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Performance Evaluation of Turkish Ports: Integrated Fuzzy Entropy- Fuzzy MARCOS Analysis

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ABSTRACT

Purpose: The aim of this study is to propose the Fuzzy Entropy based Fuzzy MARCOS method to solve the Multi Criteria Decision Making (MCDM) problem, which involves analyzing the performance of Turkish ports according to quantitative evaluation criteria.

Methodology: The uncertainty of quantitative criteria is based on the different values they take at different time periods. To overcome this problem, in this study, the importance levels of the criteria were determined by the Fuzzy Entropy method. Then, 11 port alternatives with a share of over 1% in transportation in Turkish ports were ranked according to their performance using the Fuzzy Measurement of Alternatives and Ranking to Compromise Solution (MARCOS) method.

Findings: According to the analysis results, the most important evaluation criterion used in the performance evaluation of container ports, that is, the criterion with the highest weight, is the “port area” criterion. The port with the highest performance value among the ports is Kocaeli port. This method can provide a more accurate evaluation of the performance level of ports and its use in the planning and effective use of port investments.

Originality: This research fills the gap in the literature in three ways: (1) Evaluatee the application of triangular fuzzy numbers to the panel data, which will provide effective inferences about the performanse level of the selected ports, (2) Evaluated a weighting approach using Entropy method that takes into account the distances of triangular fuzzy numbers consisting of real numbers instead of linguistic expressions, (3) An Entropy-based MARCOS method is proposed for solving the Multi-Criteria Decision Making (MCDM) problem involving the performanse analysis of Turkish ports.

Keywords: Ports, Maritime Transport, Fuzzy ENTROPY, Fuzzy MARCOS.
JEL Codes: C61, D81, L91.

Türk Limanlarının Performanslarının Değerlendirmesi: Entegre Bulanık Entropi-Bulanık MARCOS Analizi

ÖZET

Amaç: Bu çalışmanın amacı, Türk limanlarının nicel değerlendirme kriterlerine göre performanslarının analiz edilmesini içeren Çok Kriterli Karar Verme (ÇKKV) probleminin çözümü için Bulanık Entropi tabanlı Bulanık MARCOS yöntemini önermektir.

Yöntem: Nicel kriterlerin belirsizliği, farklı zaman dilimlerinde aldıkları farklı değerlere dayanmaktadır. Bu sorunu aşmak için, bu çalışmada, kriterlerin önem seviyeleri Bulanık Entropi yöntemi ile belirlenmiştir. Daha sonra, Türk limanlarında taşımacılıkta %1'in üzerinde paya sahip 11 liman alternatifi, Alternatiflerin Bulanık Ölçümü ve Uzlaşmaya Göre Sıralama (MARCOS) yöntemi kullanılarak performanslarına göre sıralanmıştır.

Bulgular: Analiz sonuçlarına göre, konteyner limanlarının performans değerlendirmesinde kullanılan değerlendirme kriterlerinden en önemlisi yani en yüksek ağırlığa sahip olan kriter liman alanı kriteridir. Limanlar arasında en yüksek performans değerine sahip liman limanın Kocaeli limanıdır. Bu yöntem limanların performans düzeyinin daha doğru değerlendirilmesini ve liman yatırımlarının planlanmasında ve etkin kullanımında kullanılmasını sağlayabilir.

Özgünlük: Bu araştırma literatürdeki boşluğu üç açıdan doldurmaktadır: (1) Seçilen limanların verimlilik düzeyi hakkında etkili çıkarımlar sağlayacak olan üçgen bulanık sayıların panel verilerine uygulanması değerlendirilmiş, (2) Dilsel ifadeler yerine gerçek sayılardan oluşan üçgen bulanık sayıların uzaklıklarını hesaba katan Entropi yöntemini kullanan bir ağırlıklandırma yaklaşımını değerlendirilmiş, (3) Türk limanlarının performans analizini içeren Çok Kriterli Karar Verme (ÇKKV) problemini çözmek için Entropi tabanlı bir MARCOS yöntemi önerilmiştir.

Anahtar Sözcükler: Limanlar, Denizyolu Taşımacılığı, Bulanık ENTROPİ, Bulanık MARCOS.
JEL Kodları: C61, D81, L91.

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1. INTRODUCTION

Maritime transportation is an economically, environmentally, and socially advantageous alternative for both cargo and passenger transportation. In parallel with global developments, there is a desire to switch from road transportation to maritime transportation within the concept of sustainable transportation. Ports are one of the most important actors in the global supply chain and world trade. Due to the great economic benefits that ports bring to port cities for regional development, there is a global economic transfer tendency towards port cities (Ferrari et al., 2010). Almost 90% of international transportation in the world is carried out by maritime transportation mode. Türkiye has a large and strategically important maritime area in the Black Sea, Western Europe, Middle East and North Africa regions, with a 8,333 km coastline providing direct sea connections to various countries in geographical and geopolitical areas. In terms of the value of the goods transported, maritime transportation has the largest share in both imports and exports in the last 10 years. While the highest share of maritime transportation in imports was 69.14% in 2015, this share was 65.74% in 2022 between 2012-2022. The highest share of maritime transportation in export shipments was 63.31% in 2018 from 2012 to 2022, and this share was 59.56% in 2022 (UTİKAD, 2022: 133).

Türkiye has many advantages on the way to becoming a logistics base in world trade. These advantages include the ability to use different modes simultaneously, the fact that it has coasts on the Mediterranean, Black and Aegean Seas for maritime transportation, and that the Sea of Marmara is an inland sea. In addition, the Baku-Tbilisi-Kars (BTK) Railway Line can be shown as the capacity to transport directly from Asia to Europe or with different mode connections. The extent to which these advantages of Turkiye can be used can be evaluated with the logistics performance index and different indices.

The Logistics Performance Index (LPI) report, which was first published in 2007 and prepared by the "Global Trade and Regional Integration Unit" of the World Bank, aims to rank countries in the world according to their logistics performance. The evaluation criteria of the logistics performance index are customs, infrastructure, international transportation, competence and quality, timing and tracking/monitoring. Türkiye ranked 47th in the LPI prepared in 2018, and 42nd in the LPI 2023, which includes 139 countries (WB, 2024). International transportation: Turkiye ranked 53rd in 2018 and rose to 26th place in 2023. One of the performance indicator indices of maritime transportation is the Regular Liner Shipping Connectivity Index (LSCI). This index measures the level of integration in regular liner shipping. Türkiye is among the countries in the 50-70 index range as a country. Different LSCI index values of Turkish ports are presented in Figure 1.

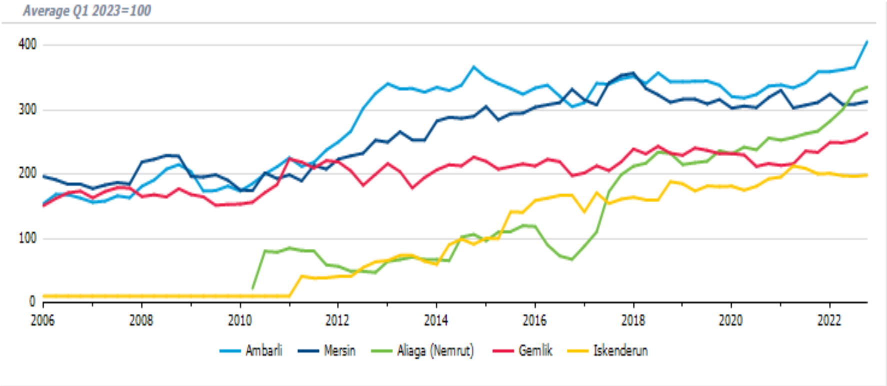

Figure 1. Port liner shipping connectivity index- Top 5 ports in 2022 (UNCTAD, 2024)

Approximately 60% of the active time in international trade is spent at sea, and the majority of delays occur at the departure or arrival points of containers (ports, airports) (Boztepe, 2023). According to the 2023 report of the Turkish Port Operators Association, Türkiye's loading and unloading averages are 54 and 30 tons per minute, while the average ship waiting times for loading and unloading are 36 and 37 hours. In addition to the inability of countries to use their existing capacity, global developments are affecting the activities of Turkish ports. There have been significant decreases in container handling in the Black Sea due to the Russia-Ukraine tension. When the data for the first 9 months of 2022 is examined, it is seen that there is a decrease of 80% in Ukrainian ports and a decrease of 11% in Russian ports in the Black Sea. In total, container handling in the Black Sea decreased by 25% (TLID, 2023: 79).

The performanse measure is directly related to the productivity measure. The idea behind the similar use of both concepts is that a firm's performance improves the more efficient and productive it is (Gonzalez and Trujillo, 2009). Port efficiency has a key role in determining transportation costs and hence international trade between countries (Clark et al., 2004). The panel set data used in this study are panel data series of port data. Since panel data sets contain different values at different times, it covers more than one data set.

This feature allows time differences in variables to be included in the model under study. For this reason, the variables are expressed in the form of triangular fuzzy numbers by taking the maximum value, minimum value and average value in the time interval in the panel data set.

Cargo ports are places that provide cargo transshipment services to and from ships (as opposed to producing a physical product). This capability is enhanced if ports are technically and cost efficient (Chang and Talley, 2019). Ports are important areas in international trade as areas where cargo is stored for a certain period of time with connections to different transportation modes and where value-added logistics services are provided (Şişlioğlu, 2021). Maritime transportation is one of the most important components of domestic and foreign trade in the world. The high increase in the demand for maritime transportation, especially container transportation, in recent years suggests that companies should choose the most suitable container port to integrate their transportation networks (Onut et al., 2011).

In the mid-90s, the performanse literature, already applied to a large number of industries, was introduced for the port sector. The diversity of approaches applied reflects the lack of consensus in identifying the method that best describes the complex reality of this sector (Gonzalez and Trujillo, 2009). Port evaluation and selection problems can be considered as multi-criteria decision problems due to the competing interests of the evaluation criteria. Each criterion has different levels of importance. These importance levels are expressed as criteria weights. Different quantitative and qualitative methods can be used to determine these weights. If the subjective evaluation of the users is to be made directly, expert opinion is used. However, quantitative methods are preferred for objective evaluation. In this study, an objective evaluation was aimed according to the existing data sets and Fuzzy Entropy method was used to determine the criteria weights. Shannon entropy, also known as information entropy, is used to describe the uncertainty in the occurrence of each possible event in an information source (Nemzer, 2017). According to Shannon, information entropy is negatively related to the regularity of the system and its value decreases as the regularity of the system increases. That is, a more ordered system has lower information entropy; a more disordered system has higher information entropy. In an MCDM problem, the smaller the information entropy of a criterion, the greater its influence on the overall evaluation and the more weight will be given to it (Li et al., 2024).

The selection of criteria weights as well as the ranking and evaluation of alternatives are complex decision problems. Making decisions based solely on intuition and experience can lead to wrong decisions and unexpected costs. Multi-criteria decision making (MCDM) approaches have been proposed in the literature to overcome this problem (Kadaifci et al., 2019). There are many different MCDM methods used to solve ranking or selection problems among alternatives. In this study, the MARCOS method presented by Stević et al. (2020) was used to rank the performanse of ports. The MARCOS method proposes a feasible compromise solution that is closest to the ideal. It is also flexible in analyzing expert preferences regardless of the type of scale (Büyüközkan, 2021). This method is used in its fuzzy form and integrated with the fuzzy Entropy method.

The contribution from this research are listed as follows;

(1) Evaluate the application of triangular fuzzy numbers to the panel data, which will provide effective inferences about the performanse level of the selected ports.

(2) Evaluation of a weighting approach using the Entropy method, which evaluates by taking into account the distance between triangular fuzzy numbers, that is, the values in the data set, which are composed of real numbers instead of linguistic expressions, that is, whether they are high or low compared to each other.

(3) An Entropy-based MARCOS method is proposed for solving the Multi-Criteria Decision Making (MCDM) problem involving the performans**e** analysis of Turkish ports.

The organization of the study is as follows: Section 2 presents preliminary information. Section 3 describes the methods used. In Section 4, our proposed method is applied and the performanse ranking of the ports is obtained. Section 5 presents and discusses the results obtained.

2. LITERATURE REVIEW

There are different studies in the literature for the evaluation of ports. Baysal et al. (2004) evaluated the efficiency and perfromanse analysis of Turkish ports with data envelopment analysis method. Onut et al. (2011) used the FANP method to solve the optimal port search problem of a company in the Marmara Region that has quality problems. Ateş and Esmer (2014) evaluated the efficiency of Turkish container ports using Data Envelopment Analysis (DEA) and Free Disposable Envelope Model (FDH) models. Ateş et al. (2013) used Data Envelopment Analysis (DEA) to determine the relative efficiencies of 9 container terminals (Novorossisk, Odesa, Varna, Burgas, Batumi, Poti, Ilyichevsk, Constanza and Trabzon) operating in the Black Sea region (Türkiye, Georgia, Ukraine, Bulgaria, Romania and Romania) within the framework of theTransport Corridor Europe-Caucasus-Asia (TRACECA) program in 2011. Akyürek (2017) analyzed the efficiency of Black Sea ports. Akgül (2018) analyzed the market structure and competitiveness of cruise ports in Türkiye. Balık (2023) In this study, the share of cargo handled in Antalya Port in total cargo handled in Türkiye and comparative cargo analysis with Mersin and Izmir ports, which are the two closest commercial ports to the east and west. Öztemiz and Vatansever (2023) investigated the relationship between container port volume and foreign trade in container port projects with econometric analysis. Özgüven and Güngör (2023) made an evaluation of blockchain technology in terms of Turkish ports.

Feng (2011) compared the performance of Western European and East Asian ports. Rudjanakanoknas and Suksirivoraboot (2012) analyzed the trade facilitation of four ports in Thailand. Cabral and Sousa (2014) This paper compared the competitiveness of Brazilian container ports handling containers in 2009. Gamassa and Chen (2017) compared port efficiency between East and West African ports using Data Envelopment Analyses. Garcia-Alonso et al. (2019) evaluated the competition between three major container ports in Spain, namely Barcelona, Bilbao and Valencia, using Geographic Information System (GIS). Ding et al. (2019) used the Analytic Hierarchy Process (AHP) method and the Decision Making Trial and Evaluation Laboratory (DEMATEL) technique to evaluate the key determinants of attractiveness and their cause/effect relationships for container ports in Taiwan. Andriotti et al. (2021) analyzed Brazilian public ports and port pricing figures, taking into account the Rio de Janeiro Port Authority and its two main managed ports (Rio de Janeiro and Itaguaí) in order to assess the need for adequacy and self-sustainability in ports. Lorencic et al. (2022) conducted a performance evaluation of four Mediterranean cruise ports, namely Barcelona, Piraeus, Civitavecchia and Marseille, using the MCDM approach. Wang et al. (2024) solved the problem of selecting sustainable food suppliers using the Pythagorean fuzzy CRITIC-MARCOS method.

Stević et al. (2020) introduced the idea of measuring and ranking alternatives according to the consensus solution (MARCOS) method, which is based on the distance of alternatives from reference points according to the criteria considered and their total score reflected by a utility function. Ali (2022) listed the advantages of the MARCOS method as follows: the consideration of reference points over the ideal and non-ideal solution at the beginning of model formation, the further determination of the degree of utility of both sets of solutions, the proposal of a new way of determining the utility functions and their sum, and the ability to consider a large number of criteria and alternatives. Wang et al. (2023) developed a Fermatean fuzzy MARCOS method based on expectation theory to analyze the risk of construction operations. Later, different methods were integrated into the MARCOS method.

Among these studies, no study was found that took into account the size differences between the members of the data sets. Fuzzy logic is generally used to convert qualitative evaluations of expert opinions into quantitative ones. However, in this study, existing quantitative panel data sets were converted into fuzzy form and used for evaluation.

3. METHODOLOGY

In the study, the evaluation criteria, which are the indicators of the performanse analysis of the ports, were weighted by Fuzzy Entropy method. Then, Fuzzy MARCOS method was applied for performanse ranking. The steps taken for the model recommendation are presented in Figure 2.

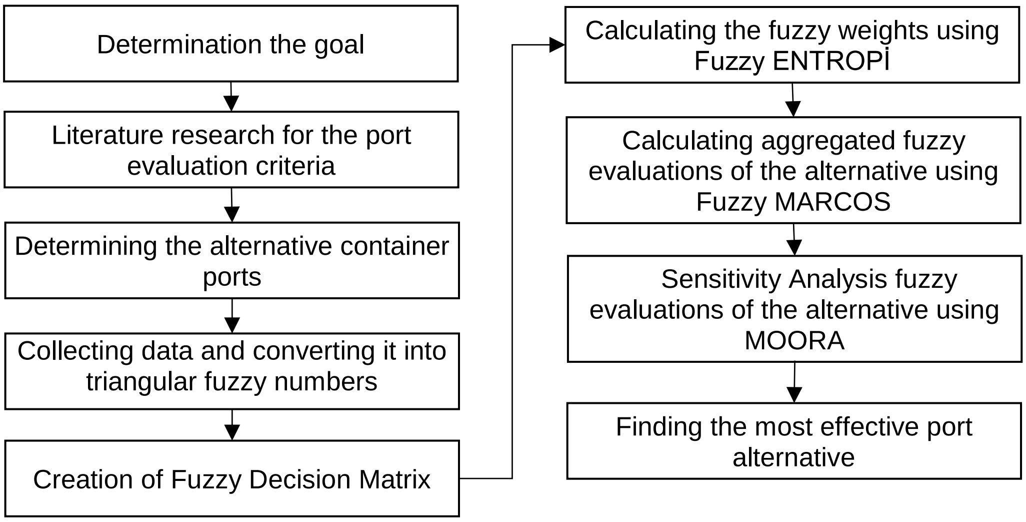

Figure 2. The proposed model for determining the performanse of Turkish ports

In the study, the evaluation criteria presented in Table 1 were used as the performanse indicators of the ports.

Table 1. List of research criteria

Criterion No	*Criteria Description*	*Abbreviation*	*Unit*	*Papers Using Criteria*
C1	Container handling operations carried out in our ports on the basis of port authorities-Import	KİTH	TEU/TEUs	Onut (2011), Balık (2023), Öztemiz and Vatansever (2023), Gamassa and Chen (2017), Ateş et al. (2013), Ateş and Esmer (2014)
C2	Container handling operations carried out in our ports on the basis of port authorities- Export	KİHR	TEU/TEUs	Onut (2011), Balık (2023), Öztemiz and Vatansever (2023), Gamassa and Chen (2017), Ateş et al. (2013), Ateş and Esmer (2014)
C3	Cargo handling carried out in our ports on the basis of port authorities-İmport	YİTR	Ton	Onut (2011), Gamassa and Chen (2017), Baysal et al. (2004)
C4	Cargo handling carried out in our ports on the basis of port authorities-Export	YİHR	Ton	Onut (2011), Gamassa and Chen (2017)
C5	Number of ships calling at our ports based on port authorities	GS	Adet	Poitras et al. (1996)
C6	Gross Ton ship calling at our ports based on port authorities	GGT	Gros Ton	Şişlioğlu (2021),
C7	Port Area	LA	m^2	Ateş et al (2013), Ateş and Esmer (2014), Kadaifci et al. (2019).
C8	Container Dock/Pier Length	LU	m	Feng et al (2011), Gamassa and Chen (2017), Ateş et al. (2013), Ateş and Esmer (2014)
C9	Draft	D	m	Ateş et al (2013), Ateş and Esmer (2014)

A set of crips numbers (sharp numbers) is a collection of $x \in X$ elements or objects that can be finite, countable or extremely variable (Zimmermann, 2001:11). Fuzzy sets were defined by Zadeh (1965) as a class of objects with a degree of continuity. Here, the membership degree of each element in the universe of discourse belongs to a fuzzy set and is represented by a real value between zero and one (Rani et al., 2024). Fuzzy numbers are divided into two as triangular and trapezoidal fuzzy numbers. Triangular fuzzy numbers were used in this study. Zadeh (1965) expressed a triangular fuzzy number mathematically as follows in Equation 1. Definitions of arithmetic solutions with triangular computational numbers can be found in Dubois and Prade (1978), Wagenknecht et al. (2001) and Zadeh (1965).

$$\mu_{\tilde{A}}(X) = \begin{cases} \frac{x-l}{m-l} & l \le x \leqslant m \\ \frac{u-x}{u-m} & m \le x \leqslant u \\ 0 & Other \end{cases} \tag{1}$$

The entropy method was proposed by Shannon (1948). This method takes into account the fact that the value of each alternative according to each criterion may vary within a range and may have different behaviors when ranked data is used (Lotfi and Fallahnejad, 2010).

3.1. Fuzzy Entropy

The solution steps of Shannon's fuzzy Entropy based on α-level clusters are as follows (Cavallaro et al., 2016; Lotfi and Fallahnejad, 2010).

Step1. The decision matrix (Equation 1) is formed. Then fuzzy data is converted to interval data using α cut sets using Equations 3 and 4.

$$\tilde{D} = \begin{vmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \dots & \tilde{x}_{mn} \end{vmatrix} \tag{2}$$

$$(\tilde{x}_{ij})_{\alpha}^{L} = l + l * (m - l),\ (\tilde{x}_{ij})_{\alpha}^{R} = u + l * (m - u) \tag{3}$$

$$[(\tilde{x}_{ij})_{\alpha}^{L}\ ,\ (\tilde{x}_{ij})_{\alpha}^{R}] = [\ \min_{x_{ij}}\{x_{ij} \in R \mid \mu_{\tilde{x}_{ij}}(x_{ij}) \geq \alpha\}, \max_{x_{ij}}\left\{x_{ij} \in R \mid \mu_{\tilde{x}_{ij}}\left(x_{ij}\right) \geq \alpha\right\}]\quad 0 \leq \alpha \leq 1 \tag{4}$$

Fuzzy data at different confidence levels are transformed into different α-level clusters via Equation 5.

$$B = \begin{vmatrix} [x_{11}^{L}, x_{11}^{R}] & [x_{12}^{L}, x_{12}^{R}] & \dots & \dots & [x_{1n}^{L}, x_{1n}^{R}] \\ [x_{21}^{L}, x_{21}^{R}] & [x_{22}^{L}, x_{22}^{R}] & \dots & \dots & [x_{2n}^{L}, x_{2n}^{R}] \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ [x_{m1}^{L}, x_{m1}^{R}] & [x_{m2}^{L}, x_{m2}^{R}] & \dots & \dots & [x_{mn}^{L}, x_{mn}^{R}] \end{vmatrix} \tag{5}$$

Step 2. The Normalized matrix is formed: The normalized matrix lover bond p_{ij}^{L} is calculated by Equation 6 and upper bond p_{ij}^{R} is calculated by Equation 7.

$$p_{ij}^{L} = \frac{x_{ij}^{L}}{\sum_{j=1}^{m} x_{ij}^{R}}\quad j = 1,2,\dots.,m \quad i = 1,2,\dots,n \tag{6}$$

$$p_{ij}^{R} = \frac{x_{ij}^{R}}{\sum_{j=1}^{m} x_{ij}^{R}}\quad j = 1,2,\dots.,m \quad i = 1,2,\dots,n \tag{7}$$

Step 3. The lower e_{i}^{L} and upper bound e_{i}^{R} ranges are determined by entropy using Equations 8 and 9.

$$e_{i}^{L} = min\{-e_{0}\sum_{j=1}^{m} p_{ij}^{L} lnp_{ij}^{L}, -e_{0}\sum_{j=1}^{m} p_{ij}^{R} lnp_{ij}^{R}\}\ \ i = 1,2,\dots,n \tag{8}$$

$$e_{i}^{R} = max\{-e_{0}\sum_{j=1}^{m} p_{ij}^{L} lnp_{ij}^{L}, -e_{0}\sum_{j=1}^{m} p_{ij}^{R} lnp_{ij}^{R}\}\ \ i = 1,2,\dots,n \tag{9}$$

Step 4. The lower d_{i}^{L} and upper d_{i}^{R} limit range change values are determined by Equations 10 and 11.

$$d_{i}^{L} = 1 - e_{i}^{R}\quad i = 1,2,\dots,n \tag{10}$$

$$d_{i}^{R} = 1 - e_{i}^{L}\quad i = 1,2,\dots,n \tag{11}$$

Step 5. The lower w_{i}^{L} and upper w_{i}^{R} values of the criterion weights are determiden by Equations 12 and 13.

$$w_{i}^{L} = \frac{d_{i}^{L}}{\sum_{s=1}^{n} d_{s}^{L}}\quad i = 1,2,\dots,n \tag{12}$$

$$w_{i}^{R} = \frac{d_{i}^{R}}{\sum_{s=1}^{n} d_{s}^{R}}\quad i = 1,2,\dots,n \tag{13}$$

Step 6. Determining the average criterion weight by taking the arithmetic average of the lower and upper values

3.2. Fuzzy MARCOS Method

Let $A = \{A_{1}, A_{2}, \dots.A_{m}\}$ be a set of alternatives and let $C = \{C_{1}, C_{2}, \dots.C_{n}\}$ be a set of criteria. The solution steps of the method are as follows (Stanković et al., 2020, Pamucar et al, 2021).

Step 1. The fuzzy decision matrix (Equation 15) is created using Equation 14.

In a decision problem with m alternatives and n criteria $\tilde{x}_{ij}$ It is the fuzzy performance value obtained as a result of evaluating alternative i according to j criterion. $\tilde{x}_{ij}$ the decision matrix consisting of performance values as a triangular fuzzy number is shown as follows.

$$\tilde{x}_{ij} = [x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}] \tag{14}$$

$$\tilde{X} = \widetilde{x_{ij}} = \begin{vmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{21} & \dots & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \dots & \tilde{x}_{mn} \end{vmatrix} \quad i = 1,2, \dots \dots m, j1,2, \dots, \tag{15}$$

Step 2. The extended initial fuzzy matrix (Equation 16) is created using Equations 17 and 18.The extension is performed by determining the fuzzy anti-ideal $\tilde{A}(AI)$ and fuzzy ideal $\tilde{A}(ID)$solution.

$$\tilde{X} = \left\{ \begin{array}{c} c) \\ \tilde{A}_1 \\ \vdots \\ \vdots \\ \tilde{A}_m \\ \tilde{A}(ID) \end{array} \right. \begin{vmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{21} & \dots & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \dots & \tilde{x}_{mn} \\ \tilde{x}_{id1} & \tilde{x}_{id2} & \dots & \dots & \tilde{x}_{idn} \end{vmatrix} \quad i = 1,2, \dots \dots m, j1,2, \dots, \tag{16}$$

The fuzzy $\tilde{A}(AI)$is the worst alternative while the fuzzy $\tilde{A}(ID)$is an alternative with the best performance. Depending on type of the criteria, $\tilde{A}(AI)$ and $\tilde{A}(ID)$are as follows. B belongs to the benefit group of criteria while C belongs to the cost group of criteria

$$\tilde{A}(AI) = \underset{i}{min} \tilde{x}_{ij} \ if \ j \in B \ and \ \underset{i}{max} \tilde{x}_{ij} \ if \ j \in C \tag{17}$$

$$\tilde{A}(ID) = \underset{i}{max} \tilde{x}_{ij} \ if \ j \in B \ and \ \underset{i}{min} \tilde{x}_{ij} \ if \ j \in C \tag{18}$$

Step 3. The normalized fuzzy matrix $\widetilde{N} = [\tilde{n}_{ij}]$ is created using Equations 19 and 20.

$$\tilde{n}_{ij} = (n_{ij}^l, n_{ij}^m, n_{ij}^u) = \left(\frac{x_{id}^l}{x_{ij}^u}, \frac{x_{id}^l}{x_{ij}^m}, , \frac{x_{id}^l}{x_{ij}^l}\right) if \ j \in C \tag{19}$$

$$\tilde{n}_{ij} = (n_{ij}^l, n_{ij}^m, n_{ij}^u) = \left(\frac{x_{id}^l}{x_{ij}^u}, \frac{x_{id}^m}{x_{ij}^u}, , \frac{x_{id}^u}{x_{ij}^u}\right) if \ j \in B \tag{20}$$

Step 4. The weighted fuzzy matrix $\tilde{V} = [\tilde{v}_{ij}]$ is calculated by multiplying matrix $\widetilde{N}$ with the fuzzy weight coefficients of the criterion $\widetilde{w}_j$ (Equation 21).

$$\tilde{v}_{ij} = (v_{ij}^l, v_{ij}^m, v_{ij}^u) = \tilde{n}_{ij} \otimes \widetilde{w}_j = (n_{ij}^l * w_j^l, n_{ij}^m * w_j^m, n_{ij}^u * w_j^u) \tag{21}$$

Step 5. The fuzzy matrix $\tilde{S}_i$ is calculated by using Equation 22. where$\tilde{S}_i = s_i^l, s_i^m, s_i^u$ represents the sum of the elements of the weighted fuzzy matrix V.

$$\tilde{S}_i = \sum_{i=1}^n \tilde{v}_{ij} \tag{22}$$

Step 6. The utility degree of alternatives $\widetilde{K}_i$ is calculated by using Equations 23 and 24.

$$\widetilde{K}_i^- = \frac{\tilde{s}_i}{\tilde{s}_{ai}} = (\frac{s_i^l}{s_{ai}^u}, \frac{s_i^m}{s_{ai}^m}, \frac{s_i^u}{s_{ai}^l}) \tag{23}$$

$$\widetilde{K}_i^+ = \frac{\tilde{s}_i}{\tilde{s}_{id}} = (\frac{s_i^l}{s_{id}^u}, \frac{s_i^m}{s_{id}^m}, \frac{s_i^u}{s_{id}^l}) \tag{24}$$

Step 7. The fuzzy matrix $\tilde{T}_i$ is calculated by using Equation 25.

$$\tilde{T}_{ij} = \tilde{t}_{ij} = (t_i^l, t_i^m, t_i^u) = \widetilde{K}_i^- \otimes \widetilde{K}_i^+ = (k_{ij}^{-l} * k_i^{+l}, k_{ij}^{-m} * k_i^{+m}, k_i^{-u} * k_i^{+u}) \tag{25}$$

Then, it is necessary to determine a new fuzzy number $\widetilde{D}$. This value is calculated by using Equation 26.

$$\widetilde{D} = (d^l, d^m, d^u) = \underset{i}{max} \tilde{t}_{ij} \tag{26}$$

Then, it is necessary to de-fuzzify the number$\widetilde{D}$ obtaining the number $dfcrisp$. This value is calculated by using Equation 27.

$$dfcrisp = \frac{l+4m+u}{6} \tag{27}$$

Step 8. The utility functions in relation to the ideal $f(\widetilde{K}_i^+)$ and anti-ideal $f(\widetilde{K}_i^-)$ solution is determined by using Equation 28 and 29.

$$f\left(\widetilde{K}_i^-\right) = \frac{\widetilde{K}_i^-}{df_{crisp}} = \left(\frac{\tilde{k}_i^{-l}}{df_{crisp}}, \frac{\tilde{k}_i^{-m}}{df_{crisp}}, \frac{\tilde{k}_i^{-u}}{df_{crisp}}\right) \tag{28}$$

$$f\left(\widetilde{K}_i^+\right) = \frac{\widetilde{K}_i^+}{df_{crisp}} = \left(\frac{\tilde{k}_i^{+l}}{df_{crisp}}, \frac{\tilde{k}_i^{+m}}{df_{crisp}}, \frac{\tilde{k}_i^{+u}}{df_{crisp}}\right) \tag{29}$$

Step 9. The utility function of alternatives fK_i is determined by using Equation 30.

$$fK_i = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{K_i^+} + \frac{1 - f(K_i^-)}{K_i^-}} \tag{30}$$

Step 10. Ranking the alternatives based on the final values of utility functions. It is desirable that an alternative have the highest possible value of the utility function.

4. RESULTS

4.1. Data Set

There are 8 thousand 333 kilometers of coastline and a total of 180 ports and piers in Türkiye, excluding marinas (Fig 3). In this research, ports with container handling volumes of more than 1% were determined. These ports are Aliağa (A1), Ambarlı (A2), Antalya (A3), Gemlik (A4), İskenderun (A5), İstanbul (A6), İzmir (A7), Kocaeli (A8), Mersin (A9), Samsun. (A10) and Tekirdağ (A11) ports. The evaluation criteria for these ports were determined by considering the literature. These criteria were determined as container handling import (C1), container handling export (C2), cargo handling import (C3), cargo handling export (C4), number of ships calling at the port (C5), Gross handling of ships calling at the port (C6), Port area (C7), Pier length (C8) and Draft (C9) (Table x) were used. These data were obtained from the statistics of the Ministry of Transport and Infrastructure of the Republic of Türkiye (UAB, 2024) and the Turkish Port Operators Association (TLID, 2024). The data set is 11-year time series data between 2013 and 2023. The reason why these data are limited to 11 years is that all statistics are available on these dates.

Figure 3. Ports in Türkiye (CH, 2024)

4.2. Calculation of Criterion Weights with Fuzzy Entropy Method

Using the 11-year data obtained in the research, the data was converted into triangular fuzzy number form. Here, the minimum value is expressed as l, the mean value as m and the maximum value as u (Wang, 2014) (Equation 31). The decision matrix has been created in this way (App 1).

$$\boldsymbol{p_{ij} = (l_{ij}, m_{ij}, u), \; l_{ij} = min_{1 \le e \le t}^{min}\{x_{ij}(e)\}, \; m_{ij} = \frac{1}{n}\sum_{e=1}^{n} x_{ij}\,(e), \; u_{ij} = max_{1 \le e \le t}^{min}\{x_{ij}(e)\}}$$

$$\boldsymbol{i = 1, 2, 3, \ldots., m, \; j = 1, 2, 3, \ldots.n \; and \;\; e = 1, 2, 3, \ldots.t}$$

(31)

Fuzzy data was converted to interval data using α cut sets. The α cut-off value was calculated with values of 0.1, 0.5, 0.9, and results with a value of 0.5 were used. Using Equations 3 and 4, the matrix in Equation 5 was created. The interval number matrix for criterion 1 is presented in Table 2.

Table 2. Range data for C1

Ports	*Lower*	*Upper*
A1	375745.74	643089.99
A2	963124.99	1119453.99
A3	34744.61	78434.11
A4	312431.09	363027.59
A5	152531.43	293578.43
A6	14192.03	37065.78
A7	173179.74	283817.24
A8	537583.12	860338.38
A9	742053.20	896586.83
A10	10870.88	28495.38
A11	65925.68	188793.68
Total		2497584.11

Normalized interval data were calculated using Equations 6 and 7, and the results for C1 are presented in Table 3.

Table 3. Normalized range data for C1

Ports	*Lower*	*Upper*
A1	0.15	0.26
A2	0.39	0.45
A3	0.01	0.03
A4	0.13	0.15
A5	0.06	0.12
A6	0.01	0.01
A7	0.07	0.11
A8	0.22	0.34
A9	0.30	0.36
A10	0.00	0.01
A11	0.03	0.08

Lower and upper bound range entropy calculations were made using Equations 8 and 9, and the results for criterion 1 are presented in Table 4.

Table 4. Lower and upper bound range entropy for C1

Lower Bound	*Upper Bound*
0.48	0.56

Lower and upper limit range change values were calculated using Equations 10 and 11 and are presented in Table 5 for C1.

Table 5. Lower and upper limit range change values for C1

Lower Limit	*Upper Limit*
0.44	0.52

Using Equations 12 and 13, the lower and upper values of the criterion weights were calculated and the results for c1 are presented in Table 6.

Table 6. Table of lower and upper values of criterion weights for C1

Lower Value	*Upper Value*
0.1178	0.1141

Then, the average criterion weights were calculated by taking the arithmetic average (Equations 14 and 15) of the lower and upper values and are presented in Table 7.

Table 7. Table of values of criterion weights for C1

l	*m*	*u*
0.1178	0.1159	0.1141

4.3. Determining the Performanse Rankings of Turkish Ports with Fuzzy MARCOS Method

The decision matrix given in App 1 is also used here. In this research, all of the criteria are benefit criteria. Maximum and minimum values are determined using Equations 17 and 18. Maximum and minimum values for Criterion 1 are presented in Table 8.

Table 8. Max and min values for C1

Min	26206.523	26206.523	26206.523
Max	1042574.8258	1042574.8258	1042574.8258
Min	4488.0000	23896.0682	50235.5000
Max	888816.5000	1037433.4773	1201474.5000

The normalized matrix is determined using Equations 19 and 20. The result obtained for C1 is presented in Table 9.

Table 9. Normalize matrix for C1

	l	*m*	*u*
Weights	0.117808276	0.115930569	0.114052862
A (AI)	0.0251	0.0251	0.0251
A1	0.2315	0.4893	0.7444
A2	0.8525	0.9951	1.1524
A3	0.0140	0.0526	0.0978
A4	0.2794	0.3200	0.3764
A5	0.0683	0.2243	0.3389
A6	0.0043	0.0229	0.0482
A7	0.0982	0.2340	0.3104
A8	0.3708	0.6604	0.9900
A9	0.6357	0.7878	0.9322
A10	0.0030	0.0179	0.0368
A11	0.0000	0.1264	0.2357
A (ID)	1.00000	1.00000	1.00000

The weighted normalized matrix is determined using Equation 21 and taking into account the criterion weights. The result obtained for criterion 1 is presented in Table 10.

Table 10. Weighted normalized matrix for C1

	L	*m*	*u*
A (AI)	0.0030	0.0029	0.0029
A1	0.0273	0.0567	0.0849
A2	0.1004	0.1154	0.1314
A3	0.0017	0.0061	0.0112
A4	0.0329	0.0371	0.0429
A5	0.0081	0.0260	0.0387
A6	0.0005	0.0027	0.0055
A7	0.0116	0.0271	0.0354
A8	0.0437	0.0766	0.1129
A9	0.0749	0.0913	0.1063
A10	0.0004	0.0021	0.0042
A11	0.0000	0.0147	0.0269
A (ID)	0.1178	0.1159	0.1141

The fuzzy matrix $\tilde{S}_i$ is determined by using Equation 22 (Table 11).

Table 11. $\tilde{S}_i$ Values

	l	*m*	*u*
A (AI)	0.0903	0.0905	0.0908
A1	0.3060	0.4900	0.7012
A2	0.4101	0.5666	0.7350
A3	0.0462	0.1930	0.3809
A4	0.2398	0.3563	0.4853
A5	0.1661	0.3848	0.6230
A6	0.0522	0.0921	0.1320
A7	0.2627	0.3348	0.3868
A8	0.4425	0.6172	0.7987
A9	0.3620	0.5329	0.7765

A10	0.1003	0.4444	0.3178
A11	0.1646	0.2391	0.3139
A (ID)	1.0000	1.0000	1.0000

The utility degree of alternatives are determined by using Equation 23 and 24 (Table 12).

Table 12. $\widetilde{K}_i$Values

Ports	*Fuzzy Ki-*			*FuzzyKi+*		
A1	3.370	5.412	7.769	0.3060	0.4900	0.7012
A2	4.517	6.259	8.144	0.4101	0.5666	0.7350
A3	0.509	2.131	4.220	0.0462	0.1930	0.3809
A4	2.641	3.936	5.376	0.2398	0.3563	0.4853
A5	1.829	4.251	6.903	0.1661	0.3848	0.6230
A6	0.575	1.017	1.462	0.0522	0.0921	0.1320
A7	2.893	3.698	4.285	0.2627	0.3348	0.3868
A8	4.873	6.818	8.849	0.4425	0.6172	0.7987
A9	3.987	5.887	8.603	0.3620	0.5329	0.7765
A10	1.105	4.908	3.521	0.1003	0.4444	0.3178

The $\tilde{T}_i$ is determined by using Equation 25 (Table 13).

Table 13. $\widetilde{T}_i$Values

Ports	*Ti*		
A1	3.6757	5.9019	8.4698
A2	4.9269	6.8257	8.8787
A3	0.5551	2.3243	4.6009
A4	2.8813	4.2922	5.8616
A5	1.9953	4.6353	7.5256
A6	0.6268	1.1089	1.5942
A7	3.1561	4.0333	4.6720
A8	5.3155	7.4351	9.6475
A9	4.3492	6.4197	9.3794
A10	1.2048	5.3527	3.8387
A11	1.9768	2.8802	3.7915

The new fuzzy number $\widetilde{D}$ is determined by using Equation 26 and 27 (Table 14).

Table 14. $\widetilde{D}$ Values tables

Ports	*Crisp K-*	*Crisp K+*
A1	5.4644	0.4945
A2	6.2828	0.5686
A3	2.2090	0.1998
A4	3.9602	0.3584
A5	4.2890	0.3881
A6	1.0174	0.0921
A7	3.6621	0.3315
A8	6.8322	0.6183
A9	6.0229	0.5450
A10	4.0431	0.3659

The utility functions in relation to the ideal $f\left(\widetilde{K}_i^{+}\right)$ and anti-ideal $f\left(\widetilde{K}_i^{-}\right)$ solutions are determined by using Equation 28 and 29 (Table 15).

Table 15. Utility functions

Ports	*Crisp F(K-)*	*Crisp F(K+)*
A1	0.0664	0.7334
A2	0.0763	0.8433
A3	0.0268	0.2965
A4	0.0481	0.5315
A5	0.0521	0.5757
A6	0.0124	0.1366
A7	0.0445	0.4915
A8	0.0830	0.9170
A9	0.0732	0.8084

A10	0.0491	0.5427
A11	0.0321	0.3547

The utility function of alternatives fK_i is determined by using Equation 30 (Table 16).

Table 16. Utility functions of altenatives

Ports	*(1-f(K-))/f(K-)*	*(1-f(K+))/f(K+)*
A1	14.0669	0.3635
A2	12.1028	0.1859
A3	36.2865	2.3727
A4	19.7883	0.8813
A5	18.1997	0.7371
A6	79.9257	6.3231
A7	21.4775	1.0345
A8	11.0492	0.0905
A9	12.6695	0.2370
A10	19.3612	0.8428
A11	30.1557	1.8197

Finally, the performanse ranking of Turkish ports is obtained as follows (Table 17).

Table 17. The performanse ranking of Turkish ports

f(K)	*Ranking*	*Port Name*
0.3862	4	Aliağa
0.5156	2	Ambarlı
0.0607	10	Antalya
0.1993	7	Gemlik
0.2346	5	İskenderun
0.0127	11	İstanbul
0.1699	8	İzmir
0.6137	1	Kocaeli
0.4723	3	Mersin
0.2079	6	Samsun
0.0874	9	Tekirdağ

4.4. Sensitivity Analysis

For the sensitivity analysis of the results we obtained with the model created for the research, the results of the model in different Multi-Criteria Decision-making methods were investigated. A ranking was obtained with the Fuzzy Moora Ratio Approach, provided that the criterion weights remained the same.

Table 18. Ranking obtained by fuzzy MOORA ratio method

Fuzzy MOORA Ratio	*Ranking*	*Port Name*
0.1682	4	Aliağa
0.1946	2	Ambarlı
0.0617	10	Antalya
0.1169	6	Gemlik
0.1285	5	İskenderun
0.0309	11	İstanbul
0.1033	7	İzmir
0.2139	1	Kocaeli
0.1855	3	Mersin
0.0928	8	Samsun
0.0787	9	Tekirdağ

The performanse rankings of the ports are presented in Figure 4 for two different methods.

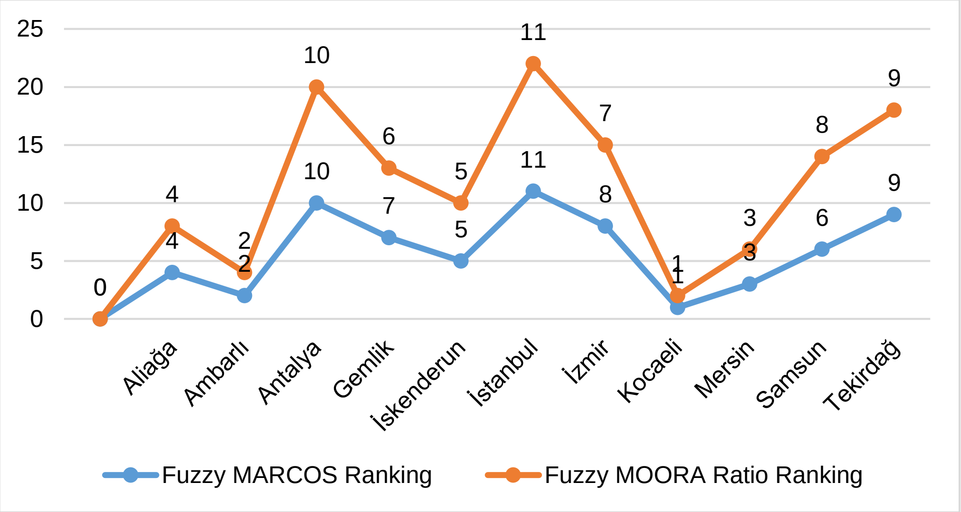

Fig 4. Comparison of port performance obtained using different methods

As can be seen in the figure, Kocaeli port is the most efficient port. Ambarlı is in 2nd rank, Mersin is in 3rd rank, Aliağa is in 4th rank, İskenderun is in 5th rank, Tekirdağ is in 9th ranked and Antalya port is in 10th rank.

5. DISCUSSION and CONCLUSION

Türkiye's ports have many different characteristics as in the world. Capacity differences due to port design and shape should be evaluated differently from the performanse of ports. Ports are the areas of use of the most widely used maritime mode in international transportation. During the pandemic period, it was seen how the disruptions in ports affected the world supply chain and the importance of ports was understood again.

Turkiye is a country where the use of other modes of transportation such as road, rail, air, pipelines is widespread along with maritime transportation. It is a country where the connection between Asia and Europe has been established with the Marmaray line and with the Baku Tbilisi Kars Railway line connections, it is a country that aims to transport from China to Europe by railway lines. Providing port connections of these lines along Türkiye will increase the performanse of ports. After the Ukraine-Russia war, Turkish ports have become important and safe alternatives to prevent disruption in the supply chain flow. In order to utilize these potentials, the performanse of the ports should be evaluated and a discussion environment should be created for development.

For this purpose, in this research, the shares of the ports in the amount of cargo handled in the ports of Turkiye were determined and the performanse of 11 ports with a share of more than 1% was evaluated. As a result of this research, the infrastructure and development process needs of other ports with potential were revealed.

Quantitative panel data were used for the research and different data were transformed into the form of triangular fuzzy numbers. In this way, both the effects of quantitative data and the dynamics of data changes in different years are captured. One of the unique aspects of the study is the use of real quantitative panel data sets and thus taking into account the differences in data size between years. To achieve this, the data were transformed into triangular fuzzy numbers and the weights of the evaluation criteria were determined as triangular fuzzy numbers using the Fuzzy Entropy method. Then, the performanse ranking of the ports was obtained with the Fuzzy MARCOS method. In addition, the sensitivity analysis of this ranking is tested by Fuzzy MOORA Ratio method.

According to the findings, Kocaeli port is the most efficient port in Turkiye according to the nine evaluation criteria, followed by Ambarlı Port (Istanbul), then Mersin port (Mersin). Another factor to be considered in these results is Türkiye's earthquake risk. Kocaeli and Ambarlı ports were affected by the 1999 earthquake and Mersin port was affected by the 2023 earthquake. Therefore, it is necessary to improve the infrastructure security of the ports, which are one of the important factors of Türkiye's foreign trade, against earthquakes. The Black Sea ports, which are at the bottom of the performanse rankings, need to expand their demand base and increase public and private investments. This is very important for the evaluation of the port performance of the Black Sea, which is the shortest route of the Asia-Europe connection.

Managerial deficiencies in ports managed by both public and private subsidiaries can lead to performanse gaps. Improving ports' connectivity to other modes of transportation will have a significant and enhancing effect on increasing demand. The results of this paper can be used by port managers, terminal operators and policy makers to plan the development of the studied ports and improve their performanse levels. Looking at the distribution of cargo handled in our ports and the performanse assessment, it is seen that the highest amount of cargo is handled in the Marmara Region, the Eastern Mediterranean region and the Aegean region. It is important to increase investments in these regions in order not to incur the costs of congestion and inability to respond to demand in the future increases in demand and to eliminate bottlenecks that may occur in undesirable situations such as earthquakes.

There are some limitations for this research. First of all, the research focuses on ports in Turkey, which may limit the applicability of the method for different countries. The dynamics of the evaluation criteria in Turkish ports and the port dynamics of different countries may be different from each other, therefore, this model may provide different outputs, especially regarding the weights of the evaluation criteria. The method proposed in the research can be strengthened by using different methods to strengthen the sensitivity analysis of the model. Each different method causes more restrictions in the ranking. The same rankings obtained in all different methods can only be interpreted. It would not be right to use a clear expression for alternatives with different rankings.

In future studies, Logistics 4.0 compliance and sustainability performances of Turkish ports can also be evaluated. Such studies will make a significant contribution to the development projection of Türkiye's ports.

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Compliance with Ethical Standards
It was declared by the author 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 author 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. Decision matrix

		Ports										
Variables	*Statistics*	*Aliağa*	*Ambarlı*	*Antalya*	*Gemlik*	*İskenderun*	*İstanbul*	*İzmir*	*Kocaeli*	*Mersin*	*Samsun*	*Tekirdağ*
KİHR	Min.	241404.5	888816.5	14616	291254.5	71246.75	4488	102364.5	386632.25	662774.75	3103	50
	Avg.	510086.9773	1037433.477	54873.22727	333607.6818	233816.1136	23896.06818	243994.9773	688534	821331.6591	18638.75	131801.3636
	Max.	776093	1201474.5	101995	392447.5	353340.75	50235.5	323639.5	1032142.75	971842	38352	245786
KİTH	Min.	210999.75	907376.75	22088.5	247418	72974.5	5241.25	141183.25	375291.25	655317.5	5230	42
	Avg.	437198.7955	1093324.045	65596.77273	309664.7273	233223.2727	33340.45455	262525.8636	668924.8864	808131.0682	25578.25	127506.4091
	Max.	700417.25	1286772.5	103017	380790	346880.5	64762.5	325859	994032.75	1013549.5	50190	256706
YİHR	Min.	11135082	8667535	1847631	4533083	5673397	55916	2684372	11957160	11949003	748768	623474
	Avg.	16734143.55	9937796.909	2927571.545	5563505.455	12700619.91	363767.7273	4330735.818	18495659	14605786.91	1927678.273	2989381.364
	Max.	23608450	11232543	4649718	7827529	20958847	881202	5485301	26735825	17768478	3151033	6137945
YİTH	Min.	23998647	9613277	659898	5343145	21293394	339893	3376133	39116118	16985102	6298324	10130815
	Avg.	35631328.73	12118716.27	1271917.273	5837472.727	32912055.09	826668.5455	4183954.091	41942448.82	19016018.18	7631766.364	12747426.82
	Max.	45630695	14999109	2092535	6382023	39047212	1329293	5117537	46622671	23003837	8911006	16684661
GS	Min.	4814	3453	524	3308	3591	538	1530	8714	3874	2349	1860
	Avg.	5334.90909	4303.54545	931.181818	3711.27273	4177	2107.09091	1958.63636	9792.36364	4253.72727	2728.72727	2486.81818
	Max.	6329	5574	2136	4069	4791	3683	2495	10621	5076	3088	2918
GGR	Min.	51828145.3	77363574.7	6233438	46500415.2	4791	2389	2047	113266618	61023512.7	11217814.9	15439791.5
	Avg.	87928781	88927828.3	11522190.9	58121370.4	55762501.8	21638168.8	28253522.3	141413526	72345678.3	14786211.2	42025945.1
	Max.	121843279	102732900	37337391.1	63544248.3	80686076.8	40054091	48245747	170788848	85526882.7	17932941	63515954
LU	Min.	164	930	342	1200	265	980	3650	36	100	408	2310
	Avg.	652.25	3465	342	1625	1015	980	3650	476.318182	1068.25	1038	2310
	Max.	1689	6000	342	2050	2300	980	3650	1455	3370	1756	2310
LA	Min.	148930	50205	23097	211000	40000	29000	635000	3060	60000	210000	152514
	Avg.	316965	69978	1030509	730500	376132	29000	635000	179558	656678	614667	152514
	Max.	485000	89750	2037920	1250000	1000000	29000	635000	60000	1253355	1189000	152514
D	Min.	21.5	13	9.5	14.5	7.5	13	6	8.5	9.8	11	12
	Avg.	24.75	15	9.5	25.25	15.287	13.5	8	16.8055556	12.8666667	379.666667	12
	Max.	28	17	9.5	36	27	14	10	30	15.8	20	12