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SELECTION OF THE RAILROAD CONTAINER TERMINAL IN SERBIA BASED ON MULTI CRITERIA DECISION-MAKING METHODS

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Abstract: *Intermodal transport is one of the key elements for sustainable freight transport at large and medium distances. However, its efficiency in many cases depends on the location of the railroad container terminals (CT). The favorable position of Serbia provides an opportunity to establish a large number of container trains, which can lead to a more developed intermodal transport system in the entire Balkans and beyond. In this paper the problem of the container terminal location in Serbia has been considered and resolved. The aim of this paper is to determine the potential macro location of the CT in Serbia, which will be most suitable for different stakeholders in the transport chain. Choosing the most suitable alternative is a complex multi-criteria task. For this reason, a multi criteria decision-making model has been formulated which consists of a number of alternatives and criteria. Alternatives represent potential areas for a site, while some of the criteria are: cargo flows, infrastructure, economic development, social and transport attractiveness and environmental acceptability. For defining weights of the criteria two approaches are used, namely, the Delphi and the Entropy method. In this paper three methods of the multi criteria decision-making, namely, TOPSIS, ELECTRE and MABAC are used. By comparing the results of these three methods, an answer to the question where to locate CT will be presented. This is the first step in determining the location of the container terminal. The next phase should respond to the issue of micro location of the terminal. Also, after certain customization, the model can be used for solving other categories of location problems.*

Key Words: *Location Model, Container Terminal, TOPSIS, ELECTRE, MABAC.*

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1. Introduction

The efficiency of intermodal transport largely depends on the location of the container terminals. The sustainability of transport in Europe requires an increasing reallocation between different modes of transport in order to reduce traffic congestion and environmental protection. Therefore, the choice of the most favorable location of the railroad terminal is one of the most important strategies for optimization of the entire transport chain. Due to its favorable geographical position and important transport corridors located on its territory, the Republic of Serbia has a great potential for developing intermodal transport. Considering that there is almost no such type of terminal in Serbia, along with the tendency to join the European transport network, the aim of this paper is to determine the potential location of CT.

There is a number of developed methods used for finding the most suitable location of the terminal, such as standard methods for finding the optimal location defined as the p-median problem (Limbourg & Jorquin, 2009). Klose & Drexl (2005) deals with different location problems formulated as optimization ones.

In addition, a large number of location problems are solved using multi criteria decision-making methods. Unlike conventional methods and techniques of operational research, these methods do not provide for an „objectively the best" solution. These methods are based on mathematical algorithms that are developed to help decision-makers in choosing the most suitable variant.

There is a large number of papers devoted to this issue, such as determining the location of the logistic center based on ELECTRE method (Žak & Weglinski, 2014), location of logistic center on the Black Sea in Turkey (Uysal &Yavuz, 2014), ELECTRE I method (Maroi et al., 2017), determining the location of the main postal center using TOPSIS method (Miletić, 2007), logistic center location in the area of western Serbia (Tomić et al., 2014), location problem based on AHP method (Stević et al., 2015). Some authors have compared several multi criteria methods, doing, for example, a comparative analysis of two weighting criteria methods entropy and CRITIC for air conditioner selection using MOORA and SAW (Vujičić et al., 2017).

More recently, combinations of multi criteria decision-making techniques and fuzzy logic are used for solving location problems (Tadić et al., 2015), fuzzy-TOPSIS method for selecting hospital locations (Senvar et al., 2016), fuzzy-AHP method for determining solar fields location (Asakereh et al., 2017). In addition to conventional methods, there are also others such as the MABAC for solving location problems of wind farms in Vojvodina (Gigović et al., 2017), COPRAS-G method for container terminal operations optimization (Barysiene, 2012), hybrid fuzzy-APH-MABAC model for selecting the location of masking bindings (Božanić et al., 2016), selection of transport and handling resources in logistics centers (Pamučar et al., 2015) and the like.

2. Problem formulation

The observed problem lies in the selection of the most suitable location/region on which the railroad terminal will be located. As a potential location for this terminal, railway sections from Serbia are used, as well as the areas in which these sections are located. Total numbers of variants are 11, although the Serbian railway network is divided into 12 sections: Požarevac, Lapovo, Niš, Zaječar, Kraljevo, Užice, Pančevo, Zrenjanin, Novi Sad, Subotica and Ruma. Belgrade railway section was not taken into consideration due to the existence of a container terminal in Belgrade in Belgrade marshalling yard „Makiš“.

2.1. Definition of variants

For each variant, a railway section is associated with a particular area in which the section is located although the boundaries of the section are different in terms of administrative division. The data about loading and unloading railway freight cars are based on the real railway sections although they cross the administrative boundaries of the area, while the other data used in this paper are taken from the areas in which the section is located.

Variant 1 - Subotica is a railway section located in the northern part of Serbia and it is the administrative center of Severna Bačka District. Its total area is close to 1784 km^2, and its population amounts to 186 906 people. The region is characterized as average in many regards. It is characterized by an average level of economic development, annual GDV per capita of 429 000 rsd and logistical and transport activities imply one important road and rail corridor. The main advantage of this variant is high investment attractiveness because of two free zones, Subotica and Apatin. The unemployment rate in this region ranks among the lowest in the country (10,7%). The volume of transported goods and number of freight cars are the lowest (4599 freight cars - 126 277 t), while in the case of unloading goods in domestic and international traffic region it is in the pre-position.

Variant 2 - Novi Sad is the capital of Južna Bačka District. Population in this area amounts to 615 371 people, while the total area is close to 4026 km^2. The economic potential is high, when considering GDV per capita of 608 000 rsd, which is of the highest value in the whole territory of Serbia, without Belgrade. Novi Sad offers a great opportunity for education of younger people with the highest number of high schools and faculties. The total volume of all transported goods in this section is average and close to 890 819 t, and 23675 used freight cars. Through the Novi Sad pass international road corridor E75 and railway corridor E85. The weakness of variant 2 is a high unemployment rate of 15,9% and existence of one free zone Novi Sad. The region is attractive is terms of environment-friendliness with low noise emission and national park Fruška Gora.

Variant 3 - Zrenjanin is the capital of Srednji Banat District, located in the northeast part of Serbia. Its total area is 3257 km^2 and its population amounts to 187 667 people. The region is characterized by a high unemployment rate of 14,1% which places this variant at the very top according to this criterion. GDV per capita is 416 000 rsd, while transport and logistic competitiveness is small because there is no large number of economic entities. Although the volume of railway transport has been growing in recent years, this section is at very bottom for number of loaded freight cars. With 5644 unloaded cars and 152 492 t of transported goods this region occupies the lowest position. Transport infrastructure in variant 3 is in a very poor condition. There is only one international railway line, while there are no state IA roads. This area is environment-friendly.

Variant 4 - Pančevo is the capital of Južni Banat District, with population of 293 730 people and an area close to 4246 km^2. The economic potential of this variant is slightly lower than average because of GDV per capita which is 384 000 rsd, and a huge unemployment rate of 20,9%. Another weakness of this variant is a very poor condition of transport infrastructure and connection with other nearby cities. Availability of transport infrastructure is lower than average with two international railway lines and no state IA roads. Investment attractiveness is low because there is a large number of business subjects. Azotara, Petrohemija and Oil Refinery in combination with the port are some of the subjects that can contribute positively to this variant. Unfortunately, it does not possess free zones. The total number of loaded and unloaded freight cars in domestic and international transport is 43849 with 1 600 600 t of transported goods.

Variant 5 - Ruma is located in the north-eastern part of the country, and it is the capital of Srem District. Its area is around 3485 km^2 and its population amounts to 312 278 people. The region is characterized by a higher than average level of GDV per capita is 411 000 rsd, and a higher unemployment rate of 18,3%. Near to this region is Šabac free zone which increases investment attractiveness. Variant 5 is environment-friendly with a low level of noise. The industrial attractiveness of this variant is reflected in the number of transported goods, which amounts to 1 102 168 t in 2016 and 30 398 used freight cars.

Variant 6 - Požarevac is located in the region of Braničevo. Its total area is 3857 km^2, and its population amounts to 183 625 people. This variant has a low unemployment rate of 11% and large industrial attractiveness. With 89 877 freight cars and 3 154 202 t transported cargo, this is the first of all the variants. The reason for this is a steel company in Smederevo, which uses two railway stations Radinac and Smederevo. Near to Smederevo passes European corridor E75 as well as state IA road and railway lines E70 and E85.

Variant 7 - Zaječar is located in the eastern part of the country in the region of Zaječar. The total area of the region is 3624 km^2 and the population is close to 119 967 people. GDV per capita is 314 000 rsd which is the second lowest value. The unemployment rate is 18,3%, but this variant has a big potential which is evident in a small number of logistic and transport companies and business subjects. The weakness of this variant is that both road and rail transport infrastructures are undeveloped; there are no state IA roads while there is only one railway line. Industrial attractiveness is good because of the mines in Bor and Majdanpek, and the total number of used freight cars is 58602 with 1 508 932 t. No free zones are in this region, either.

Variant 8 - Lapovo is the railway section which is located in the central part of Serbia in the region of Pomoravlje. The total area of this section is 2614 km^2 and its population amounts to 71 231 people. This section is located near two state IA roads, and railway corridors E70 and E85. The unemployment rate is huge (19%) and GDV per capita is 322 000 rsd. Investment attractiveness is average. Svilajnac free zone is located in this region. Number of used freight cars is 23562, and total volume of transported goods is 946 831 t.

Variant 9 - Niš is the railway section which covers the southern part of the country; it is the center of the region of Niš. The total population of the region is 376 319 people while the total area is 2728 km^2. This variant has the highest unemployment rate in Serbia 24,7%. GDV per capita is 348 000 rsd, and there are two free zones, Pirot and Vranje. With 14 faculties and higher schools this region attracts a lot of young people and offers them a great opportunity for education. Volume of loaded and unloaded cargo is very small amounting to 202 385 t loaded cargo and 499 144 t unloaded cargo. There are two road corridors and three important railway lines.

Variant 10 - Kraljevo section is located in the region of Raška. Population of this region is 309 258 people and the total area of the region is 3923 km^2. It is characterized by a low level of GDV per capita of 240 000 rsd. The region is attractive from the logistic and transport point of view. Its benefits are big industrial companies and centers located in Kragujevac as well as the existence of two free zones, Kruševac and Kragujevac. Total volume of transported goods in 2016 was 765 523 t. The weaknesses of this region are: a relatively poor condition of the transport infrastructure and serious social problems, including a very high unemployment rate of 21,6%. No highways in this region; the railway line in this variant is in a very bad condition. The region is considered to be environment-friendly because of national park Kopaonik and a low level of noise.

Variant 11 - Užice is the railway section which is located in western part of Serbia in the region of Zlatibor. This region has the largest area close to 6140 km^2. Total population is 286 549 people according to 2011 Population Census. Unemployment rate is 15% and GDV per capita is 369 000 rsd. The level of logistics and transport competitiveness is small which makes this region favorable only in terms of its location. Volume of transport is 1 051 473 t in 2016. Railway line Belgrade - Bar is in a very bad condition while a highway from Belgrade to Bar is under construction.

2.2. Formulation of criteria

C1 - availability of transport infrastructure (points). This maximized criterion is defined as number of state IA roads and international railway lines that pass through each region or section of the railway network. It measures region accessibility and transport efficiency for distributing goods. Also, it shows the condition of the road and rail infrastructure, taking into account water traffic in the case there is a port of terminal in the same region. The criterion is measured on the scale 1-6, whereby point 1 is given for a region with the lowest numbers of corridors and the worst infrastructure condition; point 6 is given, consequently, for the best region.

C2 - economic development (in thousand rsd). This maximized criterion is defined as an annual value of GDV per capita for each region in Serbia. Based on this criterion, we can measure the economic potential of each region, i.e. it can be determined whether an investor would like to invest in the given region or not.

C3 - investment attractiveness (points). This maximized criterion uses the measurement scale of 1 to 10 points for assessment of the overall level of attractiveness of the region. It is defined as a total number of free zones in regions and close to regions.

C4 - level of transport and logistics competitiveness (points). This minimized criterion is defined on the scale of 1 to 10 and it shows share of logistic and transport companies and business subjects in the region compared to their total number in Serbia. This criterion is minimized because any new investor shall first opt for the region with no competition whatsoever. The data necessary for this criterion were based on experience and interviews with experts.

C5 - transport and logistics attractiveness (t). This criterion measures the industry attractiveness of each region (max). It is expressed in total loaded and unloaded weight and transported by rail in domestic and international transport. Unfortunately, this criterion does not include data about transported goods by road. Also, given that statistics about transported containers and volume of transport goods in transit on the Serbian railway network are only conducted for the whole network, this data are not relevant and have not been taken into account when settling the problem.

C6 - unemployment rate (%). This minimized criterion is defined as a percentage of unemployed residents in the region. The level of social satisfaction affects the region. This criterion can be defined by the components such as opportunities for education and career development (number of state faculties and high schools).

C7 – environment-friendliness (points). This criterion (max) defines the environment-friendliness of each region. It includes an average daily and night level of noise in the centers of regions and the number of fully protected territories like national parks.

3. A multi criteria decision-making model

Existence of a multi criteria analysis means existence of more variants and criteria, of which some have to be minimized or maximized, where decisions are made in conflict conditions with the application of instruments that are more flexible than the mathematical method of pure optimization. Criteria that are to be maximized are in the profit criteria category although they may not necessarily be profit criteria. Similarly, the criteria that are to be minimized are in the cost criteria category. An ideal solution would maximize all the profit criteria and minimize all the cost criteria. Normally, this solution is not obtainable. In literature a large number of methods of multi criteria analysis can be found. However, not all the methods are equally theoretically and practically represented and important.

There are two types of multi criteria decision-making methods. One is compensatory and the other is a non-compensatory one. Compensatory methods are those which calculate the final solution by tolerating some of bad features of a variant under the condition that all other features of this variant are favorable. They actually permit „tradeoffs" between attributes. A slight decline in one attribute is acceptable if it is compensated by some enhancement in one or more of other attributes. Some of these methods are (Dimitrijević, 2016):

- Simple Additive Weighting (SAW),
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS),
- Preference Ranking Organization METhod of Enrichment Evaluation (PROMETHEE),
- Analytic Hierarchy Process (AHP), and,
- Elimination Et Choix Traduisant la REalite (ELECTRE).

In addition to these conventional methods, the following methods are increasingly used:

- Evaluation based on Distance from Average Solution (EDAS),
- COmplex PRoportional Assessment (COPRAS),
- EVAluation of MIXed data (EVAMIX),
- Combinative Distance-based ASessment (CODAS),
- Weighted Aggregated Sum Product ASsessment (WASPAS), and,
- Multi-Attribute Border Approximation area Comparison (MABAC).

The presented model of macro location of the container terminal was done using three compensatory methods, i.e., TOPSIS, ELECTRE and MABAC, after which the results are compared by methods, and the most favorable variant was adopted for the macro location of the container terminal in Serbia. These methods are used because of their common use in solving this type of problem in addition to their simple use and easy definition of input parameters. Models are solved by Microsoft Excel, i.e. its addition for a multi criteria analysis which is called Sanna.

The aim of this paper is to compare 11 variants, which represent sections on the railway network, in order to find an optimal solution for the railroad container terminal location. These sections are district control offices, from which the management of a certain part of the railway network is performed. There are twelve sections on the Serbian railway network, but in this model section Belgrade is not used because there is already a railroad container terminal in Belgrade marshaling yard.

The criteria for comparison and selecting the best variant are described in the previous section and their values are shown in Table 1.

Table 1 The values of the criteria for the observed variants

Variants	C1	C2	C3	C4	C5	C6	C7
Subotica	2	429	2	6	441268	10,7	7,00
Novi Sad	2	608	1	10	890819	15,9	4,25
Zrenjanin	1	416	1	2	386899	14,1	8,00
Pančevo	2	384	0	9	1592715	20,9	3,75
Ruma	3	411	1	1	1102168	18,3	8,00
Požarevac	2	405	1	8	3154202	11,0	6,00
Zaječar	1	316	0	7	1508932	15,5	7,50
Lapovo	5	322	1	5	946831	19,0	5,50
Niš	6	348	2	10	701979	24,7	3,25
Kraljevo	1	245	2	4	765523	21,6	6,00
Užice	1	369	1	3	1051473	15,0	4,75

According to Table 1, each of the above criteria needs to be maximized, except for criterion 4 (level of transport and logistic competitiveness) and criterion 6 (unemployment rate, which is a logical conclusion because a lower unemployment rate is more favorable for the development of each region).

Data about transported goods by railway and number of freight cars (C5) are obtained thanks to the statistics from sector for freight transport „Serbian Railways“ and nowadays „Serbia Cargo“. Criterion 1, availability of transport infrastructure, is covered by the data from the Statistical Office of the Republic of Serbia and working timetable which we use for calculation the number of railway lines. Data from the Statistical Office of the Republic of Serbia are used for the following criteria: economic development (C2), investment attractiveness (C3) and unemployment rate (C6). Yearly statistic handbook from the Statistical Office of the Republic of Serbia and statistics of local government are used for defining criterion 7, environment-friendliness.

3.1. Criteria weighting

One of the main problems in multi criteria problems belong to criteria (Vuković, 2014). Taking into account that the weight of criteria can significantly affect the decision-making process, special attention must be paid to the criteria weighting, which, unfortunately, is not always present in problem-solving. For that reason we use two methods, the Delphi and the Entropy.

3.1.1. Delphi method

Weights of criteria are defined through interviews with experts in the field of railway transport. The final values of weight coefficients, based on experts' answers and using the Delphi method are given in Table 2.

Weight criteria are calculated through three iterations. Mean values, standard deviation and coefficient of variation for each criterion are made, and the obtained average value of the coefficient of variation is 12,81%. In the next section, models for location railroad container terminal using TOPSIS, ELECTRE and MABAC methods are shown.

Table 2 Weight of criteria by the Delphi method

Criteria	C1	C2 (thou. rsd)	C3	C4	C5 (t)	C6 (%)	C7
Normalized weights of criteria	0,27	0,13	0,10	0,12	0,23	0,08	0,07

3.1.2. Entropy method

Determination of the objective criteria weights according to the entropy method is based on the measurement of uncertain information contained in the decision matrix. It directly generates a set of weights for a given criteria based on mutual contrast of individual criteria values of variants for each criteria and then for all the criteria at the same time (Vuković, 2014).

Determination of objective criteria weights w_j according to the entropy method is carried out in three steps (Dimitrijević, 2016). Step One involves the normalization of criteria values of variants x_{ij} from decision matrix $X = \left\| x_{ij} \right\|_{mxn}$:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \forall i, j, \tag{1}$$

Entropy E_j of all variants is calculated as:

$$E_j = -\varepsilon \sum_{i=1}^{m} p_{ij} \ln p_{ij}, \forall j, \tag{2}$$

a constant ε, $\varepsilon = 1/\ln m$, is used to guarantee that $0 \le E_j \le 1$.
The degree of divergence d_j is calculated as:

$$d_j = 1 - E_j, \; j = 1, \ldots, n, \tag{3}$$

Since the value of d_j is a specific measure of the intensity of a criteria contrast C_j, the final relative weight of the criteria, in the third step of the method, can be obtained by simple additive normalization:

$$W_j = \frac{d_j}{\sum_{i=1}^{n} d_j}, \forall j, \tag{4}$$

Final values of weight coefficients, based on Entropy method are given in Table 3.

Table 3 Weight of criteria by the Entropy method

Criteria	C1	C2	C3	C4	C5	C6	C7
e_j	0,915	0,990	0,977	0,938	0,928	0,987	0,984
d_j	0,085	0,010	0,023	0,062	0,072	0,013	0,016

w_j	0,301	0,036	0,083	0,220	0,256	0,046	0,058

3.2. Application of the TOPSIS method

TOPSIS method is the one which compares variants based on their distance from a positive and negative ideal solution (Hwang & Yoon, 1981). The method is characterized by calculation of the weighted normalized decision matrix and formulation of the positive and negative ideal solution. Also, this method is based on the concept that the chosen variant should have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution (Čičak, 2003). Weighted criterion matrix is shown in Table 4.

Table 4 Weighted criterion matrix with the Delphi method

Variants	C1	C2	C3	C4	C5	C6	C7	di+	di-	ci
Subotica	0,05692	0,04243	0,04714	0,02843	0,02258	0,03842	0,02448	0,18392	0,07634	0,29332
Novi Sad	0,05692	0,06013	0,02357	0,00000	0,04559	0,02415	0,01486	0,17721	0,06257	0,26095
Zrenjanin	0,02846	0,04114	0,02357	0,05687	0,01980	0,02909	0,02797	0,20338	0,07209	0,26171
Pančevo	0,05692	0,03798	0,00000	0,00711	0,08151	0,01043	0,01311	0,16217	0,07050	0,30300
Ruma	0,08538	0,04065	0,02357	0,06397	0,05641	0,01756	0,02797	0,14032	0,10041	0,41711
Požarevac	0,05692	0,04005	0,02357	0,01422	0,16143	0,03760	0,02098	0,12823	0,15291	0,54389
Zaječar	0,02846	0,03125	0,00000	0,02132	0,07723	0,02525	0,02623	0,17998	0,06826	0,27499
Lapovo	0,14230	0,03184	0,02357	0,03554	0,04846	0,01564	0,01923	0,12780	0,12635	0,49716
Niš	0,17076	0,03442	0,04714	0,00000	0,03593	0,00000	0,01136	0,14919	0,15112	0,50321
Kraljevo	0,02846	0,02423	0,04714	0,04265	0,03918	0,00851	0,02098	0,19463	0,06769	0,25803
Užice	0,02846	0,03649	0,02357	0,04976	0,05381	0,02662	0,01661	0,18280	0,07124	0,28042
Weights	0,27000	0,13000	0,10000	0,12000	0,23000	0,08000	0,07000			
Ideal	0,17076	0,06013	0,04714	0,06397	0,16143	0,03842	0,02797			
Basal	0,02846	0,02423	0,00000	0,00000	0,01980	0,00000	0,01136			

3.3. Application of the ELECTRE I method

Evaluation matrix for the ELECTRE method is the same as in the case with the TOPSIS method. The only difference is in the steps leading to the final solution. In this method, the variants are compared with each other as a couple; dominant and weak (or dominant and recessive) variants are identified and then weak and defeated alternatives are removed.

In the ELECTRE method, it is also necessary to define the concordance and discordance index which can be defined as the average values of all values c_{kl} and d_{kl} calculated according to the following equations (5) and (6) (Dimitrijević, 2016).

$$\bar{c} = \frac{\sum_{k=1}^{m}\sum_{s=1}^{m} c_{kl}}{m(m-1)}, \forall k \neq l, \tag{5}$$

$$\bar{d} = \frac{\sum_{k=1}^{m}\sum_{s=1}^{m} d_{kl}}{m(m-1)}, \forall k \neq l, \tag{6}$$

Based on value of concordance index *ckl* which represents domination of variant *Vk* relative to *Vl* based on weight criteria, we calculate preference threshold value ($\bar{c}$) and its value is 0,5596. Index where variant *Vk* is worse than variant *Vl* shows another index - discordance index *dkl*. In that case we calculate dispreference threshold value ($\bar{d}$) and its value is 0,7364.

3.4. Application of the MABAC method

The basic setting of the MABAC method is reflected in the definition of the distance of the criterion function of each of the observed alternatives from the approximate border area (Pamučar & Ćirović, 2015). Mathematical computation of this method is presented through six steps as follows (Božanić & Pamučar, 2016):

Step 1 Creating initial decision matrix *X*.

Step 2 Normalization of the elements of initial decision matrix *X*.

Step 3 Calculation of weighted matrix elements *V*.

Step 4 Border approximate area for each criterion is determined by expression:

$$g_i = \left(\prod_{j=1}^{m} v_{ij} \right)^{1/m}, \tag{7}$$

Matrix of approximate border areas *G* in both variants is given in Table 5.

Table 5 Matrix of approximate border areas

	Weight of criteria	C1	C2	C3	C4	C5	C6	C7
G	Delphi method	0,3342	0,1782	0,1507	0,1698	0,2873	0,1217	0,1051
	Entropy method	0,3726	0,0494	0,1251	0,3113	0,3198	0,0700	0,0871

Step 5 Calculation of the matrix elements distance from the border approximate area *Q*

Step 6 Ranking variant

Calculation of the criteria function values by variants is obtained as the sum of the distances of the variants from the border approximate areas q_i. Summing up the elements of matrix *Q* by rows gives the final values of the criteria function variants:

$$S_i = \sum_{j=1}^{n} q_{ij},\ j = 1,2,\ldots,n, i = 1,2,\ldots,m, \tag{8}$$

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

4. Results

Based on the previously defined input parameters and weight criteria, the results of the considered methods show which of the given variants is the best for the container terminal location.

4.1. Results obtained by TOPSIS method

Complete ranking of the variants using TOPSIS method is shown in Table 6. The best variant for micro location of the railroad container terminal in both the variants is variant v_6 railway section Požarevac.

Table 6 Complete order of variants with the TOPSIS method

Variant	Delphi method		Entropy method	
	R.U.V.	Rank	R.U.V.	Rank
Subotica	0,29332	6	0,26737	10
Novi Sad	0,26095	10	0,18773	11
Zrenjanin	0,26171	9	0,32506	6
Pančevo	0,30300	5	0,28655	8
Ruma	0,41711	4	0,48188	3
Požarevac	0,54389	1	0,81239	1
Zaječar	0,27499	8	0,27463	9
Lapovo	0,49716	3	0,50997	2
Niš	0,50321	2	0,47136	4
Kraljevo	0,25803	11	0,29766	7
Užice	0,28042	7	0,33564	5

4.2. Results obtained by the ELECTRE method

Using ELECTRE I method two variants are dominant and much better than the others. These variants are 5 and 6, railway sections Ruma and Požarevac. This method gave 40 preference relations of all the variants, and nine inefficient variants when using the Delphi method for weight criteria, and 42 preference relations when using the Entropy method. The final results are shown through aggregate dominance matrix in Table 7, where the first number means variant one, Delphi method and the second number means variant two, Entropy method.

Table 7 Aggregate dominance matrix

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
V2	1/1	0/0	1/1	0/0	0/0	0/0	0/0	0/0	1/1	1/1	0/0
V3	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
V4	0/0	1/1	0/0	0/0	0/0	0/0	1/1	0/0	1/1	1/1	1/1
V5	1/1	1/1	1/1	0/0	0/0	0/0	0/0	1/0	1/1	1/1	1/1
V6	0/0	1/1	1/1	1/1	0/0	0/0	1/1	1/0	1/1	1/1	1/1
V7	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/0	0/1	1/1	1/1
V8	1/1	1/1	1/1	0/0	0/0	0/0	0/0	0/0	0/1	1/1	0/0
V9	1/1	0/0	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
V10	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0	1/1	0/0	0/0
V11	0/0	1/1	1/1	0/0	0	0	0	1/1	1/1	1/1	0/0

4.3. Results obtained by MABAC method

Ranking of all variants using MABAC method is shown in Table 8.

Table 8 Rank of the variants using MABAC method

Variant	Delphi method		Entropy method	
	S_i	Rank	S_i	Rank
Subotica	0,0659	5	0,0208	5
Novi Sad	-0,0062	7	-0,1098	11
Zrenjanin	0,0014	6	0,0116	6
Pančevo	-0,1007	11	-0,1066	10
Ruma	0,1564	2	0,2083	1
Požarevac	0,1897	1	0,1658	3
Zaječar	-0,0732	9	-0,0689	9
Lapovo	0,1254	3	0,1749	2
Niš	0,0860	4	0,0881	4
Kraljevo	-0,0774	10	-0,0268	8
Užice	-0,0266	8	0,0014	7

4.4. Comparison between methods

Based on the obtained results using the ELECTRE method, the best variants and only efficient variants in both the variants are v_5 and v_6 Požarevac and Ruma. By comparison the TOPSIS and MABAC method, in both variants, in three of four cases the best variant is v_6. Also, in all situations the first four variants are always the same, Požarevac (v_6), Ruma (v_5), Lapovo (v_8) and Niš (v_9). Rank of variants is given in Table 9.

Table 9 Comparison of TOPSIS and MABAC method

Variant	MABAC	TOPSIS	MABAC	TOPSIS
	Delphi method	Delphi method	Entropy method	Entropy method
Subotica	5	6	5	10
Novi Sad	7	10	11	11
Zrenjanin	6	9	6	6
Pančevo	11	5	10	8
Ruma	2	4	1	3
Požarevac	1	1	3	1
Zaječar	9	8	9	9
Lapovo	3	3	2	2
Niš	4	2	4	4
Kraljevo	10	11	8	7
Užice	8	7	7	5

General conclusion is that the railroad container terminal should be first located in the area of the railway section Požarevac, in the region of Braničevo.

The best region for location is Požarevac. This variant is high in terms of its volume of transported goods and high investment attractiveness. The transportation infrastructure of this region represents an average level, while the unemployment rate is very low. A clear advantage of this region is great connectivity with other regions and the existence of main road and rail corridors.

By looking at the complete range of variants, with all the methods, and variants of weighting criteria it can be concluded that those with a high volume of transport and accessibility of infrastructure can be potential locations. Regions (railway sections) like Kraljevo or Zrenjanin should not be taken into further consideration because they would not justify terminal existence by any parameter.

5. Conclusion

A railroad container terminal location problem, like any other location problem, is a very complex task, which requires a detailed analysis of different segments and parameters. Using multi criteria decision-making methods, the model presented in this paper was developed. The macro location of the terminal is defined, which represents the first phase of determining its potential location.

The proposed methodology has a universal character and can be applied to different types of location models, both for the selection of the location of railroad terminals, as well as for other railway logistics location problems.

A further model development is based on a more detailed analysis of all input parameters. In particular, it is necessary to analyze the flows of goods more closely, including the volume of transported goods from road or water transport. Also, the analysis of transport infrastructure can be expanded, using water transport and its impact on potential locations. In addition, an analysis of environmental parameters as well as transport safety in each region can be approached in more detail.

Market analysis, investment attractiveness and other economic criteria are another direction in the development of the model. The model can be improved using more relevant data for weight criteria, using some other methods for its calculation. For a more detailed analysis, and comparison of the results, other methods such as ELECTRE III/IV, SAW and some newer ones can be applied.

The next step in our research and development is the formulation and solving of the second phase of the observed problem, that is, micro location of the railroad container terminal. This approach requires an analysis of the micro plan, within the region, in order to find the most suitable field for the location of the railroad container terminal.

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