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Assessment of Green Logistics Market Performance of Selected Countries: A Comprehensive and Novel Multi-Criteria Decision-Making Approach

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Abstract: *This study assesses the green logistics market performance of the top twenty emerging markets identified in the Agility Emerging Markets Logistics Index (AEMLI) report. The primary emerging markets—China, India, the United Arab Emirates, Saudi Arabia, Malaysia, Indonesia, Mexico, Qatar, Thailand, Vietnam, Chile, Türkiye, Brazil, Oman, Russia, Bahrain, Jordan, Kuwait, Uruguay, and South Africa—serve as benchmarks for evaluating logistics efficiency and environmental performance. The decision model for this study encompasses seven criteria: Domestic Logistics Opportunity, International Logistics Opportunity, Business Fundamentals, Digital Readiness, Ecosystem Vitality, Environmental Health, and Climate Change. These criteria were derived from a thorough literature review. Data were obtained from the AEMLI and Environmental Performance Index (EPI) reports published by Agility & Transport Intelligence and the Yale Center for Environmental Law & Policy. Criterion weights were established using the Symmetry Point of Criterion (SPC). The ranking of alternatives employed several MCDM methods: Ranking of Alternatives with Weights of Criterion (RAWEC), Ranking the Solutions based on the Mean Value of Criteria (RSMVC), Stable Preference Ordering Towards Ideal Solution (SPOTIS), and the Extended Alternative Ranking Order Method with two-step normalization (AROMAN). The results were aggregated using the Borda Count Method. Findings from the SPC reveal that the international logistics opportunity is the most significant criterion, whereas business fundamentals rank as the least important. The Borda Count analysis indicates that China, the United Arab Emirates, Malaysia, Saudi Arabia, and Brazil consistently rank as top performers across various methods. Conversely, Türkiye, Indonesia, Kuwait, Bahrain, South Africa, and Vietnam generally show lower rankings across most methods. Additionally, sensitivity and comparative analyses were conducted to enhance the robustness of the findings. The results of this study are anticipated to provide valuable insights into the green logistics market performance of selecting emerging markets.*

Keywords: Logistics; Sustainability; Emerging markets; MCDM

JEL Classification: R4, R40

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Introduction

Logistics has become a critical component of global trade in the interconnected and highly competitive landscape. Effective logistics services ensure the seamless transportation of goods across borders, prioritizing safety, timeliness, and cost-efficiency in delivery. By skillfully tackling the challenges associated with shipping, storage, and packaging, logistics plays a significant role in enhancing the overall efficiency of supply chains and contributes to improved business competitiveness and economic performance of nations (Martí et al., 2014). Contemporary logistics is profoundly influenced by globalization and internationalization. In the rapidly changing environment of economic globalization, challenges in transportation management are of considerable importance. The progression of global economic integration and the internationalization of trade contribute to developing international logistics frameworks and global supply chains within the global marketplace (Beysenbaev & Dus, 2020). While the fundamental concept of logistics is consistent across domestic and international operations, international logistics presents a far more intricate challenge. This complexity arises from various transportation methods, legal frameworks, and multiple transition points. To facilitate the successful functioning of international businesses, efficient logistics within the country are crucial for securing the smooth movement of goods across borders and beyond while managing costs effectively (Nayak et al., 2024).

At the micro level, one can analyze the performance of an individual company or even a specific department within a company. In contrast, the performance of a country or an entire continent can be assessed at the macro level. This disparity highlighted the need for a dedicated measurement system for logistics performance and strategies to enhance national performance. Given the significance of logistics to a country's economy, a comprehensive measurement approach was essential. Consequently, in 2007, the LPI was established by the World Bank (Rezaei et al., 2018). The LPI, developed by the World Bank, provides a comprehensive evaluation of logistics performance and serves as an international benchmarking tool designed to assess the efficiency of a country's trade and transportation systems. This assessment helps nations identify significant barriers to improvement and opportunities for enhancement. The LPI evaluates countries' performance across six key dimensions, highlighting essential aspects of the logistics sector: customs, infrastructure, international shipments, logistics quality, tracking and tracing, and timeliness. In addition to offering a thorough analysis of global logistics performance, the LPI provides valuable insights into performance trends, helping clarify changes over time (Ojala & Celebi, 2015; Arvis et al., 2023).

An additional key metric used alongside the LPI to assess logistics efficiency is the AEMLI. Published annually by Agility, the AEMLI evaluates emerging markets' logistics competitiveness by incorporating qualitative and quantitative data. The index emphasizes a comprehensive framework encompassing critical dimensions such as business fundamentals, opportunities in international logistics, domestic logistics prospects, and preparedness for digital transformation (Agility, 2025). The AEMLI is significant as it provides valuable insights into emerging economies' capacity to facilitate global trade and attract foreign investment by evaluating their logistics capabilities. The AEMLI assesses various emerging markets and gathers perspectives on logistics friendliness through a survey conducted with over 750 supply chain professionals worldwide. The scores are calculated on a scale ranging from 0 to 100, with higher values indicating superior performance and enhanced attractiveness in logistics (Bulut & Abacıoğlu, 2025).

In recent decades, a significant body of research has emerged regarding logistics performance Nevertheless, there is still a limited understanding of the effective use of indicators to develop environmentally friendly logistics strategies to enhance trade within countries. Humanity has been harming the natural environment to fulfill our needs for an extended period. One of the significant indirect threats to the environment and public health is the transportation of goods. Each year, the volume of goods transported worldwide increases dramatically. Often, the chosen transportation methods prioritize speed over eco-friendliness. As a result, humanity faces consequences such as deteriorating air quality, rising emissions, and the persistent pollution of our water, land, and air (Starostka-Patyk et al., 2024). Indices such as the Environmental Performance Index (EPI) have been developed to address environmental challenges. It assesses nations' efforts to promote sustainability and enhance the quality of life for their citizens (Block et al., 2024) Similarly, the AEMLI has been introduced to evaluate the logistics efficiency of emerging markets, scrutinizing all facets of logistics operations within a country. The AEMLI and EPI offer a holistic view of logistics performance and ecology.

The assessment of green logistics market performance, along with understanding their determinants, has become increasingly important due to their significant contributions to the global economy. This research incorporates a hybrid SPC-based RAWEC, RSMVC, SPOTIS, and Extended AROMAN decision model to evaluate the green logistics market performance of the twenty leading emerging markets highlighted in the AEMLI report. The main objective of this study is to address the following research questions:

RQ1. *What are the key factors affecting the green logistics markets performance in selected countries?*

RQ2. *How do emerging markets compare regarding the green logistics markets performance?*

RQ3. *Are there differences in the green logistics market performance of selected countries based on the MCDM methods applied?*

This research assesses the green logistics market performance of leading emerging markets through hybrid MCDM techniques. Emerging markets are vital for pinpointing regional strengths and weaknesses, assisting policymakers and investors in determining where to allocate strategic resources. Countries such as China, India, and the United Arab Emirates consistently secure high rankings, demonstrating their significant investments in logistics development and integration into global supply chains. Positioned as a link between Europe and Asia, emerging markets are instrumental in promoting economic growth, international trade, and connectivity. The selection of the 20 nations was based on their recognition as leading emerging markets, as evidenced by reputable global reports and indices, including the IMF's classification of Emerging Market Economies, World Bank data, and UNCTAD statistics related to trade and logistics. These countries were chosen for their rapid economic growth and substantial contributions to global trade, logistics, and supply chain integration. Notably, they are increasing their investments in logistics infrastructure, demonstrating a commitment to sustainable practices, and adopting green technologies, all of which align closely with the objectives of this study. In parallel, a new model is introduced that employs a novel weighting technique known as SPC alongside several advanced ranking-based methods, including RAWEC, RSMVC, SPOTIS, and Extended AROMAN. The rationale for adopting this hybrid model can be summarized as follows: (i) The SPC method evaluates the absolute distance between the criterion values of various alternatives and the symmetry point of the criterion, which represents the midpoint between two extreme criterion values (Gligorić et al., 2023). (ii) The RAWEC method consolidates two stages into a single process, effectively reducing the required steps. This approach emphasizes evaluating outcomes by analyzing deviations from ideal values rather than simply ranking options based on their decision matrix values. Its straightforward methodology enhances user-friendliness and demonstrates significant potential for applications in MCDM, as it minimizes complex calculations (Puška et al., 2024). (iii) RSMVC offers a user-friendly and computationally efficient solution by circumventing the need for complex mathematical operations or normalization processes (Thinh & Van Dua, 2023). (iv) The SPOTIS method employs the concept of reference objects. In contrast to other MCDM methods, it necessitates the establishment of data boundaries, which helps to stabilize the ranking of alternatives concerning the Ideal Solution Point and mitigates the risk of the Rank Reversal paradox (Więckowski et al., 2024b). (v) The Extended AROMAN method enhances the original AROMAN approach by integrating attribute normalization and weight sensitivity, resulting in more accurate and equitable rankings of alternatives (Bošković et al., 2023). (vi) Finally, the Borda Count method combines multiple rankings to reduce the influence or bias of any single method or opinion, thereby improving the robustness of the results (Ecer, 2021).

The novelties of this study can be expressed as follows:

- A novel hybrid decision-support framework has been developed to evaluate key emerging market economies' green logistics performance.
- This study represents the first instance of collectively applying SPC-based RAWEC, RSMVC, SPOTIS, and Extended AROMAN methods within the MCDM context.

- The proposed hybrid model is a valuable tool for the private sector, policymakers, and other relevant stakeholders to thoroughly assess and interpret emerging markets' green logistics performance.
- A hybrid model's robustness and validity have been confirmed through sensitivity and comparative analyses.

The remainder of this paper is organized as follows: Section 2 provides a review of the existing literature pertinent to the field. Section 3 details the data and research methodology utilized. Section 4 presents the findings obtained from the hybrid MCDM methods. Finally, Section 5 concludes with a summary of the results, highlighting recommendations and implications for future research.

Literature Review

Logistics efficiency and environmental sustainability are crucial factors in today's global landscape that significantly impact operational effectiveness, economic development, and a nation's competitive advantage. Countries increasingly prioritize improving logistics efficiency in response to the rapid expansion of global trade and the rising demand for faster, more reliable, and eco-friendly supply chain operations (Beysenbaev & Dus, 2020). The growing focus on environmental sustainability has led to the implementation of green logistics strategies as nations seek to balance economic growth with environmental responsibility (Lu et al., 2019). Consequently, there has been considerable growth in studies focused on evaluating logistics and environmental effectiveness through MCDM methods. Table 1 presents a summary of the relevant research conducted in this field.

Table 1: Previous Research on Logistics Performance

Author(s)	Year	Methods	Subject
Çakır	2017	CRITIC-SAW-Peters' Fuzzy Regression	Measuring the logistics performance index of OECD countries applying a fuzzy linear regression model
Ulutaş & Karaköy	2019	SWARA-CRITIC-PIV	Examination of the logistics performance index of European Union countries utilizing a combined MCDM framework
Yildirim & Adiguzel Mercangoz	2020	ARAS-G-Fuzzy AHP	Evaluating the logistics performance of OECD countries by integrated MCDM method
Isik et al.	2020	SV-MABAC	Analysis of the logistics performance index of Central and Eastern Europe countries with MCDM model
Mešić et al.	2022	CRITIC-MARCOS	Assessing the logistics performance index of the Western Balkan countries using hybrid MCDM approach

Author(s)	Year	Methods	Subject
Kara et al.	2022	ENTROPY-MABAC	Determining the logistics market performance of developing countries with combined MCDM model
Arıkan Kargı	2022	ENTROPY-WASPAS	Evaluation of logistics performance index of the OECD countries via hybrid MCDM approach
Hadzikadunic et al.	2023	CRITIC-FUCOM-MARCOS	Investigation of the logistics performance index of European Union countries by integrated MCDM method
Özbek & Özekenci	2023	LOPCOW-MAUT-TOPSIS-MARCOS-CoCoSo	Examination of digital logistics market performance of developing countries utilizing a integrated MCDM method
Miškić et al.	2023	MEREC-MARCOS	Assessment of the logistics performance index of the European Union countries with MCDM model
Özekenci	2023	SWARA-CRITIC-CoCoSo	Measurement of the logistics market performance of developing countries using a hybrid MCDM model
Çıray et al.	2024	ENTROPY-ORESTE	Evaluation of the logistics performance index of the selected countries using a hybrid MCDM framework
Ju et al.	2024	CRITIC-MEREC-ENTROPY-Fuzzy ROV	Analysis of the logistics performance index of European Union countries with MCDM method
Özekenci	2024	ENTROPY-CRITIC-LOPCOW-EDAS	Assessment of the logistics performance index of OPEC countries by combined MCDM model
Topal & Ulutaş	2024	SD-AROMAN	Measurement the logistics performance index of G8 nations using an integrated MCDM framework
Gelmez et al.	2024	SD-COPRAS-SAW	Evaluation the logistics performance index of G20 countries via hybrid MCDM method
Özekenci	2025	MPSI-Extended AROMAN	Determining the green logistics performance of the Asia-Pacific countries utilizing a combined MCDM model

Research Gap

The efficiency of supply chain operations and the enhancement of global competitiveness are profoundly influenced by logistics performance, which subsequently impacts economic growth and international trade (Arvis et al., 2023). Recently, there has been an increasing emphasis on evaluating the LPI of various countries through a range of MCDM methods. This growing focus underscores the rising complexity and multidimensional nature of global logistics systems. Research in this field predominantly examines factors such as infrastructure, customs processes, international shipping, and the quality of logistics services, offering comparative insights into the logistics strengths of different nations. Despite the increasing significance of sustainability in contemporary logistics, there remains a considerable gap in research that integrates environmental performance metrics into assessing logistics efficiency. Environmental indicators such as Ecosystem Vitality, Environmental Health, and Climate Change are directly connected to the development of green logistics. High levels of air pollution and ecosystem degradation create regulatory and societal pressures on the logistics sector to adopt cleaner technologies and more efficient transport modes (Zhang et al., 2022; Özekenci, 2025). As highlighted in recent study (Starostka-Patyk et al., 2024), integrating environmental performance metrics with logistics indicators provides a holistic evaluation framework that better reflects the realities of green logistics development. Previous studies have predominantly focused on green logistics performance through isolated indicators or specific regional analyses. For example, research conducted by Gardas et al. (2019), Zhang et al. (2020), and Bennani et al. (2022) has examined various facets of green logistics; however, a comprehensive evaluation that effectively combines both environmental and logistical dimensions is still lacking. Furthermore, there exists a significant gap in the literature explicitly addressing emerging markets, which play a crucial role in global trade and logistics networks. Current studies predominantly focus on high-performing European or global economies, often neglecting the emerging and rapidly industrializing nations simultaneously facing environmental challenges and striving for logistics modernization. To date, no research has assessed the logistics efficiency and environmental performance of leading emerging markets using the SPC-based RAWEC, RSMVC, SPOTIS, and Extended AROMAN methods—an advanced hybrid approach recognized for overcoming the limitations of traditional MCDM models by incorporating uncertainty, normalization robustness, and inter-criteria correlations (Gligorić et al., 2023; Bošković et al., 2023; Thinh & Van Dua, 2023; Puška et al., 2024). Consequently, this research addresses a significant gap by employing a novel integrated MCDM approach to evaluate green logistics markets performance in leading emerging economies. This comprehensive and unified framework offers a novel perspective by merging logistics efficiency with environmental performance. The anticipated outcomes will significantly enrich the existing literature on logistics and environmental management while providing strategic guidance to policymakers and stakeholders committed to advancing effective logistics and ecological responsibility within emerging markets.

Data and Methodology

Data

This study evaluates the green logistics markets performance of the top twenty emerging markets highlighted in the AEMLI report. The key emerging markets—China, India, the United Arab Emirates, Saudi Arabia, Malaysia, Indonesia, Mexico, Qatar, Thailand, Vietnam, Chile, Türkiye, Brazil, Oman, Russia, Bahrain, Jordan, Kuwait, Uruguay, and South Africa—are benchmarks for assessing green logistics markets performance. These nations are crucial in global trade, capitalizing on their rapidly growing economies, strategic geographic positions, and robust industrial sectors. Additionally, they are at the forefront of adopting advanced logistics technologies, sustainable supply chain practices, and establishing regulatory frameworks promoting environmental responsibility. This commitment enhances their dedication to long-term economic and ecological resilience.

The decision model of this study consists of seven criteria: Domestic Logistics Opportunity, International Logistics Opportunity, Business Fundamentals, Digital Readiness, Ecosystem Vitality, Environmental Health, and Climate Change. These criteria were established based on a comprehensive literature review (Larson, 2021; Kara et al., 2022; Özekenci, 2023; Özbek & Özekenci, 2023; Starostka-Patyk et al., 2024; Bulut & Abacıoğlu, 2025). Previous research has revealed that countries assess logistics performance across various dimensions. For instance, integrating the EPI and the LPI is employed to assess green logistics performance (Starostka-Patyk et al., 2024; Özekenci, 2025). Additionally, the combination of the Digital Economy and Global Competitiveness Index with the LPI provides a framework for analyzing logistics performance from the perspectives of both digital advancement and global competitiveness (Ekici et al., 2019; Moldabekova et al., 2021; Polat et al., 2023). As a result, the AEMLI and the EPI indices have been integrated to evaluate the logistics efficiency and environmental performance of selected emerging markets. The AEMLI data were obtained from the 2025 Agility Emerging Markets Logistics Index, while the environmental data were sourced from the 2024 Environmental Performance Index, published by the Yale Center for Environmental Law & Policy. Both indices are routinely updated, and we intentionally selected the most recent versions available at the time of our analysis. All criteria used in this study focus on maximizing benefits.

These criteria effectively encompass both logistics and environmental performance dimensions. Green logistics emerges from the interaction of logistics capacity, market opportunities, environmental conditions, and policy requirements. The first four indicators—Domestic and International Logistics Opportunities, Business Fundamentals, and Digital Readiness—perform as market drivers that influence the adoption of low-carbon logistics. The latest three indicators—Ecosystem Vitality, Environmental Health, and Climate Change—represent the environmental challenges and policy pressures that foster mitigation and adaptation within the logistics sector. Collectively, these elements shape the progress of green logistics.

Utilizing a step-by-step hybrid algorithm, the collected data were analyzed to compute and rank the performance levels of emerging markets. This study aims to establish a comprehensive framework for identifying performance criteria related to logistics and the environment by integrating a range of interconnected indicators. This framework supports benchmarking and performance evaluation while enhancing strategic decision-making for environmental sustainability and operational efficiency within the logistics industry. An overview of the indicators and the decision matrix is provided in Tables 2 and 3, respectively.

Table 2: An Overview of Criteria

Criteria	Abbr.	Optimization	Scale	Description
Domestic Logistics Opportunity	DLO	Benefit	From very low (0) to very high (10)	Assesses emerging markets' performance and capacity for sustaining domestic demand through competitive logistics.
International Logistics Opportunity	ILO	Benefit	From very low (0) to very high (10)	Evaluates demand for trade-intensive logistics services and the capacity of emerging markets for cross-border operations.
Business Fundamentals	BF	Benefit	From very low (0) to very high (10)	Assesses the openness, resilience, fairness, and vitality of emerging markets, along with the integrity of their legal frameworks and market autonomy.
Digital Readiness	DR	Benefit	From very low (0) to very high (10)	Evaluate the potential and progress of an emerging market in becoming a digitally driven, skilled, innovative, and sustainable economy.
Ecosystem Vitality	ECV	Benefit	From very low (0) to very high (100)	Measures how effectively countries manage their natural resources and protect their biodiversity and ecosystems.
Environmental Health	ENH	Benefit	From very low (0) to very high (100)	Measures how effectively countries protect public health from air pollution and other environmental risks.
Climate Change	CLC	Benefit	From very low (0) to very high (100)	Measures the long-term variations in temperature, rainfall, and other atmospheric aspects on our planet.

Source: Agility (2025); Block et al. (2024)

Table 3: Decision Matrix

Emerging Markets	DLO	ILO	BF	DR	ECV	ENH	CLC
China	8.58	9.65	6.37	8.47	35.60	29.70	39.80
India	7.59	7.49	6.03	5.76	30.40	13.50	35.00
United Arab Emirates	5.53	5.90	8.53	6.55	62.40	51.30	35.60
Saudi Arabia	5.61	6.07	7.45	5.82	50.00	40.50	33.20
Malaysia	5.26	5.78	7.72	6.41	38.90	45.80	39.90
Indonesia	6.16	6.12	5.85	5.41	38.90	25.80	32.10
Mexico	5.49	6.45	5.61	5.25	46.60	37.10	46.40
Qatar	5.36	4.92	6.97	6.25	56.40	51.30	28.00
Thailand	5.05	5.86	5.94	5.82	51.30	35.20	46.00
Vietnam	5.09	5.81	6.01	5.37	27.80	27.00	17.90
Chile	4.88	5.07	6.88	5.68	57.40	45.10	41.50
Türkiye	5.31	5.41	5.10	5.66	34.70	41.90	37.00
Brazil	5.51	5.78	4.18	5.19	63.90	42.40	45.50
Oman	5.06	4.72	6.72	5.54	64.50	50.10	32.60
Russia	5.09	5.61	4.70	5.43	48.40	55.40	36.90
Bahrain	4.99	4.49	6.91	5.72	36.90	41.60	27.90
Jordan	4.78	4.62	7.15	5.23	49.30	47.20	44.60
Kuwait	5.07	4.52	6.03	5.29	53.70	50.40	24.90
Uruguay	4.81	4.47	6.69	5.22	39.00	57.60	40.60
South Africa	4.83	4.99	5.15	5.05	49.30	24.40	48.00
max	8.58	9.65	8.53	8.47	64.50	57.60	48.00
min	4.78	4.47	4.18	5.05	27.80	13.50	17.90

Source: Agility (2025); Block et al. (2024)

Methodology

The criteria weights were determined using a recent objective weighting method called the Symmetry Point of Criterion (SPC). After determining the criteria weights, the final ranking of alternatives was performed using four novel techniques: Ranking of Alternatives with Weights of Criterion (RAWEC), Ranking the Solutions based on the Mean Value of Criteria (RSMVC), Stable Preference Ordering Towards Ideal Solution (SPOTIS), and Extended alternative ranking order method accounting two-step normalization (AROMAN). The results were synthesized and validated using the Borda Count Method, a well-established ranking aggregation technique frequently utilized in MCDM research (Barak & Mokfi, 2019; Ecer, 2021; Oufella, 2024). This method combines individual rankings from various evaluation techniques, facilitating a consensus-based final ranking of alternatives. By assigning weighted scores to each alternative based on relative performance across different criteria, the Borda Count Method improves the decision-making process and helps reduce potential biases (Emerson, 2013). The description of each method is outlined below.

SPC Method

The SPC method was introduced by Gligorić et al. in 2023 to evaluate the weights of criteria in various MCDM problems. This method leverages the symmetry point of a criterion, specifically the modulus of symmetry, to assess its impact on the overall weights. A higher modulus value indicates a greater weight assigned to the criterion. Below are the steps outlining the process for estimating the weights of criteria (Gligorić et al., 2023):

Step 1. The decision matrix is created.

Step 2. According to Eq. (1), the Symmetry Point of Criterion (SPC_j) is calculated.

$$SPC_j = \frac{\min\left\{x_{ij}\right\} + \max\left\{x_{ij}\right\}}{2}; i = 1,2,\ldots,m; \forall j \in [1,n] \tag{1}$$

Step 3. Applying Eq. (2) establishes the matrix of absolute distances.

$$D = \left\| d_{ij} \right\|_{mXn} = \begin{Vmatrix} \left|x_{11} - SPC_1\right| & \left|x_{12} - SPC_1\right| & \cdots & \left|x_{1n} - SPC_n\right| \\ \left|x_{21} - SPC_1\right| & \left|x_{22} - SPC_2\right| & \cdots & \left|x_{2n} - SPC_n\right| \\ \vdots & \vdots & \ddots & \vdots \\ \left|x_{m1} - SPC_1\right| & \left|x_{m2} - SPC_2\right| & \cdots & \left|x_{mn} - SPC_n\right| \end{Vmatrix} \tag{2}$$

Step 4. Based on Eq. (3), the matrix of the moduli of symmetry is created.

$$R = \left|r_{ij}\right|_{mXn} = \begin{vmatrix} \frac{\frac{\sum_{i=1}^{m} d_{i1}}{m}}{x_{11}} & \frac{\frac{\sum_{i=1}^{m} d_{i2}}{m}}{x_{12}} & \cdots & \frac{\frac{\sum_{i=1}^{m} d_{in}}{m}}{x_{1n}} \\ \frac{\frac{\sum_{i=1}^{m} d_{i1}}{m}}{x_{21}} & \frac{\frac{\sum_{i=1}^{m} d_{i2}}{m}}{x_{22}} & \cdots & \frac{\frac{\sum_{i=1}^{m} d_{in}}{m}}{x_{2n}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\frac{\sum_{i=1}^{m} d_{i1}}{m}}{x_{m1}} & \frac{\frac{\sum_{i=1}^{m} d_{i2}}{m}}{x_{m2}} & \cdots & \frac{\frac{\sum_{i=1}^{m} d_{in}}{m}}{x_{mn}} \end{vmatrix} \tag{3}$$

Step 5. The modulus of symmetry of the criterion is established using Eq. (4).

$$Q = \left|q_{1j}\right|_{1Xn} = \left| \frac{\sum_{i=1}^{m} r_{i1}}{m} \quad \frac{\sum_{i=1}^{m} r_{i2}}{m} \quad \cdots \quad \frac{\sum_{i=1}^{m} r_{in}}{m} \right|; \forall j \in [1, n] \tag{4}$$

Step 6. Each objective criterion weight is calculated using the vector of moduli of symmetry (Eq. 5).

$$W = \left|w_{1j}\right|_{1Xn} = \left| \frac{q_1}{\sum_{j=1}^{n} q_j} \quad \frac{q_2}{\sum_{j=1}^{n} q_j} \quad \cdots \quad \frac{q_j}{\sum_{j=1}^{n} q_j} \right|; \forall j \in [1, n] \tag{5}$$

RAWEC Method

The RAWEC approach was introduced by Puška et al. in 2024. This technique streamlines the decision-making process by minimizing the number of steps and removing intricate calculations. The sequence of the RAWEC process is outlined below (Puška et al., 2024):

Step 1. The decision matrix is formed.

Step 2. According to Eqs. (6-7), the decision matrix is normalized using a double normalization approach.

$$n_{ij} = \frac{x_{ij}}{x_{j}\ max}, \textit{and}\ n_{ij}^{'} = \frac{x_{j}\ min}{x_{ij}}, \textit{for benefit criteria}, \textit{and} \tag{6}$$

$$n_{ij} = \frac{x_{j\,min}}{x_{ij}}, and\ n_{ij}^{'} = \frac{x_{ij}}{x_{j\,max}}, for\ cost\ criteria. \tag{7}$$

Step 3. During this stage, the difference from the criterion weight is determined using equations (8-9). This procedure successfully combines the weighting of the normalized decision matrix with an assessment of the divergence from the defined criteria weights.

$$v_{ij} = \sum_{i=1}^{n} w_j . \left(1 - n_{ij}\right) \tag{8}$$

$$v_{ij}^{'} = \sum_{i=1}^{n} w_j . \left(1 - n_{ij}^{'}\right) \tag{9}$$

Step 4. The final ranking of the alternatives is determined using Eq. (10).

$$Q_i = \frac{v_{ij}^{'} - v_{ij}}{v_{ij}^{'} + v_{ij}} \tag{10}$$

The RAWEC method produces a value ranging from -1 to 1. The absolute magnitude of this value is utilized to evaluate the superiority of an alternative, with higher values signifying more favourable options. The alternative that attains the highest value is considered the optimal choice.

RSMVC Method

The RSMVC method was introduced by Van Dua and Thinh in 2023. This novel approach is utilized to rank alternatives based on the mean values of the criteria. Below are the steps involved in the RSMVC method (Van Dua & Thinh, 2023):

Step 1. The decision matrix is formed.

Step 2. Eq. (11) is utilized to calculate the average values of the criteria.

$$\bar{x}_{ij} = \frac{a_{ij} - b_{ij}}{2} \tag{11}$$

Step 3. The ranking of each criterion is determined by its mean value.

Regarding the benefit criterion, the solution that achieves the highest average value is ranked first, while the solution with the lowest average value is ranked last.

Conversely, the solution with the lowest average value is placed at the top for the cost criterion, whereas the one with the highest average value is positioned at the bottom.

Step 4. Based on Eq. (12), the scores of the alternatives are computed.

$$S_i = r_{ij} .w_j \tag{12}$$

Step 5. The final ranking is obtained based on S_i score, the lowest one is the best solution.

SPOTIS Method

The SPOTIS method was introduced by Dezert et al. in 2020. This novel approach is utilized for ranking alternatives based on an ideal solution point and is known for its low complexity. The steps involved in the SPOTIS method are outlined below (Dezert et al., 2020):

Step 1. Eq. (13) is used to normalize the distances to the ideal solution point

$$d(A_i S_j^*) = \frac{\left| S_{ij} - S_j^* \right|}{\left| S_j^{max} - S_j^{min} \right|} \tag{13}$$

Step 2. According to Eq. (14), the weighted normalized distances are calculated.

$$d\left(A_{i,} S^* \right) = \sum_{j=1}^{N} w_j d_{ij} \left(A_{i,} S^* \right) \tag{14}$$

Step 3. The final ranking is determined through the values of $d\left(A_{i,} S^* \right)$. Smaller values of $d\left(A_{i,} S^* \right)$ are desirable.

Extended AROMAN Method

An Extended AROMAN method was introduced by Bošković et al. in 2023. This method combines the standardized information from a two-step normalization process and computes an average matrix based on the normalized data. The procedures involved in the Extended AROMAN method are detailed as follows (Bošković et al., 2023):

Step 1. The decision matrix is constructed.

Step 2. The decision matrix is normalized based on a double normalization process using the following equations:

Step 2.1. *Normalization Type I (Linear)*

$$t_{ij} = (x_{ij} - \underset{i}{minx_{ij}})/(\underset{i}{maxx_{ij}} - \underset{i}{minx_{ij}}),\ i=1,2,3,\ldots..m\ ,j=1,2,\ldots..n. \tag{15}$$

Step 2.2. *Normalization Type II (Vector)*

$$t_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}},\ i=1,2,3,\ldots..m\ ,j=1,2,\ldots..n. \tag{16}$$

Step 2.3. *Aggregated Averaged Normalization*

$$t_{ij}^{norm} = \frac{\beta t_{ij} + (1-\beta) t_{ij}^{*}}{2}, \quad i=1,2,3,\ldots\ldots m \text{ , } j=1,2,\ldots\ldots n. \tag{17}$$

where t_{ij}^{norm} represents the normalized aggregation average, and β is a weighting coefficient that ranges from 0 to 1. In this case, we considered β to be 0.5.

Step 3. The weighted normalized decision matrix is obtained by applying the following equation:

$$\widehat{t_{ij}} = W_{ij} \,.\, t_{ij}^{norm}, \quad i=1,2,3,\ldots\ldots m \text{ , } j=1,2,\ldots\ldots n. \tag{18}$$

Step 4. Separately summarize the normalized weighted values of the criteria type min ($\boldsymbol{L_i}$) and the normalized weighted values of the max type ($\boldsymbol{A_i}$) as follows:

$$L_i = \sum_{j=1}^{n} \widehat{t_{ij}}^{(min)}, \quad i=1,2,3,\ldots\ldots m \text{ , } j=1,2,\ldots\ldots n. \tag{19}$$

$$A_i = \sum_{j=1}^{n} \widehat{t_{ij}}^{(max)}, \quad i=1,2,3,\ldots\ldots m \text{ , } j=1,2,\ldots\ldots n. \tag{20}$$

Step 5. Raise the obtained sum of $\boldsymbol{L_i}$ and $\boldsymbol{A_i}$ values to the degree of $\boldsymbol{\lambda}$ using the following equations:

$$L_i^{\wedge} = L_i^{\lambda} = \left(\sum_{j=1}^{n} \widehat{t_{ij}}^{(min)} \right)^{\lambda} \quad i=1,2,3,\ldots\ldots m \tag{21}$$

$$A_i^{\wedge} = A_i^{1-\lambda} = \left(\sum_{j=1}^{n} \widehat{t_{ij}}^{(max)} \right)^{1-\lambda} \quad i=1,2,3,\ldots\ldots m \tag{22}$$

where λ represents the coefficient degree of the criterion type, in this study, we considered parameter λ to be 0.5.

Step 6. Determine the final ranking of the alternatives by applying following equation:

$$\boldsymbol{R_i} = e^{\left(A_i^{\wedge} - L_i^{\wedge}\right)}, \quad i=1,2,3,\ldots\ldots m \tag{23}$$

Borda Count Method

The Borda Count method systematically ranks alternatives based on preferences, organizing them from the most favored to the least favored. In this method, the alternative ranked lowest receives 0 points, while the second-lowest earns 1 point, and this continues incrementally. The top-ranked alternative is awarded points equal to the total number of alternatives. The points assigned to each alternative are then summed across all rankings, and the alternative with the highest total Borda count is considered the best option. In a decision problem with n alternatives, each alternative is allocated (n – 1) points for the finest option, (n – 2) points for the second-best option, and so on (Ecer, 2021).

Results

This section illustrates the results of implementing various MCDM approaches used in the study. The analysis begins with criterion weighting through the SPC method (Section 4.1) and continues with ranking alternatives using the RAWEC, RSMVC, SPOTIS, and Extended AROMAN methods (Sections 4.2–4.5). To synthesize the findings from these diverse methods, the Borda Count technique is applied to generate an aggregated ranking (Section 4.6). Furthermore, a sensitivity analysis (Section 4.7) is conducted to evaluate the robustness of the results concerning variations in weights and method inputs. Finally, a comparative analysis (Section 4.8) provides additional insights into the consistency and reliability of the proposed hybrid framework across the employed techniques.

Results Obtained from the SPC Method

In the first step of the SPC method, a decision matrix is created using the numerical values obtained from the AEMLI and EPI reports. The second step entails calculating the Symmetry Point of the Criterion through the equations specified in Eq. (1). Next, an absolute distance matrix is generated according to Eq. (2). Following this, the modulus of symmetry for the criterion is computed based on Eq. (4). Lastly, the weight of the criteria is determined using Eq. (5), with the results of the SPC method presented in Table 4.

Table 4: The weights of criteria

Criterion	DLO	ILO	BF	DR	ECV	ENH	CLC
w_j	0.1652	0.1859	0.0836	0.1261	0.1287	0.1843	0.1259
rank	3	1	7	5	4	2	6

The SPC results reveal that international logistics opportunity (*ILO*) is the most significant criterion, while business fundamentals (*BF*) ranks as the least important. Additionally, environmental health (*ENH*) and domestic logistics opportunity (*DLO*) are critical indicators influencing the logistics and environmental performance of emerging markets. The overall ranking of the criteria is as follows: *ILO* > *ENH* > *DLO* > *ECV* > *DR* > *CLC* > *BF*.

Results Obtained from the RAWEC Method

The decision matrix (Table 3) outlines each alternative's maximum and minimum values, evaluated against specific criteria. This preliminary step is essential as it lays the foundation for the normalization process. Following this, the decision matrix underwent double normalization by Equations (6-7). The determination of criteria weights and the assessment of deviations from the maximum normalization values were performed using Equations (8-9). The final ranking of the alternatives was established through Equation (10), as illustrated in Table 5.

Table 5: Final ranking of alternatives (RAWEC)

Emerging Markets	υ_{ij}	υ'_{ij}	Q_i	**Rank**
China	0.1897	0.4507	0.4076	1
India	0.3689	0.2499	-0.1923	17
United Arab Emirates	0.2165	0.4089	0.3077	2
Saudi Arabia	0.2987	0.3650	0.0998	4
Malaysia	0.2872	0.3586	0.1105	3
Indonesia	0.3811	0.2998	-0.1194	16
Mexico	0.3033	0.3512	0.0732	8
Qatar	0.2903	0.3392	0.0776	7
Thailand	0.3091	0.3440	0.0534	10
Vietnam	0.4623	0.1781	-0.4437	20
Chile	0.2884	0.3394	0.0812	6
Türkiye	0.3587	0.2931	-0.1007	14
Brazil	0.2816	0.3423	0.0973	5
Oman	0.2886	0.3265	0.0617	9
Russia	0.2962	0.3250	0.0465	11
Bahrain	0.3844	0.2571	-0.1986	18
Jordan	0.3044	0.3083	0.0064	12
Kuwait	0.3435	0.2754	-0.1100	15
Uruguay	0.3091	0.2851	-0.0405	13
South Africa	0.3827	0.2544	-0.2014	19

The RAWEC results indicate that China, the United Arab Emirates, Malaysia, Saudi Arabia, and Brazil have achieved the highest logistics and environmental performance. Conversely, Indonesia, India, Bahrain, South Africa, and Vietnam have recorded the lowest performance levels. The overall rankings of the countries are as follows: China > the United Arab Emirates > Malaysia > Saudi Arabia > Brazil > Chile > Qatar > Mexico > Oman > Thailand > Russia > Jordan > Uruguay > Türkiye > Kuwait > Indonesia > India > Bahrain > South Africa > Vietnam.

Results Obtained from the RSMVC Method

According to Eq. (11), the mean value of each criterion was calculated. Afterwards, the criteria were ranked based on the mean value and the solution for each criterion. Eq. (12) was used to calculate the score of each criterion (S_i) and the best solution is the one with the smallest S_i score. Table 6 presents the results of the RSMVC method.

Table 6: Final ranking of alternatives (RSMVC)

Emerging Markets	DLO	ILO	BF	DR	ECV	ENH	CLC	*Sum* (S_i)	Rank
China	0.1652	0.1859	0.8365	0.1261	2.1891	2.9501	1.1338	7.5867	2
India	0.3303	0.3718	0.9202	0.8830	2.4466	3.6876	1.6377	10.2772	10
United Arab Emirates	0.8259	1.1155	0.0837	0.2523	0.3863	0.5531	1.5117	4.7284	1
Saudi Arabia	0.6607	0.9296	0.2510	0.6307	1.0301	2.3970	1.7637	7.6627	3
Malaysia	1.6517	1.6732	0.1673	0.3784	1.8028	1.4750	1.0078	8.1563	4
Indonesia	0.4955	0.7436	1.2548	1.6398	1.8028	3.3189	2.0156	11.2710	13
Mexico	1.1562	0.5577	1.3384	2.0182	1.5452	2.5813	0.2520	9.4491	7
Qatar	1.3214	2.7887	0.4183	0.5046	0.6438	0.5531	2.1416	8.3714	5
Thailand	2.4776	1.3014	1.1711	0.6307	0.9014	2.7657	0.3779	9.6258	8
Vietnam	1.8169	1.4873	1.0875	1.7659	2.5754	3.1345	2.5195	14.3870	20
Chile	2.8079	2.4169	0.5856	1.1352	0.5151	1.6594	0.7559	9.8760	9
Türkiye	1.4866	2.2309	1.5057	1.2614	2.3178	2.0282	1.2598	12.0904	15
Brazil	0.9910	1.6732	1.6730	2.3966	0.2575	1.8438	0.5039	9.3392	6
Oman	2.3124	2.9746	0.6692	1.3875	0.1288	1.1063	1.8896	10.4684	12
Russia	1.8169	2.0450	1.5894	1.5137	1.4165	0.3688	1.3857	10.1359	9
Bahrain	2.6428	3.5323	0.5019	1.0091	2.0603	2.2126	2.2676	14.2265	18
Jordan	3.3035	3.1605	0.3346	2.1444	1.1589	1.2907	0.6299	12.0224	14
Kuwait	2.1473	3.3464	0.9202	1.8921	0.7726	0.9219	2.3935	12.3940	16
Uruguay	3.1383	3.7182	0.7529	2.2705	1.6740	0.1844	0.8818	12.6201	17
South Africa	2.9731	2.6028	1.4221	2.5228	1.1589	3.5032	0.1260	14.3089	19

The results of the RSMVC reveal that the United Arab Emirates, China, Saudi Arabia, Malaysia, and Qatar have reached the highest levels of logistics and environmental performance. In contrast, Kuwait, Uruguay, Bahrain, South Africa, and Vietnam have recorded the lowest performance. The overall rankings of the countries are as follows: the United Arab Emirates > China > Saudi Arabia > Malaysia > Qatar > Brazil > Mexico > Thailand > Chile > Russia > India > Oman > Indonesia > Jordan > Türkiye > Kuwait > Uruguay > Bahrain > South Africa > Vietnam.

Results Obtained from the SPOTIS Method

At first, Eq. (13) was employed to normalize the distances to the ideal solution point. The weighted normalized distances were then calculated using Eq. (14). The final ranking was determined based on the resulting values of $d\left(A_{i}, S^{*}\right)$, with the optimal solution recognized as the one corresponding to the smallest value of $d\left(A_{i,\square} S^{*}\right)$. The results of the SPOTIS method are presented in Table 7.

Table 7: Final ranking of alternatives (SPOTIS)

Emerging Markets	DLO	ILO	BF	DR	ECV	ENH	CLC	∑	Rank
China	0.0000	0.0000	0.0415	0.0000	0.1014	0.1166	0.0343	0.2939	1
India	0.0430	0.0775	0.0481	0.1000	0.1196	0.1844	0.0544	0.6270	14
United Arab Emirates	0.1326	0.1346	0.0000	0.0708	0.0074	0.0263	0.0519	0.4236	2
Saudi Arabia	0.1291	0.1285	0.0208	0.0977	0.0509	0.0715	0.0619	0.5604	6
Malaysia	0.1443	0.1389	0.0156	0.0760	0.0898	0.0493	0.0339	0.5478	3
Indonesia	0.1052	0.1267	0.0515	0.1129	0.0898	0.1330	0.0665	0.6856	17
Mexico	0.1343	0.1148	0.0562	0.1188	0.0628	0.0857	0.0067	0.5793	9
Qatar	0.1400	0.1698	0.0300	0.0819	0.0284	0.0263	0.0837	0.5601	5
Thailand	0.1534	0.1360	0.0498	0.0977	0.0463	0.0937	0.0084	0.5853	10
Vietnam	0.1517	0.1378	0.0485	0.1143	0.1288	0.1279	0.1260	0.8350	20
Chile	0.1608	0.1644	0.0317	0.1029	0.0249	0.0523	0.0272	0.5642	7
Türkiye	0.1421	0.1522	0.0660	0.1036	0.1046	0.0656	0.0460	0.6801	16
Brazil	0.1334	0.1389	0.0837	0.1210	0.0021	0.0636	0.0105	0.5531	4
Oman	0.1530	0.1769	0.0348	0.1081	0.0000	0.0314	0.0645	0.5686	8
Russia	0.1517	0.1450	0.0737	0.1121	0.0565	0.0092	0.0465	0.5946	11
Bahrain	0.1560	0.1852	0.0312	0.1014	0.0968	0.0669	0.0841	0.7217	19
Jordan	0.1652	0.1805	0.0265	0.1195	0.0533	0.0435	0.0142	0.6028	12
Kuwait	0.1526	0.1841	0.0481	0.1173	0.0379	0.0301	0.0967	0.6667	15
Uruguay	0.1639	0.1859	0.0354	0.1199	0.0895	0.0000	0.0310	0.6255	13
South Africa	0.1630	0.1672	0.0650	0.1261	0.0533	0.1388	0.0000	0.7135	18

The SPOTIS results indicate that China, the United Arab Emirates, Malaysia, Brazil, and Qatar have achieved the highest logistics and environmental performance levels. In contrast, Türkiye, Indonesia, South Africa, Bahrain, and Vietnam have exhibited the lowest performance levels. The overall rankings of the countries are as follows: China > the United Arab Emirates > Malaysia > Brazil > Qatar > Saudi Arabia > Chile > Oman > Mexico > Thailand > Russia > Jordan > Uruguay > India > Kuwait > Türkiye > Indonesia > South Africa > Bahrain > Vietnam.

Results Obtained from An Extended AROMAN Method

Initially, Eqs. (15-16) were employed to normalize the decision matrix utilizing a double normalization process incorporating linear and vector methods. The aggregated average normalization was calculated using Eq. (17). The aggregated average weighted normalized matrix, which included a summary of the various criterion types, was developed through Eqs. (18-20). Since λ was considered 0,5, the values for L_i and A_i were subsequently determined using Eqs. (21-22). Eventually, the overall ranking of the alternatives was established in line with Eq. (23), and the results of the Extended AROMAN method are shown in Table 8.

Table 8: Final ranking of alternatives (Extended AROMAN)

Emerging Markets	$\hat{L_i}$	$\hat{A_i}$	$\hat{L_i} - \hat{A_i}$	R_i	*Rank*
China	0.0000	0.4195	0.4195	1.1924	1
India	0.0000	0.2383	0.2383	1.1051	14
United Arab Emirates	0.0000	0.3507	0.3507	1.1584	2
Saudi Arabia	0.0000	0.2761	0.2761	1.1228	6
Malaysia	0.0000	0.2831	0.2831	1.1261	3
Indonesia	0.0000	0.2074	0.2074	1.0909	17
Mexico	0.0000	0.2662	0.2662	1.1181	9
Qatar	0.0000	0.2766	0.2766	1.1230	5
Thailand	0.0000	0.2625	0.2625	1.1164	10
Vietnam	0.0000	0.1264	0.1264	1.0544	20
Chile	0.0000	0.2744	0.2744	1.1220	7
Türkiye	0.0000	0.2114	0.2114	1.0927	16
Brazil	0.0000	0.2808	0.2808	1.1250	4
Oman	0.0000	0.2722	0.2722	1.1209	8
Russia	0.0000	0.2589	0.2589	1.1147	11
Bahrain	0.0000	0.1884	0.1884	1.0822	19
Jordan	0.0000	0.2537	0.2537	1.1122	12
Kuwait	0.0000	0.2190	0.2190	1.0962	15
Uruguay	0.0000	0.2420	0.2420	1.1068	13
South Africa	0.0000	0.1924	0.1924	1.0840	18

The Extended AROMAN results demonstrate that China, the United Arab Emirates, Malaysia, Brazil, and Qatar have demonstrated the highest logistics and environmental performance levels. Conversely, Türkiye, Indonesia, South Africa, Bahrain, and Vietnam have shown the lowest performance levels. The overall rankings of the countries are as follows: China > the United Arab Emirates > Malaysia > Brazil > Qatar > Saudi Arabia > Chile > Oman > Mexico > Thailand > Russia > Jordan > Uruguay > India > Kuwait > Türkiye > Indonesia > South Africa > Bahrain > Vietnam.

Borda Count Results

Following a comprehensive analysis of the logistics and environmental performance of leading emerging markets, the Borda counting method was utilized to assess the overall performance of these countries. The results derived from the Borda Count method are presented in Table 9.

Table 9: Borda Count results

Emerging Markets	RAWEC		RSMVC		SPOTIS		Extended AROMAN		Borda Count	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Score	Rank
China	1	19	2	18	1	19	1	19	75	1
India	17	2	10	19	14	6	14	6	33	12
United Arab Emirates	2	18	1	19	2	18	2	18	73	2
Saudi Arabia	4	16	3	17	6	14	6	14	61	4
Malaysia	3	17	4	16	3	17	3	17	67	3
Indonesia	16	4	13	7	17	3	17	3	17	17
Mexico	8	12	7	13	9	11	9	11	47	8
Qatar	7	13	5	15	5	15	5	15	58	6
Thailand	10	10	8	12	10	10	10	10	42	10
Vietnam	20	0	20	0	20	0	20	0	0	20
Chile	6	14	9	11	7	13	7	13	51	7
Türkiye	14	6	15	5	16	4	16	4	19	15
Brazil	5	15	6	14	4	16	4	16	61	4
Oman	9	11	12	8	8	12	8	12	43	9
Russia	11	9	9	11	11	9	11	9	38	11
Bahrain	18	2	18	2	19	1	19	1	6	18
Jordan	12	8	14	6	12	8	12	8	30	13
Kuwait	15	5	16	4	15	5	15	5	19	15
Uruguay	13	7	17	3	13	7	13	7	24	14
South Africa	19	1	19	1	18	2	18	2	6	18

The Borda count results indicate that China, the United Arab Emirates, Malaysia, Saudi Arabia and Brazil consistently emerge as top performers across various methods. Qatar, Chile and Mexico maintain stable rankings; while not exceptionally high, they remain consistently good. In contrast, Türkiye, Indonesia, Kuwait, Bahrain, South Africa, and Vietnam generally rank lower across most methods. Notably, Vietnam ranks 20th in all evaluations, achieving a Borda score 0, which signifies the lowest overall performance.

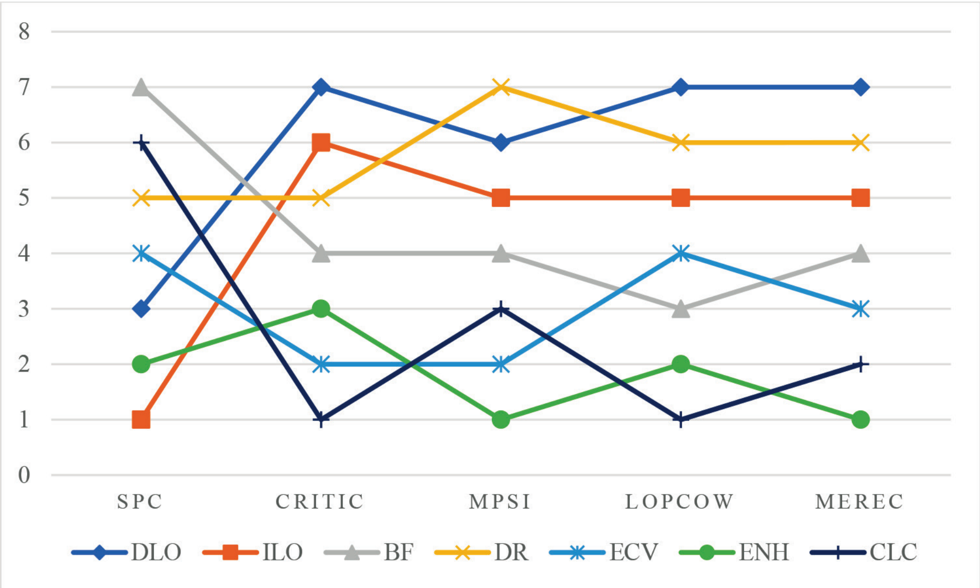
Sensitivity Analysis

Demir et al. (2024) emphasize that conducting a sensitivity analysis is essential for assessing the stability of results. Sensitivity analyses are widely utilized to validate findings within the fields of MCDM. This analysis examines the robustness of results in response to potential variations in input data, including weights, matrices, methods, or normalization metrics (Więckowski et al., 2024a). Furthermore, validating these results is critical for ensuring the accuracy and credibility of the proposed model. Given that weight coefficients significantly impact rankings, the coefficients derived from this study were compared with those obtained from other well-known weighting techniques, such as CRITIC, MPSI, LOPCOW, and MEREC. This comparison aimed to assess the effectiveness and reliability of the weight results regarding the hybrid model. The results derived from the various weighting methods are presented in Table 10 and visually represented in Figure 1.

Table 10: The ranking of the criteria based on various methods

Weighting Methods	SPC		CRITIC		MPSI		LOPCOW		MEREC	
	Coefficient	Rank	Coefficient	Rank	Coefficient	Rank	Coefficient	Rank	Coefficient	Rank
DLO	0.1652	3	0.0400	7	0.0902	6	-0.1091	7	0.0995	7
ILO	0.1859	1	0.0517	6	0.1016	5	0.0017	5	0.1153	5
BF	0.0837	7	0.1209	4	0.1170	4	0.2681	3	0.1316	4
DR	0.1261	5	0.0545	5	0.0686	7	-0.0285	6	0.1010	6
ECV	0.1288	4	0.1561	2	0.1995	2	0.2083	4	0.1379	3
ENH	0.1844	2	0.1529	3	0.2247	1	0.3277	2	0.2330	1
CLC	0.1260	6	0.4238	1	0.1984	3	0.3318	1	0.1817	2

Figure 1: Comparison of the results from different weighting methods



The findings demonstrate that the method used for weighting calculations can significantly influence the results. For instance, the MPSI and MEREC methods emphasized environmental health as the primary criterion. In contrast, alternative approaches like CRITIC and LOPCOW prioritized climate change as the key indicator for assessing logistics and environmental performance. Notably, the SPC method identified international logistics opportunities as a vital indicator, even though other methods deemed it insignificant. These findings are consistent with previous studies that pointed out discrepancies between the SPC method and those of CRITIC (Gligorić et al., 2023), LOPCOW (Durdu, 2025), and MEREC (Linh et al., 2025). Therefore, it can be concluded that the results are closely linked to the weighting method employed and are quite sensitive to these variations.

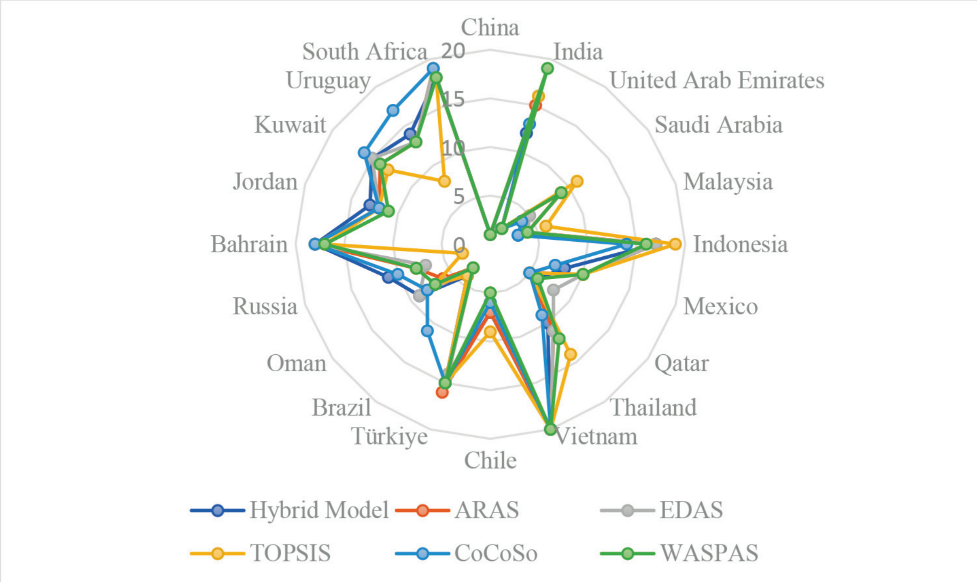
Comparative Analysis

The following phase in assessing the robustness of the results involves conducting a comparative analysis. During this stage, the proposed hybrid approach—including RAWEC, RSMVC, SPOTIS, and Extended AROMAN—is evaluated with well-known MCDM techniques, such as ARAS, EDAS, TOPSIS, CoCoSo, and WASPAS. It is important to note that all rankings are based on the criteria weights determined using the SPC method. The results derived from the various MCDM methods are presented in Table 11 and visually represented in Figure 2.

Table 11: The ranking of alternatives based on various MCDM methods

Emerging Markets	Hybrid Model	ARAS	EDAS	TOPSIS	CoCoSo	WASPAS
China	1	1	1	1	1	1
India	12	15	16	16	13	19
United Arab Emirates	2	2	2	2	2	2
Saudi Arabia	4	9	5	11	4	9
Malaysia	3	4	4	6	3	4
Indonesia	17	17	17	19	14	16
Mexico	8	10	10	10	7	10
Qatar	6	5	8	5	5	6
Thailand	10	11	11	14	9	12
Vietnam	20	20	20	20	20	20
Chile	7	7	6	9	6	5
Türkiye	15	16	14	15	15	15
Brazil	4	3	3	4	11	3
Oman	9	6	9	7	8	7
Russia	11	8	7	3	10	8
Bahrain	18	18	18	17	18	17
Jordan	13	12	12	12	12	11
Kuwait	15	14	15	13	16	14
Uruguay	14	13	13	8	17	13
South Africa	18	19	19	18	19	18

Figure 2: Comparison of rankings by different MCDM methods



The comparative analysis demonstrated that the findings derived from the hybrid model were predominantly consistent across various MCDM methods. For instance, China maintains the top position across all methods, demonstrating its consistent superiority among emerging markets. The United Arab Emirates also performs well, consistently securing second place across all methods. Meanwhile, Saudi Arabia and Malaysia remain within the top 10, although their rankings display more variability, particularly in the case of Saudi Arabia. Vietnam ranks 20th across all approaches, indicating a consistently lower level of performance. Furthermore, Bahrain and South Africa are in lower-tier rankings, generally between 17th and 19th, highlighting their weaker performance. Accordingly, these results confirm the robustness and reliability of the hybrid model. A comparison of the hybrid model with the LPI/AEMLI rankings is included in Appendix 1. Additionally, a correlation analysis was conducted to evaluate the statistical relationships among the various methods. The results of this analysis reveal strong positive correlations between the hybrid model and the ARAS, EDAS, TOPSIS, CoCoSo, and WASPAS methods. This highlights the robustness and consistency of the ranking results, as demonstrated in Appendix 2.

Discussion and Conclusion

This study examines the green logistics market performance of the twenty leading emerging markets, specifically China, India, the United Arab Emirates, Saudi

Arabia, Malaysia, Indonesia, Mexico, Qatar, Thailand, Vietnam, Chile, Türkiye, Brazil, Oman, Russia, Bahrain, Jordan, Kuwait, Uruguay, and South Africa. Recognizing that performance evaluation is influenced by various factors, a hybrid MCDM approach was employed in this study. This research focused on key emerging markets that significantly influence global energy consumption and demonstrate notable economic growth and population expansion. The initial phase involved determining the criteria weights using the SPC method. The SPC analysis revealed that international logistics opportunities and environmental health are the most critical criterions. Additionally, domestic logistics opportunities and ecosystem vitality emerged as crucial factors affecting emerging markets' logistical and environmental performance. The findings show that international logistics opportunity and environmental health indicators significantly impact performance evaluation. Furthermore, the current findings align with prior research (Özekenci, 2023; 2025; Bulut & Abacıoğlu, 2025), which indicates that international logistics opportunities and environmental health significantly influence on performance measurement. Another noteworthy finding from the sensitivity analysis revealed that the indicators of the EPI were determined as crucial criteria across various methods, including CRITIC, MPSI, and MEREC. Each indicator of the EPI consistently ranked among the top three positions across these methods. These findings can be attributed to the growing emphasis on environmental concerns within international logistics strategies. Sustainability and ecological impact have emerged as pivotal performance drivers in global supply chains (Wang et al., 2020). Consequently, countries prioritizing international logistics opportunities with an emphasis on environmental issues may achieve a competitive advantage and improve efficiency in logistics-related decision-making and operations.

Following the determination of the criteria's weight, the performance of the green logistics market in the top twenty emerging markets was assessed using various MCDM approaches, such as RAWEC, RSMVC, SPOTIS, and the Extended AROMAN method. The findings from the RAWEC method indicated that China, the United Arab Emirates, Malaysia, Saudi Arabia, and Brazil achieved the highest green logistics market performance. According to the RSMVC results, the United Arab Emirates, China, Saudi Arabia, Malaysia, and Qatar emerged as the leaders in green logistics market performance. The SPOTIS findings revealed that China, the United Arab Emirates, Malaysia, Brazil, and Qatar attained top rankings in green logistics market performance. Similarly, the Extended AROMAN results demonstrated that China, the United Arab Emirates, Malaysia, Brazil, and Qatar exhibited superior green logistics market performance. Furthermore, the Borda count results confirmed that China, the United Arab Emirates, Malaysia, Saudi Arabia, and Brazil consistently ranked as the foremost performers across the various methods. The findings imply that the highest-performing markets typically have advanced logistics infrastructures and a robust commitment to environmental sustainability. Emerging markets, such as China, the United Arab Emirates, and Saudi Arabia demonstrate strong green logistics efforts, which is driven by strategic government initiatives, substantial investments in eco-friendly infrastructure, and embracing innovative technologies (Liu et al., 2018; Wan et al., 2022; Wollenberg et al., 2023; Khan et al., 2025). These findings align with the research conducted by Kara et al. (2022), Özbek and Özekenci (2023), Özekenci (2023), and Bulut and Abacıoğlu (2025), which underscores the significant role that advanced economies in emerging markets play in the development of the logistics industry. Conversely, countries such as Indonesia, Kuwait, Bahrain, South Africa, and Vietnam exhibited the weakest performance. Several factors may be caused by this situation, including poorly structured logistics services, mismanagement, limited resources, security concerns, insufficient environmental awareness, and economic challenges.

Sensitivity and comparative analyses are frequently employed to evaluate the reliability of results in MCDM studies. Within this framework, a hybrid model was assessed using both analytical approaches. First, a sensitivity analysis was performed to compare the hybrid model with various established weighting techniques, including CRITIC, MPSI, LOPCOW, and MEREC. Subsequently, a comparative analysis was carried out to examine the stability of rankings across five different MCDM methods. The results from the comparative analysis confirmed the robustness of the hybrid model. Based on these findings, several managerial implications can be proposed:

- Decision-makers in selected countries should prioritize enhancing infrastructure and procedures that support international logistics capabilities. This initiative should improve port efficiency, streamline customs procedures, and facilitate cross-border trade.
- Policymakers must also concentrate on advancing environmentally sustainable practices within the logistics sector. This involves initiatives designed to reduce emissions and mitigate environmental damage, as the success of EPI significantly impacts the effectiveness of green logistics market performance.
- Leaders in selected countries must collaborate to establish regional logistics centers that effectively integrate rural and urban markets.
- Policymakers should prioritize ecosystem health in their long-term strategies by promoting the adoption of green technologies.
- Emerging markets have a unique opportunity to improve logistics efficiency through regional collaboration, fostering the exchange of knowledge and resources.
- Periodic comparisons with top-performing green logistics markets such as China, the United Arab Emirates, and Malaysia can provide essential understandings for identifying improvement areas. Implementing national logistics performance indicators aligning with global benchmarks will assist policymakers and industry stakeholders in enhancing green logistics market efficiency.

It is important to acknowledge that this study has several limitations despite offering valuable insights into key emerging nations' green logistics market performance.

While it employed seven criteria—three focused on environmental performance and four on logistics market performance—it may not encompass all aspects of performance evaluation. Future research could consider additional criteria. Similarly, this study centers exclusively on selected emerging nations' green logistics market performance; thus, its findings may not apply to other countries or sectors. Another limitation of this study is that, although it quantitatively evaluates green logistics performance in emerging markets, it fails to consider the specific government policies or regulations that may influence these results. Future research should incorporate insights into policies to provide a more comprehensive understanding of logistics efficiency and environmental performance in these countries. Lastly, extending the timeframe for assessing green logistics market performance could lead to a more comprehensive understanding of the subject.

Declarations

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Conflicts of interest/Competing interests

There is no conflict of interest/Competing interests

Availability of data and material

The data that support the findings of this study are openly available in the website of Agility Emerging Markets Logistics Index report (www.emli.agility.com/) and Environmental Performance Index report (https://epi.yale.edu/).

Code Availability

The computer program results are shared through the tables in the manuscript.

Authors' Contributions

The author is responsible for the entirety of the research.

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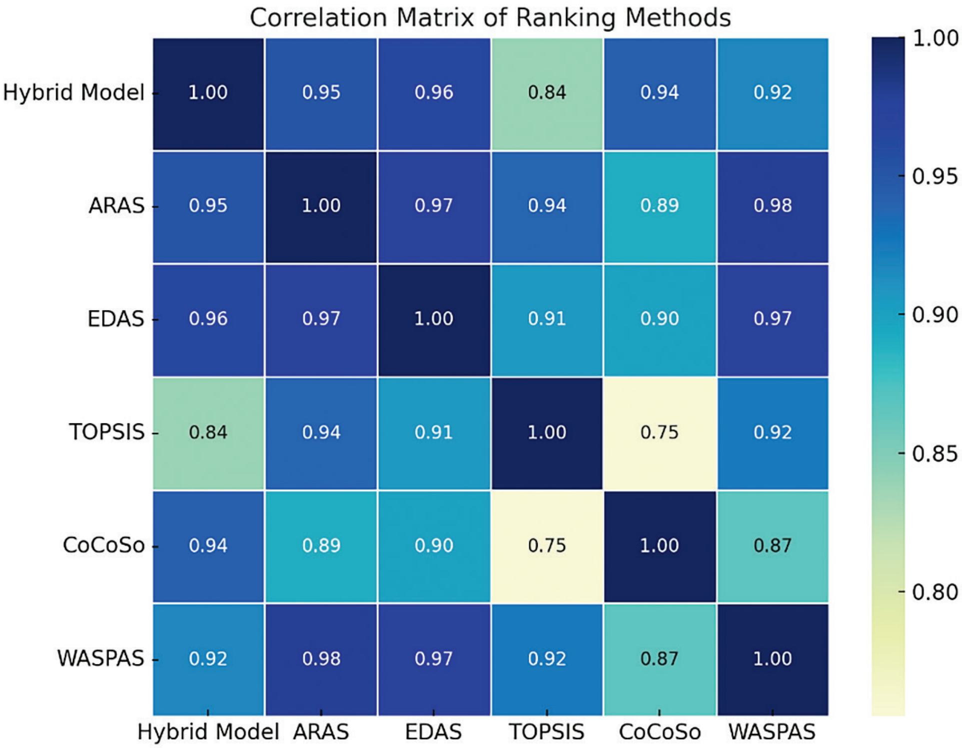
Appendix – 1

Emerging Markets	Hybrid Model	EPI	AEMLI
China	1	16	1
India	12	19	2
United Arab Emirates	2	2	3
Saudi Arabia	4	13	4
Malaysia	3	14	5
Indonesia	17	18	6
Mexico	8	10	7
Qatar	6	6	8
Thailand	10	8	9
Vietnam	20	20	10
Chile	7	4	11
Türkiye	15	15	12
Brazil	4	1	13
Oman	9	3	14
Russia	11	7	15
Bahrain	18	17	16
Jordan	13	5	17
Kuwait	15	9	18
Uruguay	14	11	19
South Africa	18	12	20

Appendix – 2


Correlation Matrix of Ranking Methods
Hybrid Model
ARAS
EDAS
TOPSIS
CoCoSo
WASPAS
1.00 0.95 0.96 0.84 0.94 0.92
0.95 1.00 0.97 0.94 0.89 0.98
0.96 0.97 1.00 0.91 0.90 0.97
0.84 0.94 0.91 1.00 0.75 0.92
0.94 0.89 0.90 0.75 1.00 0.87
0.92 0.98 0.97 0.92 0.87 1.00
1.00
0.95
0.90
0.85
0.80