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EVALUATION OF THE RAILWAY MANAGEMENT MODEL BY USING A NEW INTEGRATED MODEL DELPHI-SWARA-MABAC

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Abstract *The functioning of each traffic system depends to a great extent on the way the rail transport system operates. Taking into account the aspect of market turbulence and the dependence on adequate delivery when it comes to freight transport and traffic in accordance with a yearly Timetable in passenger traffic, transport policies are changing with time. Therefore, this document is considering the railway management models on the territory of Bosnia and Herzegovina. For the purpose of evaluating these models, a new hybrid model has been applied, i.e. the model which includes a combination of the Delphi, SWARA (Step-Wise Weight Assessment Ratio Analysis) and MABAC (Multi-Attributive Border Approximation Area Comparison) methods. In the first phase of the study, the criteria ranking was determined based on 16 expert grades used in the Delphi Method. After that, a total of 14 decision-makers determined the mutual criteria impact, which is a prerequisite for the application of the SWARA Method used to determine the relative weight values of the criteria. The third phase involves the application of the MABAC Method for evaluating and determining the most suitable variant. In addition, a sensitivity analysis involving the application of the ARAS, WASPAS, SAW and EDAS methods has been performed, thus verifying the previously obtained variant ranking.*

Key Words: *Railways, Transport Policy, Delphi, SWARA, MABAC.*

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1 Introduction

Although the railway has significant advantages which are reflected in a high level of safety, considerably less energy consumption per unit of transport and minimal impact on the environment, as well as the least impact on external transport costs comparing to other modes of transport, its participation in transport market has decreased significantly in the second half of the 20th century. To a large extent, it has been caused by historical, traditional and national influences on railway companies, and above all:

- a high level of government intervention in the business operations of national railway companies - railway companies, through state control and intervention - were used to meet political and social goals rather than to function in accordance with market principles, and,
- costs subsidizing and lack of incentives for change – a high proportion of passenger transport, which was unprofitable and politically supported, placed railway companies in the public service area, and they often transported passengers without an adequate compensation.

In Europe, all national railway administrations used to be state owned organizations which, for the sake of economic and social policy, were obliged to execute public passenger transport services. Due to lower prices, the revenues did not cover actual costs, resulting in their inability to finance exploitation and infrastructure development. The lack of financial resources further led to economic weakening of the railway companies and their position on the market.

National railway companies are integrated, i.e. they perform both functions of the infrastructure manager and operator. The regulatory framework is national with no competition in the form of foreign railways while there is no domestic market.

Due to non-profitability of the railway companies, there was a debt accumulation process in most European countries, especially in the late 1980s. The loss of railway competitiveness in the transport market in intermodal competition, a growing deficit and an increasing debt burden of the state-owned companies have triggered off reforms.

In the EU Member States and beyond, views and directives concerning the restructuring of the rail system have been adopted. Prior reforms did not allow complete railway's liberalization and meeting the requirements of transport market, the expected positive operation of the railway system, the necessary level of rail services quality, satisfaction of the interests of the social community at the national, regional and local level. Positive business results were partly achieved on the main railways (pan-European Corridors), primarily in transit traffic. Although the quality of services on railway system has improved, it is still far from the level required by transport market.

Defining the method of national railway companies restructuring, and thus the way of infrastructure management in Europe, was mainly based on experts opinions, and it depended on the defined traffic policy, the country's level of development, and the readiness to accept changes (political, social and others). Determination of the reforming method, or the most acceptable model of restructuring, is based on experiences, intuitions and subjective attitudes of individual institutions and experts.

However, the countries have undertaken reforms aimed at easing the debt burden on national rail companies, reducing demands for high subsidies, mitigating and halting the fall of railways in market share comparing to other modes of transport. There was a need to create an efficient integrated railway system in the EU and to facilitate border crossing of goods within a single European market with the ultimate aim to:

- establish a railway transport market,
- develop competition in the railway sector, and,
- reduce state subsidies in the railway sector.

The first task of railway restructuring is to transform the state organization into a business organization capable of carrying out transport operations both on the national and international transport market. In this process, the state has a role to create appropriate conditions for the development of a transport system that functions with the maximum application of market mechanisms and meets the transport needs of the society. In order to establish a harmonized market environment in which transporters functioning in different types of transport are affirmed on the basis of equal conditions of competition, it is necessary to calculate the total transport costs generated. The total costs of transport company include not only direct transport costs, infrastructure costs, traffic management and accident compensation, but also compensation for damage to the environment (CER, 2005). The actual situation is that in such conditions the railway has significant advantages over other modes of transport.

In order to fully evaluate these facts, it is necessary to reform traditional railway companies and establish optimal models for their organization and functioning.

This paper examines four different models of organization and structure of the Railways of the Republic of Srpska (ŽRS), which are defined on the base of existing solutions for the reform of national rail companies in Europe (predominantly in the European Union member states).

2 Literature review

Many studies in the domain of railway transport rely on the application of multi-criteria decision-making methods. In (Krmac & Djordjević, 2017) the Group Analytical Hierarchical Process (AHP) was used to determine the key performance indicators for assessing intelligent transport systems. An integrated model consisting of the Delphi, Group Analytical Hierarchical Process and PROMETHEE methods in (Nassereddine & Eskandari 2017) was applied in the field of public passenger transport, where, as a result, the metro is the most important passenger transport system. Also, the integrated MCDM Model (DEMATEL, ANP and VIKOR) was used to choose the transport mode in Hualien (Kuo & Chen, 2015). Aydin, (2017) commenced a three-year research in Istanbul for measuring performances of the railway transit lines. For this purpose he used the TOPSIS Method. The performance evaluation of the railway zones in India (Ranjan et al. 2016)) was conducted by combining the DEMATEL and VIKOR Methods, while in their research Sang et al. (2015) used the Fuzzy AHP Method for selection and evaluation of railway freight Third-Party-Logistics. Leonardi (2016) applied a combination of fuzzy logics with multiple-criteria decision-making (AHP Method) to plan a railway infrastructure, while in (Santarremigia et al. 2018) the AHP was also applied in the safety area during the railway transport of dangerous materials. A combination of the BWM and SAW methods was used in (Stević et al. 2017a) to determine the importance of criteria in purchasing wagons in a logistics company.

According to Hashemkhani Zolfani & Bahrami (2014), the SWARA method is suitable for decision-making at a high level of decision-making and also instead of policy-making. Its convenience in a decision-making process is reflected in the advantages it has in comparison to other methods for obtaining the weight values of criteria. These advantages are primarily seen in a significantly smaller number of comparisons in relation to other criteria, and the possibility to evaluate the opinions of experts on the significance of criteria in a process of determining their weights. Over the few past years since this method came into existence, it has been used in a number of publications to determine weight values of the criteria. The SWARA was used to assess the relation between the floods and influencing parameters in (Hong et al. 2017), while the ANFIS model is applied to flood spatial modeling and zonation, and it is used for the R&D project evaluation in (Hashemkhani Zolfani et al. 2015). Using the SWARA method in (Heidary Dahooie et al. 2018), it is concluded that subject competency is the main criteria in IT personnel selection. In (Keshavarz Ghorabaee et al. 2018), it is used to determine the significance of criteria in a process of evaluating construction equipment in sustainable conditions, while Ruzgys et al. (2014) apply it to the evaluation of external wall insulation in residential buildings. It is successfully applied to risk assessment (Valipour et al. 2017), for selection of a basic shape of the single-family residential house's plan (Juodagalvienė et al. 2017), while Karabašević et al. (2017) used the adapted SWARA with the Delphi method for selection of personnel.

The combination of the SWARA and WASPAS is used for solar power plant site selection in (Vafaeipour et al. 2014), as well as in (Ghorshi Nezhad et al. 2015) where the combination of these two methods is applied in the nanotechnology industry. This combination is also integrated in (Urošević et al. 2017) where it is used for the selection of personnel in tourism. The integration of the SWARA, Fuzzy Kano Model and ROV methods is proposed in (Jain & Singh, 2017) to solve supplier selection. The Fuzzy SWARA is used to determine the significance of criteria, and the Fuzzy COPRAS for ranking and selecting sustainable 3PRLPs in the presence risk factors. The suggested model was applied to a case study from automotive industry (Zarbakhshnia et al. 2018). A combination of the Fuzzy SWARA and the Fuzzy MOORA is used for sustainable third-party reverse logistic provider selection in plastic industry (Mavi et al. 2017). The authors in (Panahi et al. 2017) use the SWARA method for prospecting copper in the Anarak region, central Iran, while the authors in (Ighravwe & Oke, 2017) use it for sustenance of zero-loss on production lines from a cement plant.

3 Methods

3.1 Delphi method

The Delphi Method does the study of and gives projections of uncertain or possible future situations for which we are unable to perform objective statistical legalities, in order to form a model, or apply a formal method. These phenomena are very difficult to quantify because they are mainly qualitative in their nature, i.e. not enough statistical data about them exist that could be used as the basis for our studies. The Delphi Method is one of the basic forecasting methods, the most famous and most widely used expert judgment method. Methods of expert's assessments are representing significant improvement of the classical ways of obtaining the forecast by joint consultation of an expert's group for a given studied phenomenon. In other words, this is a methodologically organized use of the expert's knowledge to predict future states and phenomena. A typical group in one Delphi session ranges from a few to thirty experts. Each interviewed expert, participant in the method, relies on knowledge, experience and his / her own opinion. The goal of the Delphi Method is to exploit the collective, group thinking of experts about certain field. The goal is to reach a consensus on an event by group thinking. This is a method of indirect collective testing but with a return link. It consists of eight steps:

1: Selection of the prognostic task, defining basic questions and fields for it;
2: Selection of experts;
3: Preparation of questionnaires;
4: Delivery of questionnaires to experts;
5: Collecting responses and their evaluating;
6: Analysis and interpretation of responses;
7: Re-exams;
8: Interpretation of responses and setting up final forecast.

The advantages of the Delphi Method

- It covers the large number of respondents;
- Expert's statements are objective because they do not know the statements of others until the end of the circle;
- It is possible to examine the opinion and attitude of an individual according to a task;
- The method strengthens the sense of community and encourages thinking about the future of the organization.

Delphi Method disadvantages:

- The success of the method depends exclusively on the participants in the expert panel;
- Complicated implementation process;
- Absence of the possibility to exactly identify the number of participants in the expert panel;
- Long duration of research.

According to the rules of the Delphi Method, the submitted forecasts of the first circle are statistically processed and sent to the experts again to make possible corrections if they consider other opinions. It is characteristic that most experts remain in their first-round prognosis.

3.2 SWARA method

The SWARA (Step-wise Weight Assessment Ratio Analysis) method is one of the methods for determining weight values that play an important role in a decision-making process. The method was developed by Kersuliene et al. (2010) and, in their opinion, its basic characteristic is the possibility of assessing the opinion of experts on the significance of criteria in the process of determining their weights. After defining and forming a list of criteria involved in a decision-making process, the SWARA method consists of the following steps:

Step 1: Criteria need to be sorted according to their significance. In this step, the experts perform the ranking of the defined criteria according to the significance they have; for example, the most significant is in the first place, the least significant is in the last place, while the criteria in-between have ranked significance.

Step 2: Determine s_j - comparative importance of average value. Starting from the second ranked criterion, it is necessary to determine their significance, that is, how much criterion c_j is more important than criterion c_{j+1}.

Step 3: Calculate coefficient k_j as follows:

$$k_j = \begin{cases} 1 & j = 1 \\ s_{j+1} & j > 1 \end{cases} \tag{1}$$

Step 4: Determine recalculated weight q_j as follows:

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \tag{2}$$

Step 5: Calculate the weight values of the criteria with the sum that is equal to one:

$$w_j = \frac{q_j}{\sum_{k=1}^{m} q_j} \tag{3}$$

where w_j represents the relative weight value of the criteria.

3.3 MABAC method

The MABAC Method (Multi-Attributive Border Approximation Area Comparison) is one of the recent methods. The MABAC Method was developed by Dragan Pamučar in the Defense Research Center for Defense Logistics in Belgrade and was first presented to the scientific public in 2015 (Pamučar & Ćirović, 2015). To date, it has found very wide application and modifications solving numerous problems in the field of multi-criteria decision-making.

The basic setting of the MABAC Method is reflected in defining the distance of the criterion function of each observed alternative from the boundary approximation domain. In the following section, the procedure for implementing the MABAC Method consisting of 6 steps is shown:

Step 1: Forming initial decision matrix (X). As a first step, m alternatives are evaluated by n criteria. Alternatives are shown with vectors $A_i = (x_{i1}, x_{i2}, ..., x_{in})$, where x_{ij} is the value of *i*-... alternative by *j*-... criteria $(i = 1, 2, ..., m;\ j = 1, 2, ..., n)$.

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \tag{4}$$

Step 2: Normalization of elements of starting matrix (X).

$$N = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} t_{11} & t_{12} & \cdots & t_{1n} \\ t_{21} & t_{22} & & t_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ t_{m1} & t_{m2} & \cdots & t_{mn} \end{bmatrix} \end{array} \tag{5}$$

The elements of normalized matrix (N) are determined using the expression:

For criteria belonging to a "benefit" type (greater value of criteria is more desirable)

$$t_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{6}$$

For criteria belonging to a "cost" type (lower value of criteria is more desirable)

$$t_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{7}$$

where x_{ij}, x_i^+ and x_i^- are representing elements of the starting matrix of making decision (*X*), where x_i^+ and x_i^- are defined as:

$x_i^+ = \max\left(x_1, x_2, ..., x_m\right)$ and representing maximal values of the observed criteria by alternatives.

$x_i^- = \min\left(x_1, x_2, ..., x_m\right)$ and representing minimal values of the observed criteria by alternatives.

Step 3: Calculation of the element of more difficult matrix (*V*). Elements of more difficult matrix (*V*) are being calculated on the basis of expression (8)

$$v_{ij} = w_i \cdot t_{ij} + w_i \tag{8}$$

where t_{ij} are representing the elements of normalized matrix (*N*), w_i represents weighting coefficients of the criteria. By applying expression (8) we will get more difficult matrix V

$$V = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 \cdot t_{11} + w_1 & w_2 \cdot t_{12} + w_2 & \dots & w_n \cdot t_{1n} + w_n \\ w_1 \cdot t_{21} + w_1 & w_2 \cdot t_{22} + w_2 & \dots & w_n \cdot t_{2n} + w_n \\ \dots & \dots & \dots & \dots \\ w_1 \cdot t_{m1} + w_1 & w_2 \cdot t_{m2} + w_2 & \dots & w_n \cdot t_{mn} + w_n \end{bmatrix}$$

where *n* represents the total number of the criteria, *m* represents the total number of the alternatives.

Step 4: Determining the matrix of bordering approximative fields (*G*). Bordering approximative field (GAO) is being determined by expression (9)

$$g_i = \left(\prod_{j=1}^{m} v_{ij} \right)^{1/m} \tag{9}$$

where v_{ij} are representing the elements of weighted matrix (*V*), *m* represents the total number of the alternatives.

After calculating value g_i the matrix of bordering approximative fields is being formed according to criteria *G* (10) in format $n \ x \ 1$ (*n* represents the total number of the criteria by which the offered alternatives are being chosen).

$$\begin{matrix} & C_1 & C_2 & \dots & C_n \\ G = & [g_1 & g_2 & \dots & g_n] \end{matrix} \tag{10}$$

Step 5: The calculation of the distance matrix element is an alternative to boundary approximative area (*Q*)

$$Q = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1n} \\ q_{21} & q_{22} & & q_{2n} \\ \dots & \dots & \dots & \dots \\ q_{m1} & q_{m2} & \dots & q_{mn} \end{bmatrix} \quad (11)$$

Distance of alternatives from boundary approximative area (q_{ij}) is being determined as a difference of elements of heavier matrix (*V*) and values of bordering approximative areas (*G*).

$$Q = V - G = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{bmatrix} - \begin{bmatrix} g_1 & g_2 & \dots & g_n \end{bmatrix} \quad (12)$$

$$Q = \begin{bmatrix} v_{11}-g_1 & v_{12}-g_2 & \dots & v_{1n}-g_n \\ v_{21}-g_1 & v_{22}-g_2 & \dots & v_{2n}-g_n \\ \dots & \dots & \dots & \dots \\ v_{m1}-g_1 & v_{m2}-g_2 & \dots & v_{mn}-g_n \end{bmatrix} = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1n} \\ q_{21} & q_{22} & & q_{2n} \\ \dots & \dots & \dots & \dots \\ q_{m1} & q_{m2} & \dots & q_{mn} \end{bmatrix} \quad (13)$$

where g_i represents the bordering approximative areas for criterion C_i, v_{ij} represents elements of heavier matrix (*V*), *n* represents the number of the criteria, *m* represents the number of the alternatives.

Alternative A_i may belong to a bordering approximative area (*G*), upper bordering approximative area (G^+) or lower bordering approximative area (G^-), i.e. $A_i \in \{G \vee G^+ \vee G^-\}$. Upper approximative area (G^+) represents the area in which ideal alternative (A^+) is located, while lower approximative area (G^-) represents the area in which the anti-ideal alternative is located (A^-) (Fig. 1).

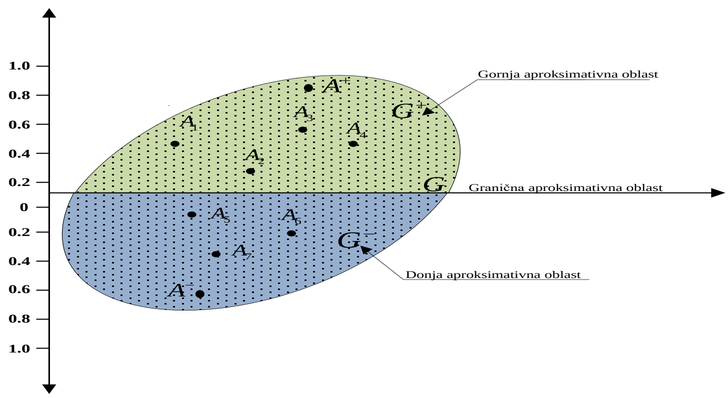

Fig. 1 Display of the upper, lower and bordering approximative areas (Pamučar & Ćirović, 2015)

Affiliation of alternative A_i to approximative area (G, G+ or G-) is determined on the basis of expression (14)

$$A_i \in \begin{cases} G^+ \ if \ q_{ij} > g_i \\ G \ \ if \ q_{ij} = g_i \\ G^- \ if \ q_{ij} < g_i \end{cases} \tag{14}$$

In order for an alternative A_i to be selected as the best from a given set, it is necessary for it to belong to the upper approximating field by as many criteria as possible (G^+). If, for example, an alternative A_i belongs to the upper approximative area by 5 criteria (out of 6 in total), and to the lower approximative area by one criterion, (G^-) that means that, by 5 criteria, this alternative is close to or equal with the ideal one, while by one criterion it is close to or equal to the anti-ideal one. If value $q_{ij} > 0$, i.e. $q_{ij} \in G^+$, then alternative A_i is close or equal to the ideal alternative. Value $q_{ij} < 0$, i.e. $q_{ij} \in G^-$, shows that alternative A_i is close or equal to the anti/ideal alternative.

Step 6: Alternatives ranking. Calculation of values of the criteria functions by alternatives (15) is obtained as the sum of distance of the alternatives from bordering approximative fields (q_i). By summarizing the elements of the Q matrix by rows, we obtain the final values of the criterion functions of alternatives (15)

$$S_i = \sum_{j=1}^{n} q_{ij},\ j = 1,2,...,n,\ i = 1,2,...,m \tag{15}$$

where n represents the number of the criteria, and m represents the number of the alternatives.

3 Case study

Four variants of the management model for railway companies were considered:

1) **Variant 1** - Model of a single (independent) legal entity with a simple organizational structure and a high degree of centralization.

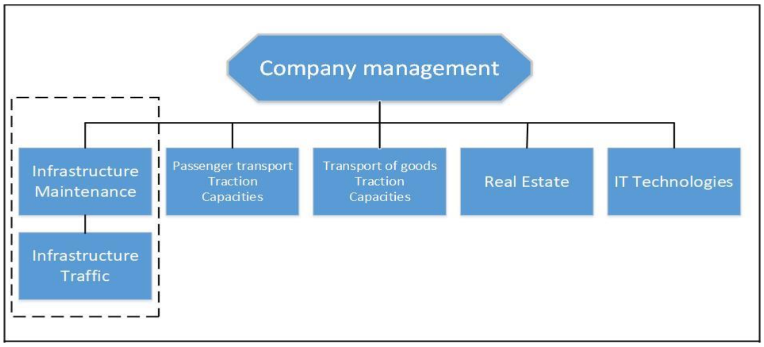

Fig. 2 Variant 1 – Model of unique (independent) legal subject

2) **Variant 2** - Clear holding is a company exclusively dealing with management activities: establishment, financing and management of companies. This type of holding does not have any other special activities. Clear holding does not deal with production or sale; neither does it perform any other business functions, even those that are common to companies - daughters or members of the holding.

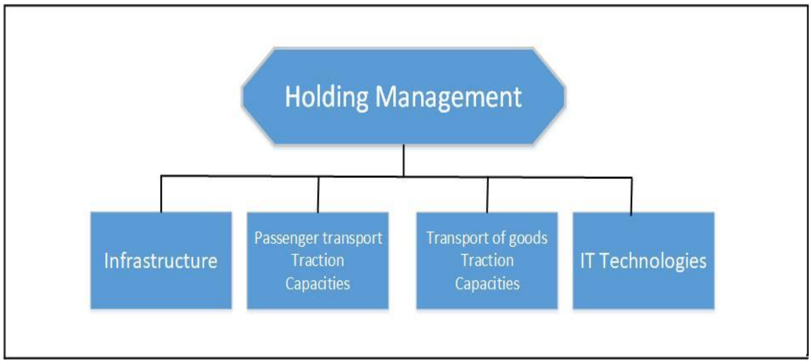

Fig. 3 Variant 2 - Clear holding

3) **Varianta 3** Mixed holding - In addition to management tasks, Mixed holding also performs other types of activities in the field of production, trade, research, finance or service activities. Within the mixed-activity holding company there is a parent company (infrastructure) and companies engaged in the transport and traction of trains.

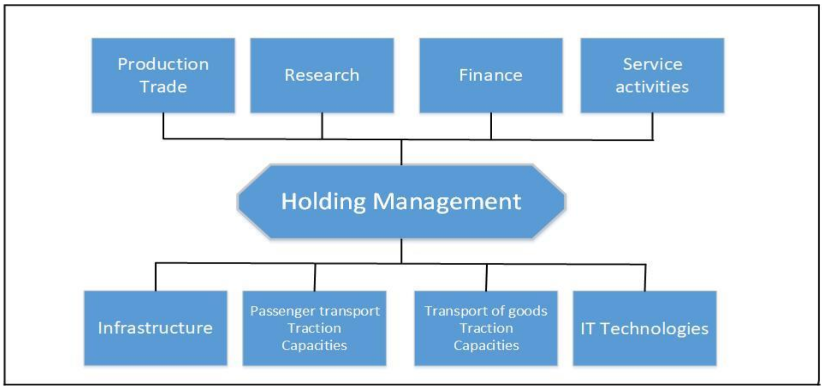

Fig. 4 Variant 3 - Mixed holding

4) **Variant 4** – Mixed holding – Model of three independent companies: Infrastructure, Transport of passengers and Transport of goods.

Criteria for selecting the most favorable model of restructuring and organization of railway companies are:

K_1 – Model's efficiency;

K_2 – The attractiveness of the model to attract an operator;

K_3 – Satisfying the needs of transport market;

K_4 – Compliance with EU directives;

K_5 – Financial independence of the model;

K_6 – Possibility of model realization.

K_1 – Efficiency is the ability to achieve results and business goals. This means that the offered model should enable its efficient exploitation and maintenance. This criterion refers to management and functionality as well as the ability to use all the resources of the model in order to achieve the necessary effectiveness. **The criterion should be maximized.**

K_2 –"The attractiveness of the model to attract an operator" implies the ability of the model to provide an open access to infrastructure operators, the use of railway infrastructure by operators under equal conditions without discrimination. In this way, preconditions for multiple operators will be created. **The criterion should be maximized**.

K_3 – It refers to the possibility of the offered model to satisfy the needs of operators in the transport market in relation to the state and capacity of railway infrastructure capacities (permitted speed, throughput, electrification, permissible axial load, etc.). Regardless of the operator's capability (transport time, prices, frequency, reliability, etc.), the state of the infrastructure significantly influences the definition of customers' demands on the market (population and economy). **The criterion should be maximized**.

K_4 – Certain models can be fully or to some extent harmonized with EU directives aimed at the creation of a single transport market, its liberalization and ensuring the independence of the management of railway undertakings. **The criterion should be maximized.**

K_5 – The infrastructure manager should be a functionally sound and financially stable company. The state allocates financial resources to infrastructure managers only for the development of railway infrastructure, and not for workers' salaries. The K_5 criterion should assess the extent to which the model can satisfy these requirements. **The criterion should be maximized**.

K_6 – It refers to the possibility of realization of the observed model from the aspect of legislation, environment, support of political, social and other participants, etc. **The criterion should be maximized**.

In the first phase of the study, the ranking of criteria was determined based on 16 expert grades in the Delphi Method. After that, a total of 14 decision-makers determined the mutual impact of the criteria, which is a prerequisite for the application of the SWARA Method used to determine relative weight values of the criteria. After applying Eqs. (1) - (3), we have obtained weight values of the criteria shown in Table 1.

Table 1 Calculation procedure and results of weight values of criteria obtained using SWARA Method

	Sj	Kj=Sj+1	qj	wj
K3	1.000	1.000	1.000	0.224
K1	0.100	1.100	0.909	0.203
K5	0.148	1.148	0.792	0.177
K2	0.179	1.179	0.672	0.150
K4	0.168	1.168	0.575	0.129
K6	0.102	1.102	0.522	0.117
			4.471	1.000

Table 1 shows, in the first column, the alternative's ranking that was previously determined using the Delphi Method, while the second column represents the effect of the previous one in relation to the next criterion, which is the average value of the response of the decision-makers. Based on the obtained results using the SWARA Method, the most important is the first criterion of the model's efficiency, while the second criterion is the attractiveness of the model to attract operators elsewhere with a slightly lower value. The general conclusion when it comes to the value of the criteria considered in this study is that all the criteria have sufficient influence on the decision-making with respect to their values. In future research related to determining the significance of the criteria, it is recommended to use the Rough SWARA Method developed in (Zavadskas et al. 2018). After obtaining the relative criteria values, it is necessary to determine the most favorable variant of Railways management in Bosnia and Herzegovina. For this purpose, the MABAC Method is used. All 14 decision-makers who had previously determined the mutual impact of the criteria have also carried out the evaluation of the alternatives. By applying the geometric middle of all the answers, the initial decision matrix is shown in Table 2.

Table 2 Starting matrix of decision-making based on the responses from 14 decision-makers

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	4.238	3.918	4.530	3.710	4.502	4.810
A_2	5.142	4.786	4.698	5.433	5.174	6.706
A_3	6.470	4.909	5.463	6.069	6.020	6.392
A_4	4.341	7.471	4.900	7.796	5.051	3.580

After the initial decision matrix, Eqs. (6) and (7) must be applied in order to start normalization. Since in this study all the criteria belong to a group of benefits for normalization, equation (6) is used, and the normalized matrix shown in Table 3 is obtained.

Table 3 Normalized matrix

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.000	0.000	0.000	0.000	0.000	0.393
A_2	0.405	0.244	0.180	0.422	0.442	1.000
A_3	1.000	0.279	1.000	0.577	1.000	0.899
A_4	0.046	1.000	0.396	1.000	0.361	0.000

Table 4 shows a more difficult normalized matrix obtained by multiplying the normalized matrix from Table 3 with the weight values of the criteria obtained using the SWARA Method. Equation (8) is used to aggravate the normalized matrix. In addition, in the integral part of Table 4, the values of the bordering approximative area are obtained by applying equation (9).

Table 4 Weighted normalized matrix

V	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.224	0.203	0.177	0.150	0.129	0.163
A_2	0.314	0.253	0.209	0.214	0.186	0.234
A_3	0.447	0.260	0354	0.237	0.257	0.222
A_4	0.234	0.407	0.247	0.301	0.175	0.117
G	0.293	0.272	0.239	0.219	0.181	0.177

Table 5 shows the distance matrix of the alternative from the bordering approximative area (Q) obtained by applying Eqs. (12) and (13) and the ranking of the model variant using equation (15).

Table 5 The distance matrix is an alternative to bordering approximative area (Q) and alternative's range

Q=V-G	C_1	C_2	C_3	C_4	C_5	C_6	S_i	Rank
A_1	-0.069	-0.068	-0.062	-0.068	-0.052	-0.014	-0.334	**4**
A_2	0.021	-0.019	-0.030	-0.005	0.004	0.056	0.029	**3**
A_3	0.154	-0.012	0.116	0.018	0.076	0.045	0.398	**1**
A_4	-0.059	0.135	0.009	0.082	-0.006	-0.060	0100	**2**

After executing the budget and applying the Hybrid model, the best-ranked variant of the Railway Management is a variant number 1 which implies that the model of a unified (independent) legal entity has a simple organizational structure with a high degree of centralization, while the worst ranking option is number 3.

4 Sensitivity analysis

In order to determine the stability of the previously obtained results using the hybrid Delphi-SWARA-MABAC Model, the budget calculation for the multi-criteria model was carried out with four more ARAS methods (Zavadskas and Turksis, 2010), WASPAS (Zavadskas et al. 2012), SAW (MacCrimmon, 1968, Stević et al. 2017a), and EDAS (Keshavarz Ghorabaee et al., 2015; Stević et al. 2016; Stević et al. 2017b). The results of the sensitivity analysis are shown in Table 6.

Table 6 The results of the sensitivity analysis

	MABAC		ARAS		WASPAS		SAW		EDAS	
V_1	-0.334	4	0.644	4	0.381	4	0.652	4	0.652	4
V_2	0.029	3	0.787	3	0.463	3	0.793	3	0.793	3
V_3	0.398	1	0.884	1	0.521	1	0.891	1	0.891	1
V_4	0.100	2	0.836	2	0.486	2	0.833	2	0.833	2

Based on the obtained results of the sensitivity analysis, the model's stability and obtained levels of variant solutions are confirmed because in applying all the four methods in the analysis of sensitivity, the levels do not change, that is, each variant retains its initial level.

5 Conclusion

Evaluation of the level of railway market restructuring and reforms is an important process that shows the phase in which a country is. Level alignment is of great importance to the countries in the environment because in this way a more stable transport market can be established. This is especially important for the railways located in strong transit directions and pan-European corridors. The European rail system should not be "scraped" on the non-synchronized rail national reform levels since this does not contribute to the creation of a single European transport market, and thus to the desired open rail market. In addition, such a situation inevitably leads to a reduction in the quality of rail services and an uncompetitive position of the railways in the transport market.

EU directives provide no unique solution in terms of selecting rail management models. The issue this document deals with is the development of a general model that provides a solution to the institutional management of rail national companies. Quantified relevant criteria have been identified for the choice of management model. The synchronization of railway reforms has been promoted through various institutions, and the implementation of reforms and liberalization has often been carried out on the basis of experts' opinions or the application of inadequate methods. This document presents a new way of determining adequate restructuring model for railway national companies, which implies the integration of the Delphi, SWARA and MABAC methods.

The three-phase hybrid model takes into account all the relevant facts and aspects that need to be considered in such research, and the integration of the above-mentioned methods is also one of the contributions of the work. In order to determine the stability of the model, a sensitivity analysis was performed in which four other methods of multi-criteria analysis were applied, the results of which have confirmed the obtained results using the hybrid model proposed in this document.

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