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How Criteria Weights Influence Performance in Evaluating Logistic Productivity: An Application in the Emerging Markets Logistics Index

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ABSTRACT

Purpose: The differences between the criteria affecting the logistics performance of countries and their importance levels are meaningful in terms of policy development processes. It has been determined that the criteria are weighted equally in the emerging markets logistics index. For this reason, the study reweighted the criteria of the Emerging Markets Logistics Index and investigated the effects of weighting on the ranking. In this respect, the study aims to make the index more objective.

***Methodology*:** In the study, Multi-Criteria Decision Making methods were utilized. Within this context, MEREC (Method Based on the Removal Effects of Criteria) was used to determine the criteria weights, while MABAC (Multi Attributive Border Approximation Area Comparison) and MAIRCA (Multi Attributive Ideal Real Comparative Analysis) methods were preferred to rank the alternatives.

Findings: In the study, it was concluded that the weighted values of the criteria are more consistent with the literature. Additionally, the new weights obtained have an effect on the ranking values of the countries.

Orginality: It is important that emerging markets provide an opportunity to develop infrastructure to increase logistics productivity and provide a platform for the implementation of new technologies in logistics operations. Furthermore, these markets enable the diversification and development of logistics services through the expanding consumer demand. This study differs from other studies in the literature because it preferred the Agility Emerging Markets Logistics Index (AEMLI) instead of the Logistic Performance Index (LPI) and used MEREC-based MABAC-MAIRCA methods.

Keywords*:* Logistic Productivity, AEMLI, MEREC, MABAC, MAIRCA.
JEL Codes: C40, F14, L90.

Lojistik Verimliliğini Değerlendirmede Kriter Ağırlıkları Performansı Nasıl Etkiliyor: Yeni Gelişen Pazarlar Lojistik Endeksinde Bir Uygulama

ÖZET

Amaç: Ülkelerin lojistik performanslarını etkileyen kriterler arasındaki farklılıklar ve önem dereceleri politika geliştirme süreçleri açısından anlam ifade etmektedir. Yeni gelişen pazarlar lojistik endeksinde kriterlere eşit düzeyde ağırlık verildiği tespit edilmiştir. Bu nedenle çalışmada Yeni Gelişen Pazarlar Lojistik Endeksi'ne ait kriterler yeniden ağırlıklandırılarak, ağırlıklandırmanın sıralamaya olan etkileri araştırılmıştır. Bu yönüyle çalışma incelemeye aldığı endeksi daha objektif hale getirmeyi amaçlamaktadır.

***Yöntem*:** Çalışmada ÇKKV yöntemlerinden faydalanılmıştır. Bu çalışmada kriter ağırlıklarının belirlenmesinde MEREC, alternatiflerin sıralanmasında ise MABAC ve MAIRCA yöntemleri tercih edilmiştir.

Bulgular: Çalışmada kriterlerin ağırlıklandırılmış değerlerinin literatür ile daha uyumlu olduğu sonucuna ulaşılmıştır. Ayrıca elde edilen yeni ağırlıkların ise ülkelerin sıra değerleri üzerinde etkisi olduğu görülmüştür.

Özgünlük: Yeni gelişen pazarlar, lojistik verimliliği artırmak için altyapı geliştirme ve yeni teknolojilerin uygulanmasına zemin sağlamaktadır. Ayrıca, genişleyen tüketici talebi ile lojistik hizmetlerin çeşitlenmesine ve gelişmesine olanak tanımaktadır. Bu çalışma, Logistic Performance Index (LPI) yerine Agility Emerging Markets Logistics Index (AEMLI)'yi tercih etmesi ve MEREC tabanlı MABAC-MAIRCA yöntemlerini kullanmasıyla literatürdeki diğer çalışmalardan ayrılmaktadır.

Anahtar Kelimeler*:* Lojistik verimliliği, AEMLI, MEREC, MABAC, MAIRCA.
JEL Kodları: C40, F14, L90.

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1. INTRODUCTION

In contemporary contexts, logistics activities are crucial not only in the realms of production, exportation, sales, and post-sales processes but also in creating value that aligns with meeting customer expectations. This capability is essential for sustaining competitiveness for both enterprises and nations. The increasing significance attributed to logistics correlates with its expanding role in international commercial relations over successive periods. This correlation directs attention to logistics as a discipline predisposed towards fostering better collaboration among stakeholders located in diverse environments, enabling them to achieve mutual understanding and effective cooperation (Kuković, 2014). The increased prominence of transportation costs within total expenditures has underscored efforts to achieve superior operational outcomes at reduced costs, thereby highlighting the critical importance of controlling transportation, storage, and distribution activities (Bayraktutan and Özbilgin, 2015). The term "logistics", derived from the Greek "logistikos" (pertaining to calculation) and the French "logistique" (pertaining to supply and lodgings), primarily originates from the fusion of "logic" and "statistics" (Gülenç and Karagöz, 2008). Logistics encompasses the entirety of activities aiding the management of product, information, and cash flows from production to consumption points (Lambert et al., 1998: 13-14). Initially confined to transportation and storage, logistics has evolved to encompass demand forecasting, inventory management, transportation, material handling, packaging, site selection, and order processing activities due to globalization and technological advancements. The importance of foreign trade, particularly in exports, is significant in enhancing countries' economic growth rates and enabling them to capture a larger share of international markets. Moreover, recent trends show that foreign trade transactions, which have increasingly become complex, now operate in conjunction with logistics. This has necessitated the imperative for countries to develop and integrate their logistics policies with their foreign trade strategies (Erkan, 2014).

The relationship between logistics performance and economic growth is becoming increasingly significant due to efficient logistics systems that facilitate trade, reduce costs, and enhance market access. Technological innovations, particularly automation and data analytics, contribute to making logistics processes more efficient, resulting in faster delivery times and lower supply chain costs. This can be considered a direct contributing factor to economic growth. In this context, investments in logistics infrastructure are said to support economic development by enhancing competitiveness. Emphasize the role of supply chains as a critical component of international trade, which includes elements such as freight transportation, warehousing, customs procedures, payment systems, and processes outsourced by manufacturers and sellers (Arvis et al., 2018: 8; Popescu and Sipos, 2014). Efficient logistics are vital for economic growth, diversification, and poverty alleviation. The logistics sector has accelerated the pace of economic globalization, enhancing inter-industry connections and intensifying the spread of growth stimuli across economic areas and on a global scale. Additionally, logistic development strengthens regional information and economic factor exchanges, expanding the market space, which in turn has a spillover effect on the economic growth of surrounding areas (Candemir and Çelebi, 2017; Khadim et al., 2021; Xu and Wang, 2017). The literature indicates that countries with better logistics infrastructure are more likely to experience high economic growth compared to those with weaker logistics infrastructure (Shikur, 2022). Numerous studies in the literature have examined the impact of logistics performance on economic development (Cheng and Peng, 2006; Chu, 2012; Hayaloğlu, 2015; Lean et al., 2014; Shikur, 2022). However, there are studies among these that have not achieved the expected results regarding the impact of logistics performance on economic development (Demurger, 2001; Pradhan and Bagchi, 2013). This raises the important question of what the sources of this discrepancy are. It is anticipated that quantitative values or numerical methods have an influence on these results. Tomassian et al. (2014) attempted to explain how a country's likelihood of development is affected while considering general logistics variables along with some traditional explanatory variables. The authors concluded that there is a positive effect between logistics performance and a country's likelihood of development. When searching for answers to the question of how quantitative values or numerical methods create differences, the following responses can be reached: the use of different measurement methods for distinct definitions (Khan et al., 2019), variations in the geography of the studies and the economic contexts related to this geography, and the improper use of numerical methods. For these reasons, there is a need for more consistent and robust methodological approaches to understand the relationship between logistics performance and economic growth. Sufficient data quality and the appropriate application of numerical methods can elucidate this relationship more accurately.

In this context, factors influencing the evolution of the concept of logistics include globalization, the emergence of new economic paradigms, differentiation in competition and its consequences, and technological advancements (Bakan and Şekkeli, 2017: 7). One of the indices used to determine the logistics performance of countries is the Agility Emerging Markets Logistics Index (AEMLI). AEMLI published by Agility, is a global study aimed at measuring the attractiveness of logistics investments in selected developing countries' markets (Bayraktutan and Özbilgin, 2015). In an index comprising specific categories, each category includes varying numbers of sub-variables. Statistical techniques are employed to calculate sub-indices, where the total index value is determined by averaging the values of these sub-indices. This scenario was exemplified in the 2023 publication of the index as follows: logistics capabilities within developing markets were measured using metrics for domestic opportunities, international opportunities, business fundamental, and digital readiness.

Technological advancements and trade liberalization offer new opportunities for countries to benefit from global markets in terms of growth and poverty reduction according to their own interests. Consequently, the cost of countries with weak connections to the global logistics network staying outside this network is increasing (Kara et al., 2009). This situation associated with domestic opportunities is significant for assessing logistics productivity and performance. Efficient utilization of infrastructure tailored to the needs of the logistics sector is considered a key element among logistics centers (Bamyacı, 2008: 68). Domestic opportunities measure the potential of domestic logistics services in emerging markets to meet domestic market demands. In addressing the information needs of foreign trade stakeholders regarding countries' logistics capacities and performances, domestic opportunities are recognized as an important factor (Kara, 2022). International opportunities are crucial in both exploring and creating prospects, referencing the vital importance of business connections for logistics (Galan and Torsein, 2021). Logistics productivity reveals how effectively supply chain companies are connected with both domestic and international opportunities (The World Bank, 2018: 7; Śtimac et al., 2021). From a business readiness perspective, the concept of logistics encompasses the analysis and determination of solutions for issues concerning business processes, costs, and services. In this context, logistics also facilitates the formation of departments and inter-company relationships within logistics enterprises (Pfohl, 2022: 45). Savytska et al. (2022) argue that in the context of digital readiness, business readiness forms the foundation for considering sector-specific factors. There is consensus in the literature that businesses are compelled and challenged to innovate in various departments of their operations due to Industry 4.0 (Chen, 2020; Khanzode et al., 2021; Masood and Sonntag, 2020; Somohano-Rodrîguez et al., 2022). It is emphasized that businesses require sufficient resources, capabilities, and strategies to possess the necessary resources for innovation. However, it has also been identified that businesses struggle to renew their processes and operations due to customer demands. Therefore, businesses collaborate with suppliers and customers in their supply chains in areas where they are lacking (Lassnig et al., 2022). Globalization and innovation management highlight the increasing importance of digital readiness for logistics productivity. The four headings described above correspond to the variables used by Agility in the AEMLI measurement from 2021 onwards. In this context, the alignment of selected variables with the literature is seen as an advantage of index calculation. Additionally, the index considers urbanization, wealth distribution, industry clustering, and market size in domestic logistics opportunities; density, customs, border, maritime, and airway efficiency in international logistics opportunities; market access, security, stability, and infrastructure in business readiness; and sustainability, skills, diversity, and development in digital transformation (Agility 2024: 62-63), which are cited as other advantages. In this context, it is stated that the index is theoretically sufficient and meets expectations. The index consists of a specific number of categories, with each category containing different numbers of sub-variables. Statistical techniques are used to calculate sub-indices, and the total index value is derived from the average of these sub-index values. This situation was exemplified in the 2023 publication of the index as follows: emerging fifty markets are measured by domestic opportunities, international opportunities, business fundamental, and digital readiness metrics, each assumed to have a 25% impact (Agility, 2022; Agility, 2023: 65). Therefore, our criticism is directed towards AEMLI allocating an equal and fixed 25% influence to each variable in the index.

In Multi-Criteria Decision Making (MCDM) methods, the stage of weighting criteria significantly influences the final decision-making process (Demir and Bircan, 2020). The accuracy of decision-making processes hinges on weighting methods that accurately determine the relative importance of each criterion (Singh and Pant, 2021). In this regard, the advantages of criterion weighting include establishing priorities, promoting higher-quality decision-making, effectively utilizing limited information presented in decision matrices, and guiding decision-making units towards sound decisions. In this context, the study suggests an alternative approach to ranking AEMLI by emphasizing the importance of weighting categories due to the utilization of MCDM methods in AEMLI index calculation. This approach aims to provide an alternative ranking to AEMLI by ensuring the proper weighting of categories.

This study aims to uncover the relationship between logistics performance and productivity through analyses that consider criterion weighting. It is observed that the significant growth of the global logistics industry has made logistics a crucial sector of the commercial economic system and a vital global economic activity in recent years. Logistics activities have an accelerating impact on the economy and productivity. Efficient logistics also play a crucial role in terms of a country's competitiveness and as a source of employment (Wong and Tang, 2018). Stock management, transportation and shipping, network and process management are considered among the primary operational efficiency factors within the concept of logistics. Evaluating logistics for productivity requires a broader assessment beyond conventional input-output concepts due to the nature of logistics. In this context, indicator and representational approaches are considered more appropriate for productivity measurements in logistics (Stainer, 1997). Today, manufacturing requires more intensive interactions to coordinate the production and distribution of numerous parts and components. It is noted that compared to the transportation networks of final goods, the networks of intermediate goods are complex and open to development. Consequently, logistics productivity is identified as a fundamental factor that needs to be analyzed when considering regional economic performance (Barilla et al., 2020). Therefore, in this study, 15 countries ranked in AEMLI are weighted and ranked using MEREC, MABAC, and MAIRCA methods based on variables determined by AEMLI. The study distinguishes itself from existing literature by aiming to contribute to the field through its findings rather than its approach to the topic. In line with this objective, the organization of the study includes a literature review that categorizes studies into three main areas: those examining logistics productivity, studies utilizing MCDM methods in logistics calculations, and studies integrating the MEREC, MABAC, or MAIRCA methods comprehensively. In addition to the introductory information provided in the study's structure, these categories are intended to enrich the literature with valuable insights. Under the methods section, explanatory details and notational representations of the numerical methods applied in the study are provided. The findings section presents numerical results obtained from the application of these methods in tabular format. In the conclusion section of the study, the findings are critically evaluated, conclusions are drawn, and implications for future research are discussed. Additionally, the expansions of all the abbreviations used in the text of this study are provided in the appendix section.

2. LITERATURE REVIEW

When considering the multidimensional impact of globalization, it is observed that the maturity of the historical background of the logistics concept aligns with its widespread presence in the literature on logistics studies. Furthermore, methods based on MCDM are increasingly utilized in the literature for conducting performance measurement and determining ranking values. Taking both aspects into account, the chronological presentation of the literature related to logistics productivity is provided. Studies that utilize MCDM methods for logistics performance measurement, integrating methods such as MEREC, MABAC, or MAIRCA, are summarized through tabular representation.

Xu et al. (2012) evaluate logistics management as a critical factor determining the successful delivery of a construction project. They investigate the loss of logistics productivity on construction sites through simulation applications, arguing that delays due to logistics activities can be better predicted. The study concludes that fluctuations in both logistics and construction activities significantly impact efficiency losses in logistics. Ohh (2012) focused on logistics productivity within the storage industry. The author employed Data Envelopment Analysis in their study. The research is significant in evaluating factors that determine efficiency in the logistics sector. The study concludes that the global number of warehouses and employees are important input criteria. Liang et al. (2020) evaluated the green total factor productivity of the logistics sector in their study. The authors suggested that governments and businesses should pay attention to the green and efficient development of the logistics sector. In Fan's (2019) study, the author utilized Data Envelopment Analysis method and the Luenberger Index to determine logistics productivity specifically within China. The study found that logistics productivities across Chinese regions are uneven, but policies implemented focus on addressing these disparities. Sereda (2021) emphasized that the digitalization of logistics processes is an effective factor in enhancing logistics productivity. The author concluded that digitalization is crucial for mitigating potential negative outcomes arising from the implementation of new technologies in logistics. Kalischuk and Nebelyuk (2021) focused on ensuring the efficiency of logistics business processes in supply chains. The authors aimed to identify logistics business processes in economic systems and concluded that the quality cycle, supply, and implementation stages are crucial. Rostek (2022) investigated the logistics productivity of a manufacturing firm. The study utilized econometric analysis as its methodology. The author proposes a productivity research procedure for the firm under study. Pfohl (2023) asserted that a prerequisite for success in logistics is the positive contribution of logistics services to the value creation of a company or an entire supply chain. A review of the literature on logistics productivity reveals that determining factors vary across companies, sectors, and countries. Furthermore, studies on logistics productivity incorporate index criteria identified by AEMLI. The literature examining the AEMLI index as a research topic has been prioritized in the initial review. In this context, Sawant (2013) applied the AEMLI to evaluate logistics infrastructure in India. Argyrou (2014), utilizing AEMLI to analyze logistics performance in Bangladesh, concluded that when local companies do not implement international supply chain management standards, logistics services are predominantly provided by foreign carriers and third-party logistics, resulting in joint venture agreements with local Bangladeshi parties. Beysenbaev (2018) investigated the importance of effective logistics and transport systems at the country level within the current international trade model. Al-Ababneh et al. (2021) examined the integration capabilities of national logistics systems in developing countries. The authors employed statistical analysis, indices, graphical and analytical methods, structural dynamic forecasting techniques, and comparisons in their studies. Kara et al. (2022) weighted the values of the AEMLI indicators using the ENTROPY method and utilized the MABAC method for ranking alternatives. Kara (2022) aimed to determine the domestic and international logistics opportunity efficiency levels of countries based on their market potentials, considering the AEMLI index. The author utilized data envelopment analysis and regression analyses in this study. Özekenci (2023) similarly employed SWARA, CRITIC, and CoCoSo methods for his research. Research utilizing MCDM methods in logistics and logistics performance measurement is summarized in Table 1.

Table 1. MCDM approach in logistics and logistics performance measurement

Author(s)	*Content*	*Method(s)*
Yalçın and Ayvaz (2020)	Logistics performance for Türkiye, Greece, Bulgaria, Georgia, and Iran	FAHP and F-TOPSIS
Alazzawi and Zak (2020)	Designing sustainable logistics corridors and supplier selection	ELECTRE III/IV and AHP
Ulutaş and Karaköy (2021)	Examining the logistics performance index values of transition economy countries	G-SWARA and G-MOORA
Korucuk (2021)	Comparative analysis of logistics performance elements in Ordu and Giresun provinces	CRITIC
Stević et al. (2021)	A proposal for customer-oriented key performance indicators (CKPIs) to determine reverse logistics quality	DELPHI, FUCOM and SERVQUAL
Altıntaş (2021)	Evaluating the logistics performance of EU countries	CRITIC, WASPAS and COPRAS
Zhang et al. (2021)	Identification of logistics center for the belt and road initiative	GRA and TOPSIS
Eren (2021)	Performance analysis of firms operating in the logistics sector	ENTROPY, CRITIC, SD and MULTIMOORA
Luyen and Thanh (2022)	Selecting and evaluating logistics service providers	SERVQUAL, FAHP and TOPSIS
Mešić et al. (2022)	Evaluating the logistics performance of Western Balkan countries	CRITIC and MARCOS
Özdağoğlu et al. (2022)	Ranking countries according to logistics assessment criteria	MAUT, TOPSIS, MOORA, MAIRCA, MABAC, WSM and WPM
Özbek and Özekenci (2023)	Investigating digital logistics market performance in developing countries	LOPCOW, MAUT, TOPSIS, MARCOS and CoCoSo
Miškić et al. (2023)	Evaluating the logistics performance index of EU countries with emphasis on the importance of criteria	MEREC and MARCOS
Pala (2023)	Comparative analysis of logistics performance between Türkiye and the Visegrád Group	MEREC-Corr and SAW
Barasin et al. (2024)	Performance evaluation of retail warehouses	G-BWM and RATMI
Pehlivan (2024)	Integrated FCM/MCDM methodology for evaluating the logistics performance index	SAM, TOPSIS, MOORA, ARAS and FCM/MCDM

Upon reviewing Table 1, it is evident that studies utilizing the MCDM approach are prominently featured in the literature on logistics and logistics performance analysis. Studies integrating the MEREC, MABAC, or MAIRCA methods comprehensively are summarized and presented in Table 2.

Table 2. Studies applying the integrated MEREC, MABAC, or MAIRCA methods

Author(s)	*Content*	*Method(s)*
Kaya (2020)	Assessing the impact of Covid-19 on countries' sustainable development levels	MABAC, MAIRCA and WASPAS
Arsu and Ayçin (2021)	Ranking the OECD countries in economic, social, and environmental aspects	CRITIC, MAIRCA, MABAC, MARCOS, WASPAS, and
Özçalıcı (2022)	Evaluation of asset allocation in portfolio management	MEREC, MABAC and MAIRCA
Ersoy (2022)	Examinating the innovation performance in OECD and EU member countries	MEREC and MARCOS
Shanmugasundar et al. (2022)	Optimal selection of spray painting robots	MEREC, CODAS, COPRAS, CoCoSo and MABAC
Işık (2022)	The impact of Covid-19 on the performance of the participation banking sector	MEREC, PSI and MAIRCA
Ecer and Ayçin (2023)	Evaluating the innovation performance in G7 countries	MEREC, CODAS, MABAC, MARCOS, CoCoSo, WASPAS and MAIRCA

Upon reviewing Table 2, it is evident that integrated applications of methods are prevalent in the literature. Moreover, the MEREC, MABAC, and MAIRCA methods have found their place in the literature both in ranking countries and economic integrations, as well as in logistics-related issues (Jusufbašić, 2023; Torkayesh et al., 2023; Chejarla et al., 2022; Tian et al., 2023). Upon reviewing the literature, it is evident that studies frequently address topics related to the LPI. However, there is notable scarcity in research specifically focusing on the AEMLI. While existing studies critique the practice of unweighted logistics ranking, they also contribute to the formulation of the LPI within their scope. Furthermore, it is observed that there are fewer studies addressing the aspects of MEREC, MABAC, and MAIRCA in relation to logistics productivity. Therefore, this study stands out from other literature due to its analysis conducted on AEMLI. It is hoped that the study will contribute to the literature through its use of integrated methods.

3. METHODOLOGY

The need to transform data into results and arguments that support more informed and better decision-making has been increasing each year (Martyn and Kadziński, 2023). The concept of decision-making is defined as the process of selecting or ranking one or more options among available alternatives that provide the solution to a encountered problem or achieve specific goals based on established criteria (Esmeray and Özveri, 2023). The decision-making process generally consists of four vital sequential steps: problem identification, needs assessment, goal setting, and determination of evaluation criteria (Baker et al., 2002: 2-5; Top and Bulut, 2022). However, decision-making often involves a complex and multi-criteria decision-making process. MCDM provides a suitable methodology for evaluating such problems. The MCDM process, which creates a framework to structure problems and facilitate the selection of the best alternative from available options, consists of six steps (Opricovic and Tzeng, 2004; Top and Bulut, 2022):

1. Establishing evaluation criteria that relate capabilities to objectives,
2. Identifying alternatives to achieve objectives,
3. Evaluating alternatives based on criteria,
4. Applying a normative multi-criteria analysis method,
5. Determining the best alternative,
6. Iterating the process to achieve an optimal solution if a final solution is not reached.

The critique in this study focuses on the equal weighting of criteria in the construction of the AEMLI index and the absence of any preference for weighting methods. Variable or criteria weighting is crucial for determining the priorities of criteria at different levels of importance, considering the impact of each criterion, enhancing accuracy and reliability in mathematical modeling, improving performance, and suitability for developing strategies based on specific outcomes. Therefore, the study utilized MCDM methods. This section introduces the MEREC method utilized for weighting the criteria, along with the MABAC and MAIRCA methods employed for ranking alternatives.

3.1. Calculating the Weights of Criteria Through the MEREC Method

This study employs the MEREC method for the criteria weighting process, which quantitatively assesses the weights based on the removal effects of criteria, as supported by the existing literature. The MEREC method is categorized as an objective approach within the spectrum of criteria weighting techniques. Developed by Keshavarz-Ghorabaee et al. (2021), this method derives weights by analyzing the implications of criterion removal on decision-making. The steps of the MEREC method are presented below.

In Equation 1, m represents the number of alternatives, while n denotes the number of criteria.

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ \dots & \dots & \dots \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (1)$$

The elements of the decision matrix are subjected to linear normalization, and the normalized values for benefit-type criteria are calculated using Equation 2 (Ersoy, 2022).

$$n_{ij}^{x} = \left\{ \frac{\min_{k} x_{kj}}{x_{ij}} ; for\ benefit\ type\ criteria \right. \quad (2)$$

In Equation 2, n_{ij}^{x} represents the elements of the normalization matrix. Subsequently, the calculation of the overall performance values of alternatives (S_i) is conducted (Equation 3).

$$S_i = ln\left(1 + \frac{1}{m}\sum_{j=1}^{n}\left\|ln\left(n_{ij}^{x}\right)\right\|\right) \quad (3)$$

In Equation 3, the overall performance values of the alternatives are calculated using a logarithmic measure with a non-linear function. The performance of alternatives, where the effect of the relevant criterion is disregarded (S'_{ij}) is computed as depicted in Equation 4. In the MEREC method, when calculating the weight of a criterion, the focus is on the change in the total criterion weight when that criterion is excluded (Noyan, 2023).

$$S'_{ij} = ln\left(1 + \frac{\sum_{j=1, j\neq k}^{n}\left(n_{ij}^{x}\right)}{n})\right) \quad (4)$$

Based on the findings obtained from Equations 3 and 4, the values E_j, which indicate the removal effect of criterion j, are obtained by summing the absolute differences. The process is represented in the model outlined in Equation 5.

$$E_j = \sum_i \left|S'_{ij} - S_i\right| \quad (5)$$

Utilizing the model presented in Equation 6, the objective weights of the criteria are determined. In the model, w_j denotes the weight of the j-th criterion.

$$w_j = \frac{E_j}{\sum_k E_k} \quad (6)$$

In this study, the authors articulate several reasons for their preference for the MEREC method in determining criteria weights. First, the MEREC method minimizes errors arising from subjectivity in the decision-making process, as it does not require subjective inputs from decision-makers when establishing the weights of criteria (Keshavarz-Ghorabaee et al., 2021). Furthermore, it is posited that the results yield greater consistency and reliability due to their data-driven nature. Unlike other multi-criteria decision-making (MCDM) methods, such as AHP or ANP, the MEREC method does not necessitate that decision-makers provide preferences or engage in pairwise comparisons, thereby rendering it a simpler and more consistent approach. The MEREC method is widely recognized in the literature across various fields and is regarded as a valuable and applicable strategy, particularly in sectors such as logistics, where dynamic and complex decision-making is essential.

3.2. Ranking the Alternatives Through the MABAC and MAIRCA Methods

Following the determination of criterion weights through the MEREC method, the MABAC and MAIRCA methods were employed for ranking alternatives. The authors' preference for the MABAC-MAIRCA approach is primarily attributed to the significant advantages both methods offer in terms of flexibility, comprehensive evaluation, and transparency in the multi-criteria decision-making (MCDM) process. These methods are particularly effective in contexts that involve complex multi-criteria decisions. The MABAC method is noted for providing consistent results, even when there are changes in the measurement units used to represent the criteria values of the alternatives. Moreover, the algorithm of the MABAC method is well-suited for addressing multi-criteria problems that involve a large number of criteria and alternatives, due to its relatively straightforward mathematical formulation, which remains manageable as the number of alternatives and criteria increases (Torkayesh et al., 2023). A distinct advantage of the MAIRCA method, compared to other approaches, is its capacity to accommodate both qualitative and quantitative objectives

(Trung and Thinh, 2021). The relative simplicity of these methods provides a significant advantage over more complex alternatives (Alıcı and Ertuğrul, 2024).

3.2.1. MABAC Method

The MABAC method was introduced to the literature by Pamućar and Ćirović (2015). This method evaluates decision alternatives based on distances from the border approximation areas of criterion functions (Milosavljević et al., 2018; Çınaroğlu, 2020). The procedural steps of the method are outlined below. The initial step involves constructing a decision matrix comprising m alternatives and n criteria, with the matrix representation being consistent with that in Equation 1. Following the establishment of the decision matrix, a normalization process is conducted. The model presented in Equation 7 is employed for benefit-type criteria.

$$n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{7}$$

In Equation 7, x_i^+ represents the maximum values of the columns of the decision matrix, while x_i^- denotes the minimum values. To obtain the weighted decision matrix, the notation in Equation 8 is utilized.

$$v_{ij} = w_i * (n_{ij} + 1) \tag{8}$$

Following the creation of the weighted decision matrix, the border approximation area for each criterion is determined according to the Equation 9.

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{\frac{1}{m}} \tag{9}$$

The border approximation area matrix is computed using the model presented in Equation 10.

$$G = [g_1, g_2, \ldots, g_n] \tag{10}$$

The distances of the alternatives from the border approximation area are calculated using the distance matrix from the border approximation area. The model representation for constructing the matrix is shown in Equation 11.

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

The conditions for each alternative, based on their border approximation area, are determined using Equation 12.

$$A_i \in \begin{cases} G^+ \ if \ q_{ij} > 0 \\ G \ if \ q_{ij} = 0 \\ G^- \ if \ q_{ij} < 0 \end{cases} \tag{12}$$

According to Equation 12, for any alternative A_i, the condition $q_{ij} > 0$ signifies the proximity of A_i to the ideal alternative, while $q_{ij} < 0$ indicates the proximity of A_i to the negative ideal alternative. The criterion function $(\mathrm{S_i})$ represents the sum of distances of each alternative from the border approximation area which is calculated using the model presented in Equation 13.

$$S_i = \sum_{j=1}^{n} q_{ij} \ ; i = 1,2, \ldots, m \ ve \ j = 1,2, \ldots, n \tag{13}$$

3.2.2. MAIRCA Method

The alternatives are ranked in descending order based on their criterion function values, and the alternative with the highest criterion function value is identified as the optimal alternative. In this study, the MAIRCA method was chosen as the second method for ranking alternatives. Introduced to the MCDM literature by Gigović et al. (2016), MAIRCA is a method based on identifying gaps between theoretical and real rankings. By summing the gaps for each criterion, a total gap is obtained for each decision alternative. At the end of the application process, the alternative with values closest to the ideal rankings across most criteria, or in other words, the alternative with the least total gap value, is determined as the best alternative. The procedural steps and notation representations of the method are detailed below (Pamućar et al., 2017; Pamućar et al., 2018; Ayçin, 2020). Since the method's decision matrix is represented identically to Equation 1, it has not been reiterated at this stage. Among the assumptions of the method is that the decision-maker does not have any priority in the alternative selection process. Thus, the priority P_{Ai} of alternative A_i, where m is the total number of alternatives, is calculated using the notation in Equation 14.

$$P_{Ai} = \frac{1}{m}\ ;\ \sum_{i=1}^{m} P_{Ai} = 1\ ;\ i = 1,2,\ldots,m \tag{14}$$

In the MAIRCA method, it is assumed that the decision-maker is equally distant from each alternative. This scenario is modeled in Equation 15.

$$P_{A1} = P_{A2} = \cdots = P_{Am} \tag{15}$$

Equation 16 presents the model for constructing the theoretical evaluation matrix to represent the matrix elements t_{pij}.

$$T_p = \begin{bmatrix} P_{\mathrm{A1}} * w_1 & P_{\mathrm{A1}*} w_2 & P_{\mathrm{A1}} * w_n \\ P_{\mathrm{A2}} * w_1 & P_{\mathrm{A2}} * w_2 & P_{\mathrm{A2}} * w_n \\ \ldots & \ldots & \ldots \\ P_{\mathrm{Am}} * w_1 & P_{\mathrm{Am}} * w_2 & P_{Am} * w_n \end{bmatrix} \tag{16}$$

The application proceeds with defining the real evaluation matrix (T_r), which is derived from the initial decision matrix and theoretical evaluation matrix (T_p). The elements of this matrix are calculated using the notation shown in Equation 17 for benefit type criteria.

$$t_{rij} = t_{pij} * \left(\frac{x_{ij} - x_{ij}^{-}}{x_{ij}^{+} - x_{ij}^{-}}\right) \tag{17}$$

In Equation 17, x_{ij}^{+} represents the maximum value taken by criterion j., while x_{ij}^{-} represents the minimum value. The real evaluation matrix obtained from these calculations is presented in Equation 18.

$$T_r = \begin{bmatrix} t_{\mathrm{r}11} & t_{\mathrm{r}12} & t_{\mathrm{r}1n} \\ t_{\mathrm{r}21} & t_{\mathrm{r}22} & t_{\mathrm{r}2n} \\ \ldots & \ldots & \ldots \\ t_{rm1} & t_{rm2} & t_{rmn} \end{bmatrix} \tag{18}$$

The total gap matrix is computed using the model shown in Equation 19.

$$G = T_p = T_r = \begin{bmatrix} g_{11} & g_{12} & g_{1n} \\ g_{21} & g_{22} & g_{2n} \\ \ldots & \ldots & \ldots \\ g_{m1} & g_{m2} & g_{mn} \end{bmatrix}\ ;\ g_{ij} = t_{pij} - t_{rij}\ , g_{ij} \in [0, \infty) \tag{19}$$

In the MAIRCA method, if an alternative has an equal and non-zero difference between its theoretical and real evaluation for a criterion, the gap will be zero. In this case, the alternative is considered an ideal alternative for that criterion. Conversely, if an alternative has an equal difference of zero between its theoretical and real evaluations for a criterion, it is evaluated as the worst alternative for that criterion. The value of the criterion functions is calculated using the model in Equation 20.

$$Q_i = \sum_{j=1}^{n} g_{ij}\ ;\ i = 1,2,\ldots,m \tag{20}$$

The Q_i values obtained from Equation 20 are sorted in ascending order to achieve the ranked results of the alternatives.

4. FINDINGS

The data used in the study were compiled as secondary data from Index journals of Agility by the authors. The study period was determined as 2021-2023. During this period, AEMLI presented data using equal weights of 25% across four criteria. This situation creates limitations for the study. Additionally, in order to verify the effectiveness of the methods and highlight the importance of weighting, the study included the top 15 countries from the AEMLI index annually from 50 countries. This aspect is also noted as another limitation of the research. The similarity of factors influencing logistics indicators across the top 15 countries is considered among the motivating factors for selecting alternatives in the study. The countries listed are China, India, United Arab Emirates, Malaysia, Indonesia, Saudi Arabia, Vietnam, Qatar, Thailand, Mexico, Türkiye, Chile, Russia, Bahrain, Kuwait, Jordan, Brazil, and Oman. All unit values of the criteria used in the study are presented in index/ratio form. The criteria, alternatives, and other descriptive information used in the study are shown in Table 3.

Table 3. Information regarding the dataset

Criteria	*Abbreviations*	*Optimization Direction*	*Abbreviations of Countries*
Domestic Opportunities	DO	Max	China (CHN), India (IND), United Arab Emirates (UAE), Malaysia (MYS), Indonesia (IDN), Saudi Arabia (SAU), Vietnam (VNM), Qatar (QAT), Thailand (THA), Mexico (MEX), Turkiye (TUR), Chile (CHL), Russia (RUS), Bahrain (BHR), Oman (OMN), Kuwait (KWT), Jordan (JOR), Brazil (BRA)
International Opportunities	IO	Max	
Business Fundametals	BF	Max	
Digital Readiness	DR	Max	

In this study, the normalized decision matrix and sample solution for the year 2021 used in determining the criterion weights are presented under this heading. The solution and procedural steps for other years can be found in the appendices section of the study. In this study, the selected fifteen countries primarily consist of the top fifteen countries each year during the examined period. These countries are notable for their high economic growth potential and dynamic markets. The strategic trade positions of the countries have also been taken into consideration during their selection. For instance, countries such as the United Arab Emirates and Qatar have become significant centers of international trade by positioning themselves strategically between the Middle East and Asia. The differing economic structures and development levels of the selected countries indicate that using equal weights in the logistics index may be problematic. For example, while countries like Malaysia and Indonesia face various challenges as emerging markets, countries like the United Arab Emirates possess more developed infrastructure. The levels of digital readiness among these countries also vary. All of these nations are emerging markets that play a crucial role in the global economic system. There are significant differences in economic structure, infrastructure, governance policies, and digital maturity levels among the countries. These differences and similarities play an important role in the evaluation of the logistics index. Employing equal weights may overlook the unique challenges and advantages of the countries, potentially leading to misleading results. By analyzing these countries, the aim is to develop a more precise and accurate logistics index. Such an approach provides more meaningful insights for policymakers and businesses, creating a more effective foundation for decision-making processes.

4.1. Calculating the Weights of Criteria Through the MEREC Method

As presented in Table 4, the normalization matrix for the year 2021 is provided before outlining the steps of the MEREC method.

Table 4. The normalization matrix (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.5703	0.4800	0.7266	0.7117
IND	0.6080	0.6473	0.8607	0.7656
UAE	0.8728	0.8168	0.5576	0.5979
MYS	0.9154	0.7905	0.6264	0.7020
IDN	0.7681	0.7866	0.8651	0.7975
SAU	0.9103	0.8494	0.6287	0.7298
QAT	0.8411	0.9571	0.6445	0.7914
THA	0.9493	0.7787	0.8814	0.7890
MEX	0.8791	0.7313	1.0000	0.9556
TUR	0.9223	0.7973	0.8739	0.8658
VNM	0.9701	0.7787	0.9361	0.8974
CHL	1.0000	0.9052	0.7155	0.8404
RUS	0.9365	0.8254	0.9310	0.8761
OMN	0.9898	0.9571	0.7066	0.9069
BHR	0.9760	1.0000	0.7027	1.0000

After normalizing the decision matrix, the overall performance values of the alternatives are computed. These values are presented in Table 5.

Table 5. Overall performance values of the alternatives (S_i) (2021)

Alternatives	S_i	Alternatives	S_i
CHN	0.3979	*MEX*	0.115
IND	0.2907	*TUR*	0.1368
UAE	0.3069	*VNM*	0.1077
MYS	0.2517	*CHL*	0.1416
IDN	0.1978	*RUS*	0.1091
SAU	0.2304	*OMN*	0.1176
QAT	0.2009	*BHR*	0.0901
THA	0.1539		

The process continues with the calculation of the overall performance values obtained by removing the effects of the criteria using the MEREC method. These values are presented in Table 6.

Table 6. Overall performance values of the alternatives by removing each criterion (S'_{ij}) (2021)

Alternatives	*DO* (S'_{ij})	*IO* (S'_{ij})	*BF* (S'_{ij})	*DR* (S'_{ij})
CHN	0.2989	0.2664	0.3428	0.3391
IND	0.1931	0.2059	0.2623	0.2395
UAE	0.2816	0.2690	0.1933	0.2075
MYS	0.2344	0.2050	0.1564	0.1805
IDN	0.1422	0.1473	0.1677	0.1503
SAU	0.2115	0.1974	0.1337	0.1658
QAT	0.1649	0.1919	0.1068	0.1519
THA	0.1427	0.0988	0.1264	0.1017
MEX	0.0858	0.0427	0.1150	0.1048
TUR	0.1190	0.0861	0.1070	0.1048
VNM	0.1008	0.0499	0.0927	0.0831
CHL	0.1416	0.1197	0.0661	0.1031
RUS	0.0943	0.0652	0.0930	0.0790
OMN	0.1153	0.1078	0.0373	0.0956
BHR	0.0845	0.0901	0.0061	0.0901

The weights of the criteria are derived based on the notation outlined in the methodology section. These results are presented in Table 7 for the year 2021.

Table 7. Summation of absolute deviations and the final weights of the criteria (2021

Values	*DO*	*IO*	*BF*	*DR*
E_j	0.4375	0.7050	0.8416	0.6511
w_j	0.1660	0.2675	0.3194	0.2471

The weights derived from the MEREC method calculations for the year 2021, as presented in the example above, are provided here. The calculation steps for subsequent years can be found in the Appendices. The results for all years are sumamrized in the following table. In this study, the criterion weights obtained using the MEREC method for prioritization are comparatively presented in Table 8 alongside AEMLI results.

Table 8. Criteria weights and the comparison of these weights (2021-2023)

Criteria	*2021*	*2022*	*2023*	*AEMLI*
DO	0.1660	0.1696	0.1580	0.25
IO	0.2675	0.2657	0.2796	0.25
BF	0.3194	0.3644	0.4302	0.25
DR	0.2471	0.2003	0.1321	0.25

When examining Table 8, it is observed that the criterion with the highest importance weight for all years is BF, while the criterion with the lowest importance weight is DO for the years 2021 and 2022, and DR for 2023. Furthermore, the average highest difference among criteria is calculated as 0.2154, indicating that the criteria should not be equally weighted. The consistent highest weight score of the business fundemetal criterion across all periods is interpreted as aligning with expectations and theory. In this context, the logistics development of countries is seen as a reflection of systematic approaches to operational issues (Nekhoroshkov et al., 2021). Additionally, logistics costs for businesses exert pressure not only on the logistics department but also on overall business economics (Majerćak et al., 2013). In the study, the domestic opportunities criterion has been identified as having the lowest weight score for the years 2021 and 2022. This period falls within the pandemic era, which significantly impacted global trade dynamics.

The risk factor crucial for logistics productivity has become more pronounced, particularly with the Covid-19 pandemic, exposing new challenges beyond traditional supply and demand uncertainties. The seamless operation of logistics and the economy is crucial as all sectors are interconnected through complex supply chains and logistics networks (Choi, 2021; Rokicki et al., 2022; Montoya-Torres, 2023). In 2023, the digital readiness criterion is observed to have the lowest weight score. This is associated with the widespread adoption of new technologies in logistics, such as big data, automation, and the Internet of Things. Technical personnel face constraints in adjusting their digital literacy skills to fit the new systems of organizations (Azhigali, 2023).

4.2. Results of the MABAC Method for Ranking Alternatives

In this study, the normalization matrix and example solutions for ranking alternatives using the MABAC method for the year 2021 are presented in this section. The solutions and procedural steps for subsequent years can be found in the Appendix of the study.

Table 9. The normalization matrix (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	1.0000	1.0000	0.4742	0.6023
IND	0.8556	0.5030	0.2039	0.4553
UAE	0.1935	0.2071	1.0000	1.0000
MYS	0.1226	0.2446	0.7518	0.6311
IDN	0.4005	0.2505	0.1966	0.3775
SAU	0.1308	0.1637	0.7445	0.5504
QAT	0.2507	0.0414	0.6953	0.3919
THA	0.0708	0.2623	0.1695	0.3977
MEX	0.1826	0.3393	0.0000	0.0692
TUR	0.1117	0.2347	0.1818	0.2305
VNM	0.0409	0.2623	0.0860	0.1700
CHL	0.0000	0.0966	0.5012	0.2824
RUS	0.0899	0.1953	0.0934	0.2104
OMN	0.0136	0.0414	0.5233	0.1527
BHR	0.0327	0.0000	0.5332	0.0000

In this study, the decision matrix utilized in the MEREC method for 2021 is not reiterated, as it is applicable to all calculations; the discussion proceeds directly to the presentation of the normalization matrix. The method then advances by calculating the weighted normalization matrix for the MABAC method. These values are presented in Table 10.

Table 10. The weighted normalization matrix (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.3320	0.5350	0.4708	0.3959
IND	0.3081	0.4021	0.3845	0.3596
UAE	0.1981	0.3229	0.6387	0.4942
MYS	0.1864	0.3329	0.5595	0.4030
IDN	0.2325	0.3345	0.3821	0.3404
SAU	0.1877	0.3113	0.5571	0.3831
QAT	0.2076	0.2786	0.5414	0.3439
THA	0.1778	0.3377	0.3735	0.3454
MEX	0.1963	0.3583	0.3194	0.2642
TUR	0.1846	0.3303	0.3774	0.3041
VNM	0.1728	0.3377	0.3468	0.2891
CHL	0.1660	0.2934	0.4795	0.3169
RUS	0.1809	0.3198	0.3492	0.2991
OMN	0.1683	0.2786	0.4865	0.2848
BHR	0.1714	0.2675	0.4897	0.2471

The process continues with the creation of the border approximation area matrix for the MABAC method and the determination of its values. The obtained results are presented in Table 11.

Table 11. Determining the border approximation area (2021)

Value	*DO*	*IO*	*BF*	*DR*
g_i	0.2001	0.3312	0.4410	0.3328

The values obtained from Table 11 are utilized to calculate the distances of the decision alternatives from the border approximation area. In the example for the year 2021, these results are presented in Table 12.

Table 12. Calculating the distance of the alternatives from the border approximation area (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.1319	0.2038	0.0298	0.0631
IND	0.1080	0.0709	-0.0565	0.0268
UAE	-0.0020	-0.0083	0.1977	0.1614
MYS	-0.0137	0.0017	0.1185	0.0702
IDN	0.0324	0.0033	-0.0589	0.0076
SAU	-0.0124	-0.0199	0.1161	0.0503
QAT	0.0075	-0.0526	0.1004	0.0111
THA	-0.0223	0.0065	-0.0675	0.0126
MEX	-0.0038	0.0271	-0.1217	-0.0686
TUR	-0.0155	-0.0009	-0.0636	-0.0287
VNM	-0.0273	0.0065	-0.0942	-0.0437
CHL	-0.0341	-0.0378	0.0384	-0.0159
RUS	-0.0192	-0.0115	-0.0918	-0.0337
OMN	-0.0318	-0.0526	0.0455	-0.0480
BHR	-0.0287	-0.0637	0.0486	-0.0857

The MABAC method is concluded by calculating the S_i values used for ranking. In the example for the year 2021, the results are presented in Table 13.

Table 13. Calculating the values of the criterion functions for the alternatives (2021)

Alternatives	S_i	Alternatives	S_i
CHN	0.4287	*MEX*	-0.167
IND	0.1491	*TUR*	-0.1088
UAE	0.3488	*VNM*	-0.1587
MYS	0.1767	*CHL*	-0.0494
IDN	-0.0156	*RUS*	-0.1562
SAU	0.1341	*OMN*	-0.0869
QAT	0.0665	*BHR*	-0.1294
THA	-0.0708		

The results obtained for all years related to the MABAC method are presented in a consolidated format in Table 14.

Table 14. Calculating the values of the criterion functions for the alternatives (2021-2023)

Alternatives	*2021*	*2022*	*2023*
CHN	0.4287	0.4241	0.4530
IND	0.1491	0.2607	0.2163
UAE	0.3488	0.3229	0.2766
MYS	0.1767	0.1466	0.1627
IDN	-0.0156	-0.0266	0.0199
SAU	0.1341	0.1107	0.0968
VNM	-0.1587	-0.1573	-0.0457
QAT	0.0665	0.1065	0.0452
THA	-0.0708	-0.0928	-0.1004
MEX	-0.1670	-0.2110	-0.1140
TUR	-0.1088	-0.1466	-0.1287
CHL	-0.0494	-0.0784	-0.0463
RUS	-0.1562	*	-0.1733
BHR	-0.1294	-0.1005	*
OMN	-0.0869	-0.0474	*
KWT	*	-0.1466	*
BRA	*	*	-0.2537
JOR	*	*	-0.0885

4.3. Results of the MAIRCA Method for Ranking Alternatives

In this study, example solutions for ranking alternatives using the MAIRCA method for the year 2021 are presented in this section. Solutions and procedural steps for subsequent years can be found in the appendix of the study. The process continues with the definition of the real evaluation matrix for the MAIRCA method, with the results for the year 2021 are presented in Table 15.

Table 15. Calculating the final values of criteria functions by alternatives (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0111	0.0178	0.0101	0.0099
IND	0.0095	0.0090	0.0043	0.0075
UAE	0.0021	0.0037	0.0213	0.0165
MYS	0.0014	0.0044	0.0160	0.0104
IDN	0.0044	0.0045	0.0042	0.0062
SAU	0.0014	0.0029	0.0159	0.0091
QAT	0.0028	0.0007	0.0148	0.0065
THA	0.0008	0.0047	0.0036	0.0066
MEX	0.0020	0.0061	0.0000	0.0011
TUR	0.0012	0.0042	0.0039	0.0038
VNM	0.0005	0.0047	0.0018	0.0028
CHL	0.0000	0.0017	0.0107	0.0047
RUS	0.0010	0.0035	0.0020	0.0035
OMN	0.0002	0.0007	0.0111	0.0025
BHR	0.0004	0.0000	0.0114	0.0000

In the MAIRCA method, the total gap matrix for the year 2021 has been constructed as presented in Table 16.

Table 16. Calculating the total gap matrix (2021)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0000	0.0000	0.0112	0.0066
IND	0.0016	0.0089	0.0169	0.0090
UAE	0.0089	0.0141	0.0000	0.0000
MYS	0.0097	0.0135	0.0053	0.0061
IDN	0.0066	0.0134	0.0171	0.0131
SAU	0.0096	0.0149	0.0054	0.0074
QAT	0.0083	0.0171	0.0065	0.0100
THA	0.0103	0.0132	0.0177	0.0099
MEX	0.0090	0.0118	0.0213	0.0153
TUR	0.0098	0.0136	0.0174	0.0127
VNM	0.0106	0.0132	0.0195	0.0137
CHL	0.0111	0.0161	0.0106	0.0118
RUS	0.0101	0.0144	0.0193	0.0130
OMN	0.0109	0.0171	0.0101	0.0140
BHR	0.0107	0.0178	0.0099	0.0165

The Q_i values derived from the MAIRCA method are presented in Table 17. These values serve as the basis for ranking.

Table 17. Calculating the criteria function (2021)

Alternatives	Q_i	Alternatives	Q_i
CHN	0.0177	*MEX*	0.0575
IND	0.0364	*TUR*	0.0536
UAE	0.0231	*VNM*	0.0569
MYS	0.0345	*CHL*	0.0496
IDN	0.0474	*RUS*	0.0567
SAU	0.0374	*OMN*	0.0521
QAT	0.0419	*BHR*	0.0550
THA	0.0510		

The Q_i values obtained from the MAIRCA method are presented in Table 18, encompassing all years and all alternatives considered.

Table 18. Calculating the criteria function (2021-2023)

Alternatives	*2021*	*2022*	*2023*
CHN	0.0177	0.0168	0.0127
IND	0.0364	0.0277	0.0285
UAE	0.0231	0.0236	0.0245
MYS	0.0345	0.0353	0.0321
IDN	0.0474	0.0469	0.0416
SAU	0.0374	0.0377	0.0365
VNM	0.0569	0.0556	0.0460
QAT	0.0419	0.0380	0.0399
THA	0.0510	0.0513	0.0496
MEX	0.0575	0.0592	0.0505
TUR	0.0536	0.0549	0.0515
CHL	0.0496	0.0503	0.0460
RUS	0.0567	*	0.0545
BHR	0.0550	0.0518	*
OMN	0.0521	0.0483	*
KWT	*	0.0549	*
BRA	*	*	0.0599
JOR	*	*	0.0488

4.4. Integrated Comparative and Ranked Presentation of Results

In this study, the findings related to the MABAC and MAIRCA methods utilized for ranking alternatives, along with their comparison to AEMLI, are presented in this section. The results obtained from these methods and the AEMLI calculations are presented comparatively in Table 19.

Table 19. Results for all years according to all methods

	2021			*2022*			*2023*		
Countries	*MABAC*	*MAIRCA*	*AEMLI*	*MABAC*	*MAIRCA*	*AEMLI*	*MABAC*	*MAIRCA*	*AEMLI*
CHN	0.4287	0.0177	8.50	0.4241	0.0168	8.31	0.4530	0.0127	8.61
IND	0.1491	0.0364	7.21	0.2607	0.0277	7.43	0.2163	0.0285	7.21
UAE	0.3488	0.0231	6.72	0.3229	0.0236	6.59	0.2766	0.0245	6.49
MYS	0.1767	0.0345	6.32	0.1466	0.0353	6.16	0.1627	0.0321	6.17
IDN	-0.0156	0.0474	6.17	-0.0266	0.0469	6.08	0.0199	0.0416	6.16
SAU	0.1341	0.0374	6.14	0.1107	0.0377	6.07	0.0968	0.0365	6.05
VNM	-0.1587	0.0569	5.55	-0.1573	0.0556	5.52	-0.0457	0.0460	5.73
QAT	0.0665	0.0419	5.95	0.1065	0.0380	6.02	0.0452	0.0399	5.85
THA	-0.0708	0.0510	5.78	-0.0928	0.0513	5.67	-0.1004	0.0496	5.59
MEX	-0.1670	0.0575	5.74	-0.2110	0.0592	5.55	-0.1140	0.0505	5.60
TUR	-0.1088	0.0536	5.69	-0.1466	0.0549	5.49	-0.1287	0.0515	5.45
CHL	-0.0494	0.0496	5.55	-0.0784	0.0503	5.43	-0.0463	0.0460	5.39
RUS	-0.1562	0.0567	5.53	*	*	*	-0.1733	0.0545	5.34
BHR	-0.1294	0.0550	5.41	-0.1005	0.0518	5.31	*	*	*
OMN	-0.0869	0.0521	5.28	-0.0474	0.0483	5.46	*	*	*
KWT	*	*	*	-0.1466	0.0549	5.25	*	*	*
BRA	*	*	*	*	*	*	-0.2537	0.0599	5.29
JOR	*	*	*	*	*	*	-0.0885	0.0488	5.19

The ranked results obtained from the methods, along with the ranked values from the AEMLI calculations, are presented comparatively in Table 20. Upon examining Table 20, it is evident that the countries CHN, IND, UAE, and MYS consistently rank highest across all periods in the MABAC and MAIRCA ranking results, while VNM, MEX, BHR, and JOR tend to rank lowest. The findings from the MABAC and MAIRCA methods supporting each other in terms of their outcomes are considered indicative of the study's consistency. The obtained results in the study are further supported and exemplified by the literature. Saudi Arabia's ranking value was found to be higher in both the MABAC and MAIRCA results. Enhancing the logistics sector and improving its ranking were among the country's foremost targeted success factors outlined in its Vision 2030 initiative (Almalki and Alkahtani, 2022). Similarly, Chile's ranking according to the AEMLI results for the period 2021-2023 was 12-13, whereas it was 8-9 according to the MABAC and MAIRCA results. Chile is recognized for having the most efficient customs regime in the region as a consequence of its free trade agreements and trade practices with a total of 31 countries (T.C. Dış İşleri Bakanlığı, 2023). Since the early 2000s, Latin American countries have initiated campaigns to promote their national brands internationally, promoting exports, direct foreign investments, and tourism offers. Chile's slogan in building its brand, "Good for you" is particularly noted (Mino and Austin, 2022). Indonesia's results from the MABAC and MAIRCA methods show that they fall behind the AEMLI results. This discrepancy is associated with urban and national logistics challenges in the country, such as urbanization, traffic density, land conflicts, and inadequate readiness of agencies in logistics processes (Widodo et al., 2018). Kailaku et al. (2022) state that Indonesia's logistics performance lags behind most ASEAN countries, attributing this to high container handling costs due to the country's dependence on intra-island connections. Nurprihatin et al. (2021) emphasize the need for improved distribution routes and government policies to meet scarce demand, particularly in the food sector. Similarly, Vietnam's results from the MABAC and MAIRCA methods also lag behind the AEMLI results. The country faces logistical challenges primarily due to domestic logistics costs often exceeding those of imported goods (Nguyen et al., 2022). The logistics challenges stem from the multiple intermediaries involved in production, distribution, and increased operational costs and selling prices in sectors such as agriculture, forestry, and fisheries (Pham and Doan, 2020). Overall, the findings underscore the impact of weighted criteria on countries' logistics performances. This influence is reflected in the ranking outcomes, which align more closely with theoretical expectations.

Table 20. Comparing the alternatives

	2021			*2022*			*2023*		
Ranking	*MABAC*	*MAIRCA*	*AEMLI*	*MABAC*	*MAIRCA*	*AEMLI*	*MABAC*	*MAIRCA*	*AEMLI*
1	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN
2	UAE	UAE	IND	UAE	UAE	IND	UAE	UAE	IND
3	MYS	MYS	UAE	IND	IND	UAE	IND	IND	UAE
4	IND	IND	MYS	MYS	MYS	MYS	MYS	MYS	MYS
5	SAU	SAU	IDN	SAU	SAU	IDN	SAU	SAU	IDN
6	QAT	QAT	SAU	QAT	QAT	SAU	QAT	QAT	SAU
7	IDN	IDN	QAT	IDN	IDN	QAT	IDN	IDN	QAT
8	CHL	CHL	THA	OMN	OMN	THA	VNM	VNM	VNM
9	THA	THA	MEX	CHL	CHL	MEX	CHL	CHL	MEX
10	OMN	OMN	TUR	THA	THA	VNM	JOR	JOR	THA
11	TUR	TUR	VNM	BHR	BHR	TUR	THA	THA	TUR
12	BHR	BHR	CHL	KWT	TUR	OMN	MEX	MEX	CHL
13	RUS	RUS	RUS	TUR	KWT	CHL	TUR	TUR	RUS
14	VNM	VNM	BHR	VNM	VNM	BHR	RUS	RUS	BRA
15	MEX	MEX	OMN	MEX	MEX	KWT	BRA	BRA	JOR

5. DISCUSSION and CONCLUSION

Logistics performance and efficiency are crucial for both countries and businesses. For businesses, logistics performance necessitates effective management of supply chain operations, storage, distribution, and customer service. This management is pivotal for cost reduction, improvement of delivery processes, and enhancement of customer satisfaction. In this context, logistics productivity enables better utilization of resources in operational processes. At the national level, logistics performance and efficiency influence national economic growth and the development of foreign trade. Well-functioning logistics systems contribute to increased trade volume and international competitiveness. Technological innovations and infrastructure investments enhance logistics productivity, thereby promoting economic growth and increasing the competitiveness of national economies. Therefore, integrated improvement of logistics performance and efficiency facilitates overall performance enhancement for both countries and businesses. This integration is also considered significant in arguments used by countries to attract investors or as evaluation criteria for investors assessing countries. The fragile nature of logistics performance gained increased significance following the attack on the World Trade Center on September 11, 2001. The risks contributing to this fragility are highly diverse and stem from sources both within and outside the supply chain (Wilson, 2007). Chopra and Sodhi (2004) identified these risks as delays, information and networking issues, forecasting, intellectual property, supply, customers, inventory, and capacity. While these categories can be further expanded, it is more appropriate and consistent to discuss this situation alongside the challenges that accompany these risks. Additionally, there are challenges that affect logistics performance, such as inadequate infrastructure, the ability to adapt to technology, uncertainty arising from demand forecasts, high transportation costs, and regulatory frameworks. Furthermore, it has been stated that logistics-related issues often originate from a global, competitive environment, constraints, social or ecological concerns, and deficiencies in information flows, information transfer, or well-integrated IT applications (Clausen et al., 2016; Wang, 2018). Logistics performance is vital for the seamless functioning of economies, and disruptions can create bottlenecks that negatively impact economic productivity and growth (Goel et al., 2021; Salvatore, 2020). In this context, the importance of logistics metrics is underscored. Logistics metrics play a critical role in enhancing logistics performance, ensuring efficiency, and overcoming related challenges. Identifying performance gaps in logistics, facilitating international comparisons, optimizing supply chain operations, and overcoming infrastructure challenges (effective logistics metrics also provide insights into where infrastructure investments are needed) are tasks accomplished through efficient logistics metric management. In this regard, the advantages of logistics metrics include data-driven decision-making, cost reduction, supplier satisfaction, and sustainability. Lai et al. (2004) argue that the intensifying global competition demands not individual performance but rather organizational excellence based on flawless inter-organizational collaboration. The continuous rise of global trade and many countries' desire to accelerate their integration into the global trading system relies not only on maintaining an open global economic system but also on enhancing the quantity and efficiency of support structures such as logistics services (Gani, 2017). Therefore, it is possible to express the growing importance of logistics metrics. Ultimately, logistics metrics enable countries to identify challenges, optimize supply chains, and enhance overall performance. Accurate measurement allows governments and businesses to respond quickly to inefficiencies, promote trade, and support economic development.

Trade, linked to the efficiency and productivity of logistics performance, is a critical factor in ensuring national and international competitiveness for countries. In this context, the positive economic and social impacts of growing sectors have been identified (Mešić et al., 2022). Indicators related to the logistics sector are utilized to enhance countries' trade capacities and increase their international competitiveness. These indicators guide both investors and countries in making strategic logistics decisions. The strategic importance lies in determining the country where logistics companies want to invest or which criteria logistics firms should focus more on (Ulutaş and Karaköy, 2019). AEMLI is considered a significant indicator, especially for emerging markets. The effectiveness of logistics services is directly related to expanding trade networks between countries, increasing foreign direct investments, and boosting economic growth (Çalık et al., 2023). This relationship underscores the importance of criterion weighting in complex evaluations such as logistics performance rankings, where different criteria weights and their contributions to the overall ranking are crucial references. Hence, in this study, sub-criteria of the AEMLI index were weighted using the MEREC method. The alignment of the importance levels derived from criterion weighting with the literature is interpreted as indicating the consistency of the study and the method. The study employed the MABAC and MAIRCA methods for ranking alternatives. It was observed that the rank positions of countries varied partially based on weighted criteria. This limitation is associated with AEMLI allocating 25% weight to four criteria during the period of 2021-2023. Consequently, it is anticipated that different results may be obtained over a broader period. Considering the examples of countries whose rankings have changed, the findings are interpreted as more consistent with the literature. Reviews of studies focusing on weighting other logistics performance indicators in the literature also support interpretations made in this study (Ulutaş and Karaköy, 2019; Mešić et al., 2022; Çalık et al., 2023; Gürler et al., 2024; Rezaei et al., 2018). Emerging markets encompass significant opportunities in logistics. Rapid economic growth in these markets facilitates increased consumer demand and the exploration of new markets. Accessing these new markets also entails adapting supply chain strategies. Optimizing new supply chains according to market dynamics is considered to create opportunities for countries. The need for infrastructure investments in logistics is crucial for stakeholders in the logistics sector and for enhancing the logistics productivities of countries. Thus, this study contributes by examining the AEMLI index, thereby differentiating itself from existing literature and contributing to it.

The AEMLI index reveals that Türkiye is among the key countries listed. In this context, this study will address aspects that emphasize the importance of logistics efficiency specifically concerning Türkiye. First and foremost, it is evident that Türkiye needs long-term visions and strategies to achieve higher rankings in international logistics rankings. Establishing a strategy such as a vision for 2030-2050-2060 (which can be named differently) is essential for strengthening Türkiye's logistics infrastructure and supporting sectoral development. Moreover, it is believed that Türkiye should focus more on urban transportation planning, traffic management, and the digitalization of logistics processes to find solutions to logistics challenges within its borders. To attract foreign investments, it is crucial for Türkiye to enhance its brand image and conduct more international promotional campaigns, as well as to participate actively in bilateral cooperation discussions. Additionally, to foster the development of exports and domestic trade, training and support programs should be established to enable local producers to deliver services that meet international standards. Alongside these programs, it is deemed essential to prioritize research and development activities in areas such as decarbonization, sustainability, and green logistics, in order to accelerate results and benefits. It is anticipated that with such strategies, Türkiye can enhance its logistics performance, becoming more competitive on the international stage.

Quantitative methods, by leveraging statistical and mathematical tools, provide a structured approach to analyzing complex datasets in social sciences, which enhances the robustness of research findings. These methods enable researchers to test hypotheses rigorously, offering more credible results that can inform both theoretical frameworks and practical applications. Furthermore, quantitative techniques allow for the replication of studies, contributing to the reliability and validity of research outcomes across different contexts. In logistics, MCDM methods are particularly valuable, as they facilitate the comparison of multiple decision criteria, ensuring a comprehensive evaluation of logistics performance. The ability of these methods to accommodate uncertainty and diverse scenarios makes them essential for both strategic decision-making and operational improvements in the logistics industry. In a MCDM problem, assigning equal weight to all criteria in logistics-related decisions can have several drawbacks, particularly for emerging markets. All logistics criteria do not carry the same level of importance depending on the context. For example, while cost may be critical for some markets, sustainability or speed may be more relevant in others. Equal weighting can obscure these differences, leading to suboptimal decisions that fail to align with the specific goals or strategic priorities of a company or market. Emerging markets often have distinct logistical challenges such as underdeveloped infrastructure, varying regulatory requirements, or different consumer preferences. In this case, assuming everything to be standard can be misleading. In summary, assigning equal weights to logistics-related criteria in MCDM problems may result in rigid and ineffective decision-making, particularly in emerging markets that require more nuanced and dynamic approaches tailored to local challenges and opportunities.

MCDM methods, with their ability to consider multiple criteria, evaluate alternatives under uncertainty or different scenarios, and impact process improvement, have found their place in the logistics sector as well as in other industries. Given the logistics sector's comprehensive and stakeholder-driven nature, and considering the unique characteristics specific to countries, there is a recommendation for greater inclusion of MCDM methods in the sector-specific literature. Particularly in recent times, studies focusing on logistics indicators and considering criterion weights have become increasingly prevalent. Acknowledging the variations among countries or firms, it is emphasized that identifying the determinants of logistics performance and efficiency through numerical methods is essential. Thus, the use of numerical methods, such as Path Analysis, to identify the determinants of logistics performance and efficiency is considered visionary for future studies. Last-mile delivery and green logistics have gained significant importance in today's context, particularly due to the rapid growth of e-commerce. In this regard, last-mile delivery offers several advantages, such as ensuring supplier and customer satisfaction, gaining competitive advantage, and facilitating cost management. Conversely, green logistics is characterized by its benefits related to sustainability, compliance with legal procedures, and effective reputation management for companies and countries. Both concepts are regarded as potential trends within contemporary literature. Last-mile delivery and green logistics are integral components of modern logistics strategies. These processes not only enhance customer satisfaction but also support environmental sustainability and help businesses remain competitive. In their research, Patella et al. (2021) suggest that the increasing number of publications on this topic in recent years indicates a growing academic interest in this field. Similarly, Eskandaripour and Boldsaikhan (2023) conclude that the challenges faced in efficient and green transportation methods align closely with the overall challenges in logistics. We posit that both areas hold significant potential for future literature and research endeavors.

Author Contributions

Elif Bulut: Literature review, Conceptualization, Methodology, Modelling, Data Curation, Analysis, Writing-original draft. *Seda Abacıoğlu:* Literature review, Conceptualization, Methodology, Modelling, Data Curation, Analysis, Writing-original draft

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Compliance with Ethical Standards

It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement

It was declared by the authors that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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APPENDIX

Table A1. Abbreviations used in the study and their explanations.

Abbreviations	*Explanations*	*Abbreviations*	*Explanations*
AEMLI	Agility Emerging Markets Logistics Index	KWT	State of Kuwait
ARAS	Additive Ratio Assessment	LOPCOW	Logarithmic Percentage Change-Driven Objective Weighting
ASEAN	Association of Southeast Asian Nations	LPI	Logistics Performance Index
BF	Business Fundametals	MARCOS	Measurement of Alternatives and Ranking according to Compromise Solution
BHR	Kingdom of Bahrain	MCDM	Multi-Criteria Decision Making
BRA	Federative Republic of Brazil	MABAC	Multi Attributive Border Approximation Area Comparison
CHL	Republic of Chile	MAIRCA	Multi-Attributive Ideal-Real Comparative Analysis
CHN	People's Republic of China	MAUT	Multi-Attribute Utility Theory
CKPI	Customer-oriented Key Performance Indicators	MEREC	Method Based on the Removal Effects of Criteria
CoCoSo	Combined Compromise Solution	MEX	United Mexican States
CODAS	Combinative Distance-Based Assessment	MOORA	Multi-Objective Optimization by Ratio Analysis
COPRAS	Complex Proportional Assessment	MYS	Malaysia
CRITIC	Criteria Importance Through Intercriteria Correlation	OMN	Sultanate of Oman
DO	Domestic Opportunities	PSI	Preference Selection Index
DR	Digital Readiness	QAT	State of Qatar
ELECTRE	ELimination Et Choix Traduisant la Realite	RATMI	Ranking the Alternatives Based on the Trace to Median Index
EU	The European Union	RUS	Russian Federation
FCM F-TOPSIS	Fuzzy Technique for Order Preference by Similarity to Ideal Solution	SAM	Similarity Aggregation Method
FAHP	Fuzzy Analytic Hierarchy Process	SAU	Kingdom of Saudi Arabia
FCM	Fuzzy C-Means	SAW	Simple Additive Weighting
FUCOM	Full Consistency Method	SD	Standard Deviation
G-BWM	Generalized Best Worst Method	SERVQUAL	Service Quality
G-MOORA	Generalized Multi-Objective Optimization by Ratio Analysis	THA	Kingdom of Thailand
G-SWARA	Generalized Step-Wise Weight Assessment Ratio Analysis	TUR	Republic of Türkiye
GRA	Grey Relational Analysis	UAE	United Arab Emirates
IDN	Republic of Indonesia	VNM	Socialist Republic of Vietnam
IND	Republic of India	WASPAS	Weighted Aggregated Sum Product Assessment
IO	International Opportunities	WPM	Weighted Product Method
JOR	Hashemite Kingdom of Jordan	WSM	Weighted Sum Method

Table A2. Normalization matrix (2022) (MEREC)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.5702	0.4759	0.6934	0.7707
IND	0.6007	0.6228	0.8300	0.6715
UAE	0.8625	0.7878	0.5418	0.6934
MYS	0.9130	0.7891	0.6280	0.7604
IDN	0.7618	0.7878	0.8544	0.8229
SAU	0.8978	0.8084	0.6272	0.8111
QAT	0.8173	0.9355	0.6225	0.8009
THA	0.9452	0.7759	0.8544	0.8460
MEX	0.8994	0.7342	1.0000	1.0000
TUR	0.9397	0.8140	0.8500	0.9291
VNM	0.9622	0.7695	0.8788	0.9411
CHL	1.0000	0.8958	0.7073	0.9207
KWT	0.9527	1.0000	0.7913	0.8872
OMN	0.9758	0.9508	0.6809	0.8795
BHR	0.9679	0.9872	0.6895	0.9569

Table A3. Normalization matrix (2023) (MEREC)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.5632	0.5055	0.6274	0.6394
IND	0.6120	0.6039	0.6630	0.8217
UAE	0.8714	0.7525	0.4834	0.7500
MYS	0.9162	0.7612	0.5370	0.7878
IDN	0.7599	0.7240	0.6936	0.9053
SAU	0.8891	0.7512	0.5783	0.8571
QAT	0.8409	0.9310	0.5839	0.8113
THA	0.9376	0.7701	0.7641	0.8790
MEX	0.8957	0.7344	0.7782	1.0000
TUR	0.9179	0.8361	0.7531	0.9181
VNM	0.9144	0.7127	0.6982	0.9923
CHL	1.0000	0.8913	0.6066	0.9451
RUS	0.9544	0.8167	0.8143	0.9331
BRA	0.8810	0.7983	1.0000	0.9904
JOR	0.9938	1.0000	0.6058	0.9829

Table A4. Normalization matrix for MABAC (2022)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	1.0000	1.0000	0.5228	0.6080
IND	0.8819	0.5499	0.2422	1.0000
UAE	0.2115	0.2446	1.0000	0.9040
MYS	0.1264	0.2427	0.7002	0.6440
IDN	0.4148	0.2446	0.2014	0.4400
SAU	0.1511	0.2153	0.7026	0.4760
QAT	0.2967	0.0626	0.7170	0.5080
THA	0.0769	0.2622	0.2014	0.3720
MEX	0.1484	0.3288	0.0000	0.0000
TUR	0.0852	0.2074	0.2086	0.1560
VNM	0.0522	0.2720	0.1631	0.1280
CHL	0.0000	0.1057	0.4988	0.1760
KWT	0.0659	0.0000	0.3118	0.2600
OMN	0.0330	0.0470	0.5540	0.2800
BHR	0.0440	0.0117	0.5324	0.0920

Table A5. Normalization matrix for MABAC (2023)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	1.0000	1.0000	0.5556	1.0000
IND	0.8177	0.6704	0.4756	0.3849
UAE	0.1903	0.3363	1.0000	0.5911
MYS	0.1180	0.3207	0.8067	0.4777
IDN	0.4075	0.3898	0.4133	0.1856
SAU	0.1609	0.3385	0.6822	0.2955
QAT	0.2444	0.0757	0.6667	0.4124
THA	0.0858	0.3051	0.2889	0.2440
MEX	0.1501	0.3697	0.2667	0.0000
TUR	0.1153	0.2004	0.3067	0.1581
VNM	0.1206	0.4120	0.4044	0.0137
CHL	0.0000	0.1247	0.6067	0.1031
RUS	0.0617	0.2294	0.2133	0.1271
JOR	0.0080	0.0000	0.6089	0.0309
BRA	0.1743	0.2584	0.0000	0.0172

Table A6. Calculating the real evaluation matrix for MAIRCA (2022)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0113	0.0177	0.0127	0.0081
IND	0.0100	0.0097	0.0059	0.0134
UAE	0.0024	0.0043	0.0243	0.0121
MYS	0.0014	0.0043	0.0170	0.0086
IDN	0.0047	0.0043	0.0049	0.0059
SAU	0.0017	0.0038	0.0171	0.0064
QAT	0.0034	0.0011	0.0174	0.0068
THA	0.0009	0.0046	0.0049	0.0050
MEX	0.0017	0.0058	0.0000	0.0000
TUR	0.0010	0.0037	0.0051	0.0021
VNM	0.0006	0.0048	0.0040	0.0017
CHL	0.0000	0.0019	0.0121	0.0024
KWT	0.0007	0.0000	0.0076	0.0035
OMN	0.0004	0.0008	0.0135	0.0037
BHR	0.0005	0.0002	0.0129	0.0012

Table A7. Calculating the real evaluation matrix for MAIRCA (2023)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0105	0.0186	0.0159	0.0088
IND	0.0086	0.0125	0.0136	0.0034
UAE	0.0020	0.0063	0.0287	0.0052
MYS	0.0012	0.0060	0.0231	0.0042
IDN	0.0043	0.0073	0.0119	0.0016
SAU	0.0017	0.0063	0.0196	0.0026
QAT	0.0026	0.0014	0.0191	0.0036
THA	0.0009	0.0057	0.0083	0.0021
MEX	0.0016	0.0069	0.0076	0.0000
TUR	0.0012	0.0037	0.0088	0.0014
VNM	0.0013	0.0077	0.0116	0.0001
CHL	0.0000	0.0023	0.0174	0.0009
RUS	0.0006	0.0043	0.0061	0.0011
JOR	0.0001	0.0000	0.0175	0.0003
BRA	0.0018	0.0048	0.0000	0.0002

Table A8. Calculating the total gap matrix for MAIRCA (2022)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0000	0.0000	0.0116	0.0052
IND	0.0013	0.0080	0.0184	0.0000
UAE	0.0089	0.0134	0.0000	0.0013
MYS	0.0099	0.0134	0.0073	0.0048
IDN	0.0066	0.0134	0.0194	0.0075
SAU	0.0096	0.0139	0.0072	0.0070
QAT	0.0080	0.0166	0.0069	0.0066
THA	0.0104	0.0131	0.0194	0.0084
MEX	0.0096	0.0119	0.0243	0.0134
TUR	0.0103	0.0140	0.0192	0.0113
VNM	0.0107	0.0129	0.0203	0.0116
CHL	0.0113	0.0158	0.0122	0.0110
KWT	0.0106	0.0177	0.0167	0.0099
OMN	0.0109	0.0169	0.0108	0.0096
BHR	0.0108	0.0175	0.0114	0.0121

Table A9. Calculating the total gap matrix for MAIRCA (2023)

Alternatives	*DO*	*IO*	*BF*	*DR*
CHN	0.0000	0.0000	0.0127	0.0000
IND	0.0019	0.0061	0.0150	0.0054
UAE	0.0085	0.0124	0.0000	0.0036
MYS	0.0093	0.0127	0.0055	0.0046
IDN	0.0062	0.0114	0.0168	0.0072
SAU	0.0088	0.0123	0.0091	0.0062
QAT	0.0080	0.0172	0.0096	0.0052
THA	0.0096	0.0130	0.0204	0.0067
MEX	0.0090	0.0117	0.0210	0.0088
TUR	0.0093	0.0149	0.0199	0.0074
VNM	0.0093	0.0110	0.0171	0.0087
CHL	0.0105	0.0163	0.0113	0.0079
RUS	0.0099	0.0144	0.0226	0.0077
JOR	0.0105	0.0186	0.0112	0.0085
BRA	0.0087	0.0138	0.0287	0.0087