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Investigation of Digital Logistics Market Performance in Developing Countries with Hybrid MCDM Methods

Gelişmekte Olan Ülkelerde Dijital Lojistik Pazar Performansının Hibrit ÇKKV Yöntemleriyle İncelenmesi

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ÖZ

Bu çalışmanın amacı, gelişmekte olan ülkelerin dijital lojistik pazar performansını bütünleşik Çok Kriterli Karar Verme (ÇKKV) yöntemlerini kullanarak değerlendirmektir. Bu çalışmada kullanılan kriterler literatür taraması sonucu belirlenmiştir. Kriter ağırlıklarının hesaplanmasında LOPCOW yöntemi kullanılırken, alternatifler MAUT, TOPSIS, MARCOS ve CoCoSo gibi farklı ÇKKV yöntemlerine göre sıralanmıştı. Ayrıca, bu çalışmada Borda sayımı yöntemi kullanılarak alternatiflere ilişkin son sıralama elde edilmiştir. LOPCOW yönteminden elde edilen sonuçlar, geleceğe hazırlık (FR) ve yurt içi lojistik fırsatlarının (DLO) sırasıyla en önemli ve en az önemli kriterler olduğunu göstermiştir. MAUT, TOPSIS, MARCOS ve CoCoSo yöntemlerinden elde edilen sıralama sonuçları, Birleşik Arap Emirlikleri'nin (BAE) en yüksek dijital lojistik pazar performansına sahip olduğunu, onu Çin ve Katar'ın takip ettiğini göstermiştir. Bu çalışmanın, gelişmekte olan ülkelerdeki politika yapıcılar ve şirketlere dijital lojistik pazar performansı hakkında fikir sağlayacağı düşünülmektedir. Bu çalışmanın temel sınırlılığı, ülkelerin dijital lojistik pazar performansının AEMLI ve DCI raporlarından elde edilen verilere dayanarak değerlendirilmesidir. Gelecekteki araştırmalarda farklı kriterlerin kullanılması mümkün olabilir.

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ABSTRACT

The aim of this paper is to evaluate the digital logistics market performance of developing countries using integrated MCDM methods. For this investigation, the criteria were determined based on the previous research. While the LOPCOW method was used to determine the weights of the criteria, the alternatives were ranked based on various MCDM methods, namely MAUT, TOPSIS, MARCOS, and CoCoSo. Additionally, in this study, the final ranking was obtained by the Borda count method. Results from the LOPCOW method showed that future readiness (FR) and domestic logistics opportunities (DLO) were the most and least important criteria, respectively. According to results obtained by the MAUT, TOPSIS, MARCOS and CoCoSo methods showed that, the United Arab Emirates (UAE) has the highest digital logistics market performance, followed by China and Qatar. It is thought that this study will provide insight into digital logistics market performance for policy makers and companies in developing countries. The main limitations of this study that the digital logistics market performance of countries was evaluated based on the data from the AEMLI and DCI reports. In future investigations, it might be possible to use different criteria.

1. Introduction

With globalization, demand for the logistics industry has increased significantly in recent years. Due to the fact that the exchange of products and services between countries will generate competition, one of the companies' objectives is to deliver the goods to the right place as quickly as possible. Therefore, it is important for companies to work efficiently in carrying out their logistics' operations to protect their brand reputation (Surucu and Sakar, 2018: 1). Additionally, the development of logistics infrastructure has a direct relationship with the improvement of national competitiveness and contribution to economic growth (Bensassi et al., 2015: 54). According to research

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conducted by Fraunhofer Institute, globalization is one of the driving forces affecting the logistics industry (Kovács and Kot, 2016: 116). On the basis of this information, it is possible to conclude that the effective development of logistics systems contributes to the global economy (Navickas et al., 2011: 236).

Logistics is a managerial system that systematically enables the efficient, reliable, and cost-effective transportation of goods to their specified destinations. In other words, it provides the effective distribution of goods and services to the appropriate unit, such as the customer, at the best possible level (Rasool et al., 2023: 564). Thus, nations need to improve their logistics systems to adapt to the global economy. One of the components of this process is measurement of logistic performance index (LPI). Logistics performance is the assessment of the effectiveness with which logistics activities are being administered inside an organization. This aspect is crucial since it directly impacts profitability, efficiency, and customer satisfaction (Chow et al., 1994). In this respect, logistics performance index was designed by the World Bank with the purpose of evaluating and tracking the logistical performance of countries, as well as assisting them in understanding the obstacles and opportunities associated with international logistics (Bugarčić et al., 2020: 453). Agility Emerging Markets Logistics Index (AEMLI) announced the logistics market performance of developing countries. AEMLI determines four key factors to develop the logistics market performance. These are domestic logistics opportunities, international logistics opportunities, business fundamentals, and digital readiness (Agility, 2023). Additionally, World Digital Competitiveness (WDC) Ranking (2022) has released three main factors, knowledge, technology, and future readiness, as indexes that define digital competition. Digital competitive ranking takes into consideration to improve the logistics market performance. This ranking indicates the significance of national factors in explaining the digital transformation of business. Kara and Yalçın (2022) emphasized the importance of digitalization in logistics market performance. Therefore, it can be pointed out that nations improve their logistics performance by using digitalization. Besides that, previous studies demonstrated that multi-criteria decision-making methods (MCDM) have been applied significantly to analyze the logistics performance of nations. For instance, Martí et al. (2017); Ulutaş and Karaköy (2019); Chejarla et al. (2022); Miškić et al. (2023) applied MCDM to evaluate the logistics performance of nations. However, few researchers have examined the logistics market performance of nations using MCDM methods. For instance, Kara et al. (2022); Kara and Yalçın (2022); Özekenci (2023) investigated the logistics market performance of countries using the MCDM methods.

Accordingly, the objective of this study is to investigate the digital logistics market performance of developing countries using integrated MCDM methods. In this study, a new objective weighting method (LOPCOW) was applied to determine the weights of the criteria. Additionally, various ranking methods based on new (MARCOS and CoCoSo) and old approaches (MAUT and TOPSIS) were conducted to evaluate the digital logistics market performance of developing countries. Thus, the results obtained from modern and traditional approaches can be compared. To the best of the authors' knowledge, this is the first study to investigate the digital logistics market performance in developing countries using the LOPCOW-based MAUT, TOPSIS, MARCOS and CoCoSo methods. Thus, this paper aims to contribute to this growing area of research by proposing a new model. The rest of the paper is organized as follows. The second section gives a brief overview of previous research in relevant fields. The third section is concerned with the methodology used for this study. The fourth section presents the findings of the research. Finally, the conclusion gives a summary and critique of the findings.

2. Literature Review

This section presents previous research on the evaluation of logistics performance. Some studies are shown in Table 1.

Table 1. Literature Review on Logistics Performance

Authors	Years	Indicators	Methods	Topics
García et al.	2015	LPI	Data Envelopment Analysis (DEA)	Calculating a synthetic index of overall logistics performance and comparing logistics performance of countries
Srisawat et al.	2017	LPI	Fuzzy-Analytical Hierarchy Process (FAHP)	Estimating a set of spatial and logistics attributes by FAHP method.
Rezaei et al.	2018	LPI	Best Worst Method (BWM)	Measuring the relative importance of the logistics performance index indicators
Dare et al.	2019	LPI	TOPSIS	Examining and Analyzing the Trade Logistics Performance Index of Ghana, Nigeria and Morocco
Lagoudis et al.	2019	LPI	Multi-Attribute Utility Theory (MAUT)	measuring the attractiveness of a maritime clusters based on logistics performance index
Yildirim &	2020	LPI	Grey Additive Ratio	Evaluating of LPI for OECD countries using the ARAS-

Adiguzel Mercangoz			Assessment (ARAS-G) and fuzzy AHP	G and FAHP methods.
Isik et al.	2020	LPI	Statistical Variance & MABAC	Analyzing the Logistics Performance Index of Central and Eastern European Countries (CEECs)
Aboul-Dahab & Ibrahim	2020	LPI	TOPSIS	Investigating the efficiency of the LPI by selecting an appropriate criterion for the weighting the LPI component
Adıgüzel Mercangöz et al.	2020	LPI	COPRAS-G	Providing logistics performance scores of the selected countries
Mešić et al.	2022	LPI	CRITIC & MARCOS	Examining Western Balkans countries to compare their logistic performance
Kara & Yalçın	2022	AEMLI & WDC	RAFSI & MEREC	Determining the digital logistics market performance of developing nations
Vukadin & Jovičić.	2022	LPI	CRITIC & MARCOS	Analyzing and ranking of the LPI in Western Balkans
Yu & Rakshit	2023	LPI	H-DEA	Investigating the importance of the indicators constituting the LPI
Özekenci	2023	AEMLI	SWARA-CRITIC CoCoSo	Assessing the logistics market performance of developing countries

Based on previous research, it can be concluded that different weighting and ranking techniques are frequently used to evaluate the logistics performance of nations. Much of the current literature has focused on the LPI. So far, however, there have been few empirical investigations into the evaluation of the digital logistics market performance of nations. Correspondingly, this study aims to contribute to existing literature by exploring the digital logistics market performance of developing countries using different MCDM methods.

3. Methods

This section of the study describes the techniques used to assess the performance of the digital logistics market in developing countries. The brief information regarding the method used in this study is presented below.

3.1. LOPCOW Method

The Logarithmic Percentage Change-driven Objective Weighting (LOPCOW) method was proposed by Ecer and Pamucar in 2022. This technique is one of the new approaches among objective weighting methods. The application steps of the LOPCOW method are follows (Ecer & Pamucar, 2022):

Step 1. For a decision-making problem with *m* alternatives and *n* criteria, at first initial decision matrix (IDM) is created.

$$IDM = \begin{bmatrix} x_{11} & \dots & x_{1j} & \dots & r_{1n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2. Then, IDM is normalized. In order to determine the normalized values of IDM elements, the linear max-min standardization technique is used.

$r_{ij} = \frac{x_{max} - x_{ij}}{x_{max} - x_{min}}$, if *j* is a cost criterion (2)

$r_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}}$, if *j* is a benefit criterion (3)

Step 3. Each criterion's percentage value (PV) is determined. In this step, the mean square value of each criterion is computed as a percentage of their respective standard deviations. This calculation aims to reduce the influence of data size on the observed differences.

$$PV_{ij} = \left| \ln \left(\frac{\frac{\sqrt{\sum_{i=1}^{m} r_{ij}^2}}{m}}{\sigma} \right) . 100 \right| \quad (4)$$

σ: standard deviation

m: the number of alternatives

Step 4. Calculate the weights of the criteria using Eq. (5).

$$w_j = \frac{PV_{ij}}{\sum_{i=1}^{n} PV_{ij}} \quad (5)$$

3.2. MAUT Method

Multi-Attribute Utility Theory (MAUT) was developed by Keeney and Raiffa in 1976. MAUT has become one of the important approaches in the field of MCDM and it has been widely used to deal with several significant problems. The application steps of the MAUT method are follows (Keeney and Raiffa, 1993; Wang et al., 2010):

Step 1. Construct the decision matrix

$$X = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \quad (6)$$

Step 2. Developing a standardized decision matrix by using Eq. (7) and obtained Eq. (8).

$$r_{ij}^{*} = \frac{r_{ij} - \min(r_{ij})}{\max(r_{ij}) - \min(r_{ij})} \quad (7)$$

$$r_{ij}^{*} = 1 + \frac{\min(r_{ij}) - r_{ij}}{\max(r_{ij}) - \min(r_{ij})} \quad (8)$$

Step 3. Marginal utility point of alternatives is calculated by using Eq. (9).

$$u_{ij} = \frac{e^{(r_{ij}^{*})^2} - 1}{1{,}71} \quad (9)$$

Step 4. Eq. (10) is used for the calculation of final utility and ranking.

$$U_i = \sum_{j=1}^{n} u_{ij} \,.\, w_j \quad (10)$$

3.3. TOPSIS Method

Technique for Order Preference by Similarity Ideal Solution (TOPSIS) is one of the ranking methods proposed by Hwang and Yoon in 1981 to select the ideal solution among the criterions (Çakir and Perçin, 2013: 452). The basic concept of this approach is that the alternative with the closest proximity to the positive ideal solution is considered the most acceptable (Han and Trimi, 2018: 136). The application steps of the TOPSIS method are follows (Roszkowska, 2011: 206-208):

Step 1. Construct the initial decision matrix by using Eq. (11)

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \quad (11)$$

Step 2. Eq (12) is used for normalization and Eq. (13) obtained as a standardization of decision matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (12)$$

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \dots & r_{mn} \end{bmatrix} \quad (13)$$

Step 3. Criterion weights should be determined before constructing weighted decision matrix. Then, weighted normalization decision matrix should be computed by using Eq. (14):

$$V = \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \dots & v_{mn} \end{bmatrix} \quad (14)$$

Step 4. Determine both the positive and negative ideal solution.

$$A^{+} = \{(maxV_{ij} \backslash j \in B), (minV_{ij} \backslash j \in C)\}; i = 1,2,3, \dots, m \quad (15)$$

$$A^{-} = \{(minV_{ij} \backslash j \in B), (maxV_{ij} \backslash j \in C)\}; i = 1,2,3, \dots, m \quad (16)$$

$$A^{+} = (v_1^{+}, v_2^{+}, \dots, v_m^{+}) \quad (17)$$

$$A^{-} = (v_1^{-}, v_2^{-}, \dots, v_m^{-}) \quad (18)$$

Step 5. The deviations of the alternatives from the positive and negative ideal solutions are obtained by Euclidean distance formula.

$$S_i^{+} = \sqrt{\sum (v_{ij} - v_j^{+})^2} \quad (19)$$

$$S_i^{-} = \sqrt{\sum (v_{ij} - v_j^{-})^2} \quad (20)$$

Step 6. Compute the relative closeness for alternative ideal solution by using Eq. (21). Finally determine the ranking with the maximum number of C_i^{+}.

$$C_i^{+} = \frac{S_i^{-}}{S_i^{+} + S_i^{-}}; 0 \le C_i^{*} \le 1 \quad (21)$$

3.4. MARCOS Method

Measurement of Alternatives and Ranking according to COmpromise Solution (MARCOS) method was developed by Stević, Pamucar, Puška and Chatterjee in 2020. The advantage of this method is considering both ideal and anti-ideal solutions at the same time. It also provides to determine utility functions with a new perspective. The application steps of the MARCOS method are follows (Stević et al., 2020):

Step 1. Construct the initial decision matrix.

Step 2. Construct the extended initial matrix by describing the ideal (AI) and anti-ideal (AAI) solution in Eq. (22).

$$x_{ij} = \begin{matrix} A_1 \\ A_2 \\ \cdots \\ A_m \\ AI \end{matrix} \begin{bmatrix} x_{aa1} & x_{aa2} & \cdots & x_{aan} \\ x_{11} & x_{12} & \dots & x_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}; i = 1,2,\dots,m; j = 1,2,\dots,n \quad (22)$$

Step 3. Extended initial matrix (X) should be normalized by using Eq. (23) and Eq. (24)

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \; if \; j \in a \; group \; of \; cost \; criteria \quad (23)$$

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \; if \; j \in a \; benefit \; group \; of \; criterion \quad (24)$$

Normalized matrix: $N = [n_{ij}]_{m \times n}$ (25)

x_{ij} *and* x_{ai} represents the elements of the matrix X.

Step 4. Eq. (25) is multiplied by weight coefficients of criterion w_j and from this formula weighted matrix is calculated.

$$v_{ij} = n_{ij} \times w_j \quad (26)$$

Step 5. Utility degree of alternatives K_i is calculated by

using Eq. (27) and Eq. (28) for both ideal and anti-ideal solutions.

$$K_i^- = \frac{S_i}{S_{aai}} \quad (27)$$

$$K_i^+ = \frac{S_i}{S_{ai}} \quad (28)$$

$$S_i = \sum_{i=1}^{n} v_{ij} \, , i = 1,2, \dots, m \quad (29)$$

Step 6. Utility function of alternatives is determined by using Eq. (30). Eq. (31) represents the utility function according to the anti-ideal solution and Eq. (32) represents the utility function according to the ideal solution.

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

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \quad (31)$$

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \quad (32)$$

Final ranking of alternatives is arranged in a descending order.

3.5. CoCoSo Method

Combined Compromise Solution (CoCoSo) method was proposed by Yazdani, Zarate, Zavadskas and Turskis in 2019. The integrated simple additive weighting and exponentially weighted product model form the basis of the proposed approach. It can be a combination of compromise solutions. The application steps of the CoCoSo method are follows (Yazdani et al., 2019):

Step 1. Determine the initial decision-making matrix

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}; i = 1,2,\dots,m; j = 1,2,\dots,n \quad (33)$$

Step 2. The compromise normalization equation provides a basis for normalizing the criteria values.

$$r_{ij} = \frac{x_{ij} - \min\limits_i(x_{ij})}{\max\limits_i(x_{ij}) - \min\limits_i(x_{ij})}; \text{ for benefit criterion} \quad (34)$$

$$r_{ij} = \frac{\max\limits_i(x_{ij}) - x_{ij}}{\max\limits_i(x_{ij}) - \min\limits_i(x_{ij})}; \text{ for cost criterion} \quad (35)$$

Step 3. S_i and P_i values are calculated by using Eq. (36) and Eq. (37) respectively. The sum of weighted comparability sequence and the total power weight of comparability sequences for each alternative is formulated as S_i and P_i values.

$$S_i = \sum_{i=1}^{n} (w_j r_{ij}) \quad (36)$$

Table 2. Summary of Criteria

The determination of S_i value is accomplished through the utilization of the grey relational generation approach.

$$P_i = \sum_{i=1}^{n} (r_{ij})^{w_j} \quad (37)$$

Step 4. The computation involves determining the relative weights of the alternative through the utilization of various aggregation strategies. In this step, three evaluation score methodologies are used to generate other possibilities by using the following formulas.

The arithmetic mean of sums of Weighted Sum Method (WSM) and Weighted Product Method (WPM) scores is formulated in Eq. (38), while Eq. (39) represents a sum of relative scores of WSM and WPM compared the best.

$$ʒ_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m} (P_i + S_i)'} \quad (38)$$

$$ʒ_{ib} = \frac{S_i}{\min\limits_i(S_i)} + \frac{P_i}{\min\limits_i(P_i)'} \quad (39)$$

$$ʒ_{ic} = \frac{\lambda S_i + (1-\lambda) P_i}{\lambda \max\limits_i(S_i) - (1-\lambda) \max\limits_i(P_i)} \; ; 0 \le \lambda \le 1 \quad (40)$$

Eq. (40) is the balanced compromise of WSM and WPM models cores. (λ is a decision-maker in equation and usually taken 0.5.)

Step 5. Final ranking alternatives are calculated.

$$ʒ_i = (ʒ_{ia} ʒ_{ib} ʒ_{ic})^{\frac{1}{3}} + \frac{1}{3}(ʒ_{ia} + ʒ_{ib} + ʒ_{ic}) \quad (41)$$

3.6. Borda Count

Borda Count provide a comprehensive ranking for researchers using different ranking methods by combining the ranks determined by various approaches (Uluskan et al., 2022: 29). The steps of the Borda count method is follows (Akyüz and Aka, 2017: 36-37):

Step 1. Borda criteria determine by using each criteria.

$$b_i = \sum_{k=1}^{n} (M - r_{ik}) \quad (42)$$

M: total number of alternatives

r_{ik}: the order of *i*th alternative under *k*th criterion

M: the number of total alternatives

4. Applications and Results

In this part, the findings obtained by various methods are presented. The weight of criteria was calculated by the LOPCOW method. Then, the alternatives were ranked based on the MAUT, TOPSIS, MARCOS and CoCoSo methods. Final ranking was obtained by the Borda count method. Table 2 illustrates the overview of criteria used in this study.

Criteria	Description	Year	Report
Domestic logistics opportunities (DLO)	Measures the performance of each emerging market and its potential to sustain and develop domestic demand that requires competitive logistics markets	2022	AEMLI
International logistics opportunities (ILO)	Measures internal and external demand for trade intensive logistics services and the capacity of individual emerging markets to facilitate cross-border logistics operations		
Business fundamentals (BF)	Measures the openness, robustness, fairness and strength of each emerging market's business environment, rule of law and market independence		
Digital Readiness (DR)	Measures the potential and progress of an emerging market in becoming a digitally-led, skills rich, innovation-oriented and sustainable economy for the future		
Knowledge (KNO)	Know-how necessary to discover and understand new technologies		DCI
Technology (TECH)	Overall context that enables the development of digital technologies		
Future readiness (FR)	Level of country preparedness to exploit digital transformation		

Source: Agility (2023); IMD (2022)

It can be seen above; the evaluation of digital logistics market performance of developing countries was carried out based on seven criteria. The criteria were determined by previous research (Kara et al., 2022; Kara and Yalçın 2022; Özekenci, 2023). The alternatives were selected from the AEMLI and DCI reports. According to the AEMLI and DCI reports, more than sixty developing countries were included in the ranking. However, two-thirds of these countries have insufficient data. For this reason, a total of twenty developing countries namely, China, Argentina, Bahrain, Brazil, Chile, Colombia, India, Indonesia, Jordan, Kazakhstan, Malaysia, Mexico, Peru, Philippines, Qatar, Saudi Arabia, South Africa, Türkiye, the UAE, and Thailand were involved in this study. The results obtained from each method are presented below.

4.1. The Results Obtained from the LOPCOW Method

At first, decision matrix was formed and shown in Table 3. Then, decision matrix was normalized based on Eq. (3) and the results are shown in Table 4.

Table 3. Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	8,47	9,75	7,11	6,63	79,27	76,69	80,93
Argentina	4,87	4,63	4,24	4,68	45,46	30,36	52,46
Bahrain	4,99	4,70	7,15	5,34	66,47	74,17	64,53
Brazil	5,42	5,42	4,13	5,19	49,52	44,38	52,13
Chile	4,83	5,18	7,01	5,55	49,78	61,42	65,11
Colombia	4,67	5,08	4,55	4,53	45,90	34,53	44,84
India	8,04	7,45	5,94	7,61	53,95	60,25	55,20
Indonesia	6,34	5,89	5,77	6,21	42,20	55,33	50,31
Jordan	4,88	4,75	6,72	5,14	48,63	51,19	45,91
Kazakhstan	4,66	4,66	6,19	5,10	67,64	61,56	67,51
Malaysia	5,29	5,88	7,85	6,72	70,08	71,45	65,33
Mexico	5,37	6,32	4,93	5,11	49,17	42,79	49,83
Peru	4,72	5,12	4,48	4,58	46,34	41,33	46,12
Philippines	5,02	5,28	4,31	5,99	40,51	51,58	43,95
Qatar	5,91	4,96	7,92	6,38	59,11	78,65	74,98
Saudi Arabia	5,38	5,74	7,86	6,30	61,96	72,92	64,34
South Africa	4,81	5,00	4,99	5,01	47,76	40,06	43,50
Türkiye	5,14	5,70	5,80	5,50	42,34	46,83	53,49
UAE	5,60	5,89	9,10	7,37	80,67	93,78	77,40
Thailand	5,11	5,98	5,77	6,04	55,52	74,97	51,7
max	8,47	9,75	9,10	7,61	80,67	93,78	80,93
min	4,48	3,96	1,56	3,99	40,39	0,00	18,22

Source: Authors' calculations.

Table 4. Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	1,0000	1,0000	0,7361	0,6724	10,3064	9,9642	10,5265
Argentina	0,0977	0,1157	0,3554	0,4138	5,8223	3,8196	6,7507
Bahrain	0,1278	0,1278	0,7414	0,5013	8,6088	9,6300	8,3515
Brazil	0,2356	0,2522	0,3408	0,4814	6,3607	5,6790	6,7069
Chile	0,0877	0,2107	0,7228	0,5292	6,3952	7,9390	8,4284
Colombia	0,0476	0,1934	0,3966	0,3939	5,8806	4,3727	5,7401
India	0,8922	0,6028	0,5809	0,8024	6,9483	7,7838	7,1141

Indonesia	0,4662	0,3333	0,5584	0,6167	5,3899	7,1313	6,4655
Jordan	0,1003	0,1364	0,6844	0,4748	6,2427	6,5822	5,8820
Kazakhstan	0,0451	0,1209	0,6141	0,4695	8,7639	7,9576	8,7467
Malaysia	0,2030	0,3316	0,8342	0,6844	9,0875	9,2692	8,4576
Mexico	0,2231	0,4076	0,4469	0,4708	6,3143	5,4682	6,4019
Peru	0,0602	0,2003	0,3873	0,4005	5,9390	5,2745	5,9098
Philippines	0,1353	0,2280	0,3647	0,5875	5,1658	6,6340	5,6220
Qatar	0,3584	0,1727	0,8435	0,6393	7,6326	10,2241	9,7374
Saudi Arabia	0,2256	0,3074	0,8355	0,6286	8,0106	9,4642	8,3263
South Africa	0,0827	0,1796	0,4549	0,4576	6,1273	5,1061	5,5623
Türkiye	0,1654	0,3005	0,5623	0,5225	5,4085	6,0040	6,8873
UAE	0,2807	0,3333	1,0000	0,7706	10,4920	12,2308	10,0584
Thailand	0,1181	0,2637	0,3300	0,3843	10,3400	14,2535	9,5714
Mean square	0,2142	0,2029	0,3946	0,3258	10,2584	10,8817	10,7341
Standard deviation	0,2740	0,2303	0,2931	0,1799	2,4427	3,4507	2,3490

Source: Authors' calculations.

PV values of each criterion was calculated according to Eq. (4) and the results are presented in Table 5.

Table 5. PV Values of Criteria

	DLO	ILO	BF	DR	KNO	TECH	FR
PV	-24,637	-12,672	29,7251	59,370	143,499	114,850	151,943

Source: Authors' calculations.

The final ranking of criteria was determined by Eq. (5) and the results are shown in Table 6.

Table 6. Final Weights of Criteria

	DLO	ILO	BF	DR	KNO	TECH	FR
w	-0,053	-0,027	0,064	0,128	0,311	0,24855	0,32883
Rank	**7**	**6**	**5**	**4**	**2**	**3**	**1**

Source: Authors' calculations.

According to results obtained by LOPCOW method, future readiness (FR), knowledge (KNO) and technology (TECH) were found to most important criteria, while domestic logistics opportunities (DLO), international logistics opportunities (ILO) and business fundamentals (BF) were found to least important criteria, respectively.

4.2. The Results Obtained from the MAUT Method

Firstly, decision matrix was formed and shown in Table 7.

Table 7. Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	8,47	9,75	7,11	6,63	79,27	76,69	80,93
Argentina	4,87	4,63	4,24	4,68	45,46	30,36	52,46
Bahrain	4,99	4,70	7,15	5,34	66,47	74,17	64,53
Brazil	5,42	5,42	4,13	5,19	49,52	44,38	52,13
Chile	4,83	5,18	7,01	5,55	49,78	61,42	65,11
Colombia	4,67	5,08	4,55	4,53	45,90	34,53	44,84
India	8,04	7,45	5,94	7,61	53,95	60,25	55,20
Indonesia	6,34	5,89	5,77	6,21	42,20	55,33	50,31
Jordan	4,88	4,75	6,72	5,14	48,63	51,19	45,91
Kazakhstan	4,66	4,66	6,19	5,10	67,64	61,56	67,51
Malaysia	5,29	5,88	7,85	6,72	70,08	71,45	65,33
Mexico	5,37	6,32	4,93	5,11	49,17	42,79	49,83
Peru	4,72	5,12	4,48	4,58	46,34	41,33	46,12
Philippines	5,02	5,28	4,31	5,99	40,51	51,58	43,95
Qatar	5,91	4,96	7,92	6,38	59,11	78,65	74,98
Saudi Arabia	5,38	5,74	7,86	6,30	61,96	72,92	64,34
South Africa	4,81	5,00	4,99	5,01	47,76	40,06	43,50
Türkiye	5,14	5,70	5,80	5,50	42,34	46,83	53,49
UAE	5,60	5,89	9,10	7,37	80,67	93,78	77,40
Thailand	5,11	5,98	5,77	6,04	55,52	74,97	51,7
w	-0,053	-0,027	0,064	0,128	0,311	0,249	0,329

Source: Authors' calculations.

Then, decision matrix was normalized based on Eq. (6) and the results are shown in Table 8.

Table 8. Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	1,000	1,336	0,643	0,517	19,583	18,906	20,018
Argentina	0,055	-0,008	-0,110	0,005	10,709	6,745	12,546
Bahrain	0,087	0,011	0,654	0,179	16,223	18,244	15,714
Brazil	0,200	0,200	-0,139	0,139	11,774	10,425	12,459
Chile	0,045	0,137	0,617	0,234	11,843	14,898	15,866
Colombia	0,003	0,110	-0,029	-0,03	10,824	7,840	10,546
India	0,887	0,732	0,336	0,774	12,937	14,591	13,265
Indonesia	0,441	0,323	0,291	0,407	9,853	13,299	11,982
Jordan	0,058	0,024	0,541	0,126	11,541	12,213	10,827
Kazakhstan	0,000	0,000	0,402	0,116	16,530	14,934	16,496
Malaysia	0,165	0,320	0,837	0,541	17,171	17,530	15,924
Mexico	0,186	0,436	0,071	0,118	11,682	10,008	11,856
Peru	0,016	0,121	-0,047	-0,02	10,940	9,625	10,882
Philippines	0,095	0,163	-0,092	0,349	9,409	12,315	10,312
Qatar	0,328	0,079	0,856	0,451	14,291	19,420	18,457
Saudi Arabia	0,189	0,284	0,840	0,430	15,039	17,916	15,664
South Africa	0,039	0,089	0,087	0,092	11,312	9,291	10,194
Türkiye	0,126	0,273	0,299	0,221	9,890	11,068	12,816
UAE	0,247	0,323	1,165	0,711	19,950	23,391	19,092
Thailand	0,118	0,347	0,291	0,362	13,349	18,454	12,347

Source: Authors' calculations.

According to Eq. (8), the marginal utility score was calculated, and the results are presented in Table 9.

Table 9. Marginal Utility Score

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	1,0048	2,8996	0,2995	0,1792	2E+166	9,8E+154	6,4E+173
Argentina	0,0018	0,0000	0,0071	0,0000	3,7E+49	3,4E+19	1,3E+68
Bahrain	0,0044	0,0001	0,3116	0,0189	1,2E+114	2,1E+144	1,0E+107
Brazil	0,0237	0,0237	0,0114	0,0114	9,4E+59	9,3E+46	1,5E+67
Chile	0,0012	0,0110	0,2707	0,0328	4,7E+60	1,4E+96	1,2E+109
Colombia	4,0E-06	0,0071	0,0005	0,0007	4,5E+50	2,89E+26	1,17E+48
India	0,6999	0,4150	0,0699	0,4802	2,8E+72	1,67E+92	1,54E+76
Indonesia	0,1255	0,0642	0,0518	0,1053	8,5E+41	3,8E+76	1,3E+62
Jordan	0,0020	0,0003	0,1986	0,0094	4,1E+57	3,5E+64	4,7E+50
Kazakhstan	0,0000	0,0000	0,1023	0,0079	2,7E+118	4,3E+96	8,9E+117
Malaysia	0,0162	0,0631	0,5940	0,1986	6,5E+127	1,7E+133	7,8E+109
Mexico	0,0207	0,1222	0,0029	0,0082	1,1E+59	1,8E+43	6,5E+60
Peru	0,0001	0,0086	0,0013	0,0003	5,5E+51	9,9E+39	1,6E+51
Philippines	0,0052	0,0157	0,0050	0,0758	1,7E+38	4,3E+65	8,9E+45
Qatar	0,0665	0,0036	0,6313	0,1322	2,9E+88	3,6E+163	5,1E+147
Saudi Arabia	0,0213	0,0489	0,5992	0,1190	9,9E+97	1,5E+139	2,1E+106
South Africa	0,0009	0,0047	0,0044	0,0050	2,2E+55	1,8E+37	7,9E+44
Türkiye	0,0094	0,0452	0,0548	0,0291	1,8E+42	9,3E+52	1,3E+71
UAE	0,0367	0,0642	1,6892	0,3851	4,2E+172	2,4E+237	1,2E+158
Thailand	0,0082	0,0746	0,0518	0,0820	1,4E+77	4,6E+147	9,3E+65

Source: Authors' calculations.

The final utility score was determined based on the Eq. (9) and the final rankings are demonstrated in Table 10.

Table 10. Final Utility Score

Country	Utility Score	Rank
China	2,1E+173	2
Argentina	4,39E+67	13
Bahrain	5,2E+143	5
Brazil	5,03E+66	14
Chile	4,1E+108	9
Colombia	1,39E+50	20
India	4,14E+91	10
Indonesia	9,46E+75	11
Jordan	8,64E+63	16
Kazakhstan	1,1E+118	8
Malaysia	4,2E+132	7
Mexico	2,16E+60	17
Peru	2,23E+51	19
Philippines	1,06E+65	15
Qatar	8,9E+162	3
Saudi Arabia	3,7E+138	6
South Africa	6,84E+54	18
Türkiye	4,17E+70	12
UAE	6,1E+236	1
Thailand	1,2E+147	4

Source: Authors' calculations.

According to results obtained by the MAUT method, the UAE, China, and Qatar have the highest digital logistics market performance, while Colombia, Peru and South Africa have the lowest digital logistics market performance in 2022, respectively.

4.3. The Results Obtained from the TOPSIS Method

According to Eq. (12), decision matrix was normalized and shown in Table 11.

Table 11. Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	0,3400	0,3914	0,2854	0,2662	3,1824	3,0789	3,2491
Argentina	0,1955	0,1859	0,1702	0,1879	1,8251	1,2189	2,1061
Bahrain	0,2003	0,1887	0,2870	0,2144	2,6686	2,9777	2,5907
Brazil	0,2176	0,2176	0,1658	0,2084	1,9881	1,7817	2,0928
Chile	0,1939	0,2080	0,2814	0,2228	1,9985	2,4658	2,6140
Colombia	0,1875	0,2039	0,1827	0,1819	1,8427	1,3863	1,8002
India	0,3228	0,2991	0,2385	0,3055	2,1659	2,4188	2,2161
Indonesia	0,2545	0,2365	0,2316	0,2493	1,6942	2,2213	2,0198
Jordan	0,1959	0,1907	0,2698	0,2064	1,9523	2,0551	1,8431
Kazakhstan	0,1871	0,1871	0,2485	0,2047	2,7155	2,4714	2,7103
Malaysia	0,2124	0,2361	0,3152	0,2698	2,8135	2,8685	2,6228
Mexico	0,2156	0,2537	0,1979	0,2051	1,9740	1,7179	2,0005
Peru	0,1895	0,2056	0,1799	0,1839	1,8604	1,6593	1,8516
Philippines	0,2015	0,2120	0,1730	0,2405	1,6263	2,0708	1,7644
Qatar	0,2373	0,1991	0,3180	0,2561	2,3731	3,1575	3,0102
Saudi Arabia	0,2160	0,2304	0,3156	0,2529	2,4875	2,9275	2,5830
South Africa	0,1931	0,2007	0,2003	0,2011	1,9174	1,6083	1,7464
Türkiye	0,2064	0,2288	0,2329	0,2208	1,6998	1,8801	2,1474
UAE	0,2248	0,2365	0,3653	0,2959	3,2386	3,7650	3,1074
Thailand	0,2051	0,2401	0,2316	0,2425	2,2289	3,0098	2,0756

Source: Authors' calculations.

Based on the Eq. (14), weighted normalized decision matrix was calculated and the results are presented in Table 12.

Table 12. Weighted Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	-0,0181	-0,0107	0,0184	0,0342	0,9883	0,7653	1,0684
Argentina	-0,0104	-0,0051	0,0110	0,0241	0,5668	0,3029	0,6925
Bahrain	-0,0107	-0,0052	0,0185	0,0275	0,8287	0,7401	0,8519
Brazil	-0,0116	-0,0060	0,0107	0,0268	0,6174	0,4428	0,6882
Chile	-0,0103	-0,0057	0,0181	0,0286	0,6206	0,6129	0,8595
Colombia	-0,0100	-0,0056	0,0118	0,0234	0,5723	0,3446	0,5919
India	-0,0172	-0,0082	0,0153	0,0393	0,6726	0,6012	0,7287
Indonesia	-0,0136	-0,0065	0,0149	0,0320	0,5261	0,5521	0,6642
Jordan	-0,0104	-0,0052	0,0174	0,0265	0,6063	0,5108	0,6061
Kazakhstan	-0,0100	-0,0051	0,0160	0,0263	0,8433	0,6143	0,8912
Malaysia	-0,0113	-0,0065	0,0203	0,0347	0,8737	0,7130	0,8624
Mexico	-0,0115	-0,0070	0,0127	0,0264	0,6130	0,4270	0,6578
Peru	-0,0101	-0,0056	0,0116	0,0236	0,5777	0,4124	0,6088
Philippines	-0,0107	-0,0058	0,0111	0,0309	0,5051	0,5147	0,5802
Qatar	-0,0127	-0,0055	0,0205	0,0329	0,7370	0,7848	0,9898
Saudi Arabia	-0,0115	-0,0063	0,0203	0,0325	0,7725	0,7276	0,8494
South Africa	-0,0103	-0,0055	0,0129	0,0258	0,5955	0,3997	0,5743
Türkiye	-0,0110	-0,0063	0,0150	0,0284	0,5279	0,4673	0,7061
UAE	-0,0120	-0,0065	0,0235	0,0380	1,0058	0,9358	1,0218
Thailand	-0,0109	-0,0066	0,0149	0,0312	0,6922	0,7481	0,6825

Source: Authors' calculations.

Ideal positive and negative solution values were calculated according to Eqs. (19-20) and the results are illustrated in Table 13.

Table 13. Ideal Positive and Negative Solution Values

	DLO	ILO	BF	DR	KNO	TECH	FR
V^+	-0,0100	-0,0051	0,0235	0,0393	1,0058	0,9358	1,0684
V^-	-0,0181	-0,0107	0,0107	0,0234	0,5051	0,3029	0,5743

Source: Authors' calculations.

Distance values from ideal solution was determined by using Eq. (21) and the results are shown in Table 14.

Table 14. Distance Values to Ideal Solution

Country	C_i^+	rank
China	0,828734	2
Argentina	0,134976	19
Bahrain	0,641356	5
Brazil	0,224696	13
Chile	0,445293	9
Colombia	0,085315	20
India	0,392419	10
Indonesia	0,265612	11
Jordan	0,238923	12
Kazakhstan	0,581651	7
Malaysia	0,652851	4
Mexico	0,194879	16
Peru	0,142788	17
Philippines	0,206253	15
Qatar	0,68038	3
Saudi Arabia	0,599938	6
South Africa	0,136981	18
Türkiye	0,218037	14
UAE	0,951859	1
Thailand	0,482185	8

Source: Authors' calculations.

According to results obtained by the TOPSIS method, the UAE, China, and Qatar have the highest digital logistics market performance, while Colombia, Argentina and South Africa have the lowest digital logistics market performance in 2022, respectively.

4.4. The Results Obtained from the MARCOS Method

Extended decision matrix was formed using Eq. (22) and shown in Table 15.

Table 15. Extended Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	8,47	9,75	7,11	6,63	79,27	76,69	80,93
Argentina	4,87	4,63	4,24	4,68	45,46	30,36	52,46
Bahrain	4,99	4,7	7,15	5,34	66,47	74,17	64,53
Brazil	5,42	5,42	4,13	5,19	49,52	44,38	52,13
Chile	4,83	5,18	7,01	5,55	49,78	61,42	65,11
Colombia	4,67	5,08	4,55	4,53	45,9	34,53	44,84
India	8,04	7,45	5,94	7,61	53,95	60,25	55,2
Indonesia	6,34	5,89	5,77	6,21	42,2	55,33	50,31
Jordan	4,88	4,75	6,72	5,14	48,63	51,19	45,91
Kazakhstan	4,66	4,66	6,19	5,1	67,64	61,56	67,51
Malaysia	5,29	5,88	7,85	6,72	70,08	71,45	65,33
Mexico	5,37	6,32	4,93	5,11	49,17	42,79	49,83
Peru	4,72	5,12	4,48	4,58	46,34	41,33	46,12
Philippines	5,02	5,28	4,31	5,99	40,51	51,58	43,95
Qatar	5,91	4,96	7,92	6,38	59,11	78,65	74,98
Saudi Arabia	5,38	5,74	7,86	6,3	61,96	72,92	64,34
South Africa	4,81	5	4,99	5,01	47,76	40,06	43,5
Türkiye	5,14	5,7	5,8	5,5	42,34	46,83	53,49
UAE	5,6	5,89	9,1	7,37	80,67	93,78	77,4
Thailand	5,11	5,98	5,77	6,04	55,52	74,97	51,7
AI	8,47	9,75	9,10	7,61	80,67	93,78	80,93
AAI	4,66	4,63	4,13	4,53	40,51	30,36	43,50

Source: Authors' calculations.

Decision matrix was normalized based on Eq. (24) and the results are presented in Table 16.

Table 16. Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	1,0000	1,0000	0,7813	0,8712	0,9826	0,8178	1,0000
Argentina	0,5750	0,4749	0,4659	0,6150	0,5635	0,3237	0,6482
Bahrain	0,5891	0,4821	0,7857	0,7017	0,8240	0,7909	0,7974
Brazil	0,6399	0,5559	0,4538	0,6820	0,6139	0,4732	0,6441
Chile	0,5702	0,5313	0,7703	0,7293	0,6171	0,6549	0,8045
Colombia	0,5514	0,5210	0,5000	0,5953	0,5690	0,3682	0,5541
India	0,9492	0,7641	0,6527	1,0000	0,6688	0,6425	0,6821
Indonesia	0,7485	0,6041	0,6341	0,8160	0,5231	0,5900	0,6216
Jordan	0,5762	0,4872	0,7385	0,6754	0,6028	0,5459	0,5673
Kazakhstan	0,5502	0,4779	0,6802	0,6702	0,8385	0,6564	0,8342
Malaysia	0,6246	0,6031	0,8626	0,8830	0,8687	0,7619	0,8072
Mexico	0,6340	0,6482	0,5418	0,6715	0,6095	0,4563	0,6157
Peru	0,5573	0,5251	0,4923	0,6018	0,5744	0,4407	0,5699
Philippines	0,5927	0,5415	0,4736	0,7871	0,5022	0,5500	0,5431
Qatar	0,6978	0,5087	0,8703	0,8384	0,7327	0,8387	0,9265
Saudi Arabia	0,6352	0,5887	0,8637	0,8279	0,7681	0,7776	0,7950
South Africa	0,5679	0,5128	0,5484	0,6583	0,5920	0,4272	0,5375
Türkiye	0,6068	0,5846	0,6374	0,7227	0,5249	0,4994	0,6609
UAE	0,6612	0,6041	1,0000	0,9685	1,0000	1,0000	0,9564
Thailand	0,6033	0,6133	0,6341	0,7937	0,6882	0,7994	0,6388

Source: Authors' calculations.

Based on the Eq. (26), weighted normalized decision matrix was calculated and the results are presented in Table 17.

Table 17. Weighted Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR	Total
China	-0,0533	-0,0274	0,0503	0,1119	0,3052	0,2033	0,3288	0,9187
Argentina	-0,0307	-0,0130	0,0300	0,0790	0,1750	0,0805	0,2131	0,5339
Bahrain	-0,0314	-0,0132	0,0505	0,0902	0,2559	0,1966	0,2622	0,8107
Brazil	-0,0341	-0,0152	0,0292	0,0876	0,1906	0,1176	0,2118	0,5875
Chile	-0,0304	-0,0146	0,0496	0,0937	0,1916	0,1628	0,2645	0,7173
Colombia	-0,0294	-0,0143	0,0322	0,0765	0,1767	0,0915	0,1822	0,5154
India	-0,0506	-0,0210	0,0420	0,1285	0,2077	0,1597	0,2243	0,6906
Indonesia	-0,0399	-0,0166	0,0408	0,1048	0,1625	0,1466	0,2044	0,6027

Jordan	-0,0307	-0,0134	0,0475	0,0868	0,1872	0,1357	0,1865	0,5996
Kazakhstan	-0,0293	-0,0131	0,0438	0,0861	0,2604	0,1632	0,2743	0,7853
Malaysia	-0,0333	-0,0165	0,0555	0,1135	0,2698	0,1894	0,2654	0,8437
Mexico	-0,0338	-0,0178	0,0349	0,0863	0,1893	0,1134	0,2025	0,5747
Peru	-0,0297	-0,0144	0,0317	0,0773	0,1784	0,1095	0,1874	0,5402
Philippines	-0,0316	-0,0149	0,0305	0,1011	0,1559	0,1367	0,1786	0,5564
Qatar	-0,0372	-0,0140	0,0560	0,1077	0,2276	0,2085	0,3047	0,8532
Saudi Arabia	-0,0339	-0,0161	0,0556	0,1064	0,2385	0,1933	0,2614	0,8051
South Africa	-0,0303	-0,0141	0,0353	0,0846	0,1839	0,1062	0,1767	0,5423
Türkiye	-0,0324	-0,0160	0,0410	0,0929	0,1630	0,1241	0,2173	0,5899
UAE	-0,0353	-0,0166	0,0643	0,1244	0,3106	0,2486	0,3145	1,0105
Thailand	-0,0322	-0,0168	0,0408	0,1020	0,2137	0,1987	0,2101	0,7163
AI	-0,4516	-0,2674	0,5854	0,9778	25,0522	23,3092	26,6119	75,8174
AAI	-0,2485	-0,1270	0,2657	0,5820	12,5804	7,5460	14,3039	34,9027

Source: Author's calculations.

Utility degree of alternatives for both ideal and anti-ideal solutions and utility function of alternatives for both ideal and anti-ideal solutions were determined using Eqs. (27-32) and the results are shown in Table 18.

Table 18. Utility Degrees and Utility Functions of Alternatives

Country	S_i	K_i^-	K_i^+	$f(K_i^-)$	$f(K_i^+)$	$f(K_i)$	Ranking
China	0,918702	0,026322	0,012117	0,315233	0,684767	0,038439	2
Argentina	0,533929	0,015298	0,007042	0,315233	0,684767	0,02234	19
Bahrain	0,810727	0,023228	0,010693	0,315233	0,684767	0,033921	5
Brazil	0,587525	0,016833	0,007749	0,315233	0,684767	0,024582	14
Chile	0,717254	0,02055	0,00946	0,315233	0,684767	0,03001	8
Colombia	0,515366	0,014766	0,006797	0,315233	0,684767	0,021563	20
India	0,690565	0,019785	0,009108	0,315233	0,684767	0,028894	10
Indonesia	0,602674	0,017267	0,007949	0,315233	0,684767	0,025216	11
Jordan	0,599624	0,01718	0,007909	0,315233	0,684767	0,025089	12
Kazakhstan	0,785269	0,022499	0,010357	0,315233	0,684767	0,032856	7
Malaysia	0,843706	0,024173	0,011128	0,315233	0,684767	0,035301	4
Mexico	0,574706	0,016466	0,00758	0,315233	0,684767	0,024046	15
Peru	0,540206	0,015477	0,007125	0,315233	0,684767	0,022603	18
Philippines	0,556377	0,015941	0,007338	0,315233	0,684767	0,023279	16
Qatar	0,853206	0,024445	0,011253	0,315233	0,684767	0,035699	3
Saudi Arabia	0,805127	0,023068	0,010619	0,315233	0,684767	0,033687	6
South Africa	0,542297	0,015537	0,007153	0,315233	0,684767	0,02269	17
Türkiye	0,589918	0,016902	0,007781	0,315233	0,684767	0,024683	13
UAE	1,010529	0,028953	0,013328	0,315233	0,684767	0,042281	1
Thailand	0,716272	0,020522	0,009447	0,315233	0,684767	0,029969	9

Source: Authors' calculations.

According to results obtained by the MARCOS method, the UAE, China, and Qatar have the highest digital logistics market performance, while Colombia, Argentina and Peru have the lowest digital logistics market performance in 2022, respectively.

4.5. The Results Obtained from the CoCoSo Method

Decision matrix was normalized according to Eq. (34) and shown in Table 19.

Table 19. Normalized Decision Matrix

Country	DLO	ILO	BF	DR	KNO	TECH	FR
China	1,0000	1,0000	0,5996	0,6818	0,9651	0,7305	1,0000
Argentina	0,0551	0,0000	0,0221	0,0487	0,1233	0,0000	0,2394
Bahrain	0,0866	0,0137	0,6076	0,2630	0,6464	0,6908	0,5618
Brazil	0,1995	0,1543	0,0000	0,2143	0,2244	0,2211	0,2306
Chile	0,0446	0,1074	0,5795	0,3312	0,2308	0,4898	0,5773
Colombia	0,0026	0,0879	0,0845	0,0000	0,1342	0,0658	0,0358
India	0,8871	0,5508	0,3642	1,0000	0,3347	0,4713	0,3126
Indonesia	0,4409	0,2461	0,3300	0,5455	0,0421	0,3937	0,1819
Jordan	0,0577	0,0234	0,5211	0,1981	0,2022	0,3284	0,0644
Kazakhstan	0,0000	0,0059	0,4145	0,1851	0,6755	0,4920	0,6415
Malaysia	0,1654	0,2441	0,7485	0,7110	0,7363	0,6479	0,5832
Mexico	0,1864	0,3301	0,1610	0,1883	0,2156	0,1960	0,1691
Peru	0,0157	0,0957	0,0704	0,0162	0,1452	0,1730	0,0700
Philippines	0,0945	0,1270	0,0362	0,4740	0,0000	0,3346	0,0120
Qatar	0,3281	0,0645	0,7626	0,6006	0,4631	0,7614	0,8410
Saudi Arabia	0,1890	0,2168	0,7505	0,5747	0,5341	0,6711	0,5568
South Africa	0,0394	0,0723	0,1730	0,1558	0,1805	0,1529	0,0000
Türkiye	0,1260	0,2090	0,3360	0,3149	0,0456	0,2597	0,2669
UAE	0,2467	0,2461	1,0000	0,9221	1,0000	1,0000	0,9057
Thailand	0,1181	0,2637	0,3300	0,4903	0,3738	0,7034	0,2191

Source: Authors' calculations.

According to Eqs. (36) and (37), weighted comparability sequences and the total power weight of comparability sequences for each alternative was calculated and the results are presented in Table 20 and 21, respectively.

Table 20. Weighted Comparability Sequences and S_i

Country	DLO	ILO	BF	DR	KNO	TECH	FR	S_i
China	-0,0533	-0,0274	0,0386	0,0876	0,2997	0,1816	0,3288	0,8556
Argentina	-0,0029	0,0000	0,0014	0,0063	0,0383	0,0000	0,0787	0,1217
Bahrain	-0,0046	-0,0004	0,0391	0,0338	0,2007	0,1717	0,1848	0,6251
Brazil	-0,0106	-0,0042	0,0000	0,0275	0,0697	0,0549	0,0758	0,2131
Chile	-0,0024	-0,0029	0,0373	0,0426	0,0717	0,1217	0,1898	0,4578
Colombia	-0,0001	-0,0024	0,0054	0,0000	0,0417	0,0163	0,0118	0,0727
India	-0,0473	-0,0151	0,0234	0,1285	0,1039	0,1171	0,1028	0,4134
Indonesia	-0,0235	-0,0067	0,0212	0,0701	0,0131	0,0979	0,0598	0,2318
Jordan	-0,0031	-0,0006	0,0335	0,0254	0,0628	0,0816	0,0212	0,2208
Kazakhstan	0,0000	-0,0002	0,0267	0,0238	0,2098	0,1223	0,2109	0,5933
Malaysia	-0,0088	-0,0067	0,0481	0,0914	0,2287	0,1610	0,1918	0,7055
Mexico	-0,0099	-0,0091	0,0104	0,0242	0,0670	0,0487	0,0556	0,1869
Peru	-0,0008	-0,0026	0,0045	0,0021	0,0451	0,0430	0,0230	0,1142
Philippines	-0,0050	-0,0035	0,0023	0,0609	0,0000	0,0832	0,0040	0,1418
Qatar	-0,0175	-0,0018	0,0491	0,0772	0,1438	0,1893	0,2766	0,7166
Saudi Arabia	-0,0101	-0,0059	0,0483	0,0738	0,1659	0,1668	0,1831	0,6218
South Africa	-0,0021	-0,0020	0,0111	0,0200	0,0561	0,0380	0,0000	0,1212
Türkiye	-0,0067	-0,0057	0,0216	0,0405	0,0142	0,0645	0,0878	0,2161
UAE	-0,0132	-0,0067	0,0643	0,1185	0,3106	0,2486	0,2978	1,0198
Thailand	-0,0063	-0,0072	0,0212	0,0630	0,1161	0,1748	0,0720	0,4336
S_i overall								8,0828

Source: Authors' calculations.

Table 21. Exponentially Weighted Comparability Sequence and P_i

Country	DLO	ILO	BF	DR	KNO	TECH	FR	P_i
China	1,0000	1,0000	0,9676	0,9520	0,9890	0,9249	1,0000	6,8336
Argentina	1,1671	*****	0,7826	0,6782	0,5220	0,0000	0,6249	3,7748
Bahrain	1,1393	1,1249	0,9685	0,8423	0,8733	0,9122	0,8273	6,6878
Brazil	1,0898	1,0526	0,0000	0,8204	0,6287	0,6872	0,6173	4,8959
Chile	1,1803	1,0631	0,9655	0,8676	0,6343	0,8374	0,8347	6,3830
Colombia	1,3728	1,0690	0,8530	0,0000	0,5360	0,5084	0,3346	4,6737
India	1,0064	1,0165	0,9371	1,0000	0,7118	0,8295	0,6822	6,1835
Indonesia	1,0446	1,0392	0,9312	0,9251	0,3739	0,7932	0,5710	5,6781
Jordan	1,1642	1,1084	0,9589	0,8122	0,6087	0,7583	0,4058	5,8165
Kazakhstan	*****	1,1514	0,9449	0,8051	0,8853	0,8384	0,8642	5,4892
Malaysia	1,1007	1,0394	0,9815	0,9571	0,9093	0,8977	0,8375	6,7234
Mexico	1,0937	1,0309	0,8891	0,8069	0,6210	0,6669	0,5575	5,6660
Peru	1,2477	1,0665	0,8431	0,5889	0,5492	0,6465	0,4171	5,3591
Philippines	1,1341	1,0582	0,8078	0,9085	0,0000	0,7618	0,2337	4,9041
Qatar	1,0612	1,0781	0,9827	0,9366	0,7874	0,9345	0,9447	6,7252
Saudi Arabia	1,0929	1,0428	0,9817	0,9313	0,8230	0,9056	0,8248	6,6022
South Africa	1,1882	1,0747	0,8933	0,7875	0,5877	0,6271	0,0000	5,1585
Türkiye	1,1168	1,0439	0,9322	0,8620	0,3832	0,7153	0,6477	5,7011
UAE	1,0775	1,0392	1,0000	0,9896	1,0000	1,0000	0,9680	7,0743
Thailand	1,1206	1,0372	0,9312	0,9125	0,7367	0,9163	0,6070	6,2614
P_i overall								116,5914

Source: Authors' calculations.

Based on Eqs. (38)-(41), three appraisal score were calculated, and the final ranking results are presented in Table 22.

Table 22. Final Aggregation and Ranking of the Alternatives

Country	k_a	k_b	k_c	k	Final Rankings
China	0,0617	13,5817	10,9339	11,2453	2
Argentina	0,0313	2,6749	7,4476	3,5921	20
Bahrain	0,0587	10,3720	10,6700	9,1973	5
Brazil	0,0410	4,2290	8,6366	4,8011	15
Chile	0,0549	7,9892	10,2755	7,6080	8
Colombia	0,0381	2,2381	8,3398	3,7755	19
India	0,0529	7,3255	10,0498	7,1079	10
Indonesia	0,0474	4,6936	9,4437	5,4286	12
Jordan	0,0484	4,5795	9,5793	5,4438	11
Kazakhstan	0,0488	9,6170	9,4318	7,8409	7
Malaysia	0,0596	11,4876	10,7465	9,8832	4
Mexico	0,0469	4,0719	9,4089	5,1087	14
Peru	0,0439	2,9915	9,0595	4,4282	16
Philippines	0,0405	3,2506	8,6093	4,3443	18
Qatar	0,0597	11,6413	10,7539	9,9758	3
Saudi Arabia	0,0579	10,3048	10,5811	9,0873	6
South Africa	0,0423	3,0335	8,8584	4,3574	17
Türkiye	0,0475	4,4835	9,4593	5,3344	13
UAE	0,0649	15,9055	11,2615	12,9536	1
Thailand	0,0537	7,6250	10,1394	7,3233	9

Source: Authors' calculations.

According to results obtained from the CoCoSo method showed that, the UAE, China, and Qatar have the highest digital logistics market performance, while Argentina, Colombia and Philippines have the lowest digital logistics market performance in 2022, respectively. So far, various MCDM methods were applied to evaluate the digital logistics market performance of developing countries. In the following section, the overall ranking results were determined by the Borda count method.

4.6. The Results Obtained from the Borda Count

In this study, four different ranking methods were conducted to examine the digital logistics market performance of selected countries. In addition, Borda counting method was also used to collect the rankings obtained from different methods under a single integrated ranking. Thus, it is thought that more robust and effective

sorting results will be obtained by using the combining advantage of the Borda counting method. According to Eq. (42), all ranking results were combined with the Borda counting method, and the overall ranking of the alternatives are shown in Table 23 and 24, respectively.

Table 23. Borda Score and Final Ranking of Alternatives.

Country	MAUT Rank	MAUT Score	TOPSIS Rank	TOPSIS Score	MARCOS Rank	MARCOS Score	CoCoSo Rank	CoCoSo Score	Borda Score	Borda Count Rank
China	**2**	18	**2**	18	**2**	18	**2**	18	72	**2**
Argentina	**13**	7	**19**	1	**19**	1	**20**	0	9	**19**
Bahrain	**5**	15	**5**	15	**5**	15	**5**	15	60	**5**
Brazil	**14**	6	**13**	7	**14**	6	**15**	5	24	**14**
Chile	**9**	11	**9**	11	**8**	12	**8**	12	46	**9**
Colombia	**20**	0	**20**	0	**20**	0	**19**	1	1	**20**
India	**10**	10	**10**	10	**10**	10	**10**	10	40	**10**
Indonesia	**11**	9	**11**	9	**11**	9	**12**	8	35	**11**
Jordan	**16**	4	**12**	8	**12**	8	**11**	9	29	**12**
Kazakhstan	**8**	12	**7**	13	**7**	13	**7**	13	51	**7**
Malaysia	**7**	13	**4**	16	**4**	16	**4**	16	61	**4**
Mexico	**17**	3	**16**	4	**15**	5	**14**	6	18	**15**
Peru	**19**	1	**17**	3	**18**	2	**16**	4	10	**17**
Philippines	**15**	5	**15**	5	**16**	4	**18**	2	16	**16**
Qatar	**3**	17	**3**	17	**3**	17	**3**	17	68	**3**
Saudi Arabia	**6**	14	**6**	14	**6**	14	**6**	14	56	**6**
South Africa	**18**	2	**18**	2	**17**	3	**17**	3	10	**17**
Türkiye	**12**	8	**14**	6	**13**	7	**13**	7	28	**13**
UAE	**1**	19	**1**	19	**1**	19	**1**	19	76	**1**
Thailand	**4**	16	**8**	12	**9**	11	**9**	11	50	**8**

Source: Authors' calculations.

Based on the results of the integrating ranking, it was seen that the country with the highest Borda score was the UAE and the country with the lowest Borda score was Colombia. The ranking results by Borda score from the highest to lowest are shown in Table 24.

Table 24. Overall Ranking of Alternatives

No	Country	Borda Score	Borda Count Rank
1	UAE	76	**1**
2	China	72	**2**
3	Qatar	68	**3**
4	Malaysia	61	**4**
5	Bahrain	60	**5**
6	Saudi Arabia	56	**6**
7	Kazakhstan	51	**7**
8	Thailand	50	**8**
9	Chile	46	**9**
10	India	40	**10**
11	Indonesia	35	**11**
12	Jordan	29	**12**
13	Türkiye	28	**13**
14	Brazil	24	**14**
15	Mexico	18	**15**
16	Philippines	16	**16**
17	South Africa	10	**17**
18	Peru	10	**17**
19	Argentina	9	**19**
20	Colombia	1	**20**

Source: Authors' calculations.

According to results obtained from the Borda count method showed that, the UAE, China, and Qatar have the highest digital logistics market performance, while Colombia, Argentina, Peru, and South Africa have the lowest digital logistics market performance in 2022, respectively.

5. Conclusion

As stated in a recent report published by Strategic Market Research (2022), the global digital logistics market size is expected to reach $77.52 billion in 2030. The digital

logistics market is growing rapidly because of the increasing requirement for cost-effective logistics and supply chain solutions across various industries. Therefore, many international corporations are expanding their partnerships through digitalization in logistics operations. For instance, Maersk and Microsoft have collaborated on digitalized and decarbonization logistics (Magli, 2023). Moreover, GUUD, which is a trade technology company, has announced a new digital logistics platform called ClickargoSG (KnowESG, 2023). In line with this, logistics industry plays a crucial role in increasing of global market expansion for countries.

This paper aims to evaluate the digital logistics market performance of developing countries with multiple MCDM methods. In this study, many MCDM methods such as LOPCOW, MAUT, TOPSIS, MARCOS, and CoCoSo were applied to analyze the digital logistics market performance of selected countries. As mentioned in the literature review, a limited number of studies have investigated the digital logistics market performance of countries using MCDM methods. In this direction, this research contributes to the relevant literature by applying the different MCDM methods. For this investigation, a new objective weighting method, namely LOPCOW was applied to determine the weights of the criteria. The digital logistics market performance of countries was evaluated using various methods namely, MAUT, TOPSIS, MARCOS, and CoCoSo. Additionally, the overall results were combined with the Borda count method.

The LOPCOW results show that future readiness and domestic logistics opportunities were found to be the most and least important criteria, respectively. Future readiness criterion is focus on the degree to which technology such as e-government, robots, cybersecurity, software etc. is adopted by, society, business and governments. Besides that, domestic logistics opportunities are concerned with the performance and potential of a country's domestic logistic market. These findings may be explained by the fact that while future readiness is associated with adaptive attitudes, information technology integration and business agility, domestic logistics opportunities is related to domestic performance of the countries. These findings may help us understand why the criteria which involves digital transformation on the international context are more important, and the criteria which focus only on domestic drivers of countries are less important.

According to results obtained from the MAUT, TOPSIS, MARCOS and CoCoSo showed that the top five ranked (the UAE, China, Qatar, Malaysia and Bahrain) is almost constant for all ranking methods. Similar ranking results were obtained based on both traditional (MAUT-TOPSIS) and modern approaches (MARCOS-CoCoSo). It can be assumed that the reliability of the results is confirmed by applying the different MCDM methods. The overall results revealed that the UAE, China, Qatar, Malaysia, and Bahrain have the highest digital logistics market performance in 2022. Besides that, Colombia, Argentina, Peru, South Africa, and the Philippines have the lowest digital logistics market performance in 2022. The findings of the current study are consistent with those of Kara and Yalçın (2022), who found that China, Qatar, Malaysia, and Bahrain have the highest digital logistics market performance, while Argentina, Colombia, Peru, and South Africa have the lowest digital logistics market performance. Taken together, it can be concluded that from the outcomes of the current and previous research (Kara and Yalçın, 2022) showed that countries with high export volumes, investments in innovation and developed logistics networks have better performance. For instance, the UAE, China and Qatar stand out predominant by making extensive investment on digital transformation for logistics operations. These countries now have the opportunity to address their logistics challenges and gain a competitive advantage over peers that are disrupting the logistics sector and claiming market share through digitization-first policies and practices (Calabrase, 2022; Borgogna et al., 2022).

Overall, this paper highlights the importance of the digital logistics market performance of countries. These findings have important implications for policymakers and organizations who have the responsible for improving the digital logistics market performance in selected countries. However, several limitations of this study need to be acknowledged. For instance, the digital logistics market performance of countries was evaluated based on the data from the AEMLI and DCI reports. In future investigations, it might be interesting to use different criteria. Also, alternatives can be expanded to include developed countries. Thus, the results can be compared between developing and developed countries. Additionally, the previous-year performance of countries might be analyzed using different MCDM methods such as MEREC, Gray relational analysis, CRADIS, etc.

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