The weights of the evaluation factors for each corridor are determined by applying SIWEC, CRITIC and LOPCOW. The MACONT method was employed to rank the countries based on their logistics performance for each corridor. Figure 1 illustrates the flow diagram of the research methodology.

Figure 1. Flow Diagram of Research Methodology



Source: Created by the authors.

3.1. SIWEC Method

The SIWEC technique is a simple and novel technique developed by Puška et al. (2024) to calculate the weights of the criteria. The most important advantage of the SIWEC method is that it reduces the complexity in determining the criteria weights in the decision-making process and simplifies the steps, thus providing an approach that a wider audience can understand (Puška et al., 2024). In this study, the SIWEC method was preferred because it simplifies the process of calculating the criteria weights using simple procedures and steps (Puška et al., 2024). Some studies using the SIWEC method: Puška et al. (2024) in determining sales channels, El-Jaberi (2024) in selecting projects based on renewable energy sources, Cao et al. (2025) in determining innovative approaches for smart cities, Gao and Qian (2025) on risk assessment, and Kaya (2025) in designing routes. The SIWEC method determines the importance levels of the criteria through six stages. These stages are (Puška et al., 2024):

Stage 1. The decision matrix is organized based on the data and is represented in Eq. (1).

$$D = [d_{ij}]_{m\times n} \tag{1}$$

The d_{ij} value presented in Eq. 1 describes the performance of alternative i on criteria j.

Stage 2. The decision matrix is normalized applying Eq. (2). Unlike other MCDM methods, in the SIWEC approach, each criterion is split by the maximum value across all criteria.

$$n_{ij} = \frac{d_{ij}}{d_{ij}mak} \tag{2}$$

$d_{ij}mak$ in Eq. (2) shows the highest value of all criteria.

Stage 3. Standard deviation values of normalized values are figured for each alternative.

Stage 4. The v_{ij} value is obtained by multiplying the normalized values of the alternatives by their respective standard deviation values.

$$v_{ij} = n_{ij} \times st.dev._j \tag{3}$$

Stage 5. The sum of the criteria weights is figured with the aid from Eq. (4).

$$s_{ij} = \sum_{j=1}^{n} v_j \tag{4}$$

Stage 6. The final crucial levels of the criteria are figured with Eq. (5).

$$w_{jSIWEC} = \frac{s_{ij}}{\sum_{j-1}^{n} s_{ij}} \tag{5}$$

3.2. CRITIC Method

In 1995, it was introduced by Diakoulaki et al. for the calculation of the objective weights of indicators (Diakoulaki et al., 1995). The advantages of the CRITIC method are outlined below:

- CRITIC is a method that takes a correlation-based approach using analytical tests to extract important data from the decision matrix (Zafar et al., 2021).
- This method determines the relative weights of different criteria precisely and consistently by using the decision matrix directly (Amari et al., 2023).
- When determining the criteria weights, the standard deviation of each criterion and the correlation coefficient between it and other criteria are taken into account. With this method, the variability of the criteria, the direction and degree of the relationships between the criteria are effective in determining the criteria weights (Ecer & Güneş, 2024).
- Furthermore, MCDM methods like CCSD, which consider the correlations among criteria, it can be effortlessly implemented without requiring any specialized software (Yürüyen et al., 2023).

Some of the studies conducted employing the CRITIC technique in the literature can be condensed as follows: Wu et al. (2020) used the CRITIC approach in the analysis of security in railway transportation, Zafar et al. (2021) used the CRITIC method in evaluating blockchain systems, Amari et al. (2023) used the CRITIC method in parking lot selection, Sarıgül et al. (2023) used the CRITIC approach in the assessing of financial performance of airline firms, Brodny and Tutak (2023) used the CRITIC method in assessing energy security, Işık et al. (2024) used the CRITIC method to assess urban competitiveness and Maruf and Özdemir (2024) used the CRITIC method in the evaluation of service performance of tourism websites. Using the CRITIC approach, the weights of the criteria are founded by appealing to the following Eq.s (Madić & Radovanović, 2015);

Stage 1. The decision matrix is organized based on the data and is represented in Eq. (1).

Stage 2. The matrix in Eq. (1) is normalized applying Eq. (6) and Eq. (7). For this process, Eq. (6) is applied for the normalization of beneficial criteria, and Eq. (7) is applied for the normalization of cost (for the non-beneficial criteria) criteria.

$$v_{ij} = \frac{d_{ij} - d_j^{min}}{d_j^{max} - d_j^{min}} \tag{6}$$

$$v_{ij} = \frac{d_j^{max} - d_{ij}}{d_j^{max} - d_j^{min}} \tag{7}$$

Stage 3. Criteria weights ($w_{jCRITIC}$) are calculated by applying Eq. (8), considering the standard deviation of the criteria and the correlations of each criterion with respect to the other criteria.

$$w_{jCRITIC} = \frac{s_j}{\sum_{k=1}^{n} s_k} \qquad j = 1,2,3,4,5, \dots, \text{n} \tag{8}$$

The value s_j in Eq. (8) indicates the quantity of information included in criteria j. This value is calculated by applying Eq. (9):

$$s_j = \sigma_j \sum_{k=1}^{n} (1 - y_{jk})\ j = 1,2,3,4,5, \ldots, \mathrm{n} \tag{9}$$

In Eq. (9) σ_j, is the standard deviation of criteria j. In the same Eq., the correlation coefficient of each criterion j and k with respect to the other criteria is denoted by y_{jk}.

3.3. LOPCOW Method

In 2022, it was developed by Ecer and Pamucar to find the objective weights of the criteria. The advantages of the LOPCOW method are outlined below:

The LOPCOW method ensures more balanced and acceptable outcomes by minimizing the weight difference between the most noteworthy and the least noteworthy criteria.

- Its ability to directly include criteria with negative values enhances the flexibility of the approach.
- It eliminates variability within a dataset by incorporating the percentage of the standard deviation of the mean square of measurements.
- The LOPCOW method proves its efficiency even when handling extensive datasets.
- Additionally, the method can be applied with any number of criteria, which ensures its adaptability to problems at different scales.

These characteristics establish the LOPCOW method as a practical and effective tool for multi-criteria decision-making processes. When some studies conducted with the LOPCOW method are examined, Ecer and Pamucar (2022) used it in the analysis of sustainability performance in the banking sector, Ulutaş et al. (2023) in the selection of natural fibers from insulation materials, Işık et al. (2023) in determining the causal relationship between financial performance and premium production, Yalman et al. (2023) in evaluating macroeconomic performance, Gülcemal and Izci (2024), in the performance evaluation of banks, Bakır and İnce (2024), in the evaluation of passenger satisfaction in airline companies, Bağci (2024), measuring the efficiency of public debt and stock exchange traded government domestic debt securities indicators, Ayçin and Bektaş (2024), in financial performance analysis, Öztaş and Öztaş (2024), in the evaluation of innovation performance of G20 countries, Korucuk et al. (2024), in the selection of storage location, Özekenci (2024), in financial performance analysis, Kahreman (2025), in his analysis of Türkiye's productive capacity performance, Yürüyen and Ulutaş (2024), in assessing urban competitiveness, Deveci et al. (2025), in the analysis of green energy in transportation, Ünal (2025), Performance evaluation of insurance companies. There are four basic steps in the method (Ecer & Pamucar, 2022);

Stage 1. The decision matrix is organized in line with the data obtained. The decision matrix is expressed in Eq. (1).

Stage 2. The matrix in Eq. (1) is normalized applying Eq. (10) and Eq. (11). It is calculated by applying Eq. (10) for beneficial criteria and Eq. (11) for cost (for the non-beneficial criteria) criteria.

$$p_{ij} = \frac{d_{ij} - min(d_{ij})}{max(d_{ij}) - min(d_{ij})} \tag{10}$$

$$p_{ij} = \frac{max(d_{ij}) - d_{ij}}{max(d_{ij}) - min(d_{ij})} \tag{11}$$

Stage 3. The % values of the criteria (PVI_{ij}) are calculated by applying Eq. (12).

$$PVI_{ij} = \left| ln \left(\frac{\sqrt{\frac{\sum_{i=1}^{m} p_{ij}^2}{m}}}{\sigma} \right) . 100 \right| \tag{12}$$

In Eq. (12), σ is the standard deviation.

Stage 4. The weights of the criteria are defined by applying Eq. (13).

$$w_{jLOPCOW} = \frac{PV_{ij}}{\sum_{i=1}^{n} PV_{ij}} \tag{13}$$

The weights of the criteria calculated according to the 3 methods are merged with the arithmetic mean. Eq. (14) shows this process.

$$w_{jUF} = \frac{w_{jSIWEC} + w_{jCRITIC} + w_{jLOPCOW}}{3} \tag{14}$$

w_{jUF} Eq. (14) represents the unified weight of the j. criterion.

3.4. MACONT Method

The MACONT approach was employed to rank the countries based on their logistics performance for each corridor. The advantages of the MACONT method are outlined below (Wen et al., 2020).

- By combining three different linear normalization techniques based on criteria types, it reduces the deviations that occur in the normalization process.
- For each criterion, a virtual reference alternative is created that represents the average performance of the alternatives. Thus, both the advantages and disadvantages of an alternative compared to other alternatives are evaluated simultaneously.
- In order to collect the distance values between each alternative and the reference alternative under each criterion, two mixed aggregation operators based on the compensability and non-compensability perspectives between the criteria are applied. Thanks to this approach, versatile and reliable alternative ranking results are obtained.

Some of the studies conducted using the MACONT method in the literature can be condensed as follows: Wen et al. (2020) used the MACONT method in the option of a sustainable third-party reverse logistics company, Wen and Liao (2021) in the selection of a retirement service organization, Ecer and Torkayesh (2022) in the selection of sustainable circular suppliers, Aksakal et al. (2022) in the selection of insulation materials, Yürüyen et al. (2023) in the performance analysis of logistics enterprises, Ulutaş et al. (2024) in the selection of 3PL for automobile manufacturing enterprises, Taşcı (2024) in the evaluation of the Turkish non-life insurance industry, Aydın Ünal (2024), in the evaluation of the Turkish health insurance sector, and Amiri et al. (2025) in their assessment of countries' Covid 19 performance. The stages of the approach are as follows (Aksakal et al., 2022; Wen et al., 2020).

Stage 1. The decision matrix is organized according to the data obtained. The decision matrix is expressed in Eq. (1).

Stage 2. The data in the decision matrix are normalized applying three normalization techniques by employing Eq. (15), Eq. (16) and Eq. (17) respectively. The first normalization approach is the normalization technique based on linear summation, as stated in Eq. (15) and the normalized data is suggested by $\hat{d}_{ij}^{1}$. The second normalization approach is the linear ratio-based normalization approach as specified in Eq. (16) and the normalized data is suggested by $\hat{d}_{ij}^{2}$. The third normalization approach is the linear max-min normalization approach, as specified in Eq. (17) and the normalized data is suggested by $\hat{d}_{ij}^{3}$. After the three-normalization approach, Eq. (18) is used to combine the normalized values.

$$\hat{d}_{ij}^{1} = \begin{cases} d_{ij} \Big/ \sum_{i=1}^{m} d_{ij} & if \;\; j \in BN \\ \dfrac{1}{d_{ij}} \Big/ \sum_{i=1}^{m} \dfrac{1}{d_{ij}} & if \;\; j \in CS \end{cases} \tag{15}$$

$$\hat{d}_{ij}^{2} = \begin{cases} d_{ij} / max_i d_{ij} & if \;\; j \in BN \\ min_i d_{ij} / d_{ij} & if \;\; j \in CS \end{cases} \tag{16}$$

$$\hat{d}_{ij}^{3} = \begin{cases} \left(d_{ij} - min_i d_{ij}\right) / \left(max_i d_{ij} - min_i d_{ij}\right) & if \; j \in BN \\ \left(d_{ij} - max_i d_{ij}\right) / \left(min_i d_{ij} - max_i d_{ij}\right) & if \; j \in CS \end{cases} \tag{17}$$

$$\hat{d}_{ij} = \theta \hat{d}_{ij}^{1} + \mu \widehat{d}_{ij}^{2} + (1 - \theta - \mu) \hat{d}_{ij}^{3} \tag{18}$$

The values of θ and μ in Eq. (18) will be taken as 0.200 in this study.

Stage 3. The two mixed adders (U_{1i} ve U_{2i}) are determined by the following Eq.s:

$$U_{1i} = \delta \frac{\pi_i}{\sqrt{\sum_{i=1}^{m} (\pi_i)^2}} + (1 - \delta) \frac{Q_i}{\sqrt{\sum_{i=1}^{m} (Q_i)^2}} \tag{19}$$

$$U_{2i} = \beta max_j \left(w_{jBR} \left(\hat{d}_{ij} - \bar{d}_j \right) \right) + (1 - \beta) min_j \left(w_{jBR} \left(\hat{d}_{ij} - \bar{d}_j \right) \right) \tag{20}$$

$\pi_i = \sum_{j=1}^{n} w_{jBR} \left(\hat{d}_{ij} - \bar{d}_j \right)$ and $Q_i = \prod_{\gamma=1}^{n} \left(\bar{d}_j - \hat{d}_{ij} \right)^{w_{jBR}} / \prod_{\omega=1}^{n} \left(\hat{d}_{ij} - \bar{d}_j \right)^{w_{jBR}}$ and γ denotes the part of the criteria that satisfies the condition $\hat{d}_{ij} < \bar{d}_j$ and ω denotes the part of the criteria that satisfies the condition $\hat{d}_{ij} \geq \bar{d}_j$. While performing these operations, the total of the criteria weights must be equivalent to "1". In this study, δ and β values equal 0.5.

Stage 4. U_i (final comprehensive score) is determined for each alternative by employing Eq. (21):

$$U_i = \frac{1}{2}\left(U_{1i} + \frac{U_{2i}}{\sqrt{\sum_{i=1}^{m}(U_{2i})^2}}\right) \tag{21}$$

The alternative with the highest U_i score is selected as the best.

4. RESEARCH APPLICATION

In this study, the logistics performances of the countries located in the northern, southern and central corridors of the railway route connecting Asia to Europe of the OBORP analyzed separately (corridor by corridor) with the help of MCDM techniques. The data utilized in the study is received the LPI report declared by the World Bank (2023). The criteria employed in the study for the analysis are the six main criteria that the World Bank takes into account when calculating the LPI values of countries. These criteria are customs (C1), infrastructure (C2), international shipping (C3), logistics quality and competence (C4), tracking and tracing (C5) and timeliness (C6). All six criteria used are useful criteria. In the study, the countries located in the northern, southern and central corridors of the railway route connecting Asia to Europe of the OBORP are listed below (Tümenbatur, 2021). According to Tümenbatur (2021), there are 8 countries in the northern corridor, 12 countries in the southern corridor, and 15 countries in the central corridor. However, the logistics performance indices of Turkmenistan, which is in both the southern corridor and the central corridor, and Azerbaijan, which is located in the central corridor, for the year 2023 were not included in the published report and were therefore excluded from the analysis. Thus, 8 countries in the northern corridor, 11 countries in the southern corridor and 13 countries in the central corridor were analyzed as alternatives. The weights of the assessment criteria were identified by applying SIWEC, CRITIC and LOPCOW methods. Utilizing the weights of the assessed criteria, MACONT approach was employed to rank the countries. Table 2 for the northern corridor, Table 3 for the southern corridor and Table 4 for the central corridor are given in the decision matrices created in line with the data received from the LPI report declared by the World Bank in 2023.

Table 2. Northern Corridor Decision Matrix

	C1	C2	C3	C4	C5	C6
China	3.3	4	3.6	3.8	3.7	3.8
Mongolia	2.5	2.3	2.5	2.3	2.7	2.4
Russia	2.4	2.7	2.3	2.6	2.9	2.5
Belarus	2.6	2.7	2.6	2.6	3.1	2.6
Poland	3.4	3.5	3.3	3.6	3.9	3.8
Germany	3.9	4.3	3.7	4.2	4.1	4.2
Belgium	3.9	4.1	3.8	4.2	4.2	4
France	3.7	3.8	3.7	3.8	4.1	4

Table 3. Southern Corridor Decision Matrix

	C1	C2	C3	C4	C5	C6
China	3.3	4	3.6	3.8	3.7	3.8
Kazakhstan	2.6	2.5	2.6	2.7	2.9	2.8
Uzbekistan	2.6	2.4	2.6	2.6	2.8	2.4
Iran	2.2	2.4	2.4	2.1	2.7	2.4
Türkiye	3	3.4	3.4	3.5	3.6	3.5
Bulgaria	3.1	3.1	3	3.3	3.5	3.3
Romania	2.7	2.9	3.4	3.3	3.6	3.5
Hungry	2.7	3.1	3.4	3.1	3.6	3.4
Austria	3.7	3.9	3.8	4	4.3	4.2
Germany	3.9	4.3	3.7	4.2	4.1	4.2
France	3.7	3.8	3.7	3.8	4.1	4

Table 4. Central Corridor Decision Matrix

	C1	C2	C3	C4	C5	C6
China	3.3	4	3.6	3.8	3.7	3.8
Kazakhstan	2.6	2.5	2.6	2.7	2.9	2.8
Kyrgyzstan	2.2	2.4	2.4	2.2	2.4	2.3
Tajikistan	2.2	2.5	2.5	2.8	2.9	2
Uzbekistan	2.6	2.4	2.6	2.6	2.8	2.4
Georgia	2.6	2.3	2.7	2.6	3.1	2.8
Türkiye	3	3.4	3.4	3.5	3.6	3.5
Bulgaria	3.1	3.1	3	3.3	3.5	3.3
Romania	2.7	2.9	3.4	3.3	3.6	3.5
Hungary	2.7	3.1	3.4	3.1	3.6	3.4
Austria	3.7	3.9	3.8	4	4.3	4.2
Germany	3.9	4.3	3.7	4.2	4.1	4.2
France	3.7	3.8	3.7	3.8	4.1	4

4.1. Criteria Weights' Calculation

Once the decision matrix was assembled, the criteria weights were figured out employing the SIWEC, CRITIC, and LOPCOW approaches. The criteria weights derived from SIWEC, CRITIC and LOPCOW methods are unified using Eq. (14). Table 5 includes the unified criteria weights of the northern corridor countries according to SIWEC, CRITIC and LOPCOW methods, Table 6 includes the unified criteria weights of the southern corridor countries according to SIWEC, CRITIC and LOPCOW methods and Table 7 includes the unified criteria weights of the central corridor countries according to SIWEC, CRITIC and LOPCOW methods.

Table 5. Unified Criteria Weights of Northern Corridor Countries

	C1	C2	C3	C4	C5	C6
w_{jSIWEC}	0.1583	0.1702	0.1572	0.1680	0.1772	0.1691
$w_{jCRITIC}$	0.1762	0.2006	0.1877	0.1213	0.1806	0.1336
$w_{jLOPCOW}$	0.1493	0.1757	0.1662	0.1644	0.1717	0.1727
w_{jUF}	0.1613	0.1822	0.1704	0.1512	0.1765	0.1585

The ranking of the unified weights of the criteria in Table 5 is as follows: C2>C5>C3>C1>C6>C4. In view of the result of the unified criteria weights, the most significant criterion for the northern corridor is C2 (infrastructure), while the least important criterion is C4 (logistics quality and competence). The results of the unified criteria weights are transferred to the MACONT method for ranking the countries.

Table 6. Unified Criteria Weights of Southern Corridor Countries

	C1	C2	C3	C4	C5	C6
w_{jSIWEC}	0.1518	0.1641	0.1647	0.1672	0.1791	0.1732
$w_{jCRITIC}$	0.2396	0.1806	0.1985	0.1520	0.1013	0.1280
$w_{jLOPCOW}$	0.1571	0.1396	0.1768	0.1921	0.1717	0.1628
w_{jUF}	0.1828	0.1614	0.1800	0.1704	0.1507	0.1547

The ranking of the unified weights of the criteria in Table 6 is as follows: C1>C3>C4>C2>C6>C5. In view of the result of the unified criteria weights, the most crucial criterion for the southern corridor is C1 (Customs), while the least crucial criterion is C5 (tracking and tracing). The results of the unified criteria weights are transferred to the MACONT method for the ranking of the countries.

Table 7. Unified Criteria Weights of Central Corridor Countries

	C1	C2	C3	C4	C5	C6
w_{jSIWEC}	0.1521	0.1628	0.1652	0.1694	0.1808	0.1697
$w_{jCRITIC}$	0.2096	0.1916	0.1818	0.1255	0.1406	0.1508
$w_{jLOPCOW}$	0.1419	0.1413	0.1611	0.1799	0.1954	0.1804
w_{jUF}	0.1679	0.1652	0.1694	0.1583	0.1723	0.1670

The ranking of the unified weights of the criteria in Table 7 is as follows: C5>C3>C1>C6>C2>C4. In view of the result of the unified criteria weights, the most crucial criterion for the central corridor is C5 (tracking and tracing), while the least crucial criterion is C4 (logistics quality and competence). The results of the unified criteria weights are transferred to the MACONT method for ranking the countries.

4.2. Countries Ranking

In this section, the MACONT method used to rank the countries in the North, South and Central corridors of the railway route connecting Asia to Europe of the OBORP. The results are calculated according to the MACONT method by applying Eq.s (15)-(21) to the decision matrices. Table 8 includes the ranking of π_i, Q_i, U_{1i}, U_{2i}, U_i and countries for each alternative in the northern corridor, Table 9 includes the ranking of π_i, Q_i, U_{1i}, U_{2i}, U_i and countries for each alternative in the southern corridor and Table 10 includes the ranking of π_i, Q_i, U_{1i}, U_{2i}, U_i and countries for each alternative in the central corridor.

Table 8. MACONT Method Results of Northern Corridor Countries

	π_i	Q_i	U_{1i}	U_{2i}	U_i	Rankings	Intra-group 2023 LPI Rankings	Change
China	0.1319	9.0307	0.3450	0.0218	0.2612	5	4	Increase
Mongolia	-0.3737	0.3717	-0.2429	-0.0626	-0.3762	8	8	No
Russia	-0.3320	0.3278	-0.2158	-0.0569	-0.3394	7	7	No
Belarus	-0.2715	0.2698	-0.1765	-0.0446	-0.2697	6	6	No
Poland	0.0884	13.3352	0.4374	0.0150	0.2797	3	5	Decrease
Germany	0.2827	3.5682	0.2927	0.0483	0.3429	1	1	No
Belgium	0.2733	3.6837	0.2896	0.0435	0.3218	2	2	No
France	0.2009	5.1079	0.2808	0.0321	0.2710	4	3	Increase

According to the MACONT method results in Table 8, the northern corridor countries are ranked as follows: Germany>Belgium> Poland> France> China> Belarus> Russia> Mongolia. Based on the ranking, the country with the best logistics performance among the northern corridor countries is Germany and the country with the lowest logistics performance is Mongolia. According to the proposed model, the correlation between the ranking obtained for the northern corridor and the LPI ranking for 2023 was tested with Pearson correlation. The Pearson correlation coefficient was calculated as 0.929. According to this result, there is a high correlation between the two rankings. This indicates that the proposed method gives accurate results.

Table 9. MACONT Method Results of Southern Corridor Countries

	π_i	Q_i	U_{1i}	U_{2i}	U_i	**Rankings**	**Intra-group 2023 LPI Rankings**	**Change**
China	0.1574	6.9095	0.4159	0.0274	0.3202	4	4	No
Kazakhstan	-0.2465	0.2423	-0.1592	-0.0446	0.2623	9	9	No
Uzbekistan	-0.2885	0.2804	-0.1865	-0.0469	0.2854	10	10	No
Iran	-0.3713	0.3697	-0.2396	-0.0620	0.3738	11	11	No
Türkiye	0.0401	5.6362	0.2783	0.0055	0.1617	5	5	No
Bulgaria	-0.0352	0.1045	-0.0196	-0.0083	0.0438	8	6	Increase
Romania	-0.0237	0.8584	0.0218	-0.0058	0.0129	6	8	Decrease
Hungry	-0.0293	0.3178	-0.0061	-0.0058	0.0268	7	7	No
Austria	0.2730	3.6881	0.3523	0.0439	0.3560	2	2	No
Germany	0.3017	3.3740	0.3581	0.0502	0.3847	1	1	No
France	0.2220	4.5564	0.3557	0.0387	0.3364	3	3	No

According to the results of the MACONT method in Table 9, the southern corridor countries are ranked as follows: Germany> Austria> France> China> Türkiye> Romania> Hungary> Bulgaria> Kazakhstan> Uzbekistan> Iran. Based on the determined ranking, the country with the best logistics performance among the southern corridor countries is Germany and the country with the lowest logistics performance is Iran. According to the proposed model, the correlation between the ranking obtained for the southern corridor and the LPI ranking for 2023 was tested with Pearson correlation. The Pearson correlation coefficient was calculated as 0.964. According to this result, there is a high correlation between the two rankings. This indicates that the proposed method gives accurate results.

Table 10. MACONT Method Results of Central Corridor Countries

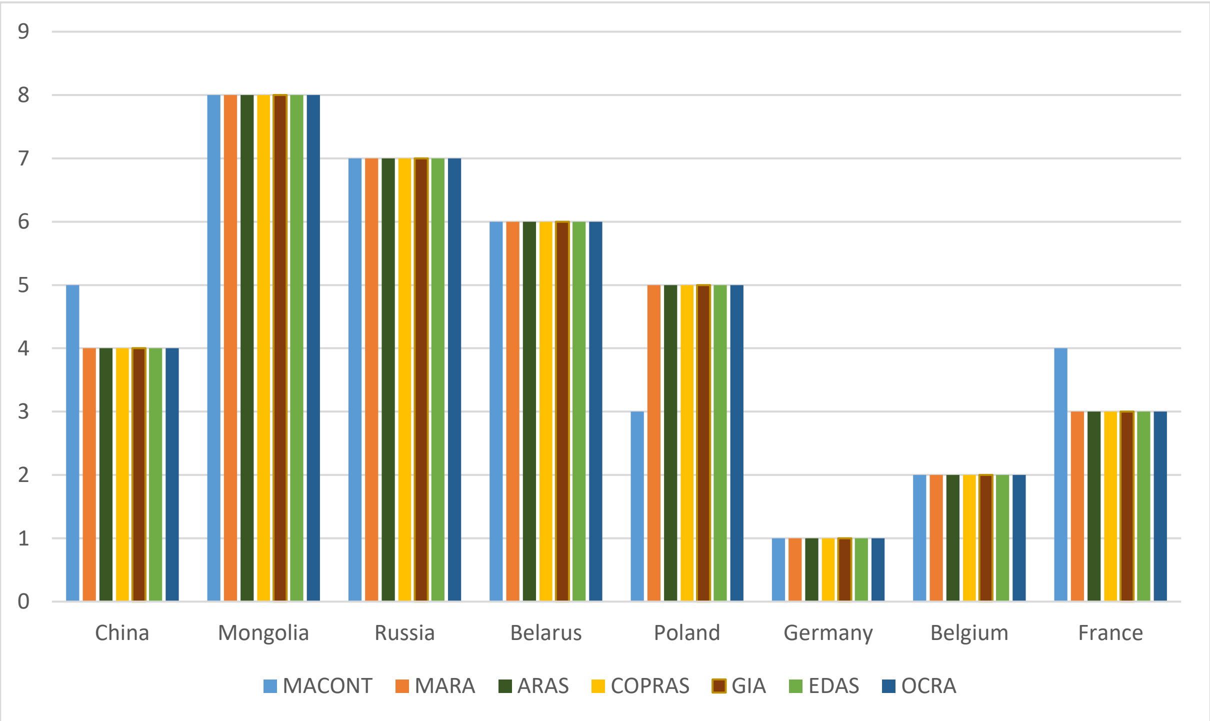
	π_i	Q_i	U_{1i}	U_{2i}	U_i	**Rankings**	**Intra-group 2023 LPI Rankings**	**Change**
China	0.1925	5.5252	0.2884	0.0340	0.2743	5	4	Increase
Kazakhstan	-0.1912	0.1867	-0.1169	-0.0341	-0.1890	10	10	No
Kyrgyzstan	-0.3277	0.3247	-0.2001	-0.0536	-0.3052	13	13	No
Tajikistan	-0.2648	0.2510	-0.1621	-0.0456	-0.2556	12	12	No
Uzbekistan	-0.2307	0.2256	-0.1410	-0.0349	-0.2041	11	11	No
Georgia	-0.1876	0.1789	-0.1148	-0.0343	-0.1887	9	9	No
Türkiye	0.0812	13.9885	0.4700	0.0126	0.2832	4	5	Decrease
Bulgaria	0.0094	2.9775	0.0950	-0.0004	0.0460	7	6	Increase
Romania	0.0204	2.7463	0.0951	0.0023	0.0564	6	8	Decrease
Hungary	0.0155	0.7052	0.0310	0.0023	0.0243	8	7	Increase
Austria	0.3015	3.3253	0.2924	0.0491	0.3341	2	2	No
Germany	0.3287	3.0958	0.3030	0.0553	0.3631	1	1	No
France	0.2528	3.9890	0.2811	0.0420	0.3013	3	3	No

According to the results of the MACONT method in Table 10, the central corridor countries are ranked as follows: Germany> Austria> France> Türkiye> China> Romania> Bulgaria> Hungary> Georgia> Kazakhstan> Uzbekistan> Tajikistan> Kyrgyzstan. Based on the determined ranking, the country with the best logistics performance among the central corridor countries is Germany and the country with the lowest logistics performance is Kyrgyzstan. According to the proposed model, the correlation between the ranking obtained for the central corridor and the LPI ranking for 2023 was tested with Spearman Rho correlation. Spearman's Rho correlation coefficient was calculated as 0.978. According to this result, there is a high correlation between the two rankings. This indicates that the proposed method gives accurate results.

4.3. Comparison with Other MCDM Approaches

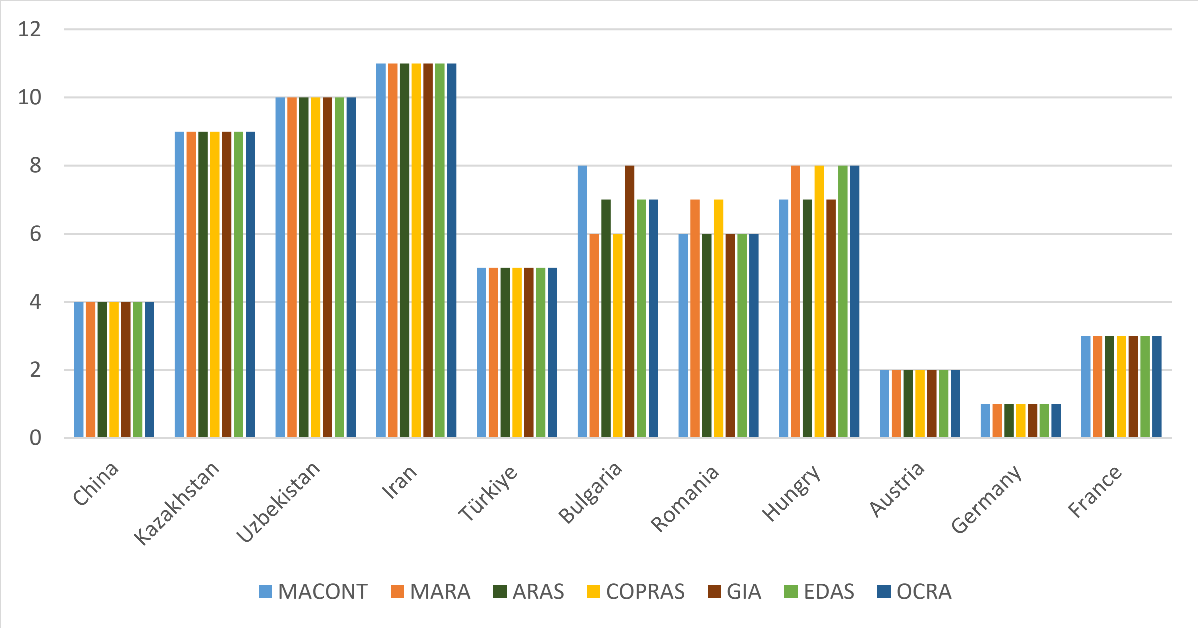
The results obtained for each corridor with the proposed decision-making approach in the study were compared with other alternative assessment approaches such as MARA, ARAS, COPRAS, GIA, EDAS and OCRA. The comparison for the northern corridor is given in Figure 2, the comparison for the south corridor is given in Figure 3 and the comparison for the central corridor is given in Figure 4.

Figure 2. Comparison of Northern Corridor Countries' Results with Other MCDM Approaches



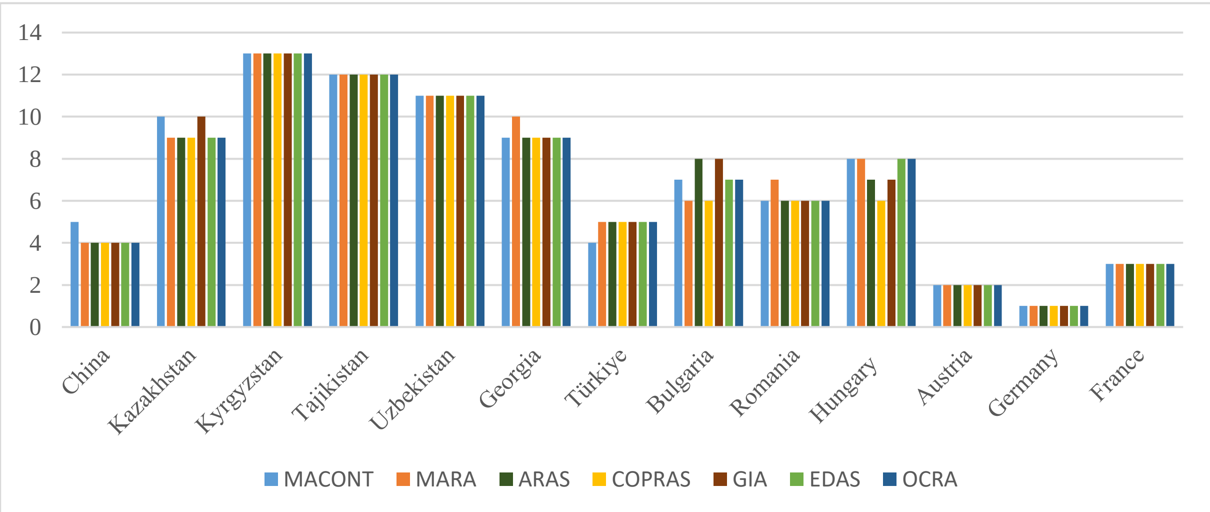
When analyzing the Northern Corridor countries, the results obtained from the MACONT method and other approaches used to make decisions were tested using Pearson's correlation coefficient. The calculated Pearson correlation coefficient of 0.929 confirms that the proposed method provides valid and reliable outputs.

Figure 3. Comparison of Southern Corridor Countries' Results with Other MCDM Approaches



When analyzing the Southern Corridor countries, the results obtained from the MACONT method and other approaches used to make decisions were compared with the Pearson correlation analysis. The correlation coefficients obtained were 0.973 with the MARA and COPRAS methods, 0.996 with the ARAS method, 1 with the GIA method, and 0.991 with the EDAS and OCRA methods. These high correlation values reveal that the proposed method produces valid, reliable and largely compatible results with other established methods.

Figure 4. Comparison of Central Corridor Countries' Results with Other MCDM Approaches



When analyzing the Middle Corridor countries, the results obtained from the MACONT method and other approaches used to make decisions were compared with Spearman's correlation analysis. The correlation coefficients obtained were 0.984 with the MARA method, 0.988 with the ARAS and COPRAS methods, 0.989 with the GIA method, and 0.993 with the EDAS and OCRA methods. These high correlation values reveal that the proposed method produces valid, reliable and largely compatible results with other established methods.

5. PRACTICAL AND MANAGERIAL IMPLICATIONS

For countries, logistics performance assessment is not only limited to trade and economy but also has critical importance in areas such as infrastructure development, sustainability, crisis management and international cooperation. Optimizing logistics processes allows a country to achieve its development goals and gain a stronger position in the global system. Some practical implications of the current article, which evaluates the multi-dimensional logistics performance of countries, are as follows:

- The first practical contribution of the research is to provide a new, holistic and hybrid decision-making approach to assess the multi-dimensional logistics performance of countries.
- The proposed decision-making approach has a simple but effective mathematical model that does not require advanced mathematics.
- The model, which combines SIWEC, CRITIC and LOPCOW methods in determining the criteria weights, helps to achieve more ideal and optimized results.
- It has been proven through comparative analysis that the proposed decision-making model produces consistent and reliable results.

The managerial implications conclusions reached in the research can be revealed as follows:

- The results of this research, which examines the multi-dimensional logistics performances of countries, provide important implications in terms of managerial strategies such as sustainable growth of national economies, increasing competitiveness in international trade, and policy regulations.
- Regular analyses of logistics performance by countries to improve their positions in global competition provide important information to policymakers and the success of strategies implemented in global integrations.
- The proposed decision-making approach allows policymakers to improve the country's logistics performance and achieve sustainable competitive advantage through these improvements, resulting in long-term benefits in terms of economic growth and development.

6. DISCUSSION AND CONCLUSION

OBORP includes sustainability and integration issues both locally and internationally. The economic and political components of the project are evaluated together. In this context, the corridors are geo-politically and geo-economically different from each other. Considering this difference, connections and connection elements and the risks that may be encountered are taken into consideration. For example, technical risks such as gauges can be mentioned in railways. In addition, the existence of collaborations such as TRACECA, Trans-Asia Railway Project, Marmaray Project, Baku-Tbilisi-Kars Railway Project, etc., which connect Europe and Asia on designated corridors, has increased the trade volume between European and Asian countries. With the increasing trade volume, countries have become obliged to develop the necessary trade logistics capabilities to increase their logistics competitiveness by identifying the possible opportunities and challenges they may be exposed to in trade logistics. At the same time, it is predicted that OBORP will significantly change the direction of trade in the world. All these situations reveal the importance and currency of OBORP railway networks.

In the study, the 2023 LPIs of the countries located in the northern, southern and central corridors of the OBORP were evaluated with an MCDM model in which different methods were integrated. The weights of the assessment criteria were identified by applying SIWEC, CRITIC and LOPCOW methods. Utilizing the weights of the assessed criteria, MACONT method was utilized to rank the countries. After calculating the criteria weights according to the three methods, the unified weights were calculated by taking the arithmetic mean of the obtained criteria weights. According to the result of the unified criteria weights, the ranking of the criteria for the northern corridor countries: C3>C2>C6>C5>C4>C1, the ranking of criteria for the southern corridor countries: C1>C3>C4>C2>C6>C5 and the ranking of criteria for the central corridor countries: C5>C3>C1>C6>C2>C4.

Countries were ranked by transferring the calculated criteria weights to the MACONT method. According to the result of MACONT method; the ranking of the northern corridor countries: Germany>Belgium> Poland> France> China> Belarus> Russia> Mongolia, ranking of the southern corridor countries: Germany> Austria> France> China> Türkiye> Romania> Hungary> Bulgaria> Kazakhstan> Uzbekistan> Iran, and the ranking of the central corridor countries: Germany> Austria> France> Türkiye> China> Romania> Bulgaria> Hungary> Georgia> Kazakhstan> Uzbekistan> Tajikistan> Kyrgyzstan. According to the proposed model, the correlation between the ranking obtained for the northern and southern corridors and the LPI ranking in 2023 was tested with Spearman Rho correlation, and the central corridor was tested with Pearson correlation. The Spearman Rho correlation coefficient is calculated as 0.929 for the northern corridor and 0.964 for the southern corridor. The Pearson correlation coefficient for the central corridor calculated as 0.978. According to this result, there is a high correlation between the two rankings. However, the results of the proposed integrated model for each corridor were compared with the MARA, ARAS, COPRAS, GIA, EDAS and OCRA methods. As a result of the comparison, it was seen that the results of the proposed model and the results of the determined methods were quite similar in the three corridors. This shows that the proposed method gives consistent and reliable results.

Policymakers should prioritize infrastructure investments to improve the LPI. Strengthening road, rail, sea and air connections will accelerate transportation processes and reduce logistics costs. Harmonizing logistics processes of countries involved in regional and global economic integration processes can accelerate trade flows and reduce costs. In addition, digitalization of customs procedures and reduction of bureaucracy will contribute to facilitating trade. Vocational training programs should be encouraged to increase service quality in the logistics sector, and the digital transformation processes of companies should be supported. In addition, the dissemination of smart logistics systems and big data analytics will increase operational efficiency and provide an advantage in global competition.

In order to increase the LPI, it is of great importance to bring the regulatory framework in line with international standards. This will encourage foreign investments and facilitate integration into global supply chains. Adopting sustainable logistics practices, supporting low-emission transportation methods, and investing in alternative energy sources will reduce environmental impacts and encourage green logistics. In addition, cooperation with international logistics networks should be increased and regional trade agreements should be prioritized. Strategies to be developed through public and private sector cooperation will contribute to economic growth by making logistics systems more effective.

The analysis results showed that high-income countries showed the best logistics performance scores, while low- and medium-income countries showed worse logistics performance scores. This result shows that the logistics performance of countries is significantly driven by income and geographical area.

Despite the comprehensiveness, originality and up-to-datedness of the study, there are also some limitations. The first limitation of the study is that it uses only objective data and does not include subjective expert judgments and does not use subjective weighting methods such as AHP, SWARA and FUCOM. The evaluation of only the criteria included in the LPI report is another limitation of the study. Recommendations for future studies: These corridors can be studied differently, taking into account geopolitical and geoeconomic differences. Objective and subjective data can be combined by obtaining expert opinions in the LPI assessment. They can choose fuzzy or gray methods in LPI evaluation. They can use the proposed model in different decision-making problems.

Ethics Committee approval was not required for this study.

The authors declare that the study was conducted in accordance with research and publication ethics.

The authors confirm that no part of the study was generated, either wholly or in part, using Artificial Intelligence (AI) tools.

The authors declare that there are no financial conflicts of interest involving any institution, organization, or individual associated with this article. Additionally, there are no conflicts of interest among the authors.

The authors affirm that they contributed equally to all aspects of the research.

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