Dokuz Eylül University Journal of Faculty of Business, Volume 27, Number 1, 2026, 170-199

Submission Date: May 31, 2025 Research Article
Acceptance Date: February 28, 2026 doi: 10.24889/ifede.1710853

Atıf/Citation:
Bayat, T. (2026). Assessing Transportation and Logistics Efficiency Through MCDM Methods-Evidence from OECD Countries. *Dokuz Eylül University Journal of Faculty of Business*, 27(1): 170-199. https://doi.org/10.24889/ifede.1710853.

ASSESSING TRANSPORTATION AND LOGISTICS EFFICIENCY THROUGH MCDM METHODS-EVIDENCE FROM OECD COUNTRIES

Tuğrul BAYAT*

ABSTRACT

Transportation and logistics systems constitute a critical foundation for economic growth, environmental sustainability, and social welfare in modern economies. In OECD countries, transportation infrastructure and logistics efficiency play a decisive role in supporting international trade, supply chain integration, and competitiveness. However, evaluating transportation and logistics performance requires a multidimensional analytical framework that simultaneously incorporates infrastructure quality, digitalization, environmental impact, financial development, and social dynamics. This study evaluates transportation and logistics efficiency across OECD countries by employing a Multi-Criteria Decision-Making (MCDM) framework. Criterion weights are objectively determined using the CRITIC method, while country performance rankings are obtained through the MABAC method. To assess the robustness and reliability of the proposed model, sensitivity analysis is conducted using alternative weighting approaches—Entropy, Standard Deviation, and Equal Weight—and alternative ranking techniques, namely ARAS, COPRAS, and VIKOR. The empirical results reveal that digitalization-related criteria, particularly the use of digital platforms in transportation services and broadband internet penetration, exert the strongest influence on overall performance. The United States, South Korea, the Netherlands, France and Japan emerge as the highest-performing countries, whereas Slovakia, Costa Rica, and Colombia display the lowest efficiency levels. Notably, Türkiye ranks seventieth, outperforming several advanced OECD economies. Overall, the findings highlight the strategic importance of digital infrastructure in enhancing transportation and logistics efficiency. The proposed MCDM framework provides policymakers with a data-driven decision-support tool for prioritizing transportation investments and designing integrated logistics, digitalization, and sustainability-oriented policies.

Keywords: Transportation, Logistics, Digitalization, Economic Growth, MCDM Methods
JEL Classification: L91, L93, 018, R11, R40

ULAŞTIRMA VE LOJİSTİK VERİMLİLİĞİN ÇKKV YÖNTEMLERİ İLE DEĞERLENDİRİLMESİ - OECD ÜLKELERİNDEN KANITLAR

ÖZ

Ulaştırma ve lojistik sistemleri, ekonomik büyüme, çevresel sürdürülebilirlik ve toplumsal refah açısından modern ekonomilerin temel bileşenleri arasında yer almaktadır. OECD ülkelerinde ulaştırma altyapısı ve lojistik verimlilik, uluslararası ticaretin desteklenmesi, tedarik zincirlerinin entegrasyonu ve rekabet gücünün artırılması açısından belirleyici bir role sahiptir. Bununla birlikte, ulaştırma ve lojistik performansının sağlıklı biçimde değerlendirilebilmesi; altyapı kalitesi, dijitalleşme, çevresel etkiler, finansal gelişmişlik ve sosyal dinamikleri eş zamanlı olarak ele alan çok boyutlu bir analitik çerçeve gerektirmektedir. Bu çalışma, OECD ülkelerinde ulaştırma ve lojistik verimliliğini Çok Kriterli Karar Verme (ÇKKV) yöntemleri kullanarak değerlendirmektedir. Kriter ağırlıkları nesnel olarak CRITIC yöntemi ile belirlenirken, ülkelerin performans sıralamaları MABAC yöntemi aracılığıyla elde edilmektedir. Önerilen modelin sağlamlığını ve güvenilirliğini test etmek amacıyla; Entropi, Standart Sapma ve Eşit Ağırlık yöntemleri ile alternatif ağırlıklandırmalar yapılmış, ARAS, COPRAS ve VIKOR yöntemleri kullanılarak duyarlılık analizi gerçekleştirilmiştir. Elde edilen bulgular, ulaştırma ve lojistik performansı üzerinde dijitalleşme ile ilişkili kriterlerin belirleyici olduğunu göstermektedir. Özellikle ulaştırma hizmetlerinde dijital platformların kullanımı ve geniş bant internet yaygınlığı, genel performans üzerinde en yüksek etkiye sahiptir. Performans sıralamasında Amerika Birleşik Devletleri, Güney Kore, Hollanda, Fransa ve Japonya üst sıralarda yer alırken; Slovakya, Kosta Rika ve Kolombiya en düşük performans gösteren ülkeler olmuştur. Türkiye ise onyedinci sırada yer alarak birçok gelişmiş OECD ülkesini geride bırakmıştır. Sonuç olarak, çalışma ulaştırma ve lojistik verimliliğinin artırılmasında dijital

* Assist. Prof., Afyon Kocatepe University, Faculty of Economics and Administrative Sciences, Department of International Trade and Finance, Afyonkarahisar, Türkiye. E-mail: tbayat@aku.edu.tr, ORCID: 0000-0003-1491-6178

altyapının stratejik önemini ortaya koymaktadır. Önerilen ÇKKV çerçevesi, politika yapıcılara ulaştırma yatırımlarının önceliklendirilmesi ve lojistik, dijitalleşme ve sürdürülebilirlik odaklı politikaların geliştirilmesi için veri temelli bir karar destek aracı sunmaktadır.

Anahtar Kelimeler: Ulaştırma, Lojistik, Dijitalleşme, Ekonomik Büyüme, ÇKKV Yöntemleri
JEL Sınıflandırılması: L91, L93, 018, R11, R40

1. INTRODUCTION

Transportation and logistics systems play a central role in economic growth, international trade, and supply chain integration in contemporary economies. Efficient transportation infrastructure facilitates the movement of goods, services, and production inputs, thereby reducing logistics costs, improving delivery reliability, and enhancing overall productivity (Rodrigue, 2020). In this context, transportation and logistics efficiency constitutes a fundamental pillar of competitiveness, particularly for countries that are deeply integrated into global value chains (Mahpour et al., 2023).

Transportation infrastructure not only supports logistics and supply chain operations but also enables the spatial diffusion of economic activity across regions. Well-developed road, rail, air, and port networks connect production centers to domestic and international markets, allowing economic benefits to spread across regions (Febriyanto et al., 2024; Sasana, 2017). As emphasized by the World Bank (2020), investments in transportation infrastructure contribute to economic growth, trade facilitation, environmental sustainability, and social well-being. However, despite the strategic importance of transportation systems, significant disparities persist across countries in terms of infrastructure quality, service efficiency, and overall logistics performance.

In OECD countries, transportation systems are increasingly shaped by structural transformations driven by digitalization, sustainability concerns, and financial development. Digital platforms and broadband connectivity improve logistics coordination, reduce delays, and enhance real-time monitoring of transportation activities (WEF, 2022). At the same time, transportation remains one of the major contributors to global carbon emissions, accounting for approximately 24% of total CO_2 emissions, which intensifies the need for environmentally sustainable transportation policies (IEA, 2023a). Financial development further conditions countries' capacity to modernize transportation infrastructure and adopt advanced logistics technologies (World Bank, 2020). These interrelated dynamics indicate that transportation and logistics efficiency cannot be adequately evaluated using single indicators or narrowly defined economic measures.

The existing literature on transportation and logistics performance has predominantly focused on individual indicators or limited sets of variables, such as infrastructure quality, trade costs, or economic output (Arvis et al., 2018; Limao & Venables, 2001). Although these studies provide valuable insights, they often fail to capture the multidimensional nature of transportation systems, particularly in the context of digital transformation and environmental sustainability. Previous research has applied various Multi-Criteria Decision-Making (MCDM) methods, including AHP (Mukul et al., 2019; Nguyen et al., 2022), TOPSIS (Nguyen et al., 2022), CoCoSo (Yazdani et al., 2019), VIKOR (Szymańska & Zalewski, 2020), EDAS and WASPAS (Gürler, 2024). However, comprehensive MCDM-based evaluations that simultaneously incorporate infrastructure, digitalization, environmental, financial, and social dimensions remain limited, particularly for OECD countries.

To address this gap, this study proposes a multidimensional evaluation framework for assessing transportation and logistics efficiency in OECD countries using MCDM methods. The analysis integrates economic (GDP per capita), structural (transportation infrastructure quality), digital (use of digital platforms and broadband penetration), environmental (CO_2 emissions), financial (financial development), and social (population) indicators. Criterion weights are objectively determined using the CRITIC method, which accounts for both data variability and inter-criteria correlations (Diakoulaki et al., 1995), while country performance rankings are obtained through the MABAC method, which enables transparent and data-driven comparisons without relying on ideal solutions (Pamučar & Ćirović, 2015).

This study contributes to the literature in several important ways. First, it provides one of the few comprehensive and multidimensional assessments of transportation and logistics efficiency focusing specifically on OECD countries. Second, by explicitly incorporating digitalization-related indicators, the analysis reflects contemporary transformations in transportation and logistics systems that are often overlooked in traditional performance evaluations (OECD, 2021a). Third, the findings reveal the relative importance of digital infrastructure compared to conventional macroeconomic indicators, highlighting digitalization as a key driver of transportation and logistics efficiency. Fourth, the study offers policy-relevant insights by identifying priority areas for transportation investment and strategic planning. Finally, the analysis provides country-specific implications, with particular attention to Türkiye's relative performance within the OECD.

The remainder of the paper is organized as follows. The next section presents the theoretical background and reviews the relevant literature. The third section describes the data and methodology, including the CRITIC and MABAC approaches. The fourth section reports and discusses the empirical findings, and the final section concludes with policy implications and directions for future research.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

Transportation and logistics constitute essential components of modern economic systems and play a decisive role in production efficiency, trade integration, and regional development. The quality and efficiency of transportation infrastructure determine the effectiveness of logistics operations by influencing delivery times, transportation costs, and the reliability of supply chains. From a production and supply chain management perspective, transportation infrastructure facilitates the spatial coordination of economic activities and supports the functioning of both domestic and international value chains (Rodrigue, 2020).

Well-developed transportation systems enhance economic productivity by improving the mobility of goods, labor, and capital. Regions with efficient road, rail, air, and port infrastructure tend to attract higher levels of domestic and foreign investment, as transportation quality directly affects firms' location decisions and operational costs (Barro, 1990; Robinson, 2010). Moreover, transportation infrastructure contributes to regional convergence by enabling economic activities to expand beyond core production centers, thereby supporting balanced regional development (Febriyanto et al., 2024; Sasana, 2017). In this sense, transportation infrastructure should be viewed not only as a physical asset but also as a strategic enabler of production processes and supply chain integration.

The literature emphasizes that transportation and logistics performance is inherently multidimensional, encompassing economic, technological, environmental, financial, and social dimensions. Consequently, evaluating transportation efficiency requires analytical frameworks capable of capturing these interrelated dimensions simultaneously. This section reviews the relevant literature by grouping the determinants of transportation and logistics efficiency into five main categories: logistics and transportation indicators, digitalization, environmental sustainability, financial efficiency, and social dimensions.

2.1. Logistics and Transportation Indicators

Logistics and transportation indicators primarily reflect the physical and operational capacity of transportation systems. Road infrastructure quality is widely recognized as a key determinant of economic connectivity and logistics performance. High-quality road networks reduce transportation costs, improve accessibility, and support economic growth by facilitating efficient freight and passenger transport (WEF, 2022). Empirical studies suggest that countries with better road quality tend to experience stronger economic performance due to reduced logistics frictions and improved market access.

Labor productivity in transportation, storage, and communications represents another important indicator of sectoral efficiency. Higher labor productivity reflects better utilization of human capital, automation, and technological adoption, which collectively enhance logistics efficiency and competitiveness (OECD, 2020; WEF, 2022). Advanced economies such as the United States and Germany demonstrate superior logistics performance partly due to the integration of digital technologies and automation into transportation operations (OECD, 2023a).

Rail, air, and port transportation efficiency further shape national logistics performance. Efficient rail services improve connectivity and reduce congestion, contributing to economic productivity and environmental sustainability (WEF, 2022). Air transportation efficiency is particularly important for countries with strong international trade and tourism sectors, as it supports high-value and time-sensitive cargo flows (IATA, 2020). Uyar et al. (2023) show that air, land, and port infrastructure quality significantly influences tourism revenues and international mobility. Similarly, port efficiency plays a crucial role in facilitating maritime trade and ensuring the smooth flow of goods, especially for countries with extensive coastlines and export-oriented economies (WEF, 2022).

Recent MCDM-based studies highlight the importance of transportation infrastructure indicators in comparative performance analysis. Gürler (2024), using EDAS, Entropy, and WASPAS methods, finds that transportation fleet size and service efficiency significantly affect country rankings. These findings underline the relevance of incorporating multiple transportation indicators into a comprehensive evaluation framework.

2.2. Digitalization Indicators

Digitalization has emerged as a transformative force in transportation and logistics systems. The adoption of digital platforms, broadband connectivity, and information and communication technologies (ICT) enhances logistics efficiency by enabling real-time monitoring, route optimization, and data-driven decision-making (WEF, 2022). Digital freight platforms, blockchain applications, and Internet of Things (IoT) technologies improve coordination across supply chain stages and reduce operational uncertainties.

Empirical evidence demonstrates a strong link between digitalization and economic performance. Konya (2024) finds that ICT usage and internet penetration positively affect economic growth in OECD countries, while Akyol et al. (2023) report similar results for European Union member states. Gomes et al. (2022) emphasize that the impact of the digital economy on growth varies according to countries' development levels and technological structures. Studies focusing on sustainability further indicate that digitalization contributes to sustainable development by improving resource efficiency and reducing environmental externalities (Altay Topçu, 2021; Konu, 2020).

Within the transportation context, Mukul et al. (2019) and Nguyen et al. (2022) show that digital connectivity and platform adoption significantly reduce freight costs and enhance transportation system performance. Broadband subscriptions, in particular, enable real-time cargo tracking and logistics coordination, with countries such as South Korea and Sweden leading in digital transportation infrastructure (ITU, 2023a). These findings justify the inclusion of digitalization indicators as core determinants of transportation and logistics efficiency.

2.3. Environmental Sustainability

Environmental sustainability has become an integral component of transportation and logistics performance assessment. Transportation activities are a major source of greenhouse gas emissions, accounting for approximately 24% of global CO_2 emissions, with road transport representing the largest share (IEA, 2023a; OECD, 2022). As logistics systems expand in response to economic growth and globalization, their environmental impact has intensified, raising concerns about long-term sustainability.

The literature consistently highlights the trade-off between logistics expansion and environmental quality. Logistics and transportation activities contribute to economic development but also increase energy consumption and emissions (Khan & Qianli, 2017; Wan et al., 2022). Ahmed et al. (2021) and Zhang et al. (2021) emphasize the importance of incorporating CO_2 emissions into performance assessments to capture environmental externalities. Szymańska and Zalewski (2020), using the VIKOR method, demonstrate that balancing cost efficiency with environmental considerations is essential for sustainable transportation planning.

OECD-focused studies further underline the importance of integrating environmental indicators into transportation efficiency analyses. Gökgöz and Yalçın (2023) show that countries such as Germany, the United Kingdom, and France achieve superior transportation sustainability performance by combining infrastructure investment with renewable energy use and emission reduction strategies. These findings support the inclusion of CO_2 emissions as a key criterion in multidimensional transportation efficiency models.

2.4. Financial Efficiency

Financial development plays a critical role in shaping transportation and logistics performance by facilitating infrastructure investment, risk management, and technological modernization. Well-functioning financial systems enable the mobilization of capital for large-scale transportation projects and support the adoption of advanced logistics technologies (Guild, 2000). Transportation infrastructure, in turn, provides physical support for financial market operations by improving market accessibility and reducing transaction costs (Arvis et al., 2007; Wong et al., 2019).

Empirical studies confirm the bidirectional relationship between financial development and logistics performance. Özdemir (2017) and Özdemir and Küçükkaya (2023) demonstrate that financial depth, access, and efficiency positively affect logistics performance across countries. Similarly, Demirbaş et al. (2021) find a significant long-run relationship between financial development and logistics efficiency in emerging markets. Bardakci et al. (2020) report that this relationship is particularly strong in advanced economies, highlighting the role of financial maturity in supporting logistics competitiveness.

These findings indicate that transportation and logistics efficiency cannot be fully understood without considering financial development, especially in economies characterized by capital-intensive infrastructure investments.

2.5. Social Dimensions

Social and demographic factors, particularly population size and density, significantly influence transportation demand and logistics system performance. Population growth increases demand for transportation services and places pressure on existing infrastructure, directly affecting efficiency and service quality (Zhao & Li, 2016). In densely populated regions, transportation systems may benefit from economies of scale, but inadequate infrastructure can lead to congestion and reduced efficiency (Downs, 2004; Litman, 2021).

Empirical evidence suggests that population dynamics shape transportation planning and investment priorities. Konečný et al. (2019) show that population size has a positive effect on public transportation demand, while Din et al. (2022) highlight the moderating role of population density in the relationship between road infrastructure, energy consumption, and environmental quality. Long-term projections by the International Transport Forum (ITF, 2019) indicate that transportation demand in OECD countries will continue to increase, underscoring the need to incorporate social dimensions into transportation efficiency assessments.

By including population as a criterion, this study captures the demand-side dynamics of transportation and logistics systems. This approach allows for a more holistic evaluation that accounts not only for infrastructure supply and technological capacity but also for the socio-demographic context within which transportation systems operate.

3. METHODOLOGY

3.1. Sample and Data

This study evaluates transportation and logistics efficiency across OECD countries using a multidimensional dataset that captures economic, infrastructural, digital, environmental, financial, and social dimensions. The sample consists of OECD member countries for which complete and comparable data were available for the selected indicators. Countries, such as Austria, the Czech Republic, Hungary, Norway, and Switzerland, with missing or inconsistent data were excluded to ensure methodological robustness and cross-country comparability.

The data were obtained from internationally recognized and reliable sources. Transportation infrastructure indicators, digitalization variables, and environmental data were collected from the World Economic Forum (WEF), the World Bank, the International Energy Agency (IEA), and the OECD databases. Financial development indicators were sourced from the World Bank, while population data were obtained from OECD statistics. All data correspond to the most recent available year to ensure temporal consistency across indicators.

The criteria used in the analysis include transportation infrastructure quality (road, rail, air, and port efficiency), labor productivity in transportation and logistics-related sectors, digitalization indicators (use of digital platforms in transportation services and broadband internet subscriptions), environmental indicators (CO_2 emissions), financial development indicators, and population size. These criteria were selected based on their theoretical relevance and empirical support in the transportation, logistics, and supply chain management literature (Arvis et al., 2018; OECD, 2023a; Rodrigue, 2020). The study evaluates countries' performance through 11 criteria. The criteria used in the research is presented in Table 1.

Table 1: Criteria Employed in the Study

Code	Indicator	Criteria	Target	Source	
K-1.	Logistics and Transportation	Quality of the Roads, 1-7 (Best)	Max	World Economic Forum	Gürler (2024); Uyar (2023)
K-2.		Efficiency of the train services, 1-7 (Best)	Max		Gürler (2024); Uyar (2023)
K-3.		Efficiency of the air transport services, 1-7 (Best)	Max		Gürler (2024); Uyar (2023)
K-4.		Efficiency of the seaport services, 1-7 (Best)	Max		Uyar, (2023)
K-5.		Use of digital platforms for providing transportation and shipping, 1-7 (Best)	Max		Uyar, (2023)
K-6.		Labor productivity in transportation, storage and communications, US$ per capita	Max		Uyar, (2023)
K-11.	Dijitalization	Broadband internet subscribers per 100 people	Max	OECD	Konya, 2024; Akyol et al. (20023); Gomes et al. (2022); Kabaklarlı and Atasoy (2019)
K-7.	Economic	GDP Per Capita ($)	Max	OECD	Uyar (2023)
K-9.		Financial Development Index (%)	Max	International Monetary Fund	Diakoulaki et al. (1995); Özbek and Oğul (2022)
K-8.	Environmental	CO_2 Emissions ($MtCO_2e$)	Min	International Energy Agency	Özgün (2024); Simic et al. (2022)
K-10.	Social	Population	Max	OECD	Uyar (2023)

Prior to analysis, the decision matrix was constructed by organizing the data in a country–criterion format. To ensure comparability across indicators measured in different units, normalization procedures inherent to the applied MCDM methods were employed, eliminating the need for subjective data transformation.

3.2. Methods

While traditional AHP and TOPSIS methods are widely used, newer techniques such as CRITIC and MABAC offer advanced accuracy for complex data sets (Diakoulaki et al., 1995; Keshavarz Ghorabaee et al., 2015). The CRITIC method objectively determines criterion weights based on data variability and correlation (Diakoulaki et al., 1995), while MABAC integrates multiple decision-making strategies for robust rankings (Pamučar and Ćirović, 2015). The study analyzes 11 criteria using MCDM methods, which are adept at processing mixed data types. By using CRITIC to determine criterion weights and MABAC to rank countries, the study addresses gaps in the existing literature in the field of logistics/transportation.

3.2.1 CRITIC (Criteria Importance Through Intercriteria Correlation)

The CRITIC method is an objective criterion weighting technique originally introduced by Diakoulaki et al. (1995). The method determines criterion weights by simultaneously considering the variability of each criterion and its correlation with other criteria. Specifically, standard deviation is used to capture the contrast intensity of criterion values, while Pearson correlation coefficients are employed to assess the degree of interrelationship among criteria (Akçakanat et al., 2018; Hassan et al., 2023; Weng et al., 2024).

The underlying rationale of the CRITIC method is that criteria exhibiting greater variability contain more information, while criteria that are weakly correlated with others contribute unique and non-redundant insights to the decision-making process. Consequently, CRITIC assigns higher weights to criteria characterized by high contrast intensity and low intercriteria correlation, thereby reflecting both information content and conflict among criteria (Diakoulaki et al., 1995).

By relying solely on statistical properties of the data, the CRITIC method minimizes subjectivity in the weighting process and avoids potential biases associated with expert-based approaches. For this reason, it is considered more objective than subjective weighting methods such as AHP, SWARA, and BWM. In the present study, the CRITIC method is employed to ensure an unbiased and data-driven determination of criterion importance, making it particularly suitable for macro-level comparisons across OECD countries. The steps of the CRITIC are as follows (Ayçin, 2020, p.4-5; Diakoulaki et al., 1995, p.765):

Step 1. Creating the Decision Matrix (X): This matrix (X) is created as shown in Equation (1).

$$X = x_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \tag{1}$$

Step 2. Creating the Normalized Matrix: The normalization process is performed based on Equation (2) for benefit-based criteria and Equation (3) for cost-based criteria.

$$r_{ij} = \frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}} \tag{2}$$

$$r_{ij} = \frac{x_j^{max} - x_{ij}}{x_j^{max} - x_j^{min}} \tag{3}$$

Step 3. Creating the Correlation Coefficient Matrix: In order to determine the level of relationship between the criteria, the correlation coefficient matrix is created using Equation (4).

$$p_{jk} = \frac{\sum_{i=1}^{m}\left(r_{ij} - \bar{r}_j\right)(r_{ik} - \bar{r}_k)}{\sqrt{\sum_{i=1}^{m}(r_{ij} - \bar{r}_j)^2 \sum_{i=1}^{m}(r_{ik} - \bar{r}_k)^2}} \; , j, k = 1,2, \ldots \ldots , n \quad (4)$$

Step 4. Calculation of C_j values: C_j values representing total information are calculated using Equations (5) and (6).

$$C_j = \sigma_j \sum_{k=1}^{n} \left(1 - p_{jk}\right), j = 1,2, \ldots . , n \quad (5)$$

$$\sigma_j = \sqrt{\sum_{i=1}^{m} \left(r_{ij} - \bar{r}_j\right)^2 / m} \quad (6)$$

Step 5. Calculation of Criterion Weights W_j: In the last stage, the weight values (W_j) of the criteria are obtained using Equation (7).

$$W_j = \frac{C_j}{\sum_{k=1}^{n} C_k}, j, k = 1,2, \ldots . , n \quad (7)$$

3.2.2 MABAC (Multi-Attributive Border Approximation Area Comparison)

The MABAC method, developed by Pamučar and Ćirović (2015), is employed in this study to rank the performance of OECD countries. MABAC is a distance-based decision-making approach that evaluates alternatives by measuring their deviation from a border approximation area within the decision matrix, thereby ensuring transparent, stable, and easily interpretable results. One of the principal advantages of the MABAC method is that it minimizes decision-maker bias and does not rely on the concept of positive or negative ideal solutions (Pamučar & Ćirović, 2015).

Although alternative MCDM techniques such as TOPSIS, VIKOR, and PROMETHEE are frequently used for performance evaluation, these methods typically depend on ideal solutions or incorporate subjective elements related to decision-maker preferences during the ranking process (Behzadian et al., 2010). In contrast, the MABAC method provides a more objective evaluation framework by relying solely on the statistical properties of the decision matrix.

Given that the primary objective of this study is to assess transportation infrastructure and logistics efficiency using objective and comparable indicators, the integrated use of CRITIC and MABAC is particularly appropriate. The CRITIC–MABAC framework enables an unbiased, data-driven performance ranking by combining objective criterion weighting with a transparent distance-based ranking mechanism.

MABAC method is based on the principle of calculating the distance of each alternative's criterion function values from the boundary approach area and the steps of the method are as follows (Çetin and Karataş, 2024, p.1480-1481; Gigović et al., 2017, p.509-512; Pamučar and Ćirović, 2015, p.3019-3021; Pamučar et al., 2018, p.97-98):

Step-1. Creating the Initial Decision Matrix: This matrix consisting of m alternatives and n criteria is created as shown in Equation (8).

$$X = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} = \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \cdots & \cdots & \ddots & \cdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix} \quad (8)$$

Step-2. Standardization (Normalization) of the Initial Decision Matrix: The standardization process uses Equation (9) for benefit-based criteria and Equation (10) for cost-based criteria. In the equations, x_i^+ represents the maximum value, while x_i^- represents the minimum value.

$$n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \quad (9)$$

$$n_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \quad (10)$$

Thus, the N standardized matrix in Equation (11) is obtained.

$$N = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} = \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \cdots & \cdots & \ddots & \cdots \\ n_{m1} & n_{m2} & \cdots & n_{mn} \end{bmatrix} \quad (11)$$

Step-3. Weighting the Standardized Matrix: In this step, criterion weights are included in the analysis process using Equation (12).

$$v_{ij} = w_i \, n_{ij} + w_i \quad (12)$$

Step-4. Creating the Boundary Proximity Area Matrix: This area values for all criteria are calculated through Equation (13).

$$g_i = \left(\prod_{j=1}^{m} v_{ij} \right)^{1/m} \quad (13)$$

The Boundary Proximity Area Matrix (G) shown in Equation (14) is obtained by calculating the g_i values for all criteria.

$$G = \begin{matrix} C_1 & C_2 & \dots & C_n \\ [\,g_1 & g_2 & \cdots & g_n\,] \end{matrix} \tag{14}$$

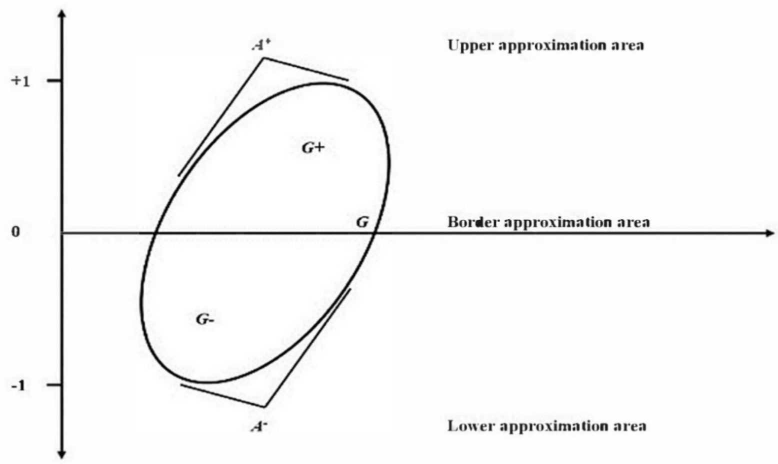
Step-5. Calculating the distances between alternatives in the boundary approach area matrix: As shown in Equation (15), the distance matrix (*Q)* is obtained by subtracting the boundary approach area matrix (*G*) from the weighted matrix (*V*).

$$Q = V - G \begin{bmatrix} v_{11} - g_1 & v_{12} - g_2 & \cdots & v_{1n} - g_n \\ v_{21} - g_1 & v_{22} - g_2 & \cdots & v_{2n} - g_n \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} - g_1 & v_{m2} - g_2 & \cdots & v_{mn} - g_n \end{bmatrix} = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix} \tag{15}$$

Step-6. Determining the Status of Decision Alternatives Based on Their Proximity to the Boundary Area. The area belonging to the A_i alternative is determined using Equation (16). The boundary approach area is denoted by G the upper boundary approach area by $G^+$and the lower boundary approach area by G^- .

$$A_i = \begin{cases} G^+ \ eğer \ q_{ij} > 0 \ ise \\ G \ \ eğer \ q_{ij} = 0 \ ise \\ G^- \ eğer \ q_{ij} < 0 \ ise \end{cases} \tag{16}$$

Figure 1: Border Proximity Areas



Source: **Based on the study by Pamučar and Ćirović (2015)**

The limit approach area is denoted by G, the upper limit approach area by G^+, and the lower limit approach area by G^- . The proximity areas are given in Figure 1.

Step 7: Ranking the Alternatives. Using Equation (17), the criterion functions are calculated by summing the distances of each alternative to the boundary approach areas.

$$S_i = \sum_{J=1}^{n} q_{ij}, j = 1, 2, 3, \dots, m \quad (17)$$

4. ANALYSIS AND FINDINGS

The methodological strategy of the study proceeds as follows. First, the CRITIC method is employed to determine the objective weights of the evaluation criteria. Second, the MABAC method is applied to rank OECD countries according to their transportation and logistics performance. Third, a sensitivity analysis is conducted using alternative weighting and ranking methods to assess the robustness and validity of the results. Finally, the empirical findings are reported and discussed.

4.1. CRITIC Method

In this section, the CRITIC method is first applied to calculate the criterion weights. The weight values for the criteria are calculated through Equations (1-7). The decision matrix created according to Equation (1) as the first step of the CRITIC is shown in Table 2.

Table 2: Initial Decision Matrix

Country	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
Australia	5.12	4.40	5.59	4.74	4.95	123435.23	64196.90	388.07	0.91	25685412	35.05
Belgium	4.94	4.44	5.22	5.07	5.02	112663.18	62077.16	97.23	0.63	11586195	40.85
Canada	5.07	4.69	5.38	5.05	5.24	117098.91	55634.07	561.99	0.87	38239864	41.80
Chile	5.23	3.42	5.43	5.26	5.53	34837.69	28874.09	98.01	0.50	19493184	19.62
Colombia	3.61	1.97	4.79	4.31	4.61	26150.39	18134.02	84.32	0.39	51516562	15.26
Costa Rica	3.70	1.00	5.26	4.28	5.16	73443.73	23664.40	8.14	0.29	5153957	19.49
Denmark	5.83	4.55	5.60	5.63	5.03	111660.27	69911.66	30.57	0.66	5856733	44.40
Estonia	4.95	4.55	4.19	5.66	5.66	63677.27	45076.64	11.64	0.25	1330932	31.33
Finland	5.33	5.43	5.82	6.07	5.47	83040.82	57783.91	39.05	0.65	5541017	33.32
France	6.01	5.13	5.64	5.06	5.12	85997.12	53462.73	324.77	0.81	67764304	46.92
Germany	5.17	4.26	5.43	4.94	4.31	106946.56	61939.81	679.27	0.70	83196078	43.02
Greece	4.62	3.29	5.65	5.18	4.51	91998.82	32797.32	54.17	0.47	10569207	40.84
Iceland	4.40	1.00	5.42	4.77	4.64	80047.74	61484.77	3.08	0.50	372520	41.56
Ireland	4.89	4.17	5.47	5.10	4.68	93053.68	114451.19	36.17	0.62	5033164	30.71
Israel	5.14	3.94	5.34	4.51	5.19	99264.77	46258.74	59.52	0.60	9371400	30.06
Italy	4.44	4.43	5.05	4.88	4.93	113909.85	49912.88	320.76	0.77	59133173	29.53
Japan	6.29	6.85	6.46	5.93	4.36	82114.78	44355.58	1075.66	0.89	125681593	34.50
Korea	6.11	6.23	6.12	5.57	6.02	66042.56	48594.96	642.90	0.82	51769539	43.55
Latvia	3.94	4.39	5.46	4.81	5.24	64823.81	36806.78	7.24	0.21	1884490	26.71

Lithuania	5.07	4.51	4.75	4.82	5.51	98321.64	46285.48	14.06	0.20	2800839	29.27
Mexico	4.13	3.16	4.39	4.26	4.95	74734.06	20983.06	441.83	0.40	126705138	16.45
Netherlands	6.53	5.93	6.41	6.38	5.57	113788.96	67693.60	144.63	0.71	17533044	43.92
New Zealand	4.52	3.50	5.78	4.72	4.90	82404.64	48092.66	34.54	0.62	5111300	34.72
Poland	4.53	4.23	4.93	4.57	4.97	81390.83	40022.85	327.23	0.43	37747124	21.70
Portugal	5.98	4.25	5.01	4.79	5.16	73302.78	39036.35	39.54	0.65	10361831	40.81
Slovakia	4.03	3.93	3.81	3.20	5.17	61200.92	37840.78	36.26	0.28	5447247	31.17
Slovenia	4.89	3.17	3.69	4.67	4.72	86085.69	46509.82	14.28	0.32	2108079	31.34
Spain	5.65	5.41	5.49	5.42	5.41	90113.41	43698.28	231.44	0.80	47415794	33.90
Sweden	5.35	4.79	5.46	5.36	5.38	93762.89	63375.14	38.03	0.78	10415811	40.61
Türkiye	5.14	4.00	5.86	4.76	4.57	255822.52	31605.63	466.79	0.50	84147318	19.84
United Kingdom	4.93	4.41	5.43	5.16	5.11	67862.15	52846.08	339.06	0.84	67026292	40.49
United States	5.84	5.22	5.79	5.49	5.73	79902.90	70181.12	4768.87	0.92	332048977	36.41

The normalization process of the initial decision matrix elements in Table 2 was performed using Equation (2) and Equation (3) depending on whether they were benefit-oriented or cost-oriented, and the normalized decision matrix is presented in Table 3.

Table 3: Normalized Decision Matrix (CRITIC)

Country	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
Australia	0.517	0.581	0.686	0.484	0.374	0.424	0.478	0.919	0.988	0.076	0.625
Belgium	0.455	0.588	0.552	0.588	0.415	0.377	0.456	0.980	0.604	0.034	0.808
Canada	0.500	0.631	0.610	0.582	0.544	0.396	0.389	0.883	0.940	0.114	0.838
Chile	0.555	0.414	0.628	0.648	0.713	0.038	0.112	0.980	0.427	0.058	0.138
Colombia	0.000	0.166	0.397	0.349	0.175	0.000	0.000	0.983	0.265	0.154	0.000
Costa Rica	0.031	0.000	0.567	0.340	0.497	0.206	0.057	0.999	0.127	0.014	0.134
Denmark	0,760	0,607	0,690	0,764	0.421	0.372	0.538	0.994	0.650	0.017	0.920
Estonia	0.459	0.607	0.181	0.774	0.789	0.163	0.280	0.998	0.078	0.003	0.508
Finland	0.589	0.757	0.769	0.903	0.678	0.248	0.412	0.992	0.623	0.016	0.570
France	0.822	0.706	0.704	0.585	0.474	0.261	0.367	0.933	0.858	0.203	1.000
Germany	0.534	0.557	0.628	0.547	0.000	0.352	0.455	0.858	0.702	0.250	0.877
Greece	0.346	0.391	0.708	0.623	0.117	0.287	0.152	0.989	0.384	0.031	0.808
Iceland	0.271	0.000	0.625	0.494	0.193	0.235	0.450	1.000	0.416	0.000	0.831
Ireland	0.438	0.542	0.643	0.597	0.216	0.291	1.000	0.993	0.594	0.014	0.488
Israel	0.524	0.503	0.596	0.412	0.515	0.318	0.292	0.988	0.566	0.027	0.467

Italy	0.284	0.586	0.491	0.528	0.363	0.382	0.330	0.933	0.792	0.177	0.451
Japan	0.918	1.000	1.000	0.858	0.029	0.244	0.272	0.775	0.959	0.378	0.608
Korea	0.856	0.894	0.877	0.745	1.000	0.174	0.316	0.866	0.863	0.155	0.894
Latvia	0.113	0.579	0.639	0.506	0.544	0.168	0.194	0.999	0.022	0.005	0.362
Lithuania	0.500	0.600	0.383	0.509	0.702	0.314	0.292	0.998	0.000	0.007	0.443
Mexico	0.178	0.369	0.253	0.333	0.374	0.212	0.030	0.908	0.285	0.381	0.038
Netherlands	1.000	0.843	0.982	1.000	0.737	0.382	0.515	0.970	0.711	0.052	0.905
New Zealand	0.312	0.427	0.755	0.478	0.345	0.245	0.311	0.993	0.584	0.014	0.615
Poland	0.315	0.552	0.448	0.431	0.386	0.241	0.227	0.932	0.325	0.113	0.203
Portugal	0.812	0.556	0.477	0.500	0.497	0.205	0.217	0.992	0.635	0.030	0.807
Slovakia	0.144	0.501	0.043	0.000	0.503	0.153	0.205	0.993	0.116	0.015	0.503
Slovenia	0.438	0.371	0.000	0.462	0.240	0.261	0.295	0.998	0.177	0.005	0.508
Spain	0.699	0.754	0.650	0.698	0.643	0.278	0.265	0.952	0.842	0.142	0.589
Sweden	0.596	0.648	0.639	0.679	0.626	0.294	0.470	0.993	0.803	0.030	0.801
Türkiye	0.524	0.513	0.783	0.491	0.152	1.000	0.140	0.903	0.421	0.253	0.145
United Kingdom	0.452	0.583	0.628	0.616	0.468	0.182	0.360	0.930	0.888	0.201	0.797
United States	0.764	0.721	0.758	0.720	0.830	0.234	0.540	0.000	1.000	1.000	0.668

In order to determine the level of relationship between the evaluation criteria. the correlation coefficient matrix obtained using Equality (4) is shown in Table 4.

Table 4: Correlation Matrix and Standard Deviations Relating to Criteria

	K-1.	**K-2.**	**K-3.**	**K-4.**	**K-5.**	**K-6.**	**K-7.**	**K-8.**	**K-9.**	**K-10.**	**K-11.**
K-1.	1.	0.768	0.559	0.736	0.321	0.218	0.405	0.295	0.652	0.249	0.620
K-2.	0.768	1.	0.440	0.632	0.371	0.162	0.344	0.285	0.566	0.271	0.445
K-3.	0.559	0.440	1.	0.649	0.044	0.277	0.307	0.247	0.640	0.226	0.382
K-4.	0.736	0.632	0.649	1.	0.313	0.086	0.412	0.197	0.495	0.139	0.469
K-5.	0.321	0.371	0.044	0.313	1.	-0.262	0.031	0.199	0.063	0.052	0.120
K-6.	0.218	0.162	0.277	0.086	-0.262	1.	0.181	0.025	0.193	0.064	0.080
K-7.	0.405	0.344	0.307	0.412	0.031	0.181	1.	0.183	0.472	0.031	0.560
K-8.	0.295	0.285	0.247	0.197	0.199	0.025	0.183	1.	0.417	0.935	0.094
K-9.	0.652	0.566	0.640	0.495	0.063	0.193	0.472	0.417	1.	0.420	0.587
K-10.	0.249	0.271	0.226	0.139	0.052	0.064	0.031	0.935	0.420	1.	-0.029
K-11.	0.620	0.445	0.382	0.469	0.120	0.080	0.560	0.094	0.587	-0.029	1.
σ_j	0.254	0.217	0.230	0.191	0.240	0.163	0.191	0.177	0.306	0.192	0.281

Finally, C_j values for each performance criterion were calculated using Equality (5) and Equality (6), and W_j values for each performance criterion were calculated using Equality (7). The results are shown in Table 5.

Table 5: Information Disclosed Regarding the Criteria and Weights

	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
C_j	1.317	1.240	1.435	1.123	2.098	1.465	1.351	1.263	1.680	1.470	1.877
W_j	0.081	0.076	0.088	0.069	0.129	0.090	0.083	0.077	0.103	0.090	0.115

As reported in Table 4, the criterion with the highest weight is Use of Digital Platforms in the Provision of Transportation and Shipping Services (K5), with a weight value of 0.129, indicating its dominant influence on overall performance. This is followed by Number of Broadband Internet Subscribers per 100 People (K11), which has a weight of 0.115, and the Financial Development Index (K9), with a weight value of 0.103. In contrast, Port Service Efficiency (K4) exhibits the lowest relative importance, with a weight of 0.069, suggesting a comparatively weaker impact within the evaluated criteria set.

4.2. MABAC Method

In this section, the criterion weights obtained through the CRITIC method are incorporated into the MABAC framework to evaluate the transportation infrastructure (TInf) performance of OECD countries. The S_i values and the corresponding rankings of the alternatives are calculated using Equations (8)–(17) and reported in Table 10. As the initial step of the MABAC procedure, the decision matrix constructed according to Equation (8) is presented in Table 2. Subsequently, the elements of the initial decision matrix are normalized using Equations (9) and (10), depending on whether the criteria are benefit-oriented or cost-oriented. The resulting normalized decision matrix, obtained in accordance with Equation (11), is shown in Table 6.

Table 6: Normalized Decision Matrix (MABAC)

Country	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
Australia	0.517	0.581	0.686	0.241	0.374	0.424	0.070	0.919	0.988	0.076	0.625
Belgium	0.455	0.588	0.552	0.293	0.415	0.377	0.030	0.980	0.604	0.034	0.808
Canada	0.500	0.631	0.610	0.290	0.544	0.396	0.090	0.883	0.940	0.114	0.838
Chile	0.555	0.414	0.628	0.323	0.713	0.038	0.023	0.980	0.427	0.058	0.138
Colombia	0.000	0.166	0.397	0.174	0.175	0.000	0.038	0.983	0.265	0.154	0.000
Costa Rica	0.031	0.000	0.567	0.169	0.497	0.206	0.004	0.999	0.127	0.014	0.134
Denmark	0.760	0.607	0.690	0.381	0.421	0.372	0.017	0.994	0.650	0.017	0.920
Estonia	0.459	0.607	0.181	0.386	0.789	0.163	0.002	0.998	0.078	0.003	0.508
Finland	0.589	0.757	0.769	0.450	0.678	0.248	0.013	0.992	0.623	0.016	0.570
France	0.822	0.706	0.704	0.292	0.474	0.261	0.156	0.933	0.858	0.203	1.000

Germany	0.534	0.557	0.628	0.273	0.000	0.352	0.220	0.858	0.702	0.250	0.877
Greece	0.346	0.391	0.708	0.310	0.117	0.287	0.014	0.989	0.384	0.031	0.808
Iceland	0.271	0.000	0.625	0.246	0.193	0.235	0.000	1.000	0.416	0.000	0.831
Ireland	0.438	0.542	0.643	0.298	0.216	0.291	0.024	0.993	0.594	0.014	0.488
Israel	0.524	0.503	0.596	0.205	0.515	0.318	0.018	0.988	0.566	0.027	0.467
Italy	0.284	0.586	0.491	0.263	0.363	0.382	0.126	0.933	0.792	0.177	0.451
Japan	0.918	1.000	1.000	0.428	0.029	0.244	0.238	0.775	0.959	0.378	0.608
Korea	0.856	0.894	0.877	0.371	1.000	0.174	0.107	0.866	0.863	0.155	0.894
Latvia	0.113	0.579	0.639	0.252	0.544	0.168	0.002	0.999	0.022	0.005	0.362
Lithuania	0.500	0.600	0.383	0.254	0.702	0.314	0.005	0.998	0.000	0.007	0.443
Mexico	0.178	0.369	0.253	0.166	0.374	0.212	0.114	0.908	0.285	0.381	0.038
Netherlands	1.000	0.843	0.982	0.498	0.737	0.382	0.050	0.970	0.711	0.052	0.905
New Zealand	0.312	0.427	0.755	0.238	0.345	0.245	0.010	0.993	0.584	0.014	0.615
Poland	0.315	0.552	0.448	0.215	0.386	0.241	0.065	0.932	0.325	0.113	0.203
Portugal	0.812	0.556	0.477	0.249	0.497	0.205	0.016	0.992	0.635	0.030	0.807
Slovakia	0.144	0.501	0.043	0.000	0.503	0.153	0.008	0.993	0.116	0.015	0.503
Slovenia	0.438	0.371	0.000	0.230	0.240	0.261	0.003	0.998	0.177	0.005	0.508
Spain	0.699	0.754	0.650	0.348	0.643	0.278	0.088	0.952	0.842	0.142	0.589
Sweden	0.596	0.648	0.639	0.339	0.626	0.294	0.027	0.993	0.803	0.030	0.801
Türkiye	0.524	0.513	0.783	0.245	0.152	1.000	0.113	0.903	0.421	0.253	0.145
United Kingdom	0.452	0.583	0.628	0.307	0.468	0.182	0.151	0.930	0.888	0.201	0.797
United States	0.764	0.721	0.758	0.359	0.830	0.234	1.000	0.000	1.000	1.000	0.668

Following the completion of the normalization process, the criterion weights derived from the CRITIC method are incorporated into the analysis using Equation (12) to construct the weighted normalized decision matrix. The resulting matrix is presented in Table 7.

Table 7: Weighted Normalization Matrix

Country	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
Australia	0.122	0.120	0.148	0.085	0.177	0.128	0.089	0.149	0.205	0.097	0.187
Belgium	0.117	0.121	0.137	0.089	0.182	0.124	0.085	0.153	0.165	0.093	0.208
Canada	0.121	0.124	0.142	0.089	0.198	0.125	0.090	0.146	0.200	0.100	0.211
Chile	0.125	0.107	0.143	0.091	0.220	0.093	0.085	0.153	0.147	0.095	0.131
Colombia	0.081	0.089	0.123	0.081	0.151	0.090	0.086	0.153	0.130	0.104	0.115
Costa Rica	0.083	0.076	0.138	0.080	0.192	0.108	0.083	0.155	0.116	0.091	0.130
Denmark	0.142	0.122	0.149	0.095	0.183	0.123	0.084	0.154	0.170	0.092	0.221
Estonia	0.118	0.122	0.104	0.095	0.230	0.104	0.083	0.155	0.111	0.090	0.173

Finland	0.128	0.133	0.156	0.100	0.216	0.112	0.084	0.154	0.167	0.091	0.181
France	0.147	0.130	0.150	0.089	0.189	0.113	0.096	0.150	0.191	0.108	0.230
Germany	0.124	0.118	0.143	0.088	0.129	0.121	0.101	0.144	0.175	0.113	0.216
Greece	0.109	0.106	0.150	0.090	0.144	0.115	0.084	0.154	0.143	0.093	0.208
Iceland	0.103	0.076	0.143	0.086	0.153	0.111	0.083	0.155	0.146	0.090	0.211
Ireland	0.116	0.117	0.144	0.089	0.156	0.116	0.085	0.154	0.164	0.091	0.171
Israel	0.123	0.114	0.140	0.083	0.195	0.118	0.084	0.154	0.161	0.093	0.169
Italy	0.104	0.121	0.131	0.087	0.175	0.124	0.093	0.150	0.184	0.106	0.167
Japan	0.155	0.152	0.176	0.098	0.132	0.112	0.102	0.137	0.202	0.124	0.185
Korea	0.150	0.144	0.165	0.094	0.257	0.105	0.092	0.144	0.192	0.104	0.218
Latvia	0.090	0.120	0.144	0.086	0.198	0.105	0.083	0.155	0.105	0.090	0.157
Lithuania	0.121	0.122	0.122	0.086	0.219	0.118	0.083	0.155	0.103	0.091	0.166
Mexico	0.095	0.104	0.110	0.080	0.177	0.109	0.092	0.148	0.132	0.124	0.119
Netherlands	0.161	0.140	0.174	0.103	0.223	0.124	0.087	0.152	0.176	0.095	0.219
New Zealand	0.106	0.108	0.154	0.085	0.173	0.112	0.084	0.154	0.163	0.091	0.186
Poland	0.106	0.118	0.127	0.084	0.178	0.111	0.088	0.150	0.136	0.100	0.138
Portugal	0.146	0.118	0.130	0.086	0.192	0.108	0.084	0.154	0.168	0.093	0.208
Slovakia	0.092	0.114	0.092	0.069	0.193	0.103	0.083	0.154	0.115	0.091	0.173
Slovenia	0.116	0.104	0.088	0.085	0.159	0.113	0.083	0.155	0.121	0.091	0.173
Spain	0.137	0.133	0.145	0.093	0.211	0.115	0.090	0.151	0.190	0.103	0.183
Sweden	0.129	0.125	0.144	0.092	0.209	0.116	0.085	0.154	0.186	0.093	0.207
Türkiye	0.123	0.115	0.157	0.086	0.148	0.180	0.092	0.147	0.146	0.113	0.132
United Kingdom	0.117	0.120	0.143	0.090	0.189	0.106	0.095	0.149	0.194	0.108	0.207
United States	0.142	0.131	0.155	0.094	0.235	0.111	0.166	0.077	0.206	0.180	0.192

After weighting, the boundary approach area matrix obtained using Equation (11) and as in Equation (12) is shown in Table 8.

Table 8: Boundary Approach Area Matrix

	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
G	0.119	0.116	0.138	0.088	0.185	0.114	0.089	0.148	0.157	0.100	0.178

The distance values of the alternatives obtained using Equality (13) to the boundary approach area matrix are shown in Table 9.

Table 9: Distance Values of Alternatives to the Boundary Approach Area Matrix

Country	K-1.	K-2.	K-3.	K-4.	K-5.	K-6.	K-7.	K-8.	K-9.	K-10.	K-11.
Australia	0.004	0.004	0.010	-0.003	-0.008	0.014	-0.001	0.000	0.027	-0.081	0.009
Belgium	-0.001	0.004	-0.001	0.001	-0.003	0.010	-0.004	0.005	-0.013	-0.085	0.030
Canada	0.002	0.007	0.004	0.001	0.014	0.011	0.001	-0.002	0.022	-0.078	0.034
Chile	0.007	-0.009	0.005	0.003	0.036	-0.021	-0.005	0.005	-0.031	-0.083	-0.047
Colombia	-0.038	-0.028	-0.015	-0.007	-0.033	-0.024	-0.003	0.005	-0.048	-0.074	-0.063
Costa Rica	-0.035	-0.040	0.000	-0.008	0.008	-0.006	-0.006	0.007	-0.062	-0.087	-0.048
Denmark	0.023	0.006	0.011	0.007	-0.002	0.009	-0.005	0.006	-0.008	-0.086	0.043
Estonia	-0.001	0.006	-0.034	0.007	0.046	-0.010	-0.006	0.006	-0.067	-0.088	-0.004
Finland	0.010	0.017	0.018	0.012	0.031	-0.002	-0.005	0.006	-0.011	-0.086	0.003
France	0.028	0.013	0.012	0.001	0.005	-0.001	0.006	0.001	0.013	-0.070	0.052
Germany	0.005	0.002	0.005	-0.001	-0.056	0.007	0.012	-0.004	-0.003	-0.065	0.038
Greece	-0.010	-0.011	0.012	0.002	-0.041	0.001	-0.005	0.006	-0.035	-0.085	0.030
Iceland	-0.016	-0.040	0.005	-0.002	-0.031	-0.003	-0.007	0.007	-0.032	-0.088	0.033
Ireland	-0.002	0.001	0.006	0.001	-0.028	0.002	-0.005	0.006	-0.014	-0.087	-0.007
Israel	0.004	-0.002	0.002	-0.005	0.010	0.004	-0.005	0.006	-0.017	-0.085	-0.009
Italy	-0.015	0.004	-0.007	-0.001	-0.009	0.010	0.004	0.001	0.007	-0.072	-0.011
Japan	0.036	0.036	0.038	0.010	-0.052	-0.002	0.013	-0.011	0.024	-0.054	0.007
Korea	0.031	0.027	0.027	0.006	0.073	-0.009	0.002	-0.004	0.014	-0.074	0.040
Latvia	-0.029	0.004	0.006	-0.002	0.014	-0.009	-0.006	0.007	-0.073	-0.087	-0.021
Lithuania	0.002	0.005	-0.016	-0.002	0.034	0.004	-0.006	0.006	-0.075	-0.087	-0.012
Mexico	-0.023	-0.012	-0.028	-0.008	-0.008	-0.005	0.003	0.000	-0.046	-0.054	-0.059
Netherlands	0.043	0.024	0.036	0.015	0.039	0.010	-0.002	0.004	-0.002	-0.083	0.041
New Zealand	-0.013	-0.008	0.016	-0.003	-0.012	-0.002	-0.006	0.006	-0.015	-0.087	0.008
Poland	-0.012	0.002	-0.011	-0.005	-0.006	-0.003	-0.001	0.001	-0.041	-0.078	-0.039
Portugal	0.028	0.002	-0.008	-0.002	0.008	-0.006	-0.005	0.006	-0.010	-0.085	0.030
Slovakia	-0.026	-0.002	-0.046	-0.019	0.009	-0.011	-0.006	0.006	-0.063	-0.086	-0.005
Slovenia	-0.002	-0.012	-0.050	-0.003	-0.025	-0.001	-0.006	0.006	-0.057	-0.087	-0.004
Spain	0.019	0.017	0.007	0.005	0.027	0.001	0.001	0.003	0.012	-0.075	0.005
Sweden	0.010	0.009	0.006	0.004	0.024	0.002	-0.004	0.006	0.008	-0.085	0.029
Türkiye	0.004	-0.001	0.019	-0.002	-0.036	0.065	0.003	-0.001	-0.032	-0.065	-0.046
United Kingdom	-0.001	0.004	0.005	0.002	0.004	-0.008	0.006	0.001	0.016	-0.070	0.029
United States	0.024	0.014	0.017	0.005	0.051	-0.003	0.076	-0.071	0.028	0.002	0.014

Finally, the status of the decision alternatives is determined based on their proximity to the border approximation area using Equation (14). Subsequently, the distances of each alternative from the border approximation areas are aggregated according to Equation (15), and the final rankings are obtained by calculating the criterion functions. The resulting the S_i values and corresponding rankings are reported in Table 10.

Table 10: S_i Ranking of Values and Alternatives

Country	S_i	Rank	Country	S_i	*Rank*	Country	S_i	*Rank*
Australia	-0.024	**12**	Greece	-0.136	**21**	New Zealand	-0.114	**19**
Belgium	-0.057	**14**	Iceland	-0.176	**25**	Poland	-0.194	**26**
Canada	0.016	**7**	Ireland	-0.126	**20**	Portugal	-0.043	**13**
Chile	-0.139	**22**	Israel	-0.097	**18**	Slovakia	-0.250	**30**
Colombia	-0.328	**32**	Italy	-0.089	**16**	Slovenia	-0.243	**29**
Costa Rica	-0.277	**31**	Japan	0.045	**5**	Spain	0.020	**6**
Denmark	0.004	**9**	South Korea	0.134	**2**	Sweden	0.009	**8**
Estonia	-0.145	**23**	Latvia	-0.197	**27**	Türkiye	-0.093	**17**
Finland	-0.009	**10**	Lithuania	-0.146	**24**	United Kingdom	-0.012	**11**
France	0.062	**4**	Mexico	-0.240	**28**	United States	0.157	**1**
Germany	-0.060	**15**	Netherlands	0.125	**3**			

The MABAC rankings corroborate the insights derived from the CRITIC-based criterion weightings. High-performing countries—including the United States (1st), Korea (2nd), the Netherlands (3rd), and France (4th)—exhibit superior transportation efficiency, largely attributable to their advanced digital ecosystems, high labor productivity, well-developed financial systems, and sustainability-oriented policy frameworks. By contrast, countries such as Colombia, Costa Rica, and the Slovakia occupy lower positions in the ranking, reflecting structural deficiencies in transportation infrastructure (TInf) quality and digitalization (DIG).

4.3. Sensitivity Analysis

A sensitivity analysis was conducted to assess the robustness and appropriateness of the proposed hybrid model in evaluating the transportation infrastructure (TInf) performance of OECD countries. The analysis was carried out in two stages: first, by comparing country rankings obtained under different criterion weighting schemes, and second, by examining ranking outcomes derived from alternative MCDM methods.

4.3.1 Comparison of Criteria Weights

In this stage of the sensitivity analysis, the impact of alternative criterion weighting schemes—namely Entropy, Standard Deviation (SD), and Equal Weight (EW)—on the ranking results was examined. These weighting techniques were selected because they generate objective weights based on the amount and distribution of information contained in the criteria, thereby minimizing subjective influence (Zavadskas & Turskis, 2011). Owing to their objectivity and methodological simplicity, Entropy, SD, and EW are widely employed in sensitivity analyses within the MCDM literature. In this study, the criterion weights obtained from these alternative methods are incorporated into the MABAC framework to compare ranking outcomes across different weighting structures.

Graph 1: Comparison of Rankings with Different Weighting Methods

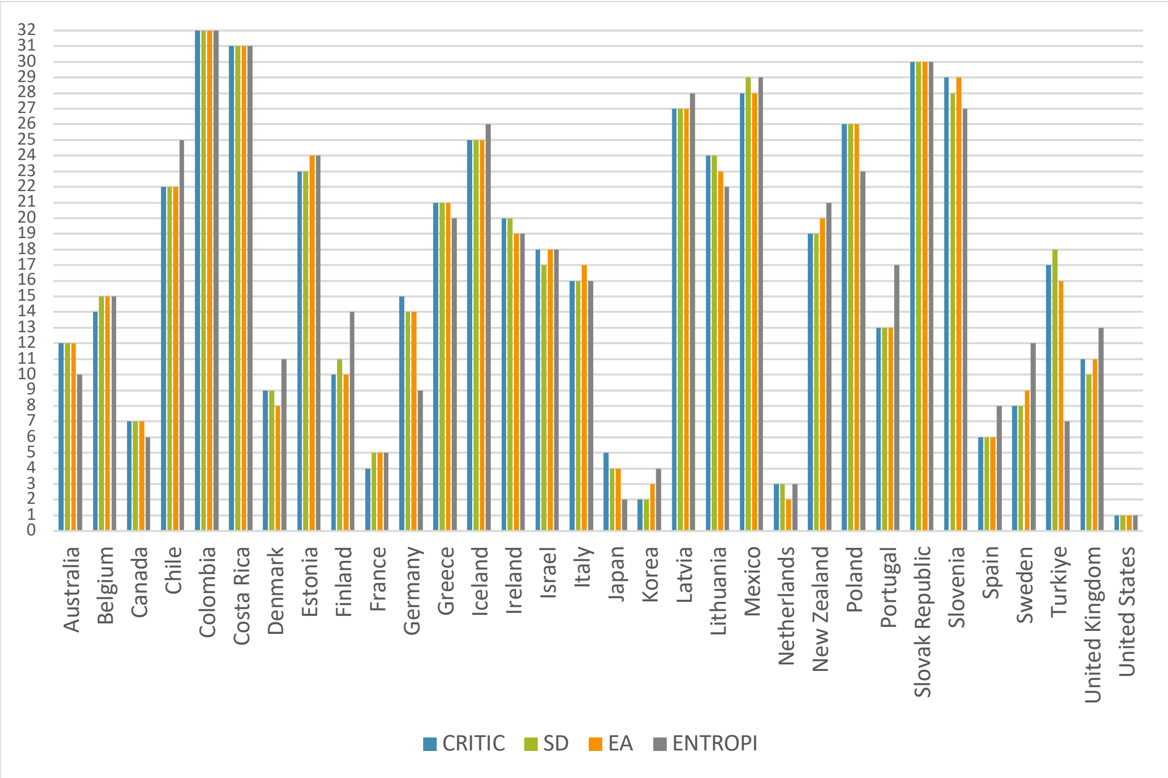


Table 11: Comparison of Rankings with Different Weighting Methods

Country	*Si (CRITIC-MABAC)*	*Rank*	*Si (SD-MABAC)*	*Rank*	*Si (EW-MABAC)*	*Rank*	*Si (Entropy-MABAC)*	*Rank*
United States	0.157	**1**	0.179	**1**	0.195	**1**	0.26	**1**
Korea	0.134	**2**	0.164	**2**	0.17	**3**	0.101	**4**
Netherlands	0.125	**3**	0.16	**3**	0.176	**2**	0.122	**3**
France	0.062	**4**	0.099	**5**	0.111	**5**	0.087	**5**
Japan	0.045	**5**	0.106	**4**	0.126	**4**	0.135	**2**
Spain	0.02	**6**	0.05	**6**	0.072	**6**	0.04	**8**
Canada	0.016	**7**	0.042	**7**	0.059	**7**	0.055	**6**
Sweden	0.009	**8**	0.036	**8**	0.055	**9**	0.019	**12**
Denmark	0.004	**9**	0.036	**9**	0.058	**8**	0.031	**11**
Finland	-0.009	**10**	0.017	**11**	0.047	**10**	-0.006	**14**
United Kingdom	-0,012	**11**	0.018	**10**	0.036	**11**	0.01	**13**
Australia	-0.024	**12**	0.008	**12**	0.028	**12**	0.031	**10**
Portugal	-0.043	**13**	-0.012	**13**	0.008	**13**	-0.031	**17**

Belgium	-0.057	**14**	-0.035	**15**	-0.005	**15**	-0.015	**15**
Germany	-0.06	**15**	-0.023	**14**	0.006	**14**	0.033	**9**
Italy	-0.089	**16**	-0.068	**16**	-0.031	**17**	-0.02	**16**
Türkiye	-0.093	**17**	-0.082	**18**	-0.013	**16**	0.048	**7**
Israel	-0.097	**18**	-0.077	**17**	-0.042	**18**	-0.072	**18**
New Zealand	-0.114	**19**	-0.092	**19**	-0.059	**20**	-0.095	**21**
Ireland	-0.126	**20**	-0.096	**20**	-0.059	**19**	-0.073	**19**
Greece	-0.136	**21**	-0.111	**21**	-0.073	**21**	-0.095	**20**
Chile	-0.139	**22**	-0.122	**22**	-0.081	**22**	-0.166	**25**
Estonia	-0.145	**23**	-0.142	**23**	-0.093	**24**	-0.144	**24**
Lithuania	-0.146	**24**	-0.145	**24**	-0.09	**23**	-0.128	**22**
Iceland	-0.176	**25**	-0.159	**25**	-0.125	**25**	-0.167	**26**
Poland	-0.194	**26**	-0.18	**26**	-0.127	**26**	-0.142	**23**
Latvia	-0.197	**27**	-0.195	**27**	-0.137	**27**	-0.187	**28**
Mexico	-0.24	**28**	-0.237	**29**	-0.174	**28**	-0.191	**29**
Slovenia	-0.243	**29**	-0.229	**28**	-0.178	**29**	-0.178	**27**
Slovakia	-0.25	**30**	-0.251	**30**	-0.201	**30**	-0.215	**30**
Costa Rica	-0.277	**31**	-0.283	**31**	-0.222	**31**	-0.282	**31**
Colombia	-0.328	**32**	-0.318	**32**	-0.258	**32**	-0.302	**32**

Based on the evidence presented in Graph 1 and Table 11, the results obtained from the four different weighting approaches—CRITIC–MABAC, SD–MABAC, EW–MABAC, and Entropy–MABAC—exhibit a high degree of similarity, despite minor ranking variations for certain countries. Notably, the countries occupying the top and bottom positions remain unchanged across all weighting schemes. This overall consistency indicates that the ranking outcomes are largely stable across alternative weighting methods, thereby confirming the robustness, validity, and internal consistency of the proposed hybrid model.

4.3.1 Comparison of Rankings with Different MCDM Methods

In this stage of the sensitivity analysis, the transportation infrastructure (TInf) performance rankings of OECD countries are compared using alternative MCDM methods. Specifically, the ARAS, COPRAS, and VIKOR methods—representing linear and compensatory decision-making approaches—are employed to examine the stability of the ranking results under different methodological assumptions. These methods are particularly suitable for sensitivity analysis, as they allow for greater discrimination among alternatives across diverse decision contexts (Tzeng & Huang, 2011).

In this study, all alternative ranking methods are implemented using the criterion weights derived from the CRITIC approach to ensure methodological consistency. The ranking outcomes obtained from the proposed hybrid model are subsequently compared with those generated by the CRITIC–ARAS, CRITIC–COPRAS, and CRITIC–VIKOR combinations. The comparative results of this analysis are illustrated in Graph 2.

Graph 2. Comparing Rankings with Different Ranking Methods

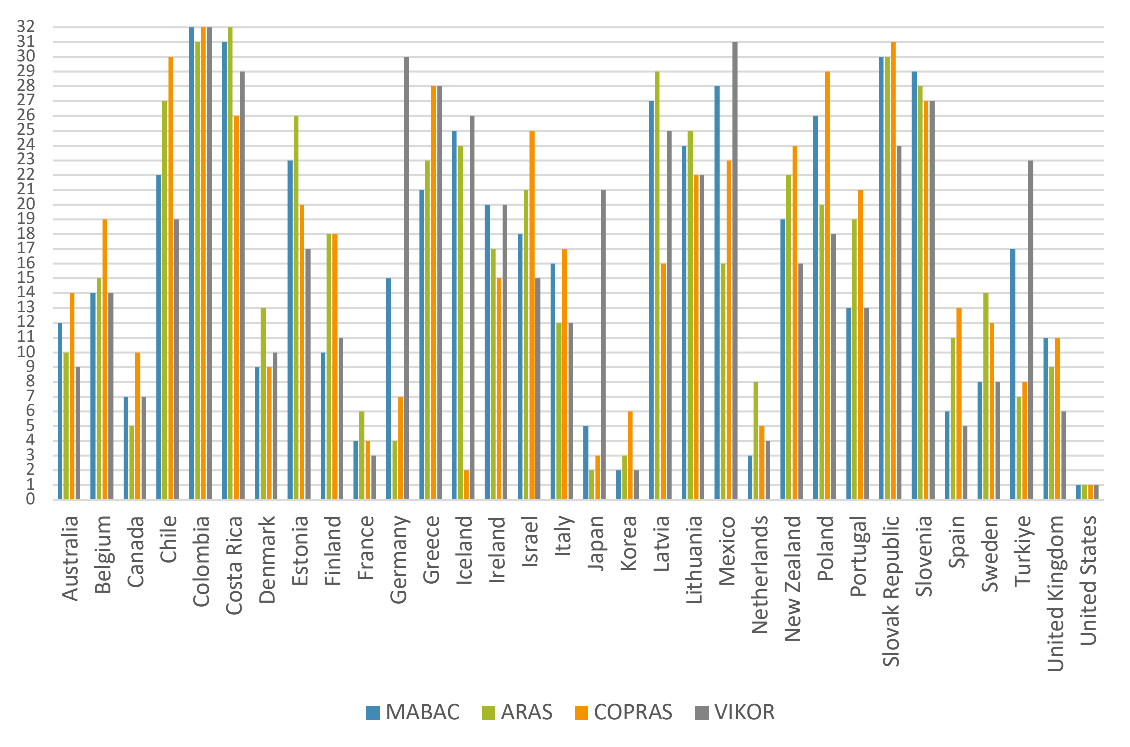


Table 12: Comparing Rankings with Different Ranking Methods

Country	***Si (CRITIC-MABAC)***	***Rank***	***Ki (CRITIC-ARAS)***	***Rank***	***Pi (CRITIC-COPRAS)***	***Rank***	***Qj (CRITIC-VIKOR)***	***Rank***
United States	0.157	**1**	1.3799	**1**	100	**1**	0.05	**1**
South Korea	0.134	**2**	0.6297	**3**	64.17	**6**	0.06	**2**
Netherlands	0.125	**3**	0.5727	**8**	64.47	**5**	0.143	**4**
France	0.062	**4**	0.5964	**6**	65.22	**4**	0.1	**3**
Japan	0.045	**5**	0.7353	**2**	71.87	**3**	0.575	**21**
Spain	0.02	**6**	0.5405	**11**	59.86	**13**	0.187	**5**
Canada	0.016	**7**	0.5972	**5**	61.46	**10**	0.217	**7**
Sweden	0.009	**8**	0.5015	**14**	60.18	**12**	0.287	**8**
Denmark	0.004	**9**	0.5079	**13**	61.79	**9**	0.301	**10**
Finland	-0.009	**10**	0.4776	**18**	57.22	**18**	0.309	**11**
United Kingdom	-0.012	**11**	0.5614	**9**	61	**11**	0.188	**6**
Australia	-0.024	**12**	0.5599	**10**	59.43	**14**	0.291	**9**
Portugal	-0.043	**13**	0.4499	**19**	54.07	**21**	0.346	**13**
Belgium	-0.057	**14**	0.4899	**15**	56.05	**19**	0.354	**14**
Germany	-0.06	**15**	0.6245	**4**	63.88	**7**	0.724	**30**
Italy	-0.089	**16**	0.5348	**12**	58.2	**17**	0.344	**12**
Türkiye	-0.093	**17**	0.5921	**7**	63.41	**8**	0.587	**23**
Israel	-0.097	**18**	0.438	**21**	51.41	**25**	0.405	**15**

New Zealand	-0.114	**19**	0.4259	**22**	51.84	**24**	0.431	**16**
Ireland	-0.126	**20**	0.4873	**17**	58.79	**15**	0.543	**20**
Greece	-0.136	**21**	0.4191	**23**	49.53	**28**	0.665	**28**
Chile	-0.139	**22**	0.3843	**27**	43.97	**30**	0.542	**19**
Estonia	-0.145	**23**	0.3855	**26**	54.88	**20**	0.506	**17**
Lithuania	-0.146	**24**	0.3941	**25**	54	**22**	0.586	**22**
Iceland	-0.176	**25**	0.3988	**24**	87.77	**2**	0.623	**26**
Poland	-0.194	**26**	0.4431	**20**	47.17	**29**	0.537	**18**
Latvia	-0.197	**27**	0.3567	**29**	58.49	**16**	0.618	**25**
Mexico	-0.24	**28**	0.4884	**16**	52.47	**23**	0.755	**31**
Slovenia	-0.243	**29**	0.3681	**28**	50.88	**27**	0.639	**27**
Slovakia	-0.25	**30**	0.3464	**30**	42.58	**31**	0.603	**24**
Costa Rica	-0.277	**31**	0.3068	**32**	50.89	**26**	0.695	**29**
Colombia	-0.328	**32**	0.3299	**31**	38.84	**32**	0.881	**32**

Based on the evidence presented in Figure 2 and Table 12, the ranking results obtained using four different MCDM methods—CRITIC–MABAC, CRITIC–ARAS, CRITIC–COPRAS, and CRITIC–VIKOR—exhibit a high degree of similarity, with only minor variations across certain countries. Across all four methods, the United States consistently ranks first, while Colombia occupies the lowest position in the MABAC, COPRAS, and VIKOR rankings and ranks 31st under the ARAS method. Although some methodological differences lead to slight ranking shifts, the overall country rankings remain largely stable. These findings confirm the robustness, validity, and internal consistency of the proposed hybrid model.

5. FINDINGS AND DISCUSSION

In this study, the CRITIC method is employed to determine the weights of transportation, financial, environmental, digital, and economic criteria, followed by the MABAC method to rank OECD countries according to their overall performance. The results indicate that top-ranked countries primarily distinguish themselves through strong digital infrastructure, efficient transportation networks, and high economic productivity (OECD, 2023b). In particular, the use of digital platforms in transportation services (w=0.129) and broadband internet penetration (w=0.115) emerge as the most influential drivers of modern logistics efficiency (World Bank, 2022).

The United States, South Korea, Netherlands, France and Japan lead the rankings due to their advanced technology-driven transportation systems, high efficiency in port logistics and railway infrastructure (OECD, 2021a). Spain, Canada, Sweden, Denmark also achieve relatively high rankings, supported by improvements in foreign direct investment inflows (w = 0.103) and road infrastructure quality (IMF, 2023). For top-performing countries, further efficiency gains can be achieved through increased investment in sustainable transportation solutions, such as electric and hydrogen-powered vehicles, to mitigate CO_2 emissions (IEA, 2023b). In addition, the integration of artificial intelligence and Internet of Things (IoT) technologies into logistics systems can facilitate smarter and more resilient supply chains (McKinsey & Company, 2022).

Countries occupying middle positions in the rankings generally display balanced but moderate performance. These countries often exhibit strengths in digitalization but face weaknesses in transportation workforce productivity or environmental performance, particularly CO_2 emissions (w=0.077). Nordic countries, including Denmark, Sweden, United Kingdom, and Finland, demonstrate high broadband adoption rates but lag behind in rail and port efficiency (ITF, 2022). Similarly, Türkiye, Italy, Portugal, and Greece encounter challenges related to economic competitiveness, as reflected in lower GDP per capita (w=0.083), and slower infrastructure modernization processes (European Commission, 2023). For these countries, efficiency improvements may be achieved through increased automation in rail and port operations and by attracting foreign direct investment in transportation infrastructure via public–private partnership models (OECD, 2022; World Bank, 2023).

Lower-ranked countries face more pronounced structural constraints, including underdeveloped transportation infrastructure, limited digitalization, and economic capacity restrictions (WEF, 2023). Mexico and Colombia are particularly affected by high CO_2 emissions and inefficient port services, while several Eastern European countries-such as Poland, Slovakia, and Slovenia-require improvements in labor productivity (w=0.090) and greater attractiveness for foreign direct investment (EBRD, 2022). For these countries, prioritizing investments in road and broadband infrastructure represents a critical first step toward enhancing transportation and logistics efficiency (ITU, 2023b). Furthermore, the adoption of green transportation policies, including the use of renewable energy in public transport systems, can contribute to both efficiency improvements and environmental sustainability (UNEP, 2022).

From Türkiye's perspective, air transport efficiency emerges as a relative strength, largely attributable to major investments in international hubs such as Istanbul Airport (Arslan & Khisty, 2020). The country's moderate performance in port services reflects its strategic geographic position and increasing maritime trade volume (OECD, 2021a). However, deficiencies in infrastructure maintenance and congestion continue to limit efficiency, with road and rail infrastructure remaining below the EU average (World Bank, 2020). In addition, relatively low broadband penetration and limited adoption of smart logistics technologies constrain digital logistics capabilities, particularly in areas such as cargo tracking and automation (OECD, 2021a). Türkiye's heavy reliance on road transportation further exacerbates environmental pressures, resulting in elevated carbon emissions (IEA, 2022).

6 CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

This study evaluates the transportation infrastructure (TInf) performance of OECD countries using a multi-criteria decision-making (MCDM) framework that integrates digitalization (DIG), economic development, financial development, environmental quality, and social conditions. The findings demonstrate that digitalization has become the dominant driver of transportation infrastructure performance, surpassing traditional physical infrastructure indicators in determining national competitiveness and logistics efficiency.

The results show that criteria related to digital platforms and broadband connectivity carry the highest weights, indicating that transportation efficiency in advanced economies increasingly depends on data-driven systems, digital connectivity, and technological integration rather than solely on roads, ports, or railways. Financial development and environmental performance play complementary but still significant roles, reflecting the need to balance efficiency gains with sustainability objectives. Labor productivity and CO_2 emissions emerge as moderate drivers, highlighting the dual challenge of improving operational performance while reducing environmental externalities.

Country-level results further reinforce these conclusions. The United States, South Korea, Netherlands, France, and the Netherlands rank at the top due to their strong digital infrastructure, high labor productivity, and integrated sustainability-oriented policies. In contrast, Slovakia, Costa Rica, and Colombia occupy lower positions, primarily due to deficiencies in digitalization and transportation infrastructure quality. Overall, the findings indicate that transportation infrastructure performance is increasingly shaped by the interaction between digitalization, finance, and sustainability, rather than by physical infrastructure alone.

By adopting a multidimensional perspective, this study contributes to the literature by demonstrating that digital transformation is no longer a supporting element of transportation systems but a core determinant of logistics efficiency and national competitiveness in OECD countries.

6.2. Policy Implications

The empirical findings offer clear and actionable guidance for policymakers and practitioners responsible for transportation, logistics, and digital infrastructure planning.

First, national transportation strategies should explicitly recognize digital infrastructure as a core policy pillar, equivalent in importance to physical assets. Investments in broadband connectivity, digital transportation platforms, and data-based traffic and logistics management systems should be prioritized to enhance efficiency, resilience, and service quality.

Second, strategic investment decisions should adopt an integrated approach that simultaneously promotes digital capacity, financial development, and sustainability. Public authorities can use the ranking results as a diagnostic tool to identify priority areas and design targeted investment programs, particularly through public–private partnerships that attract foreign direct investment into smart and green transportation projects.

Third, regulatory frameworks should be adapted to facilitate innovation in transportation services. Reducing entry barriers for digital logistics providers, supporting workforce digital skill development, and offering incentives for technology-oriented and environmentally sustainable investments can accelerate modernization without the high costs associated with large-scale physical infrastructure expansion.

Fourth, environmental considerations should be embedded into transportation policy design. Promoting green logistics solutions—such as electric and hydrogen-powered vehicles, smart ports, and energy-efficient rail systems—can improve both efficiency and environmental performance. Market-based instruments, including carbon pricing mechanisms, can further support emissions reduction while maintaining economic efficiency.

From Türkiye's perspective, the results highlight a mixed performance profile. While air transportation efficiency reflects successful large-scale investments, persistent gaps in digital logistics capabilities and environmental performance signal the need for policies focused on smart logistics adoption, broadband expansion, and emission reduction. These insights can directly inform national transportation master plans and digital transformation strategies.

6.3. Limitations and Future Research

Despite its contributions, this study has several limitations. Digitalization is represented by a limited number of indicators due to data availability constraints. In addition, the analysis relies exclusively on objective weighting methods, with CRITIC used as the primary technique, while alternative objective weights are examined only through sensitivity analysis. Future research may expand the framework by incorporating broader indicator sets, expert-based subjective weighting methods, and dynamic or fuzzy MCDM models. Integrating geopolitical risks, such as pandemics or conflicts, and exploring AI-based MCDM approaches may further enhance real-time policy relevance and country-specific decision support.

REFERENCES

Akçakanat, Ö., Aksoy, E. ve Teker, T. (2018). CRITIC ve MDL temelli EDAS yöntemi ile TR-61 bölgesi bankalarının performans değerlendirmesi. *Süleyman Demirel Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 1*(32), 1-24. E

Ahmed, Z., Ahmad, M., Rjoub, H., Kalugina, O. A., & Hussain, N. (2021). Economic growth, renewable energy consumption, and ecological footprint: Exploring the role of environmental regulations and democracy in sustainable development. *Sustainable Development*. *30*, 595–605. https://doi.org/10.1002/SD.2251

Altay Topçu, B. (2021). Dijital Ekonomi ve Göstergelerinin Sürdürülebilir Kalkınma Üzerindeki Etkisi: AB Ülkeleri Örneği. *Uluslararası Yönetim Akademisi Dergisi, 4*(2), 455-465.

Akyol, H., Akar, T. ve Akar, G. (2023). Dijitalleşme ve ekonomik büyüme: AB ülkelerinden yeni kanıtlar. *Balıkesir Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 26*(49), 99-114.

Arslan, T., & Khisty, C. J. (2020). Transportation challenges in emerging economies: The case of Turkey. *Transport Policy, 85*, 1-12. https://doi.org/10.1016/j.tranpol.2019.10.003

Arvis, J. F., Raballand, G., & Marteau, J. F. (2007). The cost of being landlocked: logistics costs and supply chain reliability (Vol. 4258). World Bank Publications.

Arvis, J. F., Saslavsky, D., Ojala, L., Shepherd, B., Busch, C., & Raj, A. (2018). Connecting to Compete 2018: Trade Logistics in the Global Economy – The Logistics Performance Index and Its Indicators. World Bank.

Ayçin, E. (2020). Personel seçim sürecinde CRITIC ve MAIRCA yöntemlerinin kullanılması. *İşletme, 1*(1), 1-12.

Bardakci, M., Erdoğdu, A., ve Barut, A. (2020). G-7 ve E-7 Ülkelerinde Lojistik Performans, Ekonomik Büyüme ve Finansal Gelişme İlişkisi. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi. 4*(4), 1011–1030. https://doi.org/10.47428/itobiad.799017

Barro, R. (1990). Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy, 98*(5), 102–125.

Behzadian, M., Otaghsara, S. K., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. *Expert Systems with Applications*, *39*(17), 13051–13069.

Çetin, Ö. O., ve Karataş, M. (2024). BİST'te işlem gören otomotiv şirketlerinin kârlılık performansının LOPCOW ve MABAC yöntemleriyle analizi. *Nevşehir Hacı Bektaş Veli Üniversitesi SBE Dergisi, 14*(3), 1470-1496.

Demirbaş, S., Üre, N., Demir, M., & Karaköy, C. (2021). The effect of financial development on logistics performance: Evidence from emerging markets. *Sustainable Economics and Management Studies,* 1(1), 1–13. https://scioasis.mycpanel.rs/sems/index.php/sems/article/view/24

Diakoulaki, D., Mavrotas, G., & Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: The CRITIC method. *Computers & Operations Research, 22*(7), 763-770. https://doi.org/10.1016/0305-0548(94)00059-H

Din, M. U., Jiang, C., Bhatti, M. I., & Shahid, M. (2022). Population density: An underlying mechanism between road transportation and environmental quality. *Frontiers in Environmental Science, 10*. https://doi.org/10.3389/fenvs.2022.940911

Downs, A. (2004). Still Stuck in Traffic: Coping with Peak-Hour Traffic Congestion. Brookings Institution Press.

European Bank for Reconstruction and Development (EBRD). (2022). Transition report 2022: Policies for a green economy. https://www.ebrd.com

European Commission. (2023). Transport in the European Union: Current trends and challenges. Publications Office of the European Union. https://transport.ec.europa.eu

Febriyanto, A., Sasana, H., Prakoso, J., & Satriagasa, M. (2024). The impact of land, sea, and air transportation infrastructure on economic growth in G7 countries. *Journal of Applied Economics in Developing Countries, 9*(2), 50-59. http://dx.doi.org/10.20961/jaedc.v9i2.90655

Gigović, L., Pamučar, D., Božanić, D. & Ljubojević, S. (2017). Application of the GIS-DANP-MABAC Multi-Criteria Model for Selecting the Location of Wind Farms: A Case Study of Vojvodina, Serbia, *Renewable Energy, 103*, 501-521.

Gomes, S., Lopes, J. M., ve Ferreira, L. (2022). The Impact of the Digital Economy on Economic Growth: The case of OECD countries. *Revista de Administração Mackenzie, 23*(6), 1–31.

Gökgöz, F., & Yalçın, E. (2023). Evaluating the transport sustainability of OECD countries with MCDM approach. In Proceedings of the Global Conference on Transport and Traffic Engineering (GCTTE) (pp. 73-81).

Guild, R. L. (2000). Infrastructure Investment and Interregional Development: Theory, Evidence, and Implications for Planning. *Journal of Planning Literature*.

Gürler, H. E. (2024). Ulaşım altyapı performansının çok kriterli karar verme yöntemleriyle değerlendirilmesi: Seçilmiş ülkeler üzerine bir analiz. *İktisadi İdari ve Siyasal Araştırmalar Dergisi, 9*(24), 238-256. https://doi.org/10.25204/iktisad.1454785

Hassan, I., Alhamrouni, I., & Azhan, N. H. (2023). A CRITIC–TOPSIS Multi-Criteria Decision-Making Approach for Optimum Site Selection for Solar PV Farm. *Energies, 16*(10), 4245. https://doi.org/10.3390/en16104245

IATA. (2020). Economic Performance of the Airline Industry. https://www.iata.org

International Energy Agency (IEA). (2022). Transport and carbon emissions. https://www.iea.org

International Energy Agency (IEA). (2023a). CO_2 Emissions in 2022. https://www.iea.org/reports/co2-emissions-in-2022

International Energy Agency (IEA). (2023b). Global EV Outlook 2023. https://www.iea.org

International Monetary Fund (IMF). (2023). World Economic Outlook: Navigating Global Divergences. https://www.imf.org/en/Publications/WEO

International Telecommunication Union (ITU). (2023a). ICT Development Index. https://www.itu.int

International Telecommunication Union (ITU). (2023b). Measuring Digital Development: Facts and figures 2023. https://www.itu.int/en/ITU-D/Statistics

International Transport Forum (ITF). (2019). ITF Transport Outlook 2019. OECD Publishing, Paris, https://www.oecd.org/publications/itf-transport-outlook-2019_transp_outlook-en-2019-en.htm

International Transport Forum (ITF). (2022). Transport Outlook 2022. https://www.itf-oecd.org

Kabaklarlı, E. & Atasoy, B. S. (2019). Broadband Infrastructure and Economic Growth: A Panel Data Approach for Selected Countries. *DIEM, 4*(1), 105-114.

Khan, S. A. R., & Qianli, D. (2017). Does national scale economic and environmental indicators spur logistics performance? Evidence from UK. *Environmental Science and Pollution Research, 24*, 26692–26705. doi:10.1007/s11356-017-0222-9

Konečný, V., Kolarovszki, P., & Machová, V. (2019). The influence of demographic development and population structure on the demand for public passenger transport. *LOGI – Scientific Journal on Transport and Logistics, 10*(1), 21–30. https://doi.org/10.2478/logi-2019-0017

Konu, A. (2020). Sürdürülebilir Kalkınma ve Dijital Ekonomi İlişkisi: AB Ülkeleri İçin Bir Araştırma. *Akademik İncelemeler Dergisi, 15*(2), 655-678. https://doi.org/10.17550/akademikincelemeler.738292

Konya, S. (2024). OECD Ülkelerinde Dijital Ekonomi-Ekonomik Büyüme İlişkisinin İncelenmesi: Bir Panel Veri Analizi. *Sakarya Üniversitesi İktisat Dergisi, 13*(3), 163-182.

Keshavarz Ghorabaee, M., Zavadskas, E. K., Olfat, L., & Turskis, Z. (2015). Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS). *Informatica, 26*(3), 435-451.

Limao, N., & Venables, A. J. (2001). Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank Economic Review*, *15*(3), 451–479. https://doi.org/10.1093/wber/15.3.451

Litman, T. (2021). Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts in Transport Planning. Victoria Transport Policy Institute. Retrieved from https://www.vtpi.org/equity.pdf

Mahpour, A., Farzin, I., Baghestani, A., Ashouri, S., Javadi, Z., & Asgari, L. (2023). Modeling the impact of logistic performance, economic features, and demographic factors of countries on the seaborne trade. *The Asian Journal of Shipping and Logistics, 39*(2), 60-66.

McKinsey & Company. (2022). The future of mobility: Reinventing transport in a digital era. https://www.mckinsey.com

Mukul, E., Büyüközkan, G., & Güler, M. (2019). Strategic analysis of intelligent transportation systems. *Beykoz Akademi Dergisi*, 148-158. https://doi.org/10.14514/byk.m.26515393.2019.sp/148-158

Nguyen, H.-Q., Nguyen, V.-T., Phan, D.-P., Tran, Q.-H., & Vu, N.-P. (2022). Multi-Criteria Decision Making in the PMEDM Process by Using MARCOS, TOPSIS, and MAIRCA Methods. *Applied Sciences, 12*(8), 3720. https://doi.org/10.3390/app12083720

Organisation for Economic Co-operation and Development (OECD) (2017). *International freight*, in ITF transport outlook 2017 (Paris: OECD Publishing). doi:10.1787/9789282108000-6-en

Organisation for Economic Co-operation and Development (OECD). (2020). Transport Infrastructure Investment and Maintenance Spending. OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). (2021a). Digital transformation in transport. https://www.oecd.org

Organisation for Economic Co-operation and Development (OECD). (2022). OECD Transport Outlook 2022. OECD Publishing. https://doi.org/10.1787/transp_outlook-en-2022

Organisation for Economic Co-operation and Development (OECD). (2023a). Transport Outlook 2023. OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). (2023b). Economic Outlook for OECD countries. https://www.oecd.org

Özbek, S., ve Oğul, B. (2022). Finansal Kuznets Eğrisi Hipotezinin Geçerliliği: Türkiye Ekonomisi Üzerine Kısa ve Uzun Dönemli Zaman Serisi Bulguları. *Dokuz Eylül Üniversitesi İşletme Fakültesi Dergisi, 23*(1), 81-97. https://doi.org/10.24889/ifede.1052625

Özdemir, L. (2017). *Relationship between financial development and logistics performance and their effects on the competitiveness: an empirical cross-country study* (Doctoral dissertation, Middle East Technical University (Turkey)).

Özdemir, L., & Küçükkaya, E. (2023). The Strength of the Association Between Financial Development and Logistics Performance. *Yönetim ve Ekonomi Dergisi*, *30*(3), 511-530.

Özgün, F. (2024). Küreselleşmenin Çevreye Etkisi: Türkiye Üzerine Bir Uygulama. *Dokuz Eylül Üniversitesi İşletme Fakültesi Dergisi,* *25*(2), 130-152. https://doi.org/10.24889/ifede.1501231

Pamučar, D. & Ćirović, G. (2015). The Selection of Transport and Handling Resources in Logistics Centers Using Multi-Attributive Border Approximation Area Comparison (MABAC), *Expert Systems with Applications, 42*(6), 3016-3028. https://doi.org/10.1016/j.eswa.2014.11.057

Pamučar, D., Petrović, I. & Ćirović, G. (2018). Modification of the Best– Worst and MABAC methods: A novel approach based on interval- valued fuzzy-rough numbers, *Expert Systems with Applications, 91*, 89-106.

Robinson, M. (2010) Transport Infrastructure Fiasco Tarnishes Australia's Reputation http://www.economy.com/dismal/analysis/121668 Retrieved:10.01.2025.

Rodrigue, J. P. (2020). The Geography of Transport Systems, 5th edition, Routledge, London.

Sasana, H. (2017). Earmarking Tax Optimization to Support the Effective and Sustainable Infrastructure. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan, 18*(2), 194-204. https://doi.org/10.23917/jep.v18i2.4168

Simic, V., Gokasar, I., Deveci, M., & Švadlenka, L. (2022). Mitigating climate change effects of urban transportation using a type-2 neutrosophic MEREC-MARCOS model. *IEEE Transactions on Engineering Management, 71*, 3233-3249.

Szymańska, E. & Zalewski, R. I. (2020). VIKOR-based assessment of EU seaports' competitiveness. *Sustainability, 12*(5), 1936.

Tzeng, G. H., & Huang, J. J. (2011). Multiple attribute decision making: methods and applications. CRC press.

United Nations Environment Programme (UNEP). (2022). Global Environment Outlook 2022: Transport and climate change. https://www.unep.org/resources/global-environment-outlook-2022

Uyar, A., Kuzey, C., Koseoglu, M. A., & Karaman, A. S. (2023). Travel and tourism competitiveness index and the tourism sector development. *Tourism Economics, 29*(4), 1005-1031.

Wan, B., Wan, W., Hanif, N., & Ahmed, Z. (2022) Logistics performance and environmental sustainability: Do green innovation, renewable energy, and economic globalization matter?. *Frontiers in Environmental Science, 10*, 996341. https://doi.org/10.3389/fenvs.2022.996341

Weng, X., Yuan, C., Li, X., & Li, H. (2024). Research on the Construction of a Risk Assessment Indicator System for Transportation Infrastructure Investment under Public–Private Partnership Model. *Buildings, 14*(6), 1679. https://doi.org/10.3390/buildings14061679

WEF (World Economic Forum). (2022). Travel & Tourism Development Index 2021: Rebuilding for a Sustainable and Resilient Future. Access on the internet: https://www.weforum.org/publications/travel-and-tourism-development-index-2021/.

WEF (World Economic Forum). (2023). The future of logistics: Digital transformation. https://www.weforum.org/reports/the-future-of-logistics-digital-transformation

Wong, M. C., & Yip, T. L. (2019). Influence of transportation infrastructure on the relationship between institutions and economic performance. *Maritime Business Review*, *4*(4), 395-412. https://doi.org/10.1108/MABR-09-2019-0038

World Bank. (2020). Connecting to compete 2020: Trade logistics in the global economy – The logistics performance index and its indicators. Washington, DC: World Bank.

World Bank. (2022). Logistics Performance Index (LPI) 2022: Connecting to compete. https://lpi.worldbank.org

World Bank. (2023). Logistics Performance Index (LPI) report. https://lpi.worldbank.org

Yazdani, M., Zarate, P., Kazimieras Zavadskas, E., & Turskis, Z. (2019). A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems. *Management Decision, 57*(9), 2501-2519. https://doi.org/10.1108/MD-05-2017-0458

Zavadskas, E. K., & Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: An overview. *Technological and Economic Development of Economy*, *17*(2), 397-427.

Zhang, L., Li, Z., Kirikkaleli, D., Adebayo, T. S., Adeshola, I., & Akinsola, G. D. (2021). Modeling CO2 emissions in Malaysia: An application of maki cointegration and wavelet coherence tests. *Environmental Science and Pollution Research, 28,* 26030–26044. doi:10.1007/s11356-021-12430-x

Zhao, P., & Li, S. (2016). Restraining transport inequality in growing cities: Can spatial planning play a role? *International Journal of Sustainable Transportation, 10*(10), 947–959. https://doi.org/10.1080/15568318.2016.1165483