USE OF THE MULTICRITERIA METHODS FOR ASSESSMENT OF INVESTMENT IN DECISION–MAKING PROCESS

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Abstract: Assessment of different types of investments and their complexity is particularly difficult. The selection of different variants of solutions are described by the technical–economic units. The relevant characteristics of the investment, defined quantitatively or qualitatively, is very important. During the project planning and preparation stage often happens that the desired values of certain criteria are estimated, difficult to measure and subjective, which is stated as "good", "much better", etc. Selected group of multicriteria evaluation methods was analysed, and according to the author these methods may be a useful tool for the evaluation of investment options in a given decision–making process.

Key words: criterion, variant, methods of multicriteria assessment, venture capital, benchmarking, degree of correlation result

1. Introduction

Assessment of investment projects concerns mainly the best choice from among various options of solutions such as system design, technological or organizational, as described the technical and economic indicators expressed in units of [2], [3], [4], [5], [6], [7], [8]. In engineering practice some help in solving this type of decision problems are, for example, the existing technical conditions to be met by construction investment projects and their location and technical standards for performance and acceptance of construction works. Much more difficult is to assess the technical and functional qualities of the investments made by the investor, deciding on its location and the direction of the design work, or by the buyer, taking the decision to buy an existing facility investment. This is primarily due to the diversity of criteria for assessing the values of buildings for different purposes and effects of various types of non–technical factors which distort the accuracy and the objectivity of the decisions taken.

According to the author by comparing, for example, construction investment in the form of residential building and the hospital, it can be concluded, among other things, that certain, whether the same evaluation criteria will be considered separately by the experts. Considering the fact as a criterion for comparison, "The location of the investment" – a feature that will have a higher weight for the hospital due to beneficial psycho–emotional status of patients is, for example, a forest or a park. However, for a residential building "good" location for its potential residents will mean for example the availability of public transportation and proximity to commercial buildings and recreational and social facilities, as for example, school, medical clinic, sport etc.

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According to [1], [7] the decision – the result of decision–making process that is taking place in all spheres of human life, and the goal of this process is to make a choice (decision). The decision making process does not always lead to a decision. It is a group of logically related operations of thought or calculation that lead to solution of the decision–making problem by the choice of one of the possible options for action. The subject of the decision–making process is the decision maker that expresses specific preferences and assesses the possibilities and results and chooses the final variant of decision–making [1], [7]. Decision situation determines the set of all factors (dependent and independent evaluator), influencing the decision by the decision maker in the decision process. The problem of decision–making is however, a problematic situation in which the decision maker is faced with the need to select one of at least two possible options for action [1]. Investment – financial outlays to create new, reconstruct, or modernize the existing assets, or newly created, reproduced or upgraded buildings [8]. Construction investment project is a complex operation with a specific start time and end time, leading to the design and implementation of construction projects [8].

Investment is however, a scheduled task in the material and financial dimension – in the sense of the overall financial statements [8].

According to the author, due to the variability of the test items and the variety of conditions, it is not possible to give a single set of parameters and evaluation criteria for technical and performance advantages of all construction projects.

The basic criterion can be, for example: strength of the structure element, the least complex technology implementation, the lowest labor, etc. The groups of parameters may also be different, for example: technical, economic, aesthetic, ergonomic, etc.

In the author's opinion, expert opinions, are formulated based on their level of knowledge and experience and are also dependent on the decision maker point of view, on whose behalf particular opinion or evaluation are made. Decision makers are often willing to accept unreasonable solutions from a technical point of view. Therefore, to improve decision making and avoid errors which distort the quality and reliability of the decision, it should also be considered the psychological aspect of decision–making in connection with personality factors of the decision maker [1]. It has been assumed that the assessor should be left free to choose the criteria and rules for valuing options.

2. Assumed methodology of conduct

2.1. Methods used for multicriteria assessment

The most frequently used in practice decision–making methods for assessing options, both for single and multiple criteria, were analyzed in doctoral thesis [8]. The following groups of multicriteria assessment methods were researched:

- mathematical methods (standardization, normalization, J. von Morgenstern method, PATTERN, synthetic evaluation formula)
- geometric methods (spider web, the resultant vector),
- taxonomic methods (taxonomic measure of development, the Czekanowski’s method, Wroclaw taxonomy),
- methods of calculability (an index of quality assessment, a global measure of quality, economic effect, a comprehensive indicator of quality, average quality signs, experts).

However, advanced mathematical methods of multicriteria assessment – based on prior experience of the author [2], [3], [4], [5], [6], [7], [8] – such as: the method ELECTRE, AHP method, the ideal point method, entropy method and the method that uses elements of fuzzy logic, were analyzed in detail.

Detailed rules for the calculation of the above methods are presented in doctoral thesis [8].
2.2. Comparative analysis of selected methods of multicriteria assessment

Comparative analysis of selected methods of multicriteria was carried out in doctoral thesis [8]. A two–stage evaluation was used. The basic groups of methods were compared in the first stage. In the second stage however, the analysis was extended and the detailed assessment of the methods belonging to the highest rated group was made. In the first stage of the assessment, the following criteria were used:

DATA INPUT – a criterion that characterizes the complexity of the method of "input" matrix solutions, which is introduced into an algorithm, as a constant for all the algorithms of analyzed methods. In some multicriteria assessment methods, before the start of calculations it is necessary to transform additionally input assessments, for example using coding. The mark "YES" refers to methods that in their algorithm do not require the conversion of input data. However, the label "NO" means a method in which the above mentioned steps are necessary. The method, which is graded YES, gets a point, but if NO – 0 points.

NUMBER OF ASSESSMENT CRITERIA – This feature determines whether the method is characterized by an appropriate computational efficiency with more options for assessment criteria. Significant reduction of the number of applicable criteria reduces the possibility of widespread use of a group of methods. Analyzed types of multicriteria assessment methods according to the criterion "number of assessment criteria" will be assessed either YES or NO on. The method, which permits in their algorithm the use of more than 5 criteria for assessing options [8] is graded YES and gets 1 point. However, assessment of NO – 0 points gains method, in which the possibility of obtaining reliable results of the calculation depends on admission to assess options for a maximum of five criteria.

EFFORT – a criterion that describes the overall complexity of the calculations necessary to carry out with the same number of criteria in the compared types of multicriteria assessments methods. Because of their specificity and variety of algorithms, it is difficult to clearly compare them with each other. Therefore, to assess these methods according to the criterion "Effort", it was also used the assessment YES and NO, resulting from the theoretical knowledge and the subjective feelings of the author. It was assumed that the assessment of YES and 1 point was given to the method in which the possible number of real operations in the calculation algorithm is not greater than seven. However, assessment of NO and 0 points, will receive methods that courses of action require more than eight computational steps.

PRESENTATION OF RESULTS – a feature that determines the degree of explicit "readability" of the results. Some methods of assessment allow the presentation of calculation results clearly to the user. However, some of them – for example, due to their specific presentation of the results, or restrictions relating to the optimal number of evaluation criteria (and / or variants), are characterized by the absence of a specific order in the hierarchy of results, and thus contribute to the difficulties of interpretation. The examined methods according to the criterion method “Presentation of results” will be assessed either YES or NO on, where YES indicates a method whose final result of the calculation allows the user to obtain a series of preferential variants. However, NO is concerned with the methods in which clear result of the assessment for various reasons, it is not possible or difficult to interpret. The method, which is graded YES, gets a point, but if NO – 0 points.

Assessment of selected types of multicriteria assessment methods were performed and presented in tabular form. Table 1 presents selected methods of assessment, expressed in numerical form. Multicriteria assessment was carried out according to the descriptions of the various criteria [8].
Comparative analysis of different groups of variants scheduling methods did not give unambiguous results. Although the highest score – 3 points – received both simple mathematical methods, calculability methods and advanced mathematical, it is possible to obtain negative values of measurement options, for example, in standardization method. In case of PATTERN method little diversity of option assessment is achieved. However, the normalization method can distort the final results of the analysis. Calculability methods analyzed in doctoral thesis [8] are primarily used to determine the global indicator of quality, which is used for improving its quality. Due to the simplicity of calculation and selection of tools to limit the undesirable decision maker subjectivity, it is possible to use only expert methods and the weighted sum. However, advanced multicriteria mathematical methods rank unambiguously the considered decision–making options, what is expected in the end by every assessor. Slightly lower results – 2 points acquired a group of taxonomic methods. A defect is an explicitness of the final assessment of options. As a result of this limited reliability, is obtained. The lowest result of 1 point achieved to a group of geometric methods, whose use is limited to the classification of variants in the number of criteria, not higher than 5 [8].

The issue of calculation effort was assessed by the author only in a general sense, since it is obvious that any method by itself is characterized by more or less complex algorithm procedure.

In the opinion of the author, a general analysis of selected types of multicriteria assessment methods confirms validity of the use to assess the investment options, advanced mathematical methods for multicriteria assessment, which include: ELECTRE, AHP, the ideal point, entropy and the method of using of fuzzy logic. These methods were analyzed in the second stage of the procedure using the additional criterion for the DEGREE OF CORRELATION RESULTS. This feature takes into account the closeness of the final results of sample variations received within the method. In order to check this criterion, calculations for a set of solutions by using methods of computational algorithm in the first stage of assessment were needed from the author.

Effort and cumbersome calculations resulted in the need to use a tool to assist, which was developed in the doctoral thesis. ESORD detailed description was presented in doctoral thesis [8]. Ten options for decision–making regard to potential decision maker preferences were adopted by the author and introduced to the program. Using them as an example it was possible to determine, among other things, a degree of correlation of the results of selected methods of multicriteria.

In order to compare the above mentioned methods, the following grading scale was adopted [8]:
- 0 points – for the method, which shows little correlation of results with other methods,
- 1 point – for the method, which shows average correlation of results with other methods,
- 2 points – for the method, which shows high correlation of results with other methods,
- 3 points – for the method, which shows very high correlation of results with other methods.

Summary assessment of the results of partial correlation for the above mentioned methods quantified is presented in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Mathematical methods</th>
<th>Geometric methods</th>
<th>Taxonomic methods</th>
<th>Quantitative methods</th>
<th>Advanced Mathematical methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of assessment criteria</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Work consumption</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Results presentation</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
<td>TOTAL</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</table>
For the final assessment of advanced mathematical methods for multicriteria according to the criterion "degree of correlation results" (Table 2) it has been assumed that the number of points 3 and less than 3 will be assigned to assess NO and 0 points. The assessment “YES” and the corresponding 1 point – is assigned a method, whereby the number of points in the sub–assessment will be more than 3 [8].

On the basis of the sensitivity analysis of the above mentioned methods, it was found that any change in decision–maker assessment makes the correlation between the results of the above mentioned methods higher or lower.

No small importance to the sensitivity of the method has also the number of, adopted to assess, criteria. Therefore, the author reserves that presented above correlation of the results correspond to the sample assessment of potential decision–maker in relation to 10 analyzed decision–making variants in doctoral thesis [8].

The final assessment of selected advanced mathematical methods for assessing multicriteria is presented in Table 3.

Table 3 presents an evaluation of these methods quantified. Multicriteria assessment was carried out according to the descriptions of the individual criteria [8].

The analysis of the above mentioned multicriteria methods shows that the highest score – 4 points – obtained the ideal point method, entropy, ELECTRE and also the method which uses elements of fuzzy logic, because of not very large computational time–consuming procedure and no need for additional conversion of preference makers. However, the AHP method received the lowest score – 2 points – largely because of the need to transform the input data matrix and its adaptation to the algorithm adopted in the nine–scale assessments. Moreover, this method has a high degree of complexity of procedures (for example, inclusion of specific criteria in the algorithm for computing weights), and thus – a major time–consuming calculations. AHP method showed a high degree of correlation of results with the ELECTRE and entropy method [8].

According to the author, analyzed multicriteria methods with the highest correlation of results can be seen as the most authoritative and representative. Furthermore, in the author’s opinion these methods may be an appropriate tool for scheduling investment options in a given decision–making process, because they:
- objectify the expert assessments,
- enable the user to evaluate a large number of criteria,
- unambiguously rank the best choice of options,
- their algorithms are not difficult to be implemented on a computer, which was presented in detail in doctoral thesis [8].

3. Conclusions
On the basis of the author's research and analysis it has been stated that:
- difficulty in assessing the investment is mainly due to the complexity of the decision task, the complexity of options and preferences of the assessor,
- scheduling options for the assumed decision–making situations studied by the author of multicriteria methods differ mainly on the following series of preferential locations. However, the order of the first three – four options are the same,
- effective way to improve decision–making process, is a computer implementation of algorithms for selected methods for assessment of solutions, which are the most appropriate for a given decision–making situation. It enables the receipt of an aggregate assessment of an investment that is analyzed.

REFERENCES