DESIGN OF PLACING THE CONTAINER RELOADING STATION BY APPLYING THE OPERATIONS RESEARCH METHODS: A RESEARCH STUDY

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Abstract

The manuscript is focused on the design of methodical procedure to locate container reloading station of national importance in the examined country. Slovakia represents the investigated country where ten container reloading stations, specialized above all in transshipment of loading units, are currently in operation. The introductory parts of the manuscript outline the most important concepts associated with the very term of intermodal transport, container reloading stations in the given country as well as a brief literature review in a given context. The following parts discuss the specification of relevant data and methods for this study as well as a description of the general procedure of multi-criteria evaluation of alternatives; namely consisting of, identifying a set of alternatives (Slovak regions), establishing a set of criteria and determining the weights of such criteria. The last part of the manuscript addresses forming a criteria matrix and subsequent calculations in order to search for the most suitable region when applying particular techniques of Operations Research. Specifically, the weights of criteria being determined based on the Saaty quantitative pairwise comparison method, and the final procedure in the context of selecting the most suitable alternative is suggested by using the Technique for Order Preference by Similarity to Ideal Solution (also called as the TOPSIS method).

Keywords: Intermodal transport; road transport; logistics chain; container reloading station; Operations Research

1. Introduction

Material transportation where the initial and the final transport leg are executed by road transport mode is called intermodal (or combined) transport. The major, i.e. the longest, transport leg is realized by railway, air, inland waterway or maritime transport mode. To support intermodal transport efficiency and facilitate the reloading process among different transport modes, it is important to cover the logistics area by the adequate high-quality transport infrastructure and transport network, and above all, container reloading stations [3, 15].

Container reloading station or container terminal is a facility / logistics object where transport mode changes from one to another. It is considered one of the most important

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components of global logistics chains. The efficiency of international transport-logistics chains depend on the effectiveness of every single part of such a chain. Thus, devices, disposition, configuration of crucial equipment as well as technology of a container facility should be designed in order not to create constraints. According to [4, 15], terminal default parameters and its conception are as follows:

- requirements for the terminal performance and its service portfolio;
- the facility reloading area size;
- the number, configuration and length of handling and transit road and intermodal infrastructure;
- the terminal connection to neighboring transport network infrastructure;
- the number, configuration and technical parameters of transshipment (reloading) devices.

Particular parameters and components of container reloading station are specified by its operator; however, it inevitably depends on a range of prospective operations ensured and its placement [8]. Although no legislation stipulates individual technical parameters of such objects [13], they are to observe the operational requirements of the European Agreement on Important International Combined Transport Lines and Related Installations (AGTC agreement) and related road transport regulations. The following figure (see Figure 1) illustrates the location of individual container reloading stations in Slovakia at present (July 2019). All of them are connected to main road and railway networks, and their operation is focused especially on providing distribution (delivery) services using road articulated vehicles, and also on warehousing as well as all kinds of reloading activities with containers.

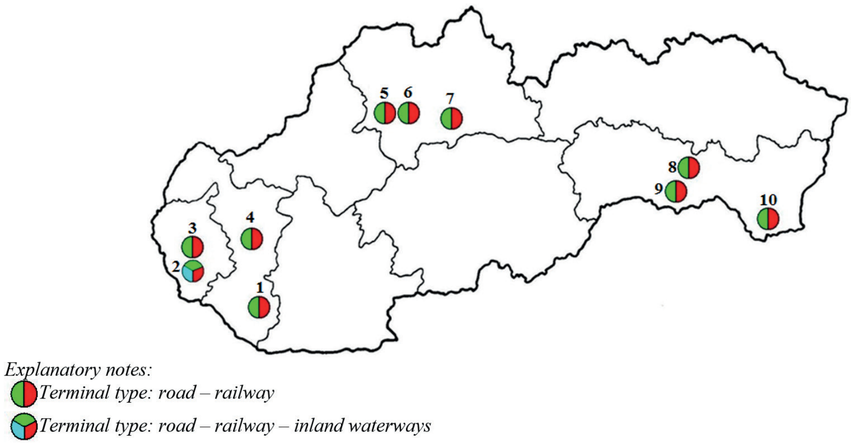

Fig. 1. Overview of the current location of container reloading stations in Slovakia. Source: Author

Individual numbers shown in the previous figure correspond to the following list which indicates the terminal name and its operator: 1. Dunajská Streda / Metrans; 2. Pálenisko / SPaP a.s.; 3. Bratislava - ÚNS / Rail Cargo Operator; 4. Sládkovičovo / Green Integrated Logistics; 5. Žilina / Rail Cargo Operator; 6. Žilina – Teplička / TIP Žilina, s.r.o. (Metrans); 7. Ružomberok / Rail Cargo Operator; 8. Košice / Rail Cargo Operator; 9. Košice - Haniská / Metrans; 10. Dobrá / ZSSK Cargo a.s. and Transcontainer Slovakia.

2. Literature review

In their literatures, numerous authors address the matter of intermodal transport as well as road transport in relation to the container reloading station location. In publication [19], a sustainable multimode multi-commodity network design model for intermodal freight transportation with transfer and emission costs is discussed. The authors [25, 26] deal with different approaches toward selection of appropriate types of road-rail container docks and their layout. Whereas literature [25] is focused on multiple equipment integrated scheduling and storage space allocation in rail-water container terminals considering energy efficiency, the authors [26] in their study address designing the efficient types of inland intermodal terminals.

The publication [28] presents an interesting view at the container reloading station location design in a particular environment, wherein the selection of facility location in order to be the most suitable for a variety of stakeholders is described. In particular, the authors suggest a new hybrid multi-criteria decision making model which combines the Delphi fuzzy techniques to provide support during the decision making process. The methodical procedure to place and design intermodal transport terminals in Croatia is proposed in the research study [20]. The purpose of their manuscript is to evaluate the criteria used for decision making on suitable locations for intermodal terminals in Croatia by applying the Analytic Hierarchy Process (AHP method).

On the other side, the publication written by the authors [18] aims to find a suitable methodology for planning the locations of road-rail container reloading facility in urban transit context while including three stages. The first stage represents the forming the geographic information system (GIS) database allowing to determine the potential locations of such objects. The second stage utilizes an optimization algorithm to identify terminal locations. The major research objective of the manuscript consists in upgrading the location planning approach by establishing an additional third stage in evaluating solutions obtained by the optimization algorithm.

Unlike the aforementioned literature sources, the presented manuscript discusses the proposal of a methodical procedure for location of one container reloading station of national importance in the examined country when suggesting specific set of criteria containing various aspects of socio-economic and transport areas (particularly covering the road transport aspects). For the scientific purposes of this study, the Saaty quantitative pairwise comparison method and the TOPSIS method are applied.

3. Data and methods

The placement-related process in terms of transshipment facility location may be considered the decision making problem for which the multi-criteria decision making methods can be applied [1, 5]. According to [27], for such a purpose, the methods of multi-criteria decision analysis (or multi-criteria decision making; MCDM) can be used. The decision making means to choose one option from a list of potentially viable alternatives against several criteria in a given situation. Next to the list of criteria indirectly forming the objective of the decision analysis, it is necessary to have a list of alternatives from which to choose. If there is a list of criteria and a list of decision making alternatives, it is necessary to consider in detail what form the final decision should take. If we insist that it is really necessary to choose only one optimal alternative, we need to accept, that in typical cases, we want to get something out of unreliable and insufficient information that is almost certainly not included. For a task formulated in this way, there is a requirement to arrange the decision making alternatives in order to find out how close they are to the optimal alternative.

In order to standardize, define and select methods of evaluation for multi-criteria evaluation of alternatives which support decision making process, it is necessary to know the following matters: what is to be decided; what goals are to be met; what aspects the decision making process must adhere and the time line for the outcome of the decision making process. The general procedure for the multi-criteria analysis, i.e. evaluation of alternatives, basically involves four follow-up steps [12]:

(1) identifying a set of alternatives;

(2) establishing a set of criteria;

(3) determining the weights of criteria;

(4) selecting the most suitable alternative.

3.1 Identifying a set of alternatives

The general procedure of multi-criteria evaluation of alternatives as an integral part of a MCDM process assumes that at least two options as solutions for the issue exist. For our purposes, individual regions located in Slovakia, wherein the container reloading station of national importance should potentially be placed, are specified as a set of alternatives; as follows:

- A - Banská Bystrica;
- B - Bratislava;
- C - Košice;
- D - Nitra;
- E - Prešov;
- F - Trenčín;
- G - Trnava and;
- H - Žilina.

In order to obtain more precise outcomes, it would be reasonable to take into consideration the division at district level; however, in such a case, it would be very hard to retrieve the particular data necessary to fill in the criteria matrix, as most of the relevant data is not publicly accessible at district level. On the other side, each region has only one larger city (county seat) in which implementation of intermodal transport solutions can be considered.

3.2 Establishing a set of criteria

The second step of the MCDM procedure consists in establishing a set of criteria which affects the whole process of decision making. After specifying goals of available experiences and the knowledge analysis relevant to this manuscript, ten criteria primarily from socio-economic and transport areas potentially related to road transport were defined. For clarity, the criteria are summarized in the overview as follows:

- Criterion 1 – **GDP** (stands for gross domestic product per capita) [PPS – purchasing power standards];
- Criterion 2 – **GDPGR** (stands for average GDP growth over 5 years) [-];
- Criterion 3 – **FDI** (stands for value of foreign direct investment) [€ thousands];
- Criterion 4 – **TGR** (stands for amount of transported goods by road transport via public roads) [thousands tons];
- Criterion 5 – **LEs** (stands for number of large enterprises; i.e. > 250 employees) [pcs];
- Criterion 6 – **SMEs** (stands for number of small and medium sized enterprises; i.e. < 250 employees) [pcs];
- Criterion 7 – **PS** (stands for population size) [pcs];
- Criterion 8 – **AGW** (stands for average gross monthly wage) [€];
- Criterion 9 – **RN** (stands for road network density, including motorways, expressways and I. class roads [km];
- Criterion 10 – **AGTC** (stands for regional connections to network of railway lines included in the European Agreement on Important International Combined Transport Lines and Related Installations [pcs].

Since the condition that all the data associated with individual alternatives by each criterion should be obtained for the same time period, only values gathered for 2017 are listed in the manuscript. Values for 2018 could only be obtained for a limited group of criteria / alternatives [24]. The following overview (see Table 1) below shows the specific values of criteria related to individual alternatives (regions in Slovakia).

Tab 1. Assignment of criteria and their values to individual alternatives. Source: Author

Criterion / Alternative	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A	16,862	1.03	928,254	3,882	47	12,773	649,788	980	768.36	0
B	53,779	1.02	27,291,407	8,138	172	48,124	650,838	1,449	240.51	3
C	19,009	1.08	2,628,408	6,170	59	14,837	799,217	1,039	384.04	2
D	19,992	1.03	1,634,817	2,967	58	15,621	678,692	1,021	555.80	2
E	13,682	1.04	523,007	4,461	56	12,992	823,826	996	752.72	2
F	18,947	1.01	1,794,988	7,091	72	10,214	587,364	1,020	404.22	2
G	24,829	1.01	3,229,763	5,766	59	13,978	562,372	1,186	360.48	3
H	20,509	1.04	2,913,839	6,497	69	16,336	691,023	1,015	673.39	3

3.3 Determining the weights of criteria

Determining the weighs of criteria is closely related to the completeness of a set of criteria reflecting the essential characteristics of the alternative. In cases where the set of criteria is relatively complete, it is necessary to consider the individual importance of each criterion while evaluating, and the result of its importance, or lack thereof, for this purpose. Weights of criteria can be established either prior to executing a partial evaluation of alternatives, or subsequently after correcting the obtained results [23].

When using differentiated weights of criteria, the evaluation results depend on the choice of these weights for which applies; i.e. if with a small number of criteria we get a high weight for a certain criterion, then the evaluation results tend to arrange the evaluated alternatives by that criterion; whereas a large number of criteria lead to the fragmentation of weights and even if the weights of individual criteria do not differ much, they still allow for differentiation [2].

Determining the weights of criteria is usually a crucial step in the model formation of multi-criteria evaluation of alternatives. The information obtained from any of optional procedures is used to determine the preferential relations between alternatives depending on the objectives of the entire analysis. The higher the weight of criterion is, the greater the effects on the decision making about the resulting alternative are. These weights can be calculated by a number of techniques.

As far as this manuscript is concerned, individual weights of criteria are about to be specified by the Saaty pairwise comparison method. The first phase of this technique is to define the relationship among each pairs of criteria [22], wherein the preference level is calculated within a range of 1-9 (1 - equal criteria i and j; 3 - slightly preferred criterion i above j; 5 - strongly preferred criterion i above j; 7 - very strongly preferred criterion i above j; 9 - absolutely preferred criterion i above j.) [10]. The evaluation process using the Saaty method is based on the fact that the decision maker compares each pair of criteria and insert the value of preferences of i-th in relation to the j- th criterion into the Saaty matrix $S=(s_{ij},\ i,j = 1,2, \ldots, k)$. In case that j-th criterion is preferred above that of the i- th criterion, inverse values are entered into the Saaty matrix (s_{ij}=1/3 for low preference, s_{ij}=1/5 for strong preference, etc.) [9].

In the Saaty matrix, $s_{ji}={}^{1}\!/_{s_{ij}}$, and furthermore $s_{ij}\approx{}^{v_i}\!/_{v_j}$ (the value of s_{ij} represents the approximate ratio of the criterion weight i and j). This already indicates the fundamental features of the Saaty matrix. Saaty designed several numerically very simple ways by which individual weights v_i can be estimated [21]. Vector of their values are denoted as $v_i = (v_1,\ v_2,\ \ldots,v_k)$. The most commonly method to be applied to calculate the weights is referred to as normalized geometric mean of a line in the Saaty matrix; this procedure is sometimes called "logarithmic least squares method". The Saaty method can be used not only to determine the preferences between criteria, but also among individual alternatives by analyzing the original assignment, which is called as an Analytic Hierarchy Process [7, 9].

This process is specified as follows:

1) to ensure the greatest possible objectivity in terms of designing the container reloading station location methodology, ten decision makers (experts in the given field of research) were asked to assign preferences among individual criteria pairs.
2) for each cell of the initial Saaty matrix, a sum of the sub-matrices of all the experts was calculated and then the arithmetic mean was obtained. In order to keep to the technique procedure, individual values were rounded down to the nearest whole number.

The following Table 2 presents resulting Saaty matrix after individual evaluation by experts.

Tab. 2. Resulting Saaty matrix after experts' evaluation. Source: Author

Criterion	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	1.00	1.00	2.00	0.33	2.00	1.00	0.50	0.50	0.25	0.33
2.	1.00	1.00	2.00	0.33	2.00	1.00	0.50	0.50	0.33	0.25
3.	0.50	0.50	1.00	0.17	1.00	0.33	0.25	0.25	0.17	0.20
4.	3.00	3.00	6.00	1.00	5.00	3.00	2.00	2.00	0.50	1.00
5.	0.50	0.50	1.00	0.20	1.00	0.50	0.25	0.25	0.13	0.20
6.	1.00	1.00	3.00	0.33	2.00	1.00	0.50	0.50	0.25	0.33
7.	2.00	2.00	4.00	0.50	4.00	2.00	1.00	1.00	0.50	0.50
8.	2.00	2.00	4.00	0.50	4.00	2.00	1.00	1.00	0.50	1.00
9.	4.00	3.00	6.00	2.00	8.00	4.00	2.00	2.00	1.00	2.00
10.	3.00	4.00	5.00	1.00	5.00	3.00	2.00	1.00	0.50	1.00

To calculate the geometric mean of each line of the matrix S, equation 1 is used [19]:

$$g_i = \sqrt[k]{\prod_{j=1}^{k} s_{ij}}\,, \dots i,j = 1,2,\dots,k, \qquad (1)$$

where: g_i is geometric mean; s_{ij} denote individual elements of Saaty matrix; $\prod$ is the product of values of the Saaty matrix elements.

The "priority vector", i.e. the normalized geometric mean, is calculated for each criterion using the geometric mean of each line in the matrix divided by the sum of the geometric means of all the criteria. This step is carried out by the following equation (Eq. 2) [9]:

$$w_i = \frac{g_i}{\sum_{i=1}^{k} g_i}, \dots i,j = 1,2,\dots,k, \qquad (2)$$

where: w_i is normalized geometric mean; g_i represents the geometric mean; $\sum$ denotes the sum of geometric means' values.

Individual resulting values obtained applying the Saaty method are summarized in the following Table 3.

Tab. 3. Values obtained using the Saaty method. Source: Author

	Criterion	Product of cell values	Geometric mean	Priority vector
1.	GDP	0.0272250	0.697424	0.0558
2.	GDPGR	0.0272250	0.697424	0.0558
3.	FDI	0.0000298	0.352713	0.0282
4.	TGR	1620.0000	2.093879	0.1675
5.	LEs	0.0000406	0.363792	0.0291
6.	SMEs	0.0408375	0.726283	0.0581
7.	PS	16.000000	1.319508	0.1055
8.	AGW	32.000000	1.414214	0.1131
9.	RN	36864.000	2.861938	0.2290
10.	AGTC	900.00000	1.974350	0.1579
			$\sum$ = 12.501370	$\sum$ = 1.00000

From table above, it is clear that the highest priority is assigned to factors associated with a transport infrastructure as well as transport characteristics of a given region. Those are represented by the road network density in km and the number of AGTC railway lines passing through a given region, as well as the amount of goods transported by road transport. The least important criteria include the number of large enterprises and the value of foreign direct investment in a certain region. Large enterprises are assumed to dispose of sufficient financial capital to construct and operate their own logistics facilities; and therefore, they do not represent the target customers of a suggested logistics object / transshipment dock. In regard to foreign direct investment, it does not necessarily create desired effects in form of increasing the employment level; nevertheless, it serves only as an indirect indicator of a given region economic performance [14].

3.4 Selecting the most suitable alternative

As indicated above, the final selection of the most suitable alternative will be executed using the Technique for Order Preference by Similarity to Ideal Solution which is shortly referred to as TOPSIS method. This technique is one of the MCDM methods where the alternatives' evaluation is carried out through comparison with ideal alternative [11, 17]. To refer the deviation from options, various units are utilized. The fundamental of the TOPSIS method lies in standard Euclidean metrics. In regard to the first sub-step of selecting the most suitable alternative, it is necessary to list individual values into a matrix which is called an input (or original) **criteria matrix.** Its lines are formed by individual alternatives and its columns correspond to individual criteria containing relevant values. An original criteria matrix in our case is as follows (identical to Table 1):

16,862	1.03	928,254	3,882	47	12,773	649,788	980	768.36	0
53,779	1.02	27,291,407	8,138	172	48,124	650,838	1,449	240.51	3
19,009	1.08	2,628,408	6,170	59	14,837	799,217	1,039	384.04	2

19,992	1.03	1,634,817	2,967	58	15,621	678,692	1,021	555.80	2
13,682	1.04	523,007	4,461	56	12,992	823,826	996	752.72	2
18,947	1.01	1,794,988	7,091	72	10,214	587,364	1,020	404.22	2
24,829	1.01	3,229,763	5,766	59	13,978	562,372	1,186	360.48	3
20,509	1.04	2,913,839	6,497	69	16,336	691,023	1,015	673.39	3

As far as the TOPSIS technique is concerned, the maximization nature is preferred, and hence all the minimization criteria must be converted into the maximization nature (see Eq. 3) [16, 17].

$$y_{ijmax} = h_{jmin} - y_{ijmin} \tag{3}$$

where: y_{ijmax} is the determined value of i-th alternative by j-th criterion with a maximization nature; h_{jmin} represents the highest value of the j-th criterion with a minimization nature; y_{ijmin} denotes the value of i-th alternative by j-th criterion with a minimization nature.

The next step is to compile a criteria matrix $R= (r_{ij})$ according to the equation 4.

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y_{ij}^2}}\ ; \mathrm{i} = 1,2, \dots , m; j = 1,2, \dots , n, \quad [\text{-}] \tag{4}$$

where: y_{ij} is the determined value of i-th alternative by j-th criterion.

As for the next step, the normalized criteria matrix $Z = (z_{ij})$ needs to be compiled by multiplying the normalized alternative's value by each criterion and the normalized weight of the relevant criterion (see Eq. 5), from which the ideal alternative H and basal alternative D can be specified subsequently [17].

$$z_{ij} = w_j r_{ij}, \quad [\text{-}] \tag{5}$$

where: w_j is relevant normalized criterion weight; r_{ij} denotes the normalized value of the particular alternative by each criterion.

The next step is to calculate the deviation d_i^+ of each Z matrix value from the ideal alternative (see Eq. 6) [17]:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (z_{ij} - h_j)^2}\ ; \ \mathrm{i} = 1,2, \dots , m; j = 1,2, \dots , n, \quad [\text{-}] \tag{6}$$

where: h_j is the best (highest) value of the j-th criterion, i.e. ideal alternative.

Analogously, the deviation d_i- of each Z matrix value from the basal alternative needs to be determined (see Eq. 7) [17]:

$$d_i^- = \sqrt{\sum_{j=1}^{n} (z_{ij} - d_j)^2}; \ \mathrm{i} = 1,2, \dots , m; j = 1,2, \dots , n, \quad [\text{-}] \tag{7}$$

where: d_j is the worst value of the j-th criterion, i.e. basal alternative.

All the alternatives are then sorted depending on the values of the relative indicator ci and the alternatives' ranking can be specified. This indicator is calculated as follows (see Eq. 8) [17]:

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-};\ \mathrm{i} = 1,2,\dots,m,\quad [\text{-}] \tag{8}$$

4. Results - multi-criteria evaluation of alternatives

In this chapter, an application of the chosen Operations Research technique, specifically the TOPSIS method, to design the final methodological procedure for placement of container reloading station of national importance in the examined country is presented.

As for a criteria matrix compiled according to the TOPSIS method, it is important so that all the criteria are of the same nature (minimization or maximization) on the basis of Eq. 3 above. Criteria conversion to a same nature is not so difficult process since each minimization criterion may be simply converted to maximization nature [6]. In our case, it is needed to modify an initial criteria matrix at the eighth criterion; i.e. of average gross monthly wage. As far as this criterion is concerned, the highest value is of € 1,449, so by performing the conversion, the original criterion values y_{i8} are replaced by values 1,449 - y_{i8}. Thus, a modified criteria matrix looks as follows:

16,862	1.03	928,254	3,882	47	12,773	649,788	469	768.36	0
53,779	1.02	27,291,407	8,138	172	48,124	650,838	0	240.51	3
19,009	1.08	2,628,408	6,170	59	14,837	799,217	410	384.04	2
19,992	1.03	1,634,817	2,967	58	15,621	678,692	428	555.80	2
13,682	1.04	523,007	4,461	56	12,992	823,826	453	752.72	2
18,947	1.01	1,794,988	7,091	72	10,214	587,364	429	404.22	2
24,829	1.01	3,229,763	5,766	59	13,978	562,372	263	360.48	3
20,509	1.04	2,913,839	6,497	69	16,336	691,023	434	673.39	3

The next partial step is to build up a criteria matrix $R = (r_{ij})$ according to Eq. 4 (see the following Table 4), while maintaining the same criteria weights calculated by the Saaty method (priority vector).

Tab. 4. Criteria matrix R obtained by the TOPSIS method. Source: Author

Criterion / Alternative	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A	0.2269	0.3535	0.0333	0.2346	0.2000	0.2106	0.3350	0.4250	0.4941	0
B	0.7238	0.3501	0.9786	0.4918	0.7321	0.7935	0.3355	0	0.1547	0.4573
C	0.2558	0.3707	0.0943	0.3729	0.2511	0.2446	0.4120	0.3715	0.2470	0.3049
D	0.2691	0.3535	0.0586	0.1793	0.2468	0.2576	0.3499	0.3878	0.3574	0.3049
E	0.1841	0.3569	0.0188	0.2696	0.2383	0.2142	0.4247	0.4105	0.4841	0.3049
F	0.2550	0.3466	0.0644	0.4285	0.3064	0.1684	0.3028	0.3887	0.2599	0.3049
G	0.3342	0.3466	0.1158	0.3485	0.2511	0.2305	0.2899	0.2383	0.2318	0.4573
H	0.2760	0.3569	0.1045	0.3926	0.2937	0.2693	0.3562	0.3932	0.4330	0.4573
Priority vector	0.0558	0.0558	0.0282	0.1675	0.0291	0.0581	0.1055	0.1131	0.2290	0.1579

As far as the next partial step is concerned (see Eq. 5), the normalized criteria matrix $Z = (z_{ij})$ needs to be compiled via multiplying the normalized alternative values by each criterion with a priority vector (normalized weights of individual relevant criteria), from which the ideal alternative H_j and basal alternative D_j can be then specified (see the following Table 5).

Tab. 5. Normalized criteria matrix Z obtained by the TOPSIS method. Source: Author

Criterion / Alternative	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A	0.0127	0.0197	0.0009	0.0393	0.0058	0.0122	0.0353	0.0481	0.1131	0
B	0.0404	0.0195	0.0276	0.0824	0.0213	0.0461	0.0354	0	0.0354	0.0722
C	0.0143	0.0207	0.0027	0.0625	0.0073	0.0142	0.0435	0.0420	0.0566	0.0481
D	0.0150	0.0197	0.0017	0.0300	0.0072	0.0150	0.0369	0.0439	0.0818	0.0481
E	0.0103	0.0199	0.0005	0.0452	0.0069	0.0124	0.0448	0.0464	0.1109	0.0481
F	0.0142	0.0193	0.0018	0.0718	0.0089	0.0098	0.0319	0.0440	0.0595	0.0481
G	0.0186	0.0193	0.0033	0.0584	0.0073	0.0134	0.0306	0.0270	0.0531	0.0722
H	0.0154	0.0199	0.0029	0.0658	0.0085	0.0156	0.0376	0.0445	0.0992	0.0722
H_j	0.0404	0.0207	0.0276	0.0824	0.0213	0.0461	0.0448	0.0481	0.1131	0.0722
D_j	0.0103	0.0193	0.0005	0.0300	0.0058	0.0098	0.0306	0	0.0354	0

And, according to the specified TOPSIS method procedure, next steps are to calculate the deviation of individual Z matrix values from the ideal alternative d_i^+ (see Eq. 6), the deviation of individual Z matrix values from the basal alternative d_i- (see Eq. 7) and the relative indicator ci (see Eq. 8) in order to sort all the alternatives in descending order (see the following Table 6).

Tab. 6. Final evaluation of alternatives using the TOPSIS method. Source: Author

Indicator / Alternative	d_i^+	d_i^-	c_i	Alternatives' ranking by the TOPSIS method
Banská Bystrica	0.1002	0.1042	0.5098	4.
Bratislava	0.0919	0.1057	0.5349	3.
Košice	0.0820	0.0761	0.4813	8.
Nitra	0.0829	0.0805	0.4927	7.
Prešov	0.0704	0.1030	0.5940	2.
Trenčín	0.0811	0.0813	0.5006	5.
Trnava	0.0846	0.0846	0.5000	6.
Žilina	0.0535	0.1125	0.6777	1.

Following the above calculations undergone in regard to decision making on identifying the proper container terminal location out of eight Slovak regions, when applying TOPSIS technique, the **Žilina region** was specified as the most suitable alternative. Prešov region seems to be the second most appropriate option.

5. Conclusion

Intermodal transport terminal is an essential component of global logistics chains. In order to ensure the efficient functionality of those chains, it is important to construct such logistics nodes in order not to create constraints regarding global freight flow. The proposal of individual parameters of reloading facilities, their configuration and ideal location need to come out on hard-and-fast technical requirements. Nevertheless, it is reasonable to use some specific SW tools or mathematical methods which can be implemented to identify the optimal (the most effective) solution out of multiple potential options. The objective of this paper was to characterize several alternatives based on determined set of criteria potentially related to the container reloading station location in order to select the most suitable region of the examined country when using different exact Operations Research techniques.

In the past, the issue discussing a container terminal location has not come out on any exact methodological procedure or guideline. In Slovakia, for instance, this concept was based on an example of reloading stations location in Germany, and no criteria and attributes influencing the suitable location were taken into account. Some existing procedures to address the effective terminal location are summarized in the second chapter; nevertheless, none of them is based on criteria suggested in this manuscript.

Based on the statements above, apparently, we must put emphasis on determining the proper location of container transshipment facilities as well as their optimal layout and equipment. As confirmed by this case study, in the context of decision making on selection of the adequate terminal location, multiple tools related to multi-criteria evaluation of alternatives (mostly referred to as multi-criteria decision making) can be utilized. For instance, the Saaty quantitative pairwise comparison method, to calculate the weights of numerous criteria, and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS method), in order to sort all the potential alternatives in an appropriate way, when taking into account a number of decision options, seem to be useful techniques. Particularly for purposes of this research study, two aforementioned methods were applied to search for the most suitable place out of eight regions to locate public container reloading station of national importance in Slovakia.

Following the results obtained, these techniques and others can be introduced in the matter of decision making tasks of similar problems in the future when using the specific computing software. And also, the next step in the future is to be addressing the financial aspect of the design for locations and constructions of such transshipment objects.

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