Journal of Green Economy and Low-Carbon Development
https://www.acadlore.com/journals/JGELCD

Comparative Evaluation of the CREAM and RETRAC Intermodal Freight Corridors: Environmental, Safety, and Economic Impacts

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Received: 01-03-2025 **Revised:** 02-19-2025 **Accepted:** 03-05-2025

Citation: M. Krstić, S. Tadić, M. Jolović, and M. Veljović, "Comparative evaluation of the CREAM and RETRAC intermodal freight corridors: Environmental, safety, and economic impacts," *J. Green Econ. Low-Carbon Dev.*, vol. 4, no. 1, pp. 1–16, 2025. https://doi.org/10.56578/jgelcd040101.

Abstract: The European Union has actively promoted the development of intermodal transport as a response to the ecological and safety challenges posed by global transportation flows. Through projects such as Customer-driven Rail-freight services on a European mega-corridor based on Advanced business and operating Models (CREAM) and Reorganization of Transport Networks through Advanced Rail Freight Concepts (RETRAC), substantial improvements in rail freight transport on European mega-corridors have been achieved. These initiatives aim to enhance transportation efficiency, reduce environmental impacts, and improve safety. The proximity of Serbia to these key corridors, coupled with its involvement in these projects, presents an opportunity for the country to enhance its infrastructure, expand its business prospects, and increase its global market competitiveness. Furthermore, such developments will contribute significantly to Serbia's economic growth and its integration into European transportation networks. This study evaluates the CREAM and RETRAC corridors by examining their effects on environmental sustainability, transportation safety, and economic development. The paper also assesses their overall efficiency and sustainability, providing valuable insights for strategic decision-making. Given the complex nature of intermodal freight corridors, the evaluation process incorporates Multi-criteria decision making (MCDM) techniques, considering a variety of performance indicators. Specifically, the hybrid model combining the Fuzzy Aggregated Distance-Based Measurement (FADAM) method and the Fuzzy Best-Worst Method (FBWM) is applied to offer a comprehensive analysis. This approach allows for the systematic assessment of the two corridors, supporting the development of strategies aimed at optimizing their performance and sustainability.

Keywords: Intermodal transport; Intermodal corridors; European mega-corridor based on Advanced business and operating Models (CREAM); Reorganization of Transport Networks through Advanced Rail Freight Concepts (RETRAC); Environmental sustainability; Transport safety; Economic development; Fuzzy Best-Worst Method (FBWM); Fuzzy Aggregated Distance-Based Measurement (FADAM); Multi-criteria decision making (MCDM)

1 Introduction

Intermodal transport has emerged as an essential part of the European Union's transport policy strategy in response to the ever-increasing complexity of the global market's demands and in support of sustainable development [1]. According to the European Commission's definition, intermodal transport involves the use of at least two different modes of transport within the same door-to-door transport chain, whereby goods are transported in the same loading unit or vehicle without direct handling during the mode change [2].

The European Commission is increasingly prioritizing environmental and safety concerns in response to various challenges in the logistics and transport sector, including air pollution, climate change, noise, traffic congestion, and accidents, by promoting intermodal transport.In this way, in the 2011 White Paper on Transport, a goal was set to shift 30% of freight currently transported by road to other modes of transport, such as rail and inland waterways, by 2030, and 50% by 2050 [3]. The European Commission seeks to minimize the negative impacts of transportation by establishing a number of programs and projects that promote effective and sustainable transportation. The development of intermodal transport in the EU is supported, among other things, through the financing of railway

https://doi.org/10.56578/jgelcd040101

development projects within the 6th Framework Programme, such as the CREAM and RETRAC projects, which are the focus of this paper [4]. These corridors have specific characteristics and challenges, making them strategic and complex components of the European logistics and transportation network.

In order to optimize logistics flows and lower transportation costs, intermodal corridors refer to the transportation infrastructure that makes it possible for various modes of transportation, including air, sea, rail, and road, to be connected efficiently. They connect two or more terminals along a main route, allowing for the effortless transfer of goods from one mode of transport to another, within or between member states, and, where applicable, to third-party European countries, without causing long delays [5].

Given the existing barriers in logistics and trade, such as infrastructure issues, numerous laws and regulations, as well as the inevitable obstacles posed by market competition, it is not enough to merely construct roads, railways, and other infrastructure projects into which significant investments are made. It is also important how the infrastructure is utilized to bring about the maximum benefit [6]. In this regard, in order to assess the advantages, limitations, and strategic potential of the mentioned intermodal corridors, the use of MCDM methods is crucial, as they allow for precise and thorough evaluation of various aspects of their performance and significance. The choice between corridors depends on the specific goal that is to be achieved. In this context, the decision-making process is highly challenging, complex, and requires careful consideration of various factors [7].

The hybrid model applied in this paper combines the FBW and FADAM methods. By integrating different methodological approaches, it allows for the utilization of their advantages and effectively solves problems under conditions of uncertainty and imprecision, providing robust and reliable solutions. The goal of this paper is a comparative analysis and evaluation of the intermodal corridors CREAM and RETRAC in order to identify their strengths and weaknesses. This research contributes to a better understanding of the role of intermodal corridors in the European transport system, considering their significance in increasing efficiency, reducing costs, and improving transport sustainability.

The structure of this paper is organized as follows: Section 2 provides a comprehensive review of the relevant literature. In Section 3, a detailed examination of the problem is presented, along with the criteria essential for its resolution. Section 4 introduces the methodology of the proposed hybrid model, designed as a tool for addressing the identified problem. Section 5 showcases the results obtained through the model's application and includes a comparative sensitivity analysis to illustrate the method's effectiveness. Finally, the concluding section summarizes the key findings and implications of the study.

2 Literature Review

Intermodal transport is one of the key elements in achieving a cost-effective freight transportation system [8]. It offers a major advantage over individual modes of transportation by reducing the negative effects of transportation while meeting increasing demand volumes with greater flexibility [9]. Since every mode of transportation has pros and cons of its own, intermodal transportation's main function is to combine them in a way that minimizes their disadvantages and optimizes the integrated transport chain's overall performance. As a result, such a transport system contributes to more efficient use of resources and the reduction of total costs, while simultaneously maintaining high standards in terms of safety, reliability, and sustainability [10]. A new transport system with a fully integrated chain that allows for full door-to-door service is created by utilizing the best aspects of various modes of transportation in a synergistic manner [11].

It is difficult to create an integrated logistics chain in Europe because of the wide variations in standards and transportation infrastructure and logistics systems among the nations. The ability of various systems to work together harmoniously, which is necessary for the effective and continuous exchange of goods, is how intermodal corridors solve these problems [12]. Intermodal corridors facilitate the flow of information and goods around the world, enabling systems to operate freely and efficiently across national borders.

The CREAM and RETRAC corridors, which are the focus of this paper, contribute to enhancing cooperation among railway infrastructure managers and ensuring a better-connected and more efficient logistics network in Europe. By reducing travel times and encouraging the switch from road to rail transportation, the CREAM project has improved rail freight transport between Western and Southeastern Europe [13]. However, a new rail service connecting Hungary and the Benelux countries was successfully launched by the RETRAC project, significantly improving connectivity and efficiency along this corridor [14]. These corridors facilitate the easier international flow of goods with shorter delivery times and lower costs by improving the organizational and technical integration of different national systems. In this manner, the European transport network is strengthened, and interoperability is encouraged, offering a strong basis for improving logistics across the continent [15].

When it comes to the analysis and evaluation of corridors, five main approaches stand out [16]: Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA), Regional Economic Impact Study (REIS), Environmental Impact Assessment (EIA), and Multi-Criteria Decision-Making Analysis (MCDMA), which will be applied in this paper.

According to Taherdoost and Madanchian [17], multi-criteria analysis is one of the most accurate decision-making methods. Every MCDM aims to assist decision-makers in situations where there are multiple approaches to a problem [7]. When solving an MCDM problem, it is first necessary to define alternatives and criteria and determine their weights, after which the alternatives are evaluated according to the defined criteria [18, 19]. Bhole and Deshmukh [20] emphasize that considering multiple criteria simultaneously, as well as providing a basis for more efficient and precise decision-making, makes MCDM methods essential in modern logistics systems, which is why they play a significant role in logistics. Additionally, they think that the use of hybrid models greatly advances and enhances MCDM in logistics and other fields.

The MCDM methods that will be used in this paper are the FBWM method for determining the weights of criteria, which takes into account the best and worst aspects of each criterion, and the FADAM method for obtaining alternative ratings, the final ranking, and selecting the most favorable alternative based on their distance from ideal values. These methods are widely used to address logistics challenges. Therefore, the FADAM method has been applied by Krstić and Tadić [21] for the optimal selection of cold chain logistics service providers in South-East Europe, Veljović et al. [22] for ranking Industry 4.0 technologies in the context of last-mile logistics, and Tadić et al. [23] for identifying the most favorable alternative for the intermodal transport chain for the import of tires from China to Bosnia and Herzegovina. However, Amiri et al. [24] used the FBWM method to evaluate and choose a sustainable supplier in supply chain management; Kurniawan and Puspitasari [25] used it to assess supplier selection factors in a small-medium scale paper manufacturer in Indonesia; Cergibozan and Gölcük [26] used it to determine the location of a regional disaster logistics warehouse in Izmir, and Krstić et al. [27] used it to solve the case study of choosing adequate handling equipment for the planned intermodal terminal in Belgrade.

3 Problem Description

By cutting down on travel times and delays at border crossings, the development of corridors significantly improves the quality of logistics services and promotes more efficient and seamless communication and flows throughout Europe [28]. According to Regmi and Hanaoka [29], the development of intermodal transport corridors is essential for promoting global trade because they connect different modes of transportation and improve logistics flow efficiency, which is particularly critical for landlocked countries like Serbia.

Chapman et al. [30] define the concept of a corridor as a linear spatial structure that runs along a transportation route and allows various modes of transportation to be integrated into a single, cohesive system. A corridor is a geographical phenomenon that includes both urban and rural regional areas. Transport infrastructure connects a number of intermodal terminals located along an intermodal corridor, which is a linear spatial structure that spans multiple nations and regions. A land belt around the corridor, transport lines or routes, intermodal terminals, roads connecting the shipper to the terminal and the terminal to the consignee, a route connecting particular points, links between these points, and shippers and consignees of goods are all part of it [31]. The intermodal corridors CREAM and RETRAC consist of railway infrastructure, which is justified considering that rail transport is the most favorable land alternative to road transport when goods are transported over medium and long distances, especially between European Union countries.

According to De Bod and Havenga [32], an intermodal corridor is crucial in determining trends in regional economic development and growth. The quality, planning, and management of the use of existing corridors is an important requirement for drawing in new customers [33]. Šakalys and Batarlienė [34] state that analyzing international transportation corridors is essential for determining competing modes of transportation and evaluating the reasons behind infrastructure investments,by implementing intermodal corridors, transport becomes faster, more efficient, and cheaper, which attracts more users and contributes to the improvement of the entire transport sector in Europe.

A key component in the analysis and evaluation of transport corridors involves the appropriate selection of a set of criteria, or performance measures, that describe the proposed alternatives (corridors).

Bunker [35] defines the following groups of criteria in his work:

- Operational efficiency of the system: measures productivity (net ton-kilometers per employee in freight transport, average freight transport revenue per employee in freight transport), capital productivity (productivity of locomotives, wagons, and tracks), and efficiency in capital utilization,
- Environmental sustainability: energy consumption, fuel use, vehicle productivity, and greenhouse gas (GHG) emissions,
- Safety: accident rate, fatality rate, and accident costs,
- Financial responsibility: transport fees and transport costs,
- Social acceptability: factors such as noise level.

Alazzawi and Żak [36] applied the following criteria: Product Purchase and Delivery Costs, Product Quality, Position and Credit of Supplier, Delivery Time, Safety and Reliability of the Corridor, Timeliness, and Environmental Friendliness (CO_2 emissions). On the other hand, Żak and Galińska [16] defined the following criteria:

Transportation Costs, Delivery Time, Timeliness of Delivery, Reliability of a Transportation Corridor, Flexibility of a Transportation Corridor, Safety of a Transportation Corridor, and Customer's Comfort.

In the evaluation criteria for ranking and identifying the more favorable of the two competing corridors, CREAM and RETRAC, various indicators and performance measures are used. Performance indicators refer to the information that is regularly collected to monitor the specific performance of a system, which, in this case, is the corridor. They allow for monitoring the system's functioning over time and enable decision-makers to assess its efficiency and effectiveness. Performance measures can be defined as quantitatively or qualitatively expressed values used to evaluate the efficiency and effectiveness of the corridor from various perspectives, such as physical/spatial or infrastructure-related, technical-technological, operational, economic, social, and environmental aspects. These measures enable the assessment of performance relative to set objectives [31, 37, 38].

The criteria that will be applied in this work for the analysis and evaluation of the CREAM and RETRAC corridors are divided into the following groups [31, 39, 40]:

Infrastructural criteria (C1) define the structural characteristics of infrastructure, transport means, and supporting equipment and facilities:

- $C1_1$– Corridor length,
- $C1_2$ – Accessibility,
- $C1_3$ – Area coverage,
- $C1_4$ – Infrastructure density,
- $C1_5$– Route length.

Technical-technological criteria (C2) define the technical characteristics of transportation systems:

- $C2_1$ – Propulsion systems,
- $C2_2$ – Electric propulsion systems,
- $C2_3$ – Length, weight, cargo capacity, and technical speed of trains,
- $C2_4$ – Length, weight, and cargo capacity of train wagons,
- $C2_5$ – Number of wagons per train,
- $C2_6$ – Interoperability.

Operational criteria (C3) relate to the efficiency of the corridor in terms of demand for transport services, capacity, and the time required for cargo delivery:

- $C3_1$ – Demand density,
- $C3_2$ – Transport capacity,
- $C3_3$ – Transport concentration,
- $C3_4$ – Transport intensity,
- $C3_5$ – Operating capacity,
- $C3_6$ – Production capacity,
- $C3_7$ – TEU transit time,
- $C3_8$ –TEU delivery time,
- $C3_9$ – Service reliability,
- $C3_{10}$ – Service punctuality,
- $C3_{11}$ – Load factor.

Economic criteria (C4) include the costs incurred during the provision of transportation services, including the assessment of economic effects:

- $C4_1$ – Operational and time costs,
- $C4_2$ – External costs,
- $C4_3$ – Total costs,
- $C4_4$ – Contribution to welfare.

Socio-ecological criteria (C5) assess the impact of the corridor on the environment and society:

- $C5_1$ – Noise,
- $C5_2$ – Safety,
- $C5_3$ – Energy/fuel consumption and greenhouse gas (GHG) effects,
- $C5_4$ – Land use.

Although the mentioned groups of criteria appear to be completely independent, it is important to emphasize the fact that they are interconnected and influence each other in reality. For example, the technical and technological performance of transport vehicles may require entirely new infrastructure, which can, in turn, impact the economic, environmental, and social performance. They can also affect other performances because the capabilities and characteristics of the technology used in the transport system directly influence how the system operates. For instance, if advanced technology is used that enables faster and more efficient movement of transport vehicles, this can directly improve operational performance, such as delivery speed or reduction in idle time. On the other hand, improved operational performance often results in lower costs or increased revenue, which can lead to better economic efficiency of the system. Furthermore, environmental and/or social performance can also accelerate the development and commercialization of entirely new technical and technological systems, such as advanced vehicles that use electric energy instead of the currently used gasoline or diesel.

4 Methodology

A structured system of pairwise comparisons serves as the foundation for the Best-Worst Method (BWM) in fuzzy environments [41]. Pairwise comparisons with two reference criteria—the best (most important) and the worst (least important)—are used to determine the weights of the criteria. To put it another way, the decision-maker determines the best and worst criteria and then assesses all the others in regard to them as reference criteria rather than directly comparing them to one another. Because it effectively eliminates the inconsistencies found in pairwise comparisons, this method is regarded as one of the most well-known and successful MCDM techniques, increasing their accuracy and practicality [42, 43]. The FADAM method, on the other hand, is a completely new class of geometric MCDM techniques in which the volumes of complex polyhedra are used to rank the alternatives. In other words, the method forms polyhedra that represent the overall evaluation of each alternative. Each alternative is assessed based on a complex aggregated value, which is obtained by combining the weights of the criteria with the values of the alternatives according to the observed criteria. The evaluations of alternatives are expressed as fuzzy values based on uncertainty. The polyhedron's volume is used for ranking; a higher volume indicates a better assessment of the alternative [44, 45].

The following describes the steps of the hybrid model, which combines the two previously mentioned methods.

Step 1: Describing the structure of the problem.

Step 2: Specifying the fuzzy scale to assess criteria and alternatives. Table 1 lists linguistic terms along with their triangular fuzzy values.

Table 1. Linguistic terms and corresponding fuzzy values

Linguistic Term	Abbreviations	Fuzzy Scale
"Extremely High"	"EH"	$(8, 9, 10)$
"Very High"	"VH"	$(7, 8, 9)$
"High"	"H"	$(6, 7, 8)$
"Fairly High"	"FH"	$(5, 6, 7)$
"Fairly Low"	"M"	$(4, 5, 6)$
"Low"	"FL"	$(3, 4, 5)$
"Very Low"	"L"	$(2, 3, 4)$
"None"	"VL"	$(1, 2, 3)$

Step 3: Applying the FBWM method to obtain criterion weights. Below is an explanation of the method's steps (3.1-3.4) [19, 46].

Step 3.1: Finding the best criterion c_B and the worst criterion c_W.

Step 3.2: Evaluating the other criteria in relation to the best criterion c_B using the triangular fuzzy numbers shown in Table 1.

Step 3.3: Evaluating the other criteria in relation to the worst criterion c_W using the triangular fuzzy numbers shown in Table 1.

Step 3.4: Determining the optimal fuzzy weights of criteria:

$$\min \max_j \left\{ \left| \frac{\widetilde{w}_B}{\widetilde{w}_j} - \tilde{a}_{Bj} \right|, \left| \frac{\widetilde{w}_j}{\widetilde{w}_W} - \tilde{a}_{jw} \right| \right\} \tag{1}$$

$$\text{If} \begin{cases} \sum_{j=1}^{n} R\left(\widetilde{w}_j\right) = 1 \\ l_j^w \leq m_j^w \leq u_j^w \\ l_j^w \geq 0 \\ j = 1, 2, \ldots, n \end{cases}$$

where, $\widetilde{w}_B = \left(l_B^w, m_B^w, u_B^w\right)$, $\widetilde{w}_j = \left(l_j^w, m_j^w, u_j^w\right)$, $\widetilde{w}_W = \left(l_W^w, m_W^w, u_W^w\right)$, $\tilde{a}_{Bj} = \left(l_{Bj}, m_{Bj}, u_{Bj}\right)$ and $\tilde{a}_{Wj} = \left(l_{Wj}, m_{Wj}, u_{Wj}\right)$ are triangular fuzzy numbers, and $R\left(\widetilde{w}_j\right)$ represents the defuzzified value of the fuzzy number $\widetilde{w}_j$ obtained by applying the equation:

$$R\left(\widetilde{w}_j\right) = \frac{l_j^w + 4m_j^w + u_j^w}{6} \tag{2}$$

Eq. (1) can be transformed into the following optimization problem with nonlinear constraints:

$$\min \tilde{\xi}$$
$$\begin{cases} \left| \frac{\widetilde{w}_B}{\widetilde{w}_j} - \tilde{a}_{Bj} \right| \leq \tilde{\xi} \\ \left| \frac{\tilde{w}_j}{\tilde{w}_w} - \tilde{a}_{jw} \right| \leq \xi \\ \sum_{j=1}^{n} R\left(\widetilde{w}_j\right) = 1 \\ l_j^w \leq m_j^w \leq u_j^w \\ l_j^w \geq 0 \\ j = 1, 2, \ldots, n \end{cases} \tag{3}$$

where, $\tilde{\xi} = \left(l^{\xi}, m^{\xi}, u^{\xi}\right)$.. Given that $l^{\xi} \leq m^{\xi} \leq u^{\xi}$, it is assumed that $\tilde{\xi}^* = (k^*, k^*, k^*)$, where, $k^* \leq l^{\xi}$. Then, Eq. (3) can be transformed into the following equation, whose solution yields the optimal fuzzy weights of the criteria:

$$\text{If} \begin{cases} \min \tilde{\zeta}^* \\ \left| \frac{(l_B^w, m_B^w, u_B^w)}{(l_j^w, m_j^w, u_j^w)} - (l_{Bj}, m_{Bj}, u_{Bj}) \right| \leq (k^*, k^*, k^*) \\ \left| \frac{\left(l_j^w, m_j^w, u_j^w\right)}{\left(l_W^w, m_W^w, u_W^w\right)} - (l_{jW}, m_{jW}, u_{jW}) \right| \leq (k^*, k^*, k^*) \\ \sum_{j=1}^{n} R\left(\widetilde{w}_j\right) = 1 \\ l_j^w \leq m_j^w \leq u_j^w \\ l_j^w \geq 0 \\ j = 1, 2, \ldots, n \end{cases} \tag{4}$$

Step 4: Applying the FADAM method to evaluate and rank the alternatives. Below is an explanation of the method's steps (4.1–4.6) [27]:

Step 4.1: Defining the decision matrix $\tilde{E}$:

$$\widetilde{\mathrm{E}} = \left[\tilde{e}_{ij}\right]_{m \times n} \tag{5}$$

where, $\tilde{e}_{ij} = (l^e, m^e, u^e)$ represents the evaluations of alternative i, where,i=(1,2,. . . ,m), in relation to criteria j, where, j=(1,2,. . . ,n).

Step 4.2: Defining the normalized decision matrix $\widetilde{N}$:

$$\widetilde{N} = \left[\tilde{n}_{ij}\right]_{m \times n} \tag{6}$$

where, $\tilde{n}_{ij} = (l^n, m^n, u^n)$ represents the normalized evaluations $\tilde{e}_{ij}$ jobtained in the following way:

$$l^n = \frac{l^e}{\max u^e} \tag{7}$$

$$m^n = \frac{m^e}{\max u^e} \tag{8}$$

$$u^n = \frac{u^e}{\max u^e} \tag{9}$$

Step 4.3: Defining the sorted decision matrix $\tilde{S}$:

$$\tilde{S} = \left[\tilde{S}_{ij}\right]_{m \times n} \tag{10}$$

where, $\tilde{s}_{ij} = (l^s, m^s, u^s)$ represents the scores $\tilde{n}_{ij}$ that are sorted in descending order according to the weight of the criteria.

Step 4.4: Finding the coordinates $(\tilde{x}_{ij}, \tilde{y}_{ij}, \tilde{z}_{ij})$ of the fuzzy reference points $\tilde{R}_{ij}$ and fuzzy weight reference points $\tilde{P}_{ij}$ that define the complex polyhedron as follows:

$$\tilde{x}_{ij} = (l^{x_{ij}}, m^{x_{ij}}, u^{x_{ij}}) = (l^{s_{ij}} \times \sin \alpha_j, m^{s_{ij}} \times \sin \alpha_j, u^{s_{ij}} \times \sin \alpha_j) \tag{11}$$

$$\tilde{y}_{ij} = \left(l^{y_{ij}}, m^{y_{ij}}, u^{y_{ij}}\right) = \left(l^{s_{ij}} \times \cos\alpha_j, m^{s_{ij}} \times \cos\alpha_j, u^{s_{ij}} \times \cos\alpha_j\right) \tag{12}$$

$$\tilde{z}_{ij} = \left(l^{z_{ij}}, m^{z_{ij}}, u^{z_{ij}}\right) = \begin{cases} (0,0,0), \text{ for } \tilde{R}_{ij} \\ \left(l^{w_j}, m^{w_j}, u^{w_j}\right), \text{ for } \tilde{P}_{ij} \end{cases} \tag{13}$$

for $\forall_j = 1, \ldots, n; \forall_i = 1, \ldots, m$, where, α_j is obtained by applying the following equation:

$$\alpha_{\mathrm{j}} = (j-1)\frac{90^\circ}{n-1}, \forall_j = 1, \ldots, n \tag{14}$$

Step 4.5: Finding the fuzzy values of the volumes of complex polyhedral $\tilde{V}_i^C$:

$$\tilde{V}_i^C = \sum_{k=1}^{n-1} \tilde{V}_k, \forall_i = 1, \ldots, m \tag{15}$$

where, $\tilde{V}_k$ is the fuzzy volume of the pyramid defined for each pair of two consecutive criteria, and is obtained by applying the following equation:

$$\tilde{V}_k = \frac{1}{3}\tilde{B}_k \otimes \tilde{h}_k, \forall_k = 1, \ldots, n-1 \tag{16}$$

where, $\tilde{B}_k$ is the fuzzy value of the base area of the pyramid and is obtained as:

$$\tilde{B}_k = \tilde{c}_k \otimes \tilde{a}_k \oplus \frac{\tilde{a}_k \otimes \left(\tilde{b}_k \ominus \tilde{c}_k\right)}{2} \tag{17}$$

where, $\tilde{a}_k = \left(l^{ak}, m^{ak}, u^{ak}\right)$ represents the fuzzy values of Euclidean distances, in which:

$$l^{a_k} = \min\left(\sqrt{\left(u^{x_{j+1}} - l^{x_j}\right)^2 + \left(u^{y_{j+1}} - l^{y_j}\right)^2}, \sqrt{\left(l^{x_{j+1}} - u^{x_j}\right)^2 + \left(l^{y_{j+1}} - u^{y_j}\right)^2}\right) \tag{18}$$

$$m^{a_k} = \sqrt{\left(m^{x_{j+1}} - m^{x_j}\right)^2 + \left(m^{y_{j+1}} - m^{y_j}\right)^2} \tag{19}$$

$$u^{a_k} = \max\left(\sqrt{\left(u^{x_{j+1}} - l^{x_j}\right)^2 + \left(u^{y_{j+1}} - l^{y_j}\right)^2}, \sqrt{\left(l^{x_{j+1}} - u^{x_j}\right)^2 + \left(l^{y_{j+1}} - u^{y_j}\right)^2}\right) \tag{20}$$

where, $\tilde{b}_k = \left(l^{b_k}, m^{b_k}, u^{b_k}\right)$ and $\tilde{c}_k = \left(l^{c_k}, m^{c_k}, u^{c_k}\right)$ are obtained in the following way:

$$\tilde{b}_k = \tilde{z}_j \tag{21}$$

$$\tilde{c}_k = \tilde{z}_{j+1} \tag{22}$$

According to Eqs. (18)-(22), Eq. (17) can be expressed as $\tilde{B}_k = \left(l^{B_k}, m^{B_k}, u^{B_k}\right)$:

$$l^{B_k} = l^{c_k} \times l^{a_k} + \frac{l^{a_k} \times \left(l^{b_k} - u^{c_k}\right)}{2} \tag{23}$$

$$m^{B_k} = m^{c_k} \times m^{a_k} + \frac{m^{a_k} \times \left(m^{b_k} - m^{c_k}\right)}{2} \tag{24}$$

$$u^{B_k} = u^{c_k} \times u^{a_k} + \frac{u^{a_k} \times \left(u^{b_k} - l^{c_k}\right)}{2} \tag{25}$$

where, $\tilde{h}_k$ represents the fuzzy values of the pyramid heights and $\tilde{S}_k$ represents the fuzzy values of the semi-perimeter of the triangles defined by the reference points of two consecutive criteria and the coordinate origin, and they are calculated as follows:

$$\tilde{h}_k = \sqrt[2]{\frac{\tilde{s}_k\left(\tilde{s}_k - \tilde{a}_k\right)\left(\tilde{s}_k - \tilde{d}_k\right)\left(\tilde{s}_k - \tilde{e}_k\right)}{\tilde{a}_k}} \tag{26}$$

$$\tilde{s}_k = \frac{\tilde{a}_k \oplus \tilde{d}_k \oplus \tilde{e}_k}{2} \tag{27}$$

where, $\tilde{d}_k$ can be expressed as $\tilde{d}_k = \left(l^{d_k}, m^{d_k}, u^{d_k}\right)$:

$$l^{d_k} = \sqrt{\left(l^{x_j}\right)^2 + \left(l^{y_j}\right)^2} \tag{28}$$

$$m^{d_k} = \sqrt{\left(m^{x_j}\right)^2 + \left(m^{y_j}\right)^2} \tag{29}$$

$$u^{d_k} = \sqrt{\left(u^{x_j}\right)^2 + \left(u^{y_j}\right)^2} \tag{30}$$

where, $\tilde{\mathrm{e}}_k$ can be expressed as $\tilde{\mathrm{e}}_k = \left(l^{\mathrm{e}_k}, m^{\mathrm{e}_k}, u^{\mathrm{e}_k}\right)$:

$$l^{e_k} = \sqrt{\left(l^{x_{j+1}}\right)^2 + \left(l^{y_{j+1}}\right)^2} \tag{31}$$

$$m^{e_k} = \sqrt{\left(m^{x_{j+1}}\right)^2 + \left(m^{y_{j+1}}\right)^2} \tag{32}$$

$$u^{e_k} = \sqrt{\left(u^{x_{j+1}}\right)^2 + \left(u^{y_{j+1}}\right)^2} \tag{33}$$

According to Eqs. (18)-(20) and (28)-(33), Eq. (27) can be expressed as $\tilde{s}_k = \left(l^{s_k}, m^{s_k}, u^{s_k}\right)$:

$$l^{s_k} = \frac{l^{a_k} + l^{d_k} + l^{e_k}}{2} \tag{34}$$

$$m^{s_k} = \frac{m^{a_k} + m^{d_k} + m^{e_k}}{2} \tag{35}$$

$$u^{s_k} = \frac{u^{a_k} + u^{d_k} + u^{e_k}}{2} \tag{36}$$

and Eq. (26) can be expressed as $\tilde{h}_k = \left(l^{h_k}, m^{h_k}, u^{h_k}\right)$:

$$l^{h_k} = \frac{\sqrt[2]{l^{s_k}\left|l^{s_k} - u^{a_k}\right|\left|l^{s_k} - u^{d_k}\right|\left|l^{s_k} - u^{e_k}\right|}}{u^{a_k}} \tag{37}$$

$$m^{h_k} = \frac{\sqrt[2]{m^{s_k}\left|m^{s_k} - m^{a_k}\right|\left|m^{s_k} - m^{d_k}\right|\left|m^{s_k} - m^{e_k}\right|}}{m^{a_k}} \tag{38}$$

$$u^{h_k} = \frac{\sqrt[2]{u^{s_k} \left|u^{s_k} - l^{a_k}\right\| u^{s_k} - l^{d_k} \left\| u^{s_k} - l^{e_k}\right|}}{l^{a_k}} \tag{39}$$

According to the transformed Eqs. (23)-(25) and (37)-(39), Eq. (16) can be expressed as $\tilde{V}_k = \left(l^{V_k}, m^{V_k}, u^{V_k}\right)$ y kojoj:

$$l^{V_k} = \frac{l^{B_k} \times l^{h_k}}{3} \tag{40}$$

$$m^{V_k} = \frac{m^{B_k} \times m^{h_k}}{3} \tag{41}$$

$$u^{V_k} = \frac{u^{B_k} \times u^{h_k}}{3} \tag{42}$$

and Eq. (15) as $\tilde{V}_i^C = \left(l^{v_i^C}, m^{v_i^C}, u^{v_i^C}\right)$, where:

$$l_i^{V_i^C} = \sum_{k=1}^{n-1} l^{V_k} \tag{43}$$

$$m^{V_i^C} = \sum_{k=1}^{n-1} m^{V_k} \tag{44}$$

$$u^{V_i^C} = \sum_{k=1}^{n-1} u^{V_k} \tag{45}$$

Step 4.6: Ranking alternatives based on the point values of the volumes of complex polyhedral:

$$\text{Crisp}\left(\widetilde{V}_i^C\right) = \frac{\left(4m^{v_i^C} + u^{v_i^C} - 2l^{v_i^C}\right)}{3\left(u_i^{v_i^C} - 2l_i^{V_i^C}\right)} \tag{46}$$

5 Results

First, the groups of criteria $C_j(J{=}1,\ldots,5)$ were compared. The "best" or most important group was selected, followed by the "worst" or least important group of criteria. Afterward, the remaining groups of criteria were evaluated in relation to these two reference groups, as explained in the previous chapter. Selecting reference groups of criteria is generally a very complex task, given the fact that different performances affect the efficiency and sustainability of freight transport in different ways. When it comes to intermodal corridors, it is difficult to single out the most important performance group, and especially the least important, because all of them collectively influence the overall success of the logistics system. However, it can be said that infrastructure performances are crucial for corridors as they relate to the physical characteristics and condition of the infrastructure, which is the foundation of efficient, reliable, and safe intermodal transport. Infrastructure performances affect transport speed, economic development promotion, cost and delivery time reduction, and enable further development, management, and improvement of the corridor. In other words, infrastructure is the backbone of any logistics system, and if it does not function properly, it can lead to numerous challenges in operation and problems for users. High-quality infrastructure is a fundamental prerequisite for achieving the goals of other performance groups, thus making infrastructure performances more important than other groups. Although socio-ecological performances are increasingly gaining significance in the context of sustainability, especially in areas such as intermodal corridors, they are prioritized over the functionality and efficiency of the system, which makes them the least important group. After evaluating the groups of criteria in relation to the best and worst, solving the nonlinear optimization problem (4) provides the optimal fuzzy values of the weights of individual groups of criteria $\widetilde{w}_{KJ}$, and the defuzzified values $R\left(\widetilde{w}_{\mathrm{KJ}}\right)$ are obtained using Eq. (2), as shown in Table 2.

Table 2. Relative weights of individual groups of criteria

$\mathbf{C_J}$			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathbf{K}J}$	$R\left(\widetilde{w}_{\mathbf{KJ}}\right)$
C1	c_B	-	$(1,1,1)$	VH	$(7,8,9)$	$(0.376,0.446,0.511)$	0.445
C2		FL	$(3,4,5)$	M	$(4,5,6)$	$(0.128,0.134,0.141)$	0.134
C3		VL	$(1,2,3)$	H	$(6,7,8)$	$(0.213,0.268,0.329)$	0.269
C4		M	$(4,5,6)$	FL	$(3,4,5)$	$(0.106,0.107,0.106)$	0.107
C5	c_W	VH	$(7,8,9)$	-	$(1,1,1)$	$(0.043,0.045,0.047)$	0.045

Table 3. Relative weights of infrastructural criteria

C1			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathbf{K1}j}$	$R\left(\widetilde{w}_{\mathbf{K1}j}\right)$
$\mathrm{C1}_1$		L	$(2,3,4)$	FL	$(3,4,5)$	$(0.138,0.149,0.190)$	0.154
$\mathrm{C1}_2$	c_B	-	$(1,1,1)$	FH	$(5,6,7)$	$(0.343,0.381,0.446)$	0.385
$\mathrm{C1}_3$		VL	$(1,1,2)$	M	$(4,5,6)$	$(0.276,0.328,0.305)$	0.316
$\mathrm{C1}_4$	c_W	FH	$(5,6,7)$	-	$(1,1,1)$	$(0.049,0.052,0.067)$	0.054
$\mathrm{C1}_5$		M	$(4,5,6)$	L	$(2,3,4)$	$(0.092,0.090,0.095)$	0.091

Table 4. Relative weights of technical-technological criteria

C2			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathbf{K2}j}$	$R\left(\widetilde{w}_{\mathbf{K2}j}\right)$
$\mathrm{C2}_1$		N	$(1,1,2)$	H	$(6,7,8)$	$(0.244,0.317,0.289)$	0.300
$\mathrm{C2}_2$		VL	$(1,2,3)$	FH	$(5,6,7)$	$(0.163,0.182,0.250)$	0.190
$\mathrm{C2}_3$		M	$(4,5,6)$	L	$(2,3,4)$	$(0.072,0.073,0.081)$	0.074
$\mathrm{C2}_4$		M	$(4,5,6)$	L	$(2,3,4)$	$(0.072,0.073,0.081)$	0.074
$\mathrm{C2}_5$	c_W	H	$(6,7,8)$	-	$(1,1,1)$	$(0.037,0.038,0.046)$	0.039
$\mathrm{C2}_6$	c_B	-	$(1,1,1)$	H	$(6,7,8)$	$(0.270,0.317,0.393)$	0.322

Table 5. Relative weights of operational criteria

C3			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathbf{K3}j}$	$R\left(\widetilde{w}_{\mathbf{K3}j}\right)$
$\mathrm{C3}_1$	c_B	-	$(1,1,1)$	FH	$(5,6,7)$	$(0.174,0.226,0.269)$	0.225
$\mathrm{C3}_2$		FL	$(3,4,5)$	L	$(2,3,4)$	$(0.063,0.066,0.067)$	0.066
$\mathrm{C3}_3$		FL	$(3,4,5)$	L	$(2,3,4)$	$(0.063,0.066,0.067)$	0.066
$\mathrm{C3}_4$		FL	$(3,4,5)$	L	$(2,3,4)$	$(0.063,0.066,0.067)$	0.066
$\mathrm{C3}_5$		VL	$(1,2,3)$	M	$(4,5,6)$	$(0.111,0.132,0.159)$	0.133
$\mathrm{C3}_6$		VL	$(1,2,3)$	M	$(4,5,6)$	$(0.111,0.132,0.159)$	0.133
$\mathrm{C3}_7$		L	$(2,3,4)$	FL	$(3,4,5)$	$(0.083,0.088,0.094)$	0.088
$\mathrm{C3}_8$		L	$(2,3,4)$	FL	$(3,4,5)$	$(0.083,0.088,0.094)$	0.088
$\mathrm{C3}_9$		M	$(4,5,6)$	VL	$(1,2,3)$	$(0.047,0.053,0.056)$	0.052
$\mathrm{C3}_{10}$		M	$(4,5,6)$	VL	$(1,2,3)$	$(0.047,0.053,0.056)$	0.052
$\mathrm{C3}_{11}$	c_W	FH	$(5,6,7)$	-	$(1,1,1)$	$(0.029,0.031,0.036)$	0.032

Table 6. Relative weights of economic criteria

C4			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathrm{K4j}}$	$R\left(\widetilde{w}_{\mathbf{K4}j}\right)$
$\mathrm{C4}_1$		FL	$(3,4,5)$	FH	$(5,6,7)$	$(0.172,0.197,0.230)$	0.198
$\mathrm{C4}_2$		M	$(5,6,7)$	FL	$(3,4,5)$	$(0.123,0.131,0.138)$	0.131
$\mathrm{C4}_3$	c_B	-	$(1,1,1)$	H	$(6,7,8)$	$(0.560,0.610,0.650)$	0.609
$\mathrm{C4}_4$	c_W	H	$(6,7,8)$	-	$(1,1,1)$	$(0.055,0.062,0.072)$	0.062

After determining the relative weights of the individual groups of criteria, the next step involves determining the relative weights of the criteria within each group. Accordingly, the previously described procedure is repeated for the criteria within each group separately, and the results are shown in Table 3, Table 4, Table 5, Table 6, and Table 7.

After calculating the criteria weights within each group using the FBWM method, the final criteria weights are obtained by multiplying the relative criteria weights with the corresponding group weights. Based on the results presented in Table 8, it can be concluded that the most important criterion is $\mathrm{C1}_2$ – Accessibility, while the least important criterion is $\mathrm{C5}_1$ – Noise.

Table 7. Relative weights of socio-ecological criteria

C5			$\tilde{a}_{Bj}$		$\tilde{a}_{jW}$	$\widetilde{w}_{\mathbf{K5}j}$	$R\left(\widetilde{w}_{\mathbf{K5}j}\right)$
C5$_1$	c_W	EH	$(8,9,10)$	-	$(1,1,1)$	$(0.044,0.049,0.066)$	0.051
C5$_2$	c_B	-	$(1,1,1)$	EH	$(8,9,10)$	$(0.088,0.696,0.720)$	0.599
C5$_3$		H	$(6,7,8)$	H	$(7,8,9)$	$(0.075,0.136,0.125)$	0.124
C5$_4$		VH	$(7,8,9)$	FH	$(5,6,7)$	$(0.111,0.119,0.770)$	0.226

Table 8. Final criteria weights

Criterion	$R\left(\widetilde{w}_{KJj}\right) \cdot R\left(\widetilde{w}_{KJ}\right)$
C1$_1$	0.069
C1$_2$	0.172
C1$_3$	0.141
C1$_4$	0.024
C1$_5$	0.040
C2$_1$	0.040
C2$_2$	0.026
C2$_3$	0.010
C2$_4$	0.010
C2$_5$	0.005
C2$_6$	0.043
C3$_1$	0.060
C3$_2$	0.018
C3$_3$	0.018
C3$_4$	0.018
C3$_5$	0.036
C3$_6$	0.036
C3$_7$	0.024
C3$_8$	0.024
C3$_9$	0.014
C3$_{10}$	0.014
C3$_{11}$	0.009
C4$_1$	0.021
C4$_2$	0.014
C4$_3$	0.065
C4$_4$	0.007
C5$_1$	0.002
C5$_2$	0.027
C5$_3$	0.006
C5$_4$	0.010

When the final weights of the criteria are collected, the next step involves evaluating intermodal corridors according to the criteria based on numerical values from a case study [31], as shown in Table 9. The corridors are evaluated on a scale presented in Table 1, where the applied evaluation method ensures that the corridor with the best performance according to the observed criterion receives the highest rating, while the other corridor receives a rating proportional to its distance from the best rating, thus allowing for an easy comparison of alternatives.

When evaluating the corridors, it is particularly important to ensure that the corridors have different ratings for each criterion. Otherwise, if both corridors have identical ratings for a certain criterion, the criterion becomes irrelevant to the decision-making process and cannot contribute to distinguishing and ranking the corridors. Instead, it would make the decision-making process more complex. For this reason, criteria by which the corridors do not differ are disregarded and removed from further consideration. These include criteria C2$_4$, C3$_5$, C3$_9$, and C4$_4$. Only those criteria that provide visible differences in the ratings of the corridors are included in the final analysis.

After evaluating the alternatives based on criteria, the FADAM method was applied to assess and select the best alternative, and the results are shown in Table 10. This table, in addition to the final scores, also displays the evaluations of the corridors according to the individual groups of criteria.

Based on the results, it can be seen that the CREAM corridor is the preferred alternative in terms of infrastructure and operational criteria, which leads to its higher final score precisely because these two groups are among the most important performance factors. Specifically, in terms of infrastructure criteria, the CREAM corridor achieves a better score due to its longer corridor length, better area coverage, and stronger infrastructure density, where these factors compensate for its weaknesses in accessibility and route length. Regarding operational criteria, the CREAM corridor is preferred in every criterion except for transportation concentration. From the perspective of economic and socio-ecological groups, the RETRAC corridor achieves more favorable scores on nearly every criterion, while from the technical-technological group, it represents the better alternative, mainly due to greater interoperability, i.e., fewer different propulsion systems used, which are specific to each country.

Table 9. Evaluations of alternatives based on criteria

Evaluations	RETRAC		CREAM	
$C1_1$	M	$(4,5,6)$	EH	$(8,9,10)$
$C1_2$	EH	$(8,9,10)$	H	$(6,7,8)$
$C1_3$	FH	$(5,6,7)$	EH	$(8,9,10)$
$C1_4$	H	$(6,7,8)$	EH	$(8,9,10)$
$C1_5$	EH	$(8,9,10)$	FH	$(5,6,7)$
$C2_1$	EH	$(8,9,10)$	M	$(4,5,6)$
$C2_2$	FH	$(5,6,7)$	EH	$(8,9,10)$
$C2_3$	VH	$(7,8,9)$	EH	$(8,9,10)$
$C2_4$	-	-	-	-
$C2_5$	VH	$(7,8,9)$	EH	$(8,9,10)$
$C2_6$	EH	$(8,9,10)$	FH	$(5,6,7)$
$C3_1$	N	$(1,1,2)$	EH	$(8,9,10)$
$C3_2$	H	$(6,7,8)$	EH	$(8,9,10)$
$C3_3$	EH	$(8,9,10)$	VH	$(7,8,9)$
$C3_4$	H	$(6,7,8)$	EH	$(8,9,10)$
$C3_5$	-	-	-	-
$C3_6$	FH	$(5,6,7)$	EH	$(8,9,10)$
$C3_7$	FH	$(5,6,7)$	EH	$(8,9,10)$
$C3_8$	M	$(4,5,6)$	EH	$(8,9,10)$
$C3_9$	-	$-$	-	-
$C3_{10}$	VH	$(7,8,9)$	EH	$(8,9,10)$
$C3_{11}$	VH	$(7,8,9)$	EH	$(8,9,10)$
$C4_1$	EH	$(8,9,10)$	H	$(6,7,8)$
$C4_2$	EH	$(8,9,10)$	VH	$(7,8,9)$
$C4_3$	EH	$(8,9,10)$	H	$(6,7,8)$
$C4_4$	-	-	-	-
$C5_1$	EH	$(8,9,10)$	FH	$(5,6,7)$
$C5_2$	EH	$(8,9,10)$	FH	$(5,6,7)$
$C5_3$	VH	$(7,8,9)$	EH	$(8,9,10)$
$C5_4$	EH	$(8,9,10)$	M	$(4,5,6)$

Table 10. Evaluations of alternatives based on groups of criteria

Criteria Group	RETRAC	CREAM	Rank
Infrastructural	0.0474	0.0673	2/1
Technical-technological	0.0646	0.0485	1/2
Operational	0.0206	0.0410	2/1
Economical	0.1094	0.0691	1/2
Socio-ecological	0.0899	0.0166	1/2
All groups	**0.0199**	**0.0230**	**2/1**

It is expected that when the weights of the criteria are changed, the final results may also change because the results of MCDM methods primarily rely on the relative weights assigned to individual criteria, frequently in a subjective manner. Given this, a sensitivity analysis of the results is required in order to thoroughly review the outcomes of using a particular MCDM method [47]. In MCDM, sensitivity analysis is the process of examining or confirming the solution's behavior or stability when minor adjustments are made to the parameters' values or preferences while the problem-solving process is underway. With the help of this technique, decision-makers can evaluate the efficacy of the applied method and comprehend how changes to the input data—that is, the criterion weights—affect the final results. This type of analysis is helpful for choosing the best option and validating rankings derived from different approaches [48, 49].

The sensitivity analysis was conducted to evaluate how changes in the weights of criteria affect the ranking of corridors. It is presented through 18 scenarios (Table 11), where the weight was reduced by 15%, 30%, 45%, 60%, 75%, and 90%, respectively, for the most important criterion $C1_2$ in the first 6 scenarios, the second most important criterion $C1_3$ in the next 6 scenarios, and the third most important criterion $C1_1$ in the last 6 scenarios. The obtained results were compared with the results from the baseline, i.e., zero scenario.

Table 11. Sensitivity analysis of the results

Scenario	RETRAC	CREAM	Rank
0	0.0199	0.0230	2/1
1	0.0196	0.0226	2/1
2	0.0198	0.0228	2/1
3	0.0201	0.0232	2/1
4	0.0205	0.0235	2/1
5	0.0209	0.0239	2/1
6	0.0212	0.0242	2/1
7	0.0195	0.0223	2/1
8	0.0190	0.0217	2/1
9	0.0186	0.0211	2/1
10	0.0183	0.0209	2/1
11	0.0182	0.0209	2/1
12	0.0180	0.0210	2/1
13	0.0199	0.0228	2/1
14	0.0200	0.0228	2/1
15	0.0200	0.0228	2/1
16	0.0201	0.0228	2/1
17	0.0202	0.0227	2/1
18	0.0203	0.0227	2/1

6 Conclusions

This paper aimed to evaluate intermodal railway-road freight corridors described in the EU-funded CREAM and RETRAC projects using a number of criteria. These projects represent a key strategy for improving intermodal transport in Europe, including Serbia. While the RETRAC project shares similar objectives, such as creating creative solutions to enhance intermodal transport with a focus on flexibility and competitiveness, the CREAM project concentrates on optimizing intermodal transport by enhancing logistics systems, reducing transport time and expenses, and increasing reliability and efficiency. Their importance lies in enabling more efficient and sustainable goods transportation, leading to a reduction in harmful emissions, traffic congestion, and road blockages, as well as reducing transportation time and costs while increasing safety and supporting economic growth through better connectivity with international markets. These projects give Serbia the chance to improve its competitiveness and economy by improving its transport infrastructure, making it more appealing to investors, and better integrating into European transport networks. With a wide range of potential applications, the findings of this study represent a substantial contribution to the field of intermodal transportation and logistics. They can be used as a starting point for the strategic planning of new transportation corridors in the future or for the optimization of current ones. Furthermore, these findings might help optimize resource use and infrastructure, which would drastically lower the time and cost of transportation—two factors that are crucial to a region's economic competitiveness.It is important to note that these projects also highlight the need for introducing innovative transport solutions and more flexible transport services, which lead to numerous positive effects such as increasing delivery accuracy and reliability, as well as enhancing customer satisfaction. To evaluate these corridors based on multiple criteria for the selection of the best solution, a hybrid FBWM-FADAM model was proposed. The methodology involved defining a set of alternatives and criteria, defining a fuzzy scale for evaluating criteria and alternatives, obtaining criterion weights through the FBWM method, and evaluating and ranking alternatives using the FADAM method.In the context of intermodal transport, i.e., intermodal freight corridors, the criteria were expressed in terms of infrastructural, technical-technological, operational, economic, and socio-ecological performances. These criteria are interconnected and influence each other, enabling a comprehensive evaluation of intermodal freight corridors. According to the results of using the suggested hybrid model, the CREAM corridor was chosen as the best option, more precisely the preferred option when considering the operational and infrastructure criteria, which are the most important. In contrast, the RETRAC corridor was chosen when considering other groups of criteria that are less important. By performing a sensitivity analysis of the results, it can be concluded that, regardless of changes in the weights of the criteria, the solution remains the same. This indicates that the results are reliable and consistent, and that the proposed hybrid MCDM model is an adequate and well-applicable decision-making tool in practice.

Data Availability

We have replied what need to be done.

Conflicts of Interest

The authors declare no conflict of interest.

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