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SELECTION OF THE LOCATION OF THE MAIN WAREHOUSE USING THE EDAS METHOD

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Abstract

When solving problems related to capital investments in the company, it is necessary to work out the problem in detail and take into account as many influential parameters as possible in order to make the optimal decision. One such problem is the selection of the main warehouse location for the needs of a given company with dispersed centers. Multi-criteria decision-making methods can be applied to successfully solve such complex problems.

In this paper, the EDAS method will be applied to achieve the optimal selection of the location of the main warehouse in a company with several dispersed centers.

Key words: *location selection, warehouse, multi-criteria decision-making methods, EDAS method.*

INTRODUCTION

One of the very important decisions of any company that has several dispersed centers is the choice of the location of the main warehouse. The optimal location of the main warehouse is of great importance for the smooth functioning of the company itself. When choosing the location of the main warehouse, it is necessary to take into account as many influential parameters as possible. Usually, in all cases, some parameters have greater influence and others have smaller influence on the choice of location. In some cases, the current location decision is optimal, but over a period of time expressed in years it may become suboptimal. The optimal choice of the location of the main warehouse has a direct impact on the costs of logistics, marketing, production, consumption, and finance [1].

The parameters, that is, the criteria by which potential locations for housing the main warehouse are compared, can be quantitative and qualitative. In essence, decision-making is the choice of one of several possible alternatives for a given problem. In order to be able to apply decision-making, it is necessary that there are two or more possible alternatives for a given problem. The application of decision-making to solve a given problem can be single-criteria or multi-criteria. In single-criteria decision-making, only one criterion is applied, while in multi-criteria decision-making, several criteria are applied to make the final decision. Single-criterion optimization uses only one criterion during optimization, thereby reducing the actual solution to a given problem. Multi-criteria optimization uses several criteria so that the obtained solution is the most optimal for the given problem.

There are numerous authors who have been involved in research related to location selection, applying some of the methods for multi-criteria decision making. Some authors who conducted research in this direction are mentioned below. In 2022, Wang et al. investigated the application of a multi-criteria decision-making method for the analysis of location selection and evaluation in urban integrated power plants based on a geographic information system [2]. Margana et al. in 2021 conducted research with the aim of determining the location of the distribution center in a small and medium-sized enterprise, using the center of gravity method [3]. In 2021, Shaikh et al. conducted a study on the application of multi-criteria decision-making methods for making a decision on the identification of an ideal business location [4]. In 2018, Siam et al. conducted a study to determine the optimal location of a central spare parts warehouse for a certain leading taxi company in Indonesia [5]. In 2013, Chakraborty et al. conducted research on the application of multi-criteria decision-making methods for choosing the location of a distribution center [6]. In 2024, during the preparation of his master's thesis, Stefanov conducted research on the selection of the location of the main warehouse in a company with dispersed centers [7]. In 2014, during the preparation of his doctoral dissertation, Marković conducted research on the regional logistics model for transport systems using multi-criteria decision-making methods [8]. In 2016, during the preparation of his doctoral dissertation, Rangelović conducted research on optimization models in the selection of the location of production facilities in the function of local economic development [9]. There are many other studies related to this issue.

METHODS FOR MULTI-CRITERIA DECISION MAKING

There are a number of methods for multi-criteria decision-making, which can be successfully applied to solve various problems in logistics [10]. The most commonly used methods for multi-criteria decision making are: ELECTRE method, PROMETHEE method, AHP method, ANP method, VIKOR method, TOPSIS method, EDAS method, etc. Common to all multi-criteria decision-making methods is the choice between more than two alternatives and according to more influential criteria. All criteria have a different weight, that is, they influence the choice of the optimal alternative. The sum of weights for all criteria must be equal to one. Criteria have their purpose, that is, they can aim for a maximum (max) or a minimum (min). The criteria can be quantitative or qualitative, but in order to be able to perform the calculation, it is necessary to convert the descriptive assessment into numbers in order to be able to perform the corresponding further mathematical operations. There are basically three types of scales that can be used when measuring different quantities: ordinal (ordinary) scale, interval scale, and ratio scale. In this paper, the Interval Scale will be used to translate qualitative values into quantitative ones.

In this paper, the EDAS method will be applied to solve problems related to the selection of the location of the main warehouse in a company with dispersed centers [11].

The EDAS method was proposed by Mehdi Keshavarz Ghorabaee in 2016, and it is an Estimate based on the Distance from the Average Solution or EDAS for short. This distance is calculated in the positive and negative direction in relation to the average solution, individually and according to the selected useful or useless criteria [12]. According to this method, it is necessary to create an inactive solution, where the largest values of the positive distance from the average solution and the smallest values of the negative solution give the best solution from the average solution [13]. The EDAS method differs from other multi-criteria decision-making methods in the fact that the result is obtained from the average solution, thus eliminating the risk of expert bias towards alternatives. The result obtained from the average solution normalizes the data, which greatly limits the chances of deviation from the best solution. In this way, a better and more accurate solution is obtained, compared to the solution obtained with most multi-criteria decision-making methods.

Solving this problem according to this method is carried out in several steps, which are given below [14]:

Step 1. Selecting the most important criteria that describe the alternatives and construct the matrix for average decisions;

Step 2. Construction of matrix of criteria weights;

Step 3. Constructing the average solution matrix;

Step 4. Calculating Positive Distance from Average (PDA) and Calculating Negative Distance from Average (NDA);

Step 5. Calculating the weighted sum of positive (SP) and negative (SN) distances for all alternatives;

Step 6. Normalizing values for the sum of positive (NSP) and negative (NSN) distances for all alternatives;

Step 7. Calculating the Assessment Score (AS) of all alternatives;

Step 8. Ranking of alternatives according to descending grade (AS) values. The alternative with the highest AS value is ranked best.

CASE STUDY

In this paper, we will consider a company that deals with ensuring timely, efficient, and coordinated performance of water management activities on the territory of the entire country. The company has 14 branches in different cities across the country, i.e., dispersed centers. Of all the existing subsidiaries, 4 subsidiaries can be singled out as the most significant and with the greatest importance.

The company's most important subsidiaries will represent alternatives for choosing a location for setting up a company-wide main warehouse of spare parts and consumables. Alternatives for the given example would be:

A_1 – Branch in Kavadarci;
A_2 – Branch in Kocani;
A_3 – Branch in Sveti Nikole;
A_4 – Branch in Skopje.

The comparison of alternatives will be done according to several influential parameters, which will represent the criteria. The criteria for a specific example will be:

C_1 – The strategic importance of the subsidiary at the state level;
C_2 – Average annual revenues of the subsidiary company;
C_3 – Average distance to all branches;
C_4 – Average size to cover and serve municipalities;
C_5 – Average cost of warehouse service;
C_6 – The need for new facilities;
C_7 – Average delivery of spare parts and consumables;
C_8 – The need for new employment.

Each criterion has its own influence (weight) on the alternatives, and, in order to define the weights of the criteria, the following were created:

- Techno-economic analyses and other professional information;
- Consultations and surveys of logistics experts;
- Calculation of the average values of weights obtained from the above procedures.

All multi-criteria methods use so-called normalized weights, where the sum of all criteria weights should be equal to 1 (one). After normalization by weighting the weights, the normalized criteria are obtained and the nature of the criteria is displayed. The criteria have their purpose, that is, they aim for a maximum or a minimum, and they can be qualitative or quantitative. Table 1 shows the normalized criteria.

Table 1. Normalized criteria and nature of criteria

Criteria	**Mark**	**Normalized weights**	**Goal**	**Category**
The strategic importance of the subsidiary at the state level	C_1	0,14	max	Qualitative
Average annual revenues of the subsidiary company [million euros]	C_2	0,16	max	Quantitative
Average distance to all branches [kilometers]	C_3	0,13	min	Quantitative
Average size to cover and serve municipalities [number of municipalities]	C_4	0,09	max	Quantitative
Average cost of warehouse service	C_5	0,11	min	Qualitative
The need for new facilities	C_6	0,12	min	Qualitative
Average delivery of spare parts and consumables	C_7	0,17	max	Qualitative
The need for new employment	C_8	0,08	min	Qualitative

After the analysis to evaluate the individual criteria for each alternative, the following multi-criteria model was obtained (Tab. 2).

Table 2. Multi-criteria model

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	Very big	78,50	102,00	5,00	Very small	Very small	Very big	Very small
A_2	Very big	37,50	123,00	5,00	Very small	Very small	Big	Very small
A_3	Very big	24,00	100,00	4,00	Small	Very small	Big	Very small
A_4	Big	22,50	111,00	8,00	Small	Small	Mediu m	Small
Weights	0,14	0,16	0,13	0,09	0,11	0,12	0,17	0,08

After translating qualitative values into quantitative ones, an input multi-criteria model is obtained (Tab. 3). For this purpose, we used an interval scale to translate qualitative values into quantitative ones. In further calculations to solve the specific problem, the appropriate equations for the EDAS method will be used [10].

Table 3. Input model for the EDAS method

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	9,00	78,50	102,00	5,00	1,00	1,00	9,00	1,00
A_2	9,00	37,50	123,00	5,00	1,00	1,00	7,00	1,00
A_3	9,00	24,00	100,00	4,00	3,00	1,00	7,00	1,00
A_4	7,00	22,50	111,00	8,00	3,00	3,00	5,00	3,00
Weights	0,14	0,16	0,13	0,09	0,11	0,12	0,17	0,08

Table 4. Determine the average solution (AV_j)

Average solution	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
AV_j	8.50	40.63	109.0	5.50	2.00	1.50	7.00	1.50

Table 5. Calculate the positive distance from average (PDA)

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	0.059	0.932	0.064	0.000	0.500	0.333	0.286	0.333
A_2	0.059	0.000	0.000	0.000	0.500	0.333	0.000	0.333
A_3	0.059	0.000	0.083	0.000	0.000	0.333	0.000	0.333
A_4	0.000	0.000	0.000	0.455	0.000	0.000	0.000	0.000
Weights	0.140	0.160	0.130	0.090	0.110	0.120	0.170	0.080

Table 6. Calculate the negative distance from average (NDA)

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	0.000	0.000	0.000	0.091	0.000	0.000	0.000	0.000
A_2	0.000	0.077	0.128	0.091	0.000	0.000	0.000	0.000
A_3	0.000	0.409	0.000	0.273	0.500	0.000	0.000	0.000
A_4	0.177	0.446	0.018	0.000	0.500	1.000	0.286	1.000
Weights	0.140	0.160	0.130	0.090	0.110	0.120	0.170	0.080

Table 7. Weighted sum of PDA

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	0.008	0.149	0.008	0.000	0.055	0.040	0.049	0.027
A_2	0.008	0.000	0.000	0.000	0.055	0.040	0.000	0.027
A_3	0.008	0.000	0.011	0.000	0.000	0.040	0.000	0.027
A_4	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.000

Table 8. Weighted sum of NDA

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Goal	**max**	**max**	**min**	**max**	**min**	**min**	**max**	**min**
A_1	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000
A_2	0.000	0.012	0.017	0.008	0.000	0.000	0.000	0.000
A_3	0.000	0.066	0.000	0.025	0.055	0.000	0.000	0.000
A_4	0.025	0.071	0.002	0.000	0.055	0.120	0.049	0.080

Table 9. Calculation of the normalized values for SP, SN, NSP, NSN and AS

Alternatives	SP_i	SN_i	NSP_i	NSN_i	AS_i
A_1	0.336	0.008	1.000	0.980	0.990
A_2	0.130	0.037	0.387	0.908	0.647
A_3	0.086	0.145	0.255	0.639	0.447
A_4	0.041	0.402	0.122	0.000	0.061

Table 10. Ranking of alternatives

Alternatives	AS_i	Rank
A_1	0.990	1
A_2	0.647	2
A_3	0.447	3
A_4	0.061	4

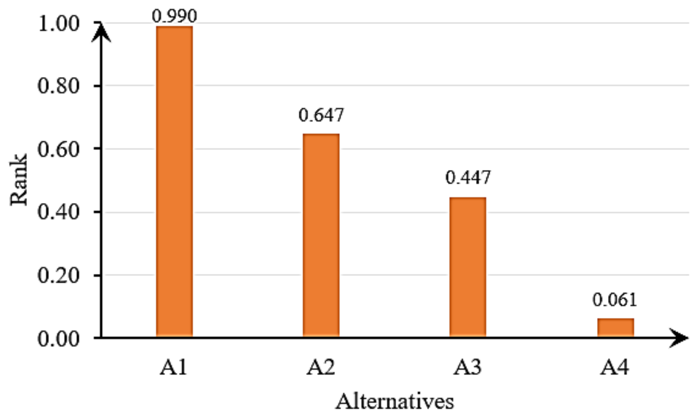

Figure 1. Presentation of the ranking of alternatives

After the calculation is completed, the ranking of the alternatives is obtained and the same is shown in Table 10. According to the ranking shown in Table 10, it can be noted that the best ranked alternative is A_1, i.e., the Branch in Kavadarci (Fig. 1), whereby this Branch was chosen as the most acceptable location for the construction of the main warehouse of spare parts and consumables for the needs of companies with dispersed centers. The alternative A_2 is in the second rank, then the alternative A_3 and the last ranked alternative is A_4. According to the obtained ranking of the alternatives, we can notice that there is a relatively large difference between each of the alternatives. Alternative A_1 is by far the best compared to the others and we can choose the optimal location of the main warehouse without hesitation.

CONCLUSION

Every company, when solving some strategic problems, such as the choice of the main warehouse, must take into account several influential parameters. The main goal of including as many influential parameters as possible is to take into account the influence of all parameters and thus make the most optimal decision, that is, to choose the most acceptable alternative. The parameters that influence the final decision have different weights, i.e., some parameters have smaller and others larger influence. Sometimes these influencing parameters cannot be measured and are therefore presented descriptively. When a final decision is made on a strategic problem, representatives from the planning, production, engineering, logistics, and finance departments are involved.

The multi-criteria decision-making methods can be very successfully when applied in the process of choosing the most suitable location, where a large number of influential parameters can be taken into account. In the process of choosing the optimal location for the main warehouse, some of the following multi-criteria decision-making methods can be applied: AHP, ELECTRE, PROMETHEE, TOPSIS, VIKOR, EDAS and others. In this paper, the location of the main warehouse was selected using the EDAS method, four alternatives (locations) were considered and compared based on several criteria, with the conclusion that the most acceptable location is the Branch in Kavadarci.

The direction of research in the future for solving such complex problems can be the application of several methods for multi-criteria decision-making, and then the comparison of the obtained results. When solving a given problem by applying different methods for multi-criteria decision-making, there is a possibility of obtaining a different ranking of alternatives. For this reason, it is desirable to apply at least three methods from the group of methods for multi-criteria decision-making, and the ranking obtained by each method should be compared and an average ranking of the alternatives should be performed. In this way, the most optimal decision will be obtained, that is, the most suitable location for the construction of the main warehouse in a company that has several dispersed centers.

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