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Ranking Countries According to Logistics and International Trade Efficiencies Via REF-III

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Abstract: The interrelation between logistics and international trade is crucial for understanding a country's ability to increase its share in global trade. An adequate and well-integrated logistics sector and infrastructure are required for this purpose. This study employs the novel Multi-Criteria Decision Analysis (MCDA) approach known as REF-III and two distinct models to investigate the activities of countries in terms of infrastructure, logistics, international trade, and economic growth. The results from both models indicate that China and Russia are leading the rankings. However, when focusing on the efficiency of trade and economic growth, the United States occupies the first place. Notably, several Caucasian and Balkan countries rank poorly in both models, possibly due to the multiple crises, wars, and turmoil they have experienced over the past forty years. The investments and improvements made in infrastructure and logistics by the countries excelling in global trade and logistics should serve as a model for other nations to emulate.

Keywords: Efficiency, International trade, Infrastructure, Logistics, REF, REF-III, MCDA

1 Introduction

Logistics originated from the need to fulfill military requirements on schedule, in the appropriate place, and in full. It has since become an essential component of modern international trade. In its contemporary definition, logistics encompasses a collection of processes, such as packing, shipping, and inventory management, which are executed to provide necessary products or services at the right time, volume, location, and quality. A nation's economic power is signified by its ability to control foreign and international trade, which is characterized as the exchange of goods with the rest of the world. To capitalize on market opportunities and increase their share of global trade, countries and companies should focus their investment activities on logistics. The logistics sector plays a vital role in international trade, as it covers operations including inventory management, foreign shipping, customs clearance, and payment systems. Logistics activities have gained increasing importance in global competition and as an economic feature. The strength of the logistics sector in production and supply influences the competitiveness of businesses in countries competing in the same market by achieving the desired low cost and fast delivery speed [1–5].

Performance and efficiency factors ought to be considered when evaluating the effectiveness of a country's logistics activities. These activities have a direct impact on international trade and affect countries' GDP. Logistics efficiency strategies should ensure that business inputs are utilized effectively, resources are employed efficiently, and the business achieves its objectives with appropriate strategies. Moreover, logistics efficiency strategies are among the key features that involve effective distribution approaches [6]. Countries can then assess how well their current inputs can be transformed into logistics outcomes. Additionally, countries may examine the accuracy of the objectives set in logistical activities or the extent to which the right tasks are performed, specifically within the framework of logistics efficiency measurement. The results of a country's logistics efficiency research can be used to analyze the degree to which the logistical inputs converge to ideal values, the level of accuracy of the tasks, and the weaknesses [7]. In summary, it is crucial to determine whether adequate production is generated in return for infrastructure and logistics investments, or, in other words, efficiency. In this context, efficiency analysis will

be conducted using infrastructure investments, logistics capabilities, and international trade data from the studied countries. For this purpose, Nearest Solution to References-III (REF-III), a novel multi-criteria decision analysis (MCDA) method, is proposed and employed in this study. REF-III is an extension of the REF [8–12] for evaluating and analyzing efficiency. It is anticipated that the study will identify differences between countries and provide recommendations for improvement.

The subsequent section of the study will include a literature review. Explanatory information about the proposed methodology will then be provided within the scope of the study. Following the reporting and evaluation of the findings, the study will conclude with the presentation of conclusions and recommendations.

2 Literature

The World Bank's Logistics Performance Index (LPI) reports, published since 2007, represent the most significant research on a country's logistics performance. The LPI is a survey of international logistics service providers from around the world, and it serves as the most important indicator for comparing the global logistics sector between countries [3, 4, 13]. The sixth LPI report was published in 2018. The LPI 2018 assessed countries based on six components, which are outlined below [13]:

- The efficiency of customs and border management clearance
- The quality of trade- and transport-related infrastructure
- The ease of arranging competitively priced international shipments
- The competence and quality of logistics services
- The ability to track and trace consignments
- The frequency with which shipments reach consignees within the scheduled or expected delivery time.

Table 1 summarizes the key findings of research on logistics and international trade, apart from the LPI.

Table 1. Literature review on logistics and international trade

Author(s)	Benchmark	Application(s)
Gani [2]	Regression analysis	Regression analysis was employed to examine the effects of countries' logistical performance on international trade. LPI data from 2007, 2010, 2012, and 2014 were utilized. It was found that logistics exert a positive influence on international trade and the local economy.
Sezer and Abasız [14]	Panel data analysis	The logistics sector was argued to have a favorable impact on job creation, economic growth, and international trade. Moreover, it was determined that developments in the logistics sector are the most crucial predictors of economic growth.
Yeo et al. [15]	Generalized structured component analysis (GSCA)	The importance of increasing middle-income countries' volume in international trade through infrastructure investments and improved logistics performance for achieving long-term growth was emphasized.
Martí et al. [3]	The gravity model	The growing influence of logistics and transportation on international trade was highlighted. It was posited that any improvement in any of the LPI components contributes positively to the relevant country's trade.
Zhan and Wang [16]	VAR model	In China's Sichuan Province, a significant long-term relationship between logistical performance and foreign trade was identified.
Zhu and Yang [17]	Granger causal relationship test	In Shanghai, China, a substantial long-term relationship between air logistics and international trade was discovered. It was also suggested that improvements in air logistics would positively impact the economy.
Jiang and Prater [18]	Descriptive assessment	The study investigated the transformation China experienced up until 2002. In the context of the data from the relevant period and China's accession to the WTO, the necessary reforms for future development in the logistics sector and infrastructure were underlined.

Author(s)	Benchmark	Application(s)
Goh and Ling [19]	Descriptive assessment	It was emphasized that China's participation in the WTO would attract more international investment and that improvements in the logistics and infrastructure sectors would be required to meet increasing demand.
He et al. [20]	The panel unit root test and the fixed effect model	International logistics was employed as an explanatory variable in a model attempting to explain foreign trade. Logistics, it was posited, has a dynamic effect on international trade.
Rashid et al. [21]	Descriptive assessment	A comparison was made between Türkiye and Tanzania in the area of logistics. It was argued that both countries require a robust and reliable logistics infrastructure for economic development.
Tunç and Kaya [22]	Granger causality test	The findings suggested a two-way relationship between logistics and foreign trade in Türkiye.
Korkut et al. [23]	Panel cointegration, panel causality	The study found that the current account balance and all infrastructure expenditures move together in the long run. A two-way causality relationship between railway infrastructure expenditures and the current account balance was also discovered. It was theorized that a one-way causality exists between the current account balance and highway infrastructure spending.
Ofluoğlu et al. [24]	The gravity model	The research suggested that logistics performance could be one of the most crucial drivers in cross-national competition. To increase exports and become more competitive in the global market, countries should enhance their logistics performance, according to the study.
Korucuk [25]	SWARA, ARAS and COPRAS methods	The importance levels of SCM performance criteria were determined, and the most suitable competition strategy selection was made for manufacturing enterprises with 50 or more employees in Ordu province.
Halaszovich and Kinra [26]	Theoretical Discussion	The researchers examined the impact of transportation systems and logistics performance on foreign direct investment and international trade patterns in Asia's global value chain.
Zhu et al. [27]	Data Envelopment Analysis (DEA)	International trade performance was measured using a data-driven approach that accounts for trade imbalances.
Jomthanachai et al. [28]	CoDEA method	The study presented the development of a productivity metric using the CoDEA method to assess the level of vulnerability (or conversely, robustness) of the supply chain systems of six ASEAN countries.
Storto and Evangelista [29]	DEA-based dynamic mapping	Using DEA-based dynamic mapping, infrastructure efficiency, logistics quality, and environmental impacts of agricultural logistics systems in the EU were examined.
Altıntaş [7]	DEA-EATWIOS	The G7 countries' logistics efficiencies and the importance levels of the LPI components were evaluated.
Görçün [30]	Entropy-EATWIOS	The logistics and transportation efficiencies of the Central Asian Turkic Republics were investigated.
Yıldız et al. [31]	Cluster analysis	Türkiye's position in the logistics performance index was assessed using cluster analysis.
Acar [32]	DEA	Türkiye's logistics efficiency was compared to that of OECD countries for the period covering 2007-2018.
Akandere [33]	Entropy-TOPSIS	The Belt Road countries' logistics and environmental performance were examined.

In general, as demonstrated in Table 1, a two-way relationship between logistics and foreign/international trade

is emphasized. Numerous studies have noted that advancements in logistics and infrastructure positively influence economic growth and international trade. In this study, evaluations will be conducted in the areas of logistics, transportation infrastructure, and foreign trade. The REF-III method will be employed to rank countries based on their performance in these areas. The key features and process steps of REF-III will be explained in the following section.

3 Methodology

This section of the study includes explanations regarding the methodology. First, explanations regarding REF will be provided in this framework. Then, in order to provide efficiency rankings of decision-making units or alternatives, detailed explanations and implementation steps of REF-III will be given.

3.1 REF

Aytekin [9] proposed the REF (Nearest Solution to References) method, which is based on the ideal value or interval in the solution of decision problems. The REF-I, REF-II, and REF-Sort are extensions of this relatively new methodology. The primary objective of the REF methods is to help decision-makers obtain the best decision by using references for each criterion. REF methods differ from other MCDA methods in the literature in that they provide a framework for identifying the reference value as a range/interval, taking into account secondary reference (successor) values/intervals, and evaluating criteria measured by different scales [8–12, 34].

The following subsection necessitates a more detailed explanation of the REF. This section will provide definitions and explanations for REF in this context. An analyst, decision-maker, expert, or facilitator who is in charge of computing and solving the decision problem can use REF-I to apply nominal (binary and multinominal), ordinal, interval, and ratio scale criteria to the same problem. On the other hand, the term "decision maker" will be used to refer to the person in charge of finding a solution to the decision problem in the explanations that follow. As a reference value for the criteria, the decision-maker might select a specific point, interval, or category. The primary goal of REF is to solve the decision problem by better understanding decision-makers' aspirations, preferences, and goals. When changing alternative sets, REF-II handles the rank reversal problem and the necessity for recalculation for current alternatives. As compared to REF-I, REF-II requires that the decision matrix values be quantifiable (i.e., they must include preference or performance values on at least an interval scale) [8, 9, 11, 35, 36]. The decision-maker determines reference values or intervals separately from the decision matrix in REF-II. By normalizing the decision matrix to this reference, REF-II eliminates the rank reversal problem. Additionally, in REF-I and REF-II, a parameter called the unacceptance value can be employed to adjust the effects of points/intervals other than the reference point/interval on the solution [8, 9].

Before moving on to the REF method implementation steps, some concepts in the context of the decision matrix X in Eq. (1) should be clarified.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad \begin{matrix} i = 1, \ldots, m \\ j = 1, \ldots, n \end{matrix} \tag{1}$$

In Eq. (1), the performance value of alternative i under criterion j is represented by χ_{ij}. The reference, a specific value or range of values, is used by the decision-maker to evaluate the alternatives. For criterion j, R_j represents the reference if given as a specific value. If the reference (R_j) is presented as an interval, ${}_1R_j$ signifies the lower limit, while ${}_2R_j$ illustrates the upper limit.

During the decision-making process, the decision-maker may assess distances from the reference differently, depending on a specified interval, point, or direction. Values to the right of a reference point or interval might be more acceptable than those to the left, or the preferability levels of values to the right and left of different intervals could vary. In this context, the successor point or interval is deemed less critical than the reference. ${}_vV_j$ represents the successor point or interval for criterion j, and multiple successor intervals or points ($v = 1, \ldots, q$) can be determined within criterion j.

The decision-maker evaluates the influence of successor intervals on the decision problem, either symmetrically or asymmetrically. Each successor point or interval is assigned an unacceptance value (β) to reflect the undesirable level of value within the successor interval relative to the reference point or interval [8, 9]. The β value, ranging from 0 to 1, is determined by the decision-maker, who should consistently decide the appropriate successor values or intervals for the solution. Scientific instruments or approaches can be employed to determine e ${}_vV_j$ and β_j [8, 9].

The application processes of REF-III, a novel approach, are explored in the subsequent section.

3.2 REF-III

DEA is frequently employed to evaluate the efficiency of institutions or individuals. However, inconsistencies exist between DEA-based methodologies used for DMU (Decision Making Unit) rankings and DEA efficiency results. EATW(I)OS and OCRA are two alternative approaches for determining DMU efficiency rankings. This study aims to propose a novel method for assessing DMU efficiency, which is based on the reference values to be determined in the input and output criteria. The primary objective of this new approach, known as REF-III, is to evaluate DMU efficiency by comparing input and output levels. The steps for implementing REF-III are as follows:

Step 1. Define the decision problem, which involves determining both the input and output criteria as well as listing the decision-making units or alternatives for efficiency analysis. Independently create the decision matrix stated in Eq. (1) for input and output criteria. As seen in Eqns. (2)-(3), G represents the input decision matrix, while O denotes the output decision matrix, where $j = 1, \ldots, g$ for input criteria and $j = g+1, \ldots, n$ for output criteria.

$$G = \begin{bmatrix} x_{11} & \cdots & x_{1g} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mg} \end{bmatrix} \quad \begin{matrix} i = 1, \ldots, m \\ j = 1, \ldots, g \end{matrix} \tag{2}$$

$$O = \begin{bmatrix} x_{1g+1} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{mg+1} & \cdots & x_{mn} \end{bmatrix} \quad \begin{matrix} i = 1, \ldots, m \\ j = g+1, \ldots, n \end{matrix} \tag{3}$$

Step 2. Determine the reference point or interval, successor points or intervals, and unacceptance values for each criterion. For efficiency analyses, define reference points or intervals and associated successor points or intervals with unacceptance degrees in the input criteria to use minimal resources. Similarly, set reference and successor points or intervals in output criteria to maximize product or output generation. Additionally, the utopian or ideal solution approach can be utilized to define reference and successor values or intervals independently from the decision matrix.

Step 3. Establish the priority levels of the evaluated criteria, which often differ. Subjective judgments or various techniques can be applied to determine the weight values of the criteria in REF-III. It is essential for scaling that the criteria weights range from 0 to 1 and their sum equals 1.

Step 4. Compute the weighted normalized distances of alternatives from the references. In this context, two different evaluations are employed. Calculate the input-weighted normalized distance value (Φ_{ij}) of the i-th alternative in criterion j using Eq. (4), where a_{*j} is the domain value. Determine the output-weighted normalized distance value value (θ_{ij}) of the i-th alternative in criterion j using Eq. (5).

$$\Phi_{ij} = w_j \frac{|x_{ij} - a_{*j}|_v \beta_j}{\sum_{j=1}^{g} \left(|x_{ij} - a_{*j}|_v \beta_j \right)} \tag{4}$$

$$\theta_{ij} = w_j \frac{|x_{ij} - a_{*j}|_v \beta_j}{\sum_{j=g+1}^{n} \left(|x_{ij} - a_{*j}|_v \beta_j \right)} \tag{5}$$

a_{*j} values are determined via Eq. (6).

$$a_{*j} = \begin{cases} R_j, \text{ if the reference is determined as a point} \\ {}_1R_j, \text{ if the reference is determined as an interval and } x_{ij} < {}_1R_j \\ {}_2R_j, \text{ if the reference is determined as an interval and } x_{ij} > {}_2R_j \\ x_{ij}, \text{ if the reference is determined as an interval and } {}_1R_j \leq x_{ij} \leq {}_2R_j \text{ ise} \end{cases} \tag{6}$$

Step 5. Calculate an input-overall score (Φ_i) and an output-overall score (Θ_i) for each alternative. Eqns. (7)-(8) illustrate the computation of Φ_i and Θ_i, respectively.

$$\Phi_i = \sum_{j=1}^{g} \Phi_{ij} \tag{7}$$

$$\Theta_i = \sum_{j=g+1}^{n} \theta_{ij} \tag{8}$$

Step 6. Compute the overall efficiency distance score (δ_i) by applying Eq. (8). δ_i represents the ratio of the output overall value to the input overall value. Rank alternatives from smallest to largest based on their overall efficiency distance score. For an alternative with utopian or ideal efficiency, δ_i will equal 0.

$$\delta_i = \frac{\Theta_i}{\Phi_i} \tag{9}$$

4 Results

The significance of the LPI in evaluating a country's logistics performance cannot be overstated. However, due to the lack of published LPI reports and data for the post-2018 period, data from various sources were compiled, particularly considering the effects of the COVID-19 pandemic. Logistics and international trade data were gathered from an array of sources [37–42].

The criteria used in this study are: K1 (total inland transport infrastructure investment, in euros), K2 (total inland freight transport, in million tonnes-kilometers), K3 (number of road injury accidents), K4 (road motor vehicles per 1,000 inhabitants), K5 (total roadways length, including paved and unpaved), K6 (number of airports), K7 (gross value added by transport, storage, and communication, in billion USD), K8 (total highways per 1,000 people), K9 (motor vehicles per 1,000 people), K10 (railway length in kilometers), K11 (road density, in km of road per 100 sq. km of land area), K12 (total route-km of rail lines), K13 (logistics performance index), K14 (export trade volume, in USD), K15 (import trade volume, in USD), and K16 (GDP per capita, in current USD).

Two distinct models, named Model 1 and Model 2, will be employed for the efficiency analysis of countries. In Model 1, the number of accidents and logistics performance outcomes will serve as output criteria, while infrastructure and transportation investments will be used as input criteria. In Model 2, infrastructure and logistical criteria will act as inputs, while economic growth and international trade indicators will function as output criteria. The criteria for Model 1 and Model 2 are provided in Table 2.

Table 2. Input criteria, output criteria and efficiency models

Model 1				Model 2			
Inputs	**References**	**Outputs**	**References**	**Inputs**	**References**	**Outputs**	**References**
K1	34,928,249	K3	0	K1	34,928,249	K14	2,590,600,666,465
K2	1,195	K7	34,928,249	K2	1,195	K15	2,405,381,557,667
K4	18	K13	5	K4	18	K16	115,874
K5	2,875			K5	2,875		
K6	2			K6	2		
K8	1			K10	288		
K9	12			K11	5		
K10	288			K12	288		
K11	5			K13	1		
K12	288						

As illustrated in Table 2, the reference values are considered as single points. For K14 and K15, the global trade volume serves as the reference value. The data from individual countries, based on input and output orientation, were employed to establish the reference value in other criteria. In this study, references were determined as points, and successor points or intervals were not utilized. Additionally, all criteria were assigned equal weight. Table 3 displays the country rankings according to the REF-III method.

In the Model 1 evaluation, China, Canada, Australia, Russia, and France were ranked first to fifth, respectively. Meanwhile, Armenia, Moldova, Georgia, Albania, and Azerbaijan occupied the bottom five positions in ascending order. As highlighted in the literature review, China, one of the top five countries, has made significant investments in the logistics sector. Furthermore, except for France, the leading countries are all expansive in terms of land area, which might contribute to fewer accidents. It is also worth noting that the bottom five countries are situated in the Caucasus and Balkans regions and have experienced substantial conflict and turmoil over the past forty years.

Model 2 analyzed economic growth and international trade. The top five countries in the Model 2 evaluation were the United States, China, Russia, India, and Germany, in that order. Armenia, Albania, Moldova, Georgia, and

Table 3. REF-III results for efficiency of countries

	Model 1				Model 2			
Country	Φ_i	Θ_i	δ_i	**Ranking**	Φ_i	Θ_i	δ_i	**Ranking**
Albania	0.0026	0.0484	18.66	48	0.0015	0.0231	15.02	50
Armenia	0.0020	0.0494	24.10	51	0.0011	0.0231	20.80	51
Australia	0.0279	0.0413	1.48	3	0.0212	0.0182	0.86	10
Austria	0.0141	0.0386	2.73	15	0.0089	0.0189	2.11	25
Azerbaijan	0.0030	0.0510	16.75	47	0.0030	0.0231	7.59	46
Belarus	0.0069	0.0499	7.24	40	0.0058	0.0228	3.95	38
Belgium	0.0176	0.0389	2.21	7	0.0146	0.0183	1.25	16
Bosnia and Herzegovina	0.0038	0.0536	14.23	46	0.0026	0.0230	8.98	47
Bulgaria	0.0058	0.0449	7.68	41	0.0048	0.0225	4.65	42
Canada	0.0388	0.0572	1.47	2	0.0389	0.0179	0.46	6
Chile	0.0055	0.0479	8.78	43	0.0048	0.0221	4.64	41
China	0.1476	0.0857	0.58	1	0.1741	0.0091	0.05	2
Croatia	0.0064	0.0447	6.99	39	0.0045	0.0223	4.98	44
Czechia	0.0124	0.0398	3.21	24	0.0113	0.0207	1.83	21
Denmark	0.0106	0.0325	3.07	20	0.0072	0.0182	2.53	27
Estonia	0.0134	0.0405	3.02	18	0.0059	0.0216	3.68	37
Finland	0.0127	0.0329	2.60	9	0.0093	0.0194	2.07	24
France	0.0265	0.0450	1.70	5	0.0277	0.0174	0.63	8
Georgia	0.0025	0.0519	21.01	49	0.0017	0.0231	13.27	48
Germany	0.0260	0.0896	3.45	27	0.0302	0.0125	0.42	5
Greece	0.0084	0.0437	5.22	36	0.0073	0.0219	3.01	33
Hungary	0.0133	0.0422	3.17	23	0.0106	0.0216	2.03	22
Iceland	0.0152	0.0413	2.71	12	0.0046	0.0189	4.13	39
India	0.0497	0.1351	2.72	14	0.0651	0.0215	0.33	4
Ireland	0.0120	0.0389	3.25	25	0.0063	0.0163	2.57	28
Israel	0.0053	0.0427	8.11	42	0.0042	0.0198	4.77	43
Italy	0.0187	0.0695	3.72	29	0.0182	0.0184	1.01	12
Japan	0.0269	0.1080	4.01	32	0.0280	0.0167	0.60	7
Korea	0.0227	0.0826	3.64	28	0.0237	0.0182	0.77	9
Latvia	0.0115	0.0470	4.07	33	0.0051	0.0221	4.34	40
Lithuania	0.0113	0.0444	3.94	31	0.0064	0.0218	3.40	34
Luxembourg	0.0107	0.0365	3.41	26	0.0071	0.0145	2.04	23
Mexico	0.0168	0.0457	2.72	13	0.0191	0.0205	1.07	13
Moldova	0.0023	0.0510	22.66	50	0.0017	0.0231	13.60	49
Netherlands	0.0143	0.0353	2.47	8	0.0124	0.0165	1.33	17
New Zealand	0.0129	0.0356	2.75	16	0.0067	0.0201	2.99	32
Norway	0.0116	0.0361	3.13	22	0.0067	0.0179	2.65	29
Poland	0.0165	0.0435	2.63	11	0.0171	0.0208	1.22	15
Portugal	0.0084	0.0430	5.15	35	0.0058	0.0214	3.66	35
Romania	0.0081	0.0487	6.03	37	0.0082	0.0220	2.69	30
Russian Federation	0.0493	0.0799	1.62	4	0.0659	0.0208	0.32	3
Serbia	0.0052	0.0487	9.33	44	0.0042	0.0228	5.38	45
Slovak Republic	0.0073	0.0447	6.12	38	0.0059	0.0215	3.67	36
Slovenia	0.0106	0.0414	3.91	30	0.0072	0.0214	2.95	31
Spain	0.0190	0.0544	2.86	17	0.0173	0.0195	1.13	14
Sweden	0.0163	0.0339	2.08	6	0.0125	0.0186	1.49	18
Switzerland	0.0119	0.0366	3.07	19	0.0090	0.0151	1.69	19
Türkiye	0.0082	0.0773	9.44	45	0.0091	0.0217	2.39	26
Ukraine	0.0103	0.0515	5.00	34	0.0135	0.0229	1.69	20
United Kingdom	0.0188	0.0577	3.07	21	0.0194	0.0174	0.89	11
United States	0.1604	0.4194	2.61	10	0.1924	0.0073	0.04	1

Bosnia and Herzegovina occupied the bottom five positions in ascending order. The United States' dominance in global trade is evident, as demonstrated by its first-place ranking in the Model 2 results. It is not surprising that the United States currently ranks first in efficiency, followed by its recent trade war rival, China. The findings in Model 2 are similar to those in Model 1, with Caucasus and Balkan countries ranking the lowest.

Considering the findings of Model 1 and Model 2, it can be concluded that countries that invest strategically in infrastructure and logistics can reap substantial benefits in terms of international trade and economic growth. China's investments in the logistics sector were emphasized in the reviewed studies. Table 3 demonstrates that China's investments have yielded positive results, making it a leader in efficiency in this field. Additionally, the United States stands out in terms of logistics, infrastructure, foreign trade, and economic growth efficiency.

5 Conclusions

Globalization has made international trade and logistics increasingly vital for countries, determining their level of development. The effective, efficient, and cost-effective execution of these activities provides countries with significant competitive advantages and contributes to their foreign trade and logistics performance. As a result, the efficiency of a country's international trade and logistics is considered a measure of its supply chain management performance.

Numerous studies have emphasized the reciprocal relationship between logistics and international or foreign trade. In this research, country efficiency analyses were conducted based on relationships between infrastructure, logistics, and traffic accidents, as well as infrastructure, logistics, international trade, and economic growth. Two alternative models were analyzed in this context using a new Multi-Criteria Decision Analysis (MCDA) method called REF-III.

According to the findings, China and Russia emerged as leaders in both models. In contrast, the United States ranked first in a model examining efficiency in international trade and economic growth. However, some Caucasian and Balkan countries, which have experienced various crises, wars, and turmoil over the past four decades, ranked last in both models. The infrastructure and logistics reforms and investments undertaken by leading countries should serve as inspiration for others.

The ranking of countries based on their performance in logistics and international trade is an important topic overall. Pursuing international trade, i.e., establishing a global supply chain at the desired level, is directly linked to logistics efficiency and productivity factors. Trade and logistics efficiency, which directly influence a country's gross domestic product, can also be considered a development indicator. This study highlights these issues and presents valuable insights for countries and policymakers.

Moreover, countries aiming to develop their international logistics and trade management strategies must implement policies to enhance logistics efficiency. It is also crucial to plan measures to reduce bureaucracy in international trade and execute them as quickly as possible.

Additionally, it is vital to take necessary measures to maintain international trade at the desired level and pace by implementing more effective and efficient service delivery in the logistics sector. Assessing the efficiency of international trade and logistics among developed countries contributes to the implementation of sustainable strategies for achieving a competitive advantage and GDP growth. The current research results and situations can be regarded as other significant findings.

This study offers another opportunity to evaluate the efficiency of international trade and logistics. It also serves as the foundation for an optimal solution to a given decision problem, providing a reasonable and robust outcome environment.

There are some limitations to the research. The most significant limitation is the difficulty in obtaining current and complete logistics and infrastructure data. Some countries' recent statistics were not accessible. Due to insufficient data, many countries and criteria could not be included in the study. International organizations play a crucial role in maintaining up-to-date infrastructure and logistics data on a global scale. Comprehensive analyses can be conducted in the future if data is kept up-to-date in terms of countries and criteria. Additionally, the REF-III method proposed in this study is believed to be applicable to a wide range of decision problems due to its understandable structure and ease of application. Issues such as efficiency assessment of intelligent inventory systems [43], ranking outsourcing suppliers based on their efficiencies [44], implementing failure mode and effects analysis (FMEA) [45–47], and comparing countries from different perspectives [48–51] can be resolved using REF-III.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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