Journal of ETA Maritime Science 2024;12(2):213-223

Temporal Analysis of Factors Influencing Countries' Maritime Trade Performance with CRITIC-based VIKOR Method

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Abstract

Shipping and world trade have grown simultaneously as a result of the increased need for freight transportation capacity brought about by the expansion of world trade. It is important for countries to compare their maritime trade performance in relation to their respective characteristics. It is essential to adhere to the competitive circumstances in order to obtain a larger proportion of the world trade. This study compares maritime trade performance of the 20 countries with the greatest number of ports of call worldwide using multi criteria decision making techniques. Six indicators are weighted by Criteria Importance Through Intercriteria Correlation method and the performances of the countries are ranked by VIšeKriterijumska Optimizacija I Kompromisno Resenje method. Rankings for the years 2018-2022 were constructed independently, and after using the Borda approach to integrate them together, the final ranking was produced. The results provide a perspective for countries to improve their maritime trade performance and the opportunity to make an assessment from macro perspective.

Keywords: Maritime trade, CRITIC, VIKOR, port call

1. Introduction

IInternational trade has grown 140 times in the past 150 years [1]. The growth in world trade has increased the need for cargo transportation capacity, and accordingly, shipping and world trade have developed together. Energy, mining, agriculture and forestry are the largest production industries of the world economy [2]. Transportation solutions are produced according to changing parcels depending on the transportation of raw materials or processed goods, and maritime trade is at the center.

Due to China's and East Asia's economic and industrial growth, this region is now the hub of global trade, forcing major shipping companies to adapt their business models to the conditions of this region and leading to the improvement of global maritime network [3]. Although ship design, technology, customer profile, etc. have changed throughout history, the basic principles of maritime trade have not changed. It can be stated that the analysis of the future in shipping industry, where success is achieved especially in periods when world political dynamics are balanced, is based on the both economic and geopolitical environment.

Comparing the maritime trade performance in terms of their characteristics is significant for countries. In order to get a larger share from the world trade, it is necessary to follow the competitive conditions. As the distance between countries decreases, competition between countries has also intensified due to overlapping hinterlands. The privatization of port operations, especially with the widespread use of container shipping, has an important role in increasing the competition [4-6]. In this context, ports have a vital place in determining the maritime trade performance of countries. Specifically, ports are the areas where the connection between foreland and hinterland is provided, where cargo is collected and consolidated, and where many value-added activities are carried out within industrial and logistics processes [7]. Today, work force is replaced by machinery and equipment at every stage of the work carried out in the ports, and depending on technological development; ports offer safer, modern, faster and more economical

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Received: 09.01.2024
Last Revision Received: 02.04.2024
Accepted: 02.05.2024

To cite this article: E. Akdamar, E. F. Akgül, M. Gögebakan, and E. Işık. "Temporal Analysis of Factors Influencing Countries' Maritime Trade Performance with CRITIC-based VIKOR Method." *Journal of ETA Maritime Science*, vol. 12(2), pp. 213-223, 2024.

services. Accordingly, the following research questions are investigated in this study:

i. What are the importance levels of the factors affecting countries' maritime trade performance and how have they changed over the years?

ii. According to the determined importance levels, what is the performance ranking of the countries and how has it changed over the years?

Among the various initiatives to determine the position of countries in maritime trade, data on port calls shared by the United Nations Conference on Trade and Development (UNCTAD) provide important information on data on port calls and performance that give an overview of the attributes of the ships and the duration they stayed in national ports throughout a given time period. In order to answer the above-mentioned questions, the importance levels of various performance indicators in the UNCTAD database of the 20 countries with the highest number of port calls were determined by Criteria Importance Through Intercriteria Correlation (CRITIC) method, one of the multi-criteria decision-making methods, taking into account the years 2018-2022, and using the VIšeKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) technique, the countries' performances were ranked in relation to the specified importance levels.

The originality of this study has two strands. First, it provides a data-driven perspective for countries' maritime trade performance by answering the research questions considered. Secondly, by taking into account the last 5-year period in which developments such as the COVID-19 pandemic, trade wars between the US and China, the Russia-Ukraine war, the emergence of alternative supply chains, increased regulations on climate change, and the blockage of shipping corridors have been intensively experienced, the time-dependent change of performance indicators and the response of countries to this change have been dynamically revealed in this study.

This paper is structured as follows: The review of the literature on ports and maritime trade is presented in section two. The data set and methods utilized in the study are described in Section 3; the findings and an in-depth overview are presented in Section 4. The conclusion of this study highlights its limitations, implications, and future research recommendations.

2. Literature Review

The success of the global supply chain depends on efficient port operations since they serve as essential bridges between countries. It is critical to comprehend the complex relationship between port call activities and a nation's overall success as the economic landscape changes. The purpose of this literature review is to summarize the state of the art about this intersection, with a particular emphasis on ports and maritime trade performance. A thorough analysis of the body of research indicates that port efficiency and maritime trade performance are the two primary areas of focus. Researchers have carefully examined these elements on their own, offering insightful information about the efficiency of ports' operations and how it affects a nation's economic position. Still, in order to fully understand the complex relationships that exist between port call activities and overall performance of countries, a synthesis of different viewpoints is necessary.

As Owen [8] noted, a port is seen as a country's trading gateway; the more open the gate and the smoother the route, the greater the trade advantage to a country [9]. Supporting this point, various evidence has been presented that there is a linear relationship between the port efficiency and countries' maritime trade performance. From the holistic perspective, Santhi and Setyari [10] investigated the effects of "Trade Facilitation", which means the simplification of countries' international trade activity processes, on the export performance of six ASEAN countries. Among the various indicators used to measure Trade Facilitation, it was suggested port efficiency positively affected countries' export performance. As emphasized by Dick [11], an efficient port infrastructure has a positive impact on increasing the trade volume of countries as well as expanding the range of traded products. It can also contribute to reducing inflationary pressure due to reduced logistics costs and facilitating access to products. Wilson et al. [12] argue that gains in port efficiency have a significant and positive influence on the ability of a country for trade. Among their findings is that a 50% improvement in Trade Facilitation led to an increase of USD 254 billion in intra-APEC trade, half of which was due to an increase in port efficiency.

Similar results are observed when country-based studies are analyzed. Sant' Anna and Kannebley Júnior [13], who examine the relationship between port efficiency and exports in Brazil and consider port time as an indicator of port infrastructure quality, find that every 10% decrease in the port time of ships provides a 1% increase in exports. Similarly, the study by Jordaan [14] emphasized that port efficiency has a positive contribution to exports.

While significant progress has been made on port efficiency and trade performance, there is still a significant gap in combining these perspectives, particularly in light of factors affecting maritime trade, and in cross-country comparative analysis. This study designates the gap as the central focus of our investigation, with the goal of providing quantitative proof and a detailed comparative assessment to enhance

the link about port call and maritime trade performance of countries.

The approach utilized in this study is applied for performance evaluations across several business fields and countries. For instance, CRITIC method was used by Diakoulaki et al. [15] on performance measurement of pharmaceutical companies, Wu et al. [16] on urban rail transit operation safety of Beijing (China) Railways, Jati et al. [17] on components influencing a website's search engine exposure as well as the visibility ranking of the indicators influencing it. Deng et al. [18] applied CRITIC and Entropy to evaluate financial performance of textile companies. VIKOR method also was used by Opricovic and Tzeng [19] on fuel choice for public transport and Paksoy [20] on determining the performance and development levels of Türkiye and European countries. Perçin and Çakır [21] investigated logistics companies by using CRITIC, VIKOR, TOPSIS, SAW, BORDA methods. To the best of our knowledge, since there has never been any prior research on port calls and countries' performance assessments, the major goal of this study is to add something new to the existing collection of knowledge in this field.

3. Data and Methodology

This section introduces the data set and methodology used in the study. In this context, the database from which the data are obtained, the countries analyzed and port call and performance indicators are explained. The CRITIC technique, which establishes the significance levels of performance indicators, and the VIKOR technique, which ranks national performance, and the BORDA Census Technique used to make a holistic assessment covering the years 2018-2022 are discussed.

UNCTAD established in 1964 with the aim of enabling more prosperous member countries to benefit less developed countries supports the sustainable development efforts of developing countries in terms of trade, finance and technology. UNCTAD makes available a free-to-use database called UNCTADstat. The UNCTADstat database contains various datasets on population, economy, trade, technology and transportation. In this study, data on port call and performance statistics were used. The data covers the years between 2018 and 2022. The aim here is to evaluate the countries' port call and performance between 2018 and 2022 separately for each year and ultimately to make a common and single assessment covering all years. Since UNCTADstat publishes data on the 20 countries with the highest number of calls, the measurement and comparison of performance is carried out for these countries that are illustrated in Table 1. In terms of total carrying capacity, the 20 countries considered in this study control 65% of the world merchant fleet according to UNCTADStat. This ratio proves that these countries carry the majority of global merchandise and shape its trade. Also, countries elected to the Council of the World Maritime Organization (IMO) are classified as category (a), which includes the 10 States with the largest interest in providing international shipping services, category (b), which includes 10 States with the largest interest in international seaborne trade, and category (c), which includes 20 States not elected under (a) or (b) above, which have special interests in maritime transport or navigation and whose election to the Council will ensure the representation of all major geographic areas of the world. Since eight of the twenty countries considered in this study are in Category (a), seven in Category (b) and three in Category (c), it can be stated that they have a significant share in world maritime activities and represent the industry in general.

Six indicators as depicted in Table 2 are used in the study to measure the performance of the countries. Although it is possible to include subjective factors consisting of the views of relevant stakeholders in addition to the objective factors discussed in this study when evaluating the performance of countries, subjective factors are not included since this study aims to measure maritime trade performance through analytical methods based on an objective paradigm rather than a subjective one. It is of course possible to evaluate maritime trade performance using different objective

Table 1. *Countries considered in the study*

Germany	Spain
United States of America (USA)	Sweden
Australia	Italy
United Kingdom	Japan
China	Canada
Denmark	Republic of Korea
Indonesia	Norway
France	Russian Federation
Croatia	Türkiye
Kingdom of the Netherlands	Greece

Table 2. *Indicator codes, units of measurement and directions*

Indicator code	Indicator	Unit	Direction
G1	Median time in port	Day	Cost (-)
G2	Average age of vessels	Year	Cost (-)
G3	Average size of vessel	GT	Cost (-)
G4	Average cargo carrying capacity per vessel	Dwt	Cost (-)
G5	Maximum cargo carrying capacity of vessels	Dwt	Benefit (+)
G6	Maximum size of vessels	GT	Benefit (+)

indicators. However, the indicators used in this study are the group of indicators whose data are available for the countries included in the scope of the assessment. The fact that these indicators are worth following by UNCTAD supports the fact that these indicators are objective determinants of fleet performance. In this study, it is aimed to measure the world maritime trade performance through the existing set of variables.

Median time in port (days): It is the average number of days that ships spend within the port borders. The reasons of waiting at ports could be; congestion, strikes or relocation of ships or traffic problems in ports [22]. These problems pose a problem for the carrier and the shipper. The fact that the ship spends less time in port compared to the time it spends at sea can be characterized as a cost factor. Among these cost factors, minimizing the costs of services such as maintenance-repair, accommodation and terminal can be expressed as a goal of carriers [23].

Average age of vessels (years): Ship age is one of the most important characteristics of ships. The age of a ship is calculated as of the date of delivery to the shipowner by the shipyard where it was built. Insurance, flag and classification society certificates should be issued according to that date [24]. As the ship ages, structural elements should also be updated. Another significant factor influencing the frequency of ship collision is ship age. An old ship is more likely to be involved in a collision due to structural failure [25]. In this study, the average age of the ships calling at the country's ports during the period was taken into consideration.

Average size (GT) of vessels: It shows the total volume of indoor spaces of the ships calling at the country's ports during the period.

Average cargo carrying capacity (dwt) per vessel: It is the value found as a result of subtracting the empty ship weight from the loaded displacement of the ship. This weight includes cargo, fuel, fresh water and ballast water etc.

Maximum cargo carrying capacity (dwt) of vessels: This indicator includes the deadweight tonnage of the ship with the highest deadweight tonnage that called at any of the country's ports at least once during the period.

Maximum size (GT) of vessels: This indicator includes the value of the ship with the highest gross tonnage that called at any of the country's ports at least once during the period.

UNCTAD only considers arrivals to measure the total number of ships calling at a port, and passenger ships and Ro/Ro ships are not included in the calculations [26]. In performance measurement, it should be decided whether the indicators considered in the study are cost-oriented or benefit-oriented. Accordingly, if an upturn in an indicator's value corresponds to better performance, that indicator is determined as benefit-oriented. If an indicator's value declines and performance increases as a result, that indicator is determined as cost-side. In this context, the abbreviations, measurement units and directions of the indicators used in the study are shown in Table 2.

3.1. The CRITIC Method

CRITIC as an objective weighting method developed by Diakoulaki et al. [15] in 1995 is frequently used by the analysts [27].

The method provides an objective calculation by using the values of the indicators in the initial decision matrix instead of the subjective evaluation of the decision makers. When calculating the importance weights of indicators, each indicator's standard deviation and correlation coefficients with other indicators serve as the foundation [28]. Thus, the variability of the indicators, the degree and direction of the relationship between the indicators determine the indicator weights used in the problem.

Calculation of the CRITIC method consists of 4 steps [15]:

Step 1: The initial decision matrix is developed. In the X_{ij} element in the matrix, it corresponds to the values of i alternatives and j indicators. When the decision matrix is being developed, the first decision matrix with n possibilities and m indicators is formulized as follows:

$$X = [X_{ij}]_{nxm} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix} \quad (1)$$

Step 2: With the normalization process from the initial decision matrix, the benefit and cost values of the indicators were obtained by Equations (2) and (3), respectively, as follows.

$$r_{ij} = \frac{X_{ij} - X_j^{min}}{X_j^{max} - X_j^{min}} \quad (2)$$

$$r_{ij} = \frac{X_j^{max} - X_{ij}}{X_j^{max} - X_j^{min}} \quad (3)$$

Where, the indicator's normalized value j belonging to alternative I is shown as r_{ij}. X_j^{max} and X_j^{min} denotes, respectively, the highest and lowest values of indicator j.

Step 3: Relationship coefficients are obtained from normalized matrices. The correlation coefficient between two indicators is calculated as p_{jk} as in (4).

$$p_{jk} = \frac{\sum_{i=1}^{n}(x_{ij}-\bar{x}_j)(x_{ik}-\bar{x}_k)}{\sqrt{\sum_{i=1}^{n}(x_{ij}-\bar{x}_j)^2 \sum_{i=1}^{n}(x_{ik}-\bar{x}_k)^2}} \quad j,k = 1,2,3,\dots m \tag{4}$$

The standard deviation of j indicators is shown in Equation (5). To determine the contrast between indicators, the total amount of information carried by indicator j was calculated with C_j in Equation (6).

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{n}(r_{ij}-\bar{r}_j)^2}{n}} \tag{5}$$

$$C_j = \sigma_j \sum_{k=1}^{m}(1-p_{jk}) \tag{6}$$

Step 4: In this step, the indicator weights denoted by w_j are obtained from the degree of information and the correlation coefficient calculated for each indicator as follows:

$$w_j = \frac{C_j}{\sum_{j=1}^{m} C_j} \tag{7}$$

The order of importance of the indicators is determined according to the height of the w_j value obtained.

3.2. The VIKOR Method

VIKOR technique is developed for multi-criteria decision optimization of multi-criteria complex systems based on finding the closest reasonable solution to the ideal solution by focusing on sorting and choosing between alternatives with different weights [19,29]. In this method, the initial weight, benefit and cost aspects of the indicators must be known. The VIKOR method is calculated in 7 steps as follows [19,30].

Step 1: In the decision matrix X, the indices I and j refer to the alternatives and indicators, respectively.

$$X = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix} \tag{8}$$

Step 2: Using the elements in the decision matrix, j to show the (f_j^*) best and (f_j^-) worst values for each indicator. Benefit-oriented values from the indicator are calculated with Equations (9) and cost-oriented values (10).

$$\begin{aligned} f_j^* &= \max_i X_{ij} \\ f_j^- &= \min_i X_{ij} \end{aligned} \tag{9}$$

$$\begin{aligned} f_j^* &= \min_i X_{ij} \\ f_j^- &= \max_i X_{ij} \end{aligned} \tag{10}$$

Step 3: Normalization operations are carried out using the benefit-cost values of the decision matrix. The values normalized of r_{ij} are acquired from (11) as following.

$$r_{ij} = \frac{f_j^* - X_{ij}}{f_j^* - f_j^-} \tag{11}$$

The R normalized matrix from r_{ij} values, where i=1,2,3,..., n and j=1,2,3,..., m, is shown as follows:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \tag{12}$$

Step 4: V decision matrix; The weighted normalized matrix's elements are employed to calculate it, as demonstrated in the equation as follows.

$v_{ij} = r_{ij} w_{ij}$, where $\sum w_{ij} = 1$ represents the relative weights of the indicators.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1m} \\ v_{21} & v_{22} & \cdots & v_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ v_{n1} & v_{n2} & \cdots & v_{nm} \end{bmatrix} \tag{13}$$

Step 5: S_i; *i*. The total indicator value of the alternative and R_j ; *j*. To show the value of the maximum indicator, the largest value of the weighted normalized matrix $\max_j v_{ij}$ is calculated as follows.

$$\begin{aligned} S_i &= \sum_{j=1}^{m} v_{ij} \\ R_j &= \max_j v_{ij} \end{aligned} \tag{14}$$

Step 6: The min and max values of S_i and R_j are obtained respectively as follows.

$$\begin{aligned} S^* &= \min_i S_i \\ S^- &= \max_i S_i \\ R^* &= \min_j R_j \\ R^* &= \max_j R_j \end{aligned} \tag{15}$$

Q_i values for the ranking of alternatives are calculated as follows:

$$Q_i = \frac{q.(S_i - S^*)}{(S^- - S^*)} + \frac{(1-q).(R_j - R^*)}{(R^- - R^*)} \tag{16}$$

The q value in (16) shows the weight of the option that maximizes group advantage. (1-q) is defined as the strategy weight that ensures regret in opposing views. When the q value is selected (>0.5), it indicates that the majority tends to have a positive attitude towards the Q_i index, and when (<0.5) is selected, it indicates that the majority shows a negative attitude towards the Q_i index. In studies, q=0.5 is generally chosen. In other words, it is assumed that the

experts receiving the evaluation display a conciliatory attitude [31].

Step 7: The obtained Q_i, S_i *and* R_j values are sorted from smallest to largest. The optimum option is identified as the one with the lowest Q_i value. But in order for this outcome to be legitimate, two requirements need to be fulfilled. These conditions are;

Condition 1 (Acceptable advantage): This requirement entails demonstrating that the best and options that are most similar to the best differ significantly from one another. While $Q(P1)$ is the lowest first alternative; $Q(P1)$ is the second lowest alternative. The DQ value is obtained as follows.

$$Q(P2) - Q(P1) \geq DQ$$
$$DQ = \frac{1}{(i-1)} \quad (17)$$

Condition 2 (Acceptable stability): A high score for at least one of the S and R values of the option with the best Q value is required to demonstrate the stability of the compromise solution. If one of the two specified conditions is not met, the compromise solution set is proposed as follows:

- If the 2nd condition is not met, P1 and P2 alternatives,
- If condition 1 is not met, the inequality is reviewed as follows, taking into account the alternatives P1, P2,... PN.

$$Q(PN) - Q(P1) < DQ \quad (18)$$

The compromise solution set is sorted according to Q values. One of the options with the lowest Q value is the best option, as determined by Q values.

3.3. BORDA Counting Method

BORDA Counting Method, one of the most used voting techniques in social election theory, emerged in 1784 with the work of Jeans-Charles de Borda. It is a method that does not ensure that units are ranked according to their preference scores in social selection problems [32]. Units are ranked according to the board score calculated from the rankings determined by the decision makers. In addition, since BORDA Counting Methods are known as a data fusion technique, it allows creating a more realistic ranking result by combining two or more ranking lists.

In this method, which is based on selecting the decision units most suitable for the purpose, The most desired option among n choices receives (n-1) points, the second most preferred receives (n-2) points, and the least preferred receives 0 points in the calculation of board scores. With these obtained scores, the best unit is determined by ranking them from largest to smallest [33]. In the calculation of the BORDA Counting Method; The formula used to represent B_i^k, k value represents the classifier, and the i value determined by the classifier represents the rank given to the unit [33].

$$B(i) = \sum_{k=1}^{n} B_i^k \quad (19)$$

4. Findings

In this section, firstly, performance indicators are weighted for each year between 2018 and 2022 employing CRITIC method and the importance weights (weight coefficients) of the indicators are determined. Secondly, using the weights obtained from the CRITIC method, countries are ranked and compared according to their performance using the VIKOR method.

4.1. Determination of Importance Weights with CRITIC Method

The importance weights of the performance indicators were determined by following the previously given steps of the CRITIC technique. In Table 3, the standard deviation, amount of information and weight coefficient of each indicator values for the time period considered are calculated. The indicator with the highest importance weight for 2018 is the Maximum size (GT) of vessels (22.42%) indicated by G6, while the indicator with the lowest importance weight is the Average cargo carrying capacity (dwt) per vessel (13.34%) indicated by G4. In 2019, the most important indicator and the least important indicator are the same as in 2018. Maximum size (GT) of vessels (20.75%), denoted by G6, has the highest importance weight, Average cargo carrying capacity (dwt) per vessel (12.61%), denoted by G4, has the lowest importance weight among the indicators. The most striking change was in the indicator Maximum cargo carrying capacity (dwt) of vessels denoted by G5. This indicator was ranked 5th in terms of importance in 2018 and 2nd in 2019. The difference in 2020 results from 2019 is that the importance rankings of the Average age of vessels (years) indicator denoted by G2 and the Average size (GT) of vessels indicator denoted by G3 have changed places. In 2020, as in the previous two years, Maximum size (GT) of vessels (20.75%), denoted by G6, has the highest importance weight, while Average cargo carrying capacity (dwt) per vessel (12.61%), denoted by G4, has the lowest importance weight among the indicators. Looking at the 2021 fleet performance indicators' weight coefficient values, different rankings are observed in importance weights compared to previous years. While the indicator Maximum size (GT) of vessels denoted by G6 was the indicator with the highest importance weight in all of the previous three years, this indicator was replaced by the indicator Maximum cargo carrying capacity (dwt) of vessels denoted by G5 (19.83%)

in 2021. As in the previous three years, the Average cargo carrying capacity (dwt) per vessel indicator denoted by G4 is the indicator with the least importance weight (12.32%) among the other indicators in 2021.

The position of the indicator with the lowest importance weight, Average cargo carrying capacity (dwt) per vessel (12.78%), denoted by G4, has not changed in 2022. However, the indicator Maximum cargo carrying capacity (dwt) of vessels, denoted by G5, which had the highest importance weight in the previous year, ranked fourth in terms of importance in 2022. Unlike previous years, the indicator with the greatest weight of significance in 2022 was the Average age of vessels (years) (21.40%) denoted by G2.

Table 3. *Standard deviation of indicators, amount of information (C_j) and weight coefficient (w_j) values for the year 2022*

Indicator	Year	σ	C_j	w_j	$\%w_j$	Ranking
Median time in port (G1)	2018	0.306	1.026	0.148	14.88%	4
	2019	0.316	1.097	0.149	14.94%	5
	2020	0.281	1.007	0.129	12.92%	5
	2021	0.292	0.97	0.135	13.57%	5
	2022	0.305	0.975	0.134	13.40%	5
Average age of vessels (G2)	2018	0.258	1.096	0.158	15.89%	3
	2019	0.272	1.172	0.159	15.97%	4
	2020	0.318	1.373	0.176	17.61%	3
	2021	0.301	1.237	0.173	17.32%	4
	2022	0.317	1.536	0.214	21.40%	1
Average size of the vessel (G3)	2018	0.249	1.302	0.188	18.87%	2
	2019	0.245	1.3	0.177	17.72%	3
	2020	0.248	1.303	0.167	16.72%	4
	2021	0.255	1.262	0.176	17.67%	3
	2022	0.267	1.277	0.183	18.31%	2
Average cargo carrying capacity per vessel (G4)	2018	0.24	0.92	0.133	13.34%	6
	2019	0.239	0.925	0.126	12.61%	6
	2020	0.239	0.919	0.118	11.80%	6
	2021	0.238	0.88	0.123	12.32%	6
	2022	0.236	0.894	0.127	12.78%	6
Maximum cargo carrying capacity of vessels (G5)	2018	0.23	1.006	0.145	14.59%	5
	2019	0.272	1.32	0.179	17.98%	2
	2020	0.265	1.437	0.184	18.44%	2
	2021	0.279	1.417	0.198	19.83%	1
	2022	0.259	1.126	0.159	15.91%	4
Maximum size of vessels (G6)	2018	0.349	1.546	0.224	22.42%	1
	2019	0.354	1.523	0.207	20.75%	1
	2020	0.359	1.753	0.224	22.49%	1
	2021	0.33	1.376	0.192	19.26%	2
	2022	0.304	1.275	0.181	18.17%	3

When the changes in the importance levels of the indicators over the years are analyzed, it is seen that the least important indicator is the Average cargo carrying capacity (dwt) per vessel for all years. The importance of the Maximum size (GT) of vessels indicator has decreased over the years. In addition, the importance of the Maximum cargo carrying capacity (dwt) of vessels indicator increased in 2019, 2020 and 2021, and the Average age of vessels (years) became the most important indicator in 2022.

4.2. Ranking of Countries with VIKOR Method

Applying the importance weights that the CRITIC technique provided, the performance of the countries between 2018-2022 was ranked and compared with the VIKOR method. As mentioned before, there are two conditions necessary for the VIKOR method results to be valid. The option with the highest Q value ranking is suggested as an acceptable compromise if the requirements are achieved [34].

For all years, it was observed that the conditions detailed in the methodology section were met. It was also observed that a compromise solution was reached when the "q" value was taken as 0.5. Therefore, interpretations and rankings are based on q=0.5. Table 4 illustrates the calculated Q_i values for the countries considered. A low Q_i value indicates high performance. Table 4 shows that Japan, the Netherlands, and Germany are generally among the best performers on a consistent basis, while Australia, Russian Federation and Croatia are among the worst performers. The rankings for each year are shown in Table 5.

4.3. Ranking of Countries by Borda Counting Method

The Borda counting method is the last stage of the study and was used to obtain a single ranking by combining the values obtained for the five years of the CRITIC-based VIKOR method analyzed. The findings are shown in Table 5.

The integrated ranking was calculated by obtaining the VIKOR method rankings and Borda scores of the countries in Table 5 for the years 2018-2022. In this ranking, Japan ranked first, Netherlands second and Germany third. Considering that the factors that cause the importance of indicators to change are the developments in the world, the change in country rankings over the years should be read from this perspective. Within the context of this study, both the performances of the countries and the indicators affecting their performances are comparatively shown in Table 6. Thus, it is revealed how country performances are affected by changes in the importance of indicators.

The importance levels of indicators change from year to year due to the international conjuncture and shocks such as pandemics. In this case, countries need to achieve an agile structure in terms of all indicators. For example, in the transition from 2021 to 2022, when the maximum cargo

Table 4. *Time dependent variation of values of countries*

	Q_i values				
Country	**2018**	**2019**	**2020**	**2021**	**2022**
Japan	0	0	0.099663	0	0.039967
Netherlands	0.100274	0.094595	0.031141	0.057888	0.010035
Germany	0.130046	0.162475	0.115662	0.158235	0.273513
Denmark	0.145359	0.623183	0.580787	0.70822	0.498661
Greece	0.195612	0.29214	0.553602	0.71398	0.389771
Spain	0.202752	0.207294	0.416274	0.53489	0.12997
United Kingdom	0.273869	0.278804	0.153919	0.20725	0.187671
Republic of Korea	0.311406	0.282615	0.216903	0.239464	0.14806
France	0.398051	0.42579	0.257965	0.344361	0.29172
Norway	0.450015	0.469943	0.493658	0.15876	0.069681
Sweden	0.520954	0.68173	0.332439	0.365805	0.542618
Italy	0.531819	0.586731	0.577297	0.710261	0.750567
USA	0.540871	0.621283	0.498077	0.626477	0.789911
China	0.603413	0.564735	0.44689	0.567589	0.536055
Croatia	0.660743	0.845586	0.816843	0.713887	0.589903
Canada	0.660791	0.674271	0.681384	0.656198	0.653487
Russian Federation	0.696667	0.775659	0.791723	0.947166	0.944444
Türkiye	0.697671	0.596991	0.520783	0.385308	0.582929
Australia	0.850066	0.87809	0.870261	0.866053	0.844496
Indonesia	0.89129	0.631204	0.619282	0.545238	0.40753

Table 5. *VIKOR and BORDA ranking for 2018-2022*

	VIKOR ranking					BORDA total points	BORDA ranking
	2018	**2019**	**2020**	**2021**	**2022**		
Germany	3	3	3	3	7	81	3
USA	13	13	11	13	18	32	14
Australia	19	20	20	19	19	3	20
United Kingdom	7	5	4	5	6	73	4
China	14	10	9	12	12	43	11
Denmark	4	14	15	15	11	40	12
Indonesia	20	15	16	11	10	28	16
France	9	8	6	7	8	62	8
Croatia	15	19	19	17	15	15	18
Netherlands	2	2	1	2	1	92	2
Spain	6	4	8	10	4	68	6
Sweden	11	17	7	8	13	44	10
Italy	12	11	14	16	17	30	15
Japan	1	1	2	1	2	93	1
Canada	16	16	17	14	16	21	17
Republic of Korea	8	6	5	6	5	70	5
Norway	10	9	10	4	3	64	7
Russian Federation	17	18	18	20	20	7	19
Türkiye	18	12	12	9	14	34	13
Greece	5	7	13	18	9	50	9

carrying capacity lost its importance in performance and the average age of vessels gained importance, countries with older ships experienced a decline in performance. In this respect, in order to determine the extent to which countries have been able to achieve stability in their rankings over the years, standard deviation values for their five-year rankings were calculated and given in Table 7.

According to Table 7, where a standard deviation of 3 and above is considered as high variability, the countries that failed to achieve stability are Greece, Denmark, Indonesia, Sweden, Norway, Norway and Türkiye, respectively.

The countries whose ranking has changed the least over the years and whose standard deviation value is below 1 point are Japan, Netherlands and Australia, respectively. It should be noted here that Japan and Netherlands have achieved stability at the top, while Australia has always been at the bottom.

5. Conclusion

For much of the last 50 years, globalization has been the wind in the sails of multinational corporations and investors, with China's gradual opening up to western trade, the collapse of the Iron Curtain, the rise of the BRICS (Brazil, Russia, India, China, South Africa, Iran, Egypt, Ethiopia, and the United Arab Emirates) countries, and the liberal policies adopted in free trade. In a highly integrated trade scene, the ability of countries to realize their ambitions of becoming the main actor and getting a bigger piece of the pie is undoubtedly highly dependent on their ability to allocate sea power or to maintain or strengthen their existing positions.

The weighting of indicators with analytical decision-making methods provides descriptive information in terms of evaluating the port call and performance of countries. The CRITIC method used for this purpose is preferred because it does not include subjective approaches in the weighting of indicators. When the indicators are ranked in terms of their importance levels for the years 2018-2022, it is observed that a different indicator stands out in terms of

Table 7. *Standard deviation values for five-year rankings of countries*

Country	Std. Dev.	Country	Std. Dev.
Germany	1.79	Spain	2.61
USA	2.61	Sweden	4.02
Australia	0.55	Italy	2.55
United Kingdom	1.14	Japan	0.55
China	1.95	Canada	1.10
Denmark	4.66	Republic of Korea	1.22
Indonesia	4.04	Norway	3.42
France	1.14	Russian Federation	1.34
Croatia	2.00	Türkiye	3.32
Netherlands	0.55	Greece	5.18
Std. Dev.: Standard deviation			

Table 6. *Analyzing country performances based on indicators*

Change in indicators	Change in country rankings
Maximum cargo carrying capacity becomes important in the transition from 2018 to 2019	**Underperformers:** Australia, Denmark, Croatia, Greece, Russia, Sweden, Sweden, Russia **High performers:** China, Indonesia, France, France, Italy, Italy, Republic of Korea, Norway, Norway, Türkiye, Spain, United Kingdom **Constant performers:** Germany, USA, Netherlands, Japan, Canada
From 2019 to 2020, average age of vessels rises to 3rd place, average size of vessels falls to 4th place.	**Underperformers:** Australia, Denmark, Indonesia, Canada, Indonesia, Italy, Japan, Norway, Spain, Sweden, Sweden **High performers:** China, France, France, Republic of Korea, Greece, Netherlands, United Kingdom, USA **Constant performers:** Germany, Australia, Croatia, Russia, Türkiye
In the transition from 2020 to 2021, the average age of vessels fell back to 4th place, while the average size of vessels rose to 3rd place. In addition, maximum cargo carrying capacity became the most important indicator.	**Underperformers:** USA, United Kingdom, China, France, Netherlands, Spain, Sweden, Italy, Republic of Korea, Russian Federation, Greece **High performers:** Australia, Indonesia, Croatia, Japan, Canada, Norway, Türkiye **Constant performers:** Germany, Denmark
In the transition from 2021 to 2022, the average age of vessels rose from 4th to 1st place in terms of importance. Maximum cargo carrying capacity decreased from 1st to 4th place.	**Underperformers:** Germany, USA, United Kingdom, France, Sweden, Italy, Japan, Canada, Türkiye **High performers:** Denmark, Indonesia, Croatia, Netherlands, Spain, Republic of Korea, Norway, Greece **Constant performers:** Australia, China, Russian Federation

importance each year. This variability in the importance of indicators shows that the determinants of countries' performance are affected by time-dependent economic, social and environmental factors. Therefore, countries need to be prepared in terms of all indicators in order to demonstrate an effective performance and to be prepared for these factors.

Country performance scores were obtained according to the weighted indicators of the countries with the VIKOR method and the rankings obtained with the BORDA method for the years 2018-2022 were combined. In the last five years, Japan, Netherlands, Germany, the United Kingdom and Republic of Korea have been the five countries with the best performance in the ranking of countries based on weighted indicators. Port call and performance of the countries is directly proportional to their share in world trade.

The analyses show how the changes in the importance levels of the indicators affect the performance of the countries, to what extent the five-year performance rankings of the countries vary, and which countries have changed their rankings in the same direction and in the opposite direction due to the changes in the importance levels of the indicators. It can be said that the maritime trade structures of the countries affected in the same direction in terms of ranking are similar, while the maritime trade structure of the countries affected in the opposite direction are different. It can be stated that countries that have low standard deviation in terms of five-year performance rankings and have achieved stability are resistant to changes in the importance levels of indicators, that is, to economic, social and environmental events occur over the years. In other words, these changes did not affect the performance ranking of these countries. Among these countries, Japan and Netherlands performed well in the face of all kinds of changes, while Australia continued to perform poorly even though the importance levels of indicators changed.

On the other hand, countries such as Greece, Denmark, Indonesia, Sweden, Norway and Türkiye, whose performance varies greatly as the importance levels of indicators change, can be said to have strong or weak performance in terms of certain indicators. These countries should focus on improving their weaknesses in order to become more resilient to economic, social and environmental developments related to their port call and performance.

This study is anticipated to contribute to the body of literature. on the evaluation of port call and performance. As a matter of fact, the number of studies on the subject with multi criteria decision making techniques is quite low. The Critic method used for weighting indicators is a method of objective weighting, and methods of subjective weighting are likely to produce different results. This may be considered as a limitation of this study. Moreover, different time spans could yield different results.

In future studies, first, it would be more appropriate to conduct country-specific studies on countries that are small but have an important place in maritime trade. Second, the fact that the impact of emerging technologies (such as blockchain and autonomous ships) and new regulations (such as those targeting emissions) on maritime trade performance can also be investigated. Third, exploring dynamic weighting of indicators over time could offer insights into changing priorities and factors influencing maritime trade performance. Fourth, the use of different sets of indicators in the evaluation of maritime trade performance can be considered. Lastly, comparative analyses can be made on the weighting of indicators and ranking of countries with different methods..

Authorship Contributions

Concept design: E. Akdamar, E. F. Akgül, and E. Işık, Data Collection or Processing: E. Akdamar, M. Gögebakan, and E. Işık, Analysis or Interpretation: E. Akdamar, E. F. Akgül, M. Gögebakan, and E. Işık, Literature Review: E. Akdamar, E. F. Akgül, and M. Gögebakan, Writing, Reviewing and Editing: E. Akdamar, E. F. Akgül, and M. Gögebakan.

Funding: The authors declare that no funds, grants, or other support was received during the preparation of this manuscript.

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