THE MULTICRITERIAL PERSPECTIVE IN ASSESSING OF AN INVESTMENT PROJECT IN THE ENERGY MINING INDUSTRY

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Abstract
The research is particularly useful to the management of the company as it has an appropriate tool in evaluating a multicriterial investment project. The multicriterial approach structures and combines the various assessments that are considered in the decision-making process for selecting the optimal variant of several possible alternatives, the treatment applied to each of them conditional on the choice of the final decision. The opportunity to choose this approach in the efficient selection of the most feasible alternative within an investment project is an undeniable premise of organizational development, given the existence of a competitive market which is continuous dynamic.

Keywords*: multicriterial analysis, investment project, options, criteria.*

Classification JEL: *L72, Q30, Q40*

1. Introduction

The multicriteria analysis used in performance evaluation refers to any action taken to determine the preference for the choice of several possible (alternative) options that lead to the objectives of the organization's management.

The influences of multicriteria analysis are manifested in the second half of the 20th century (Köksalan M. et al., 2011) [6]. It currently has a wide applicability in the design, evaluation and implementation of projects (Beria et al., 2011) [3]. It uses a consistent palette of indicators focusing on qualitative analysis (scoring, hierarchy and weighting) of an extended range of categories and qualitative impact criteria. Also, social and environmental indicators can be used along with economic costs and benefits. Moreover, it provides techniques for making a comparison, hierarchy of different results, regardless of the number of indicators used.

Multicriteria analysis is only applicable when a single criterion approach is not sufficient, due to the fact that significant social and environmental impacts have not been attributed to monetary values.

Considered as a working tool, multicriterial analysis structures and combines different evaluations or estimates considered in the decision-making process to select the optimal variant of several possible alternatives, the treatment applied to each conditional choice of the final decision.

2. Research methodology

The methodological approach initiated in this paper considered the action of consulting some well-known bibliographic materials, consisting of books and articles published at national or international level. Also, the applicative documentation for this study was possible on the background of research into issues that require the attention of decision-makers who are pursuing the development of the energy mining industry in order to identify the real problems they are facing. It has been necessary to consult the specialists in the field, to collect and select the data necessary for the multicriteria analysis.

The qualitative research undertaken in the study content allows a deductive approach. It starts from the concepts, theoretical notions and regulations specific to the study area and continues with the foundation of a practical application based on the data and the identified investment need.

The research methods used in our research are: observation, grouping, comparison and case study. Grouping, as a working method, we use to highlight the data needed for working group analysis according to the similar characteristics of the previously identified options in order to derive the conclusions regarding the studied phenomenon as a whole. The comparison method is used to study the criteria of each alternative, in relation to the particularities identified in the competing options.

3. Options and criteria for multicriterial analysis

The options (alternatives) are the way to achieve the objectives pursued. The valid option will be the one that will help achieve the goals.

The assessment and comparison of the alternatives (options) by the decision-makers is made according to certain criteria (attributes) in order to determine to what extent the objectives pursued are met. Each criterion independently measures a relevant aspect. In the literature, the criteria by which the options under consideration are evaluated should be (Baker D. et al., 2002) [1]:

- Operational;
- Complete, to include all goals;
- Capable of selecting the alternatives "decisively" with the ability to support an objective comparison between the performances of the options under consideration;
- Non-redundant

The authors Keeney R. and Raiffa H, 1976 [5] argue that non-redundancy is in the form of independence.

In order to highlight the practical way of applying the multicriterial analysis in a procurement project, we conducted a case study in a representative organization of the energy mining industry. The investment project provides for the renewal of the fleet by the purchase of 12 vans required for the transport of spare parts and maintenance intervention to the work units located within a distance of 3-15 km in the hard-to-reach coal exploitation perimeters.

The object of the multicriteria analysis is to select a model of vans from three possible alternatives, the options analyzed by the decision makers being presented in Table no. 1.

Table no. 1. The options (alternatives) involved in the multicriterial analysis of the investment project

Alternative	Mark	Model
A_1	Volkswagen	Transporter
A_2	Toyota	Hylux
A_3	Mercedes - Benz	Sprinter

Source: Own processing

After establishing alternative makers focused analysis of the criteria by which analyzes the available options according to Table no. 2.

Table no. 2. Criteria and value ranges

Criteria analyzed		Indicator	Intervals Values	Effect Maximum (+)/minimum (-)
C1	Price	Purchase price expressed in foreign currency (euro).	17.000 - 35.000	-
C2	Performance	Engine capacity expressed in horsepower	110 - 160	+
C3	Economy	Fuel consumption (l / 100 km)	7 - 12	-
C4	Maintenance costs	Cost (EUR per year)	500 - 1500	-
C5	Appearance	1 is ugly and 5 is beautiful	1 - 5	+

Source: own processing

The data in Table no. 2 shows the description of the five criteria analyzed in our investment project (Price, Performance, Economy, Maintenance Cost and Appearance), the indicator analyzed according to the criteria considered, the range of values for the criterion to be pursued and the effect sought for each criterion in part. According to the data in the table, the management of the organization has sufficient criteria to substantiate the analysis necessary to make the decision to purchase that car variant that suits the organization's exploitation needs at a viable cost.

4. The performance matrix used in multicriterial analysis

Author Roman M., 2012 [9], points out that "besides analyzing the criteria necessary for choosing the optimal automotive variant, the decision makers of the organization use a specific instrument of multicriterial analysis called the performance matrix, being recognized by the theoreticians as the" matrix decision or table of consequences where each row of the matrix describes an option (alternative) and each column describes the performance of each option according to each criterion. Individual performance ratings are often numerical, but can also be expressed in graphical or color code scores. "

Multicriterial analysis within the organization of the mining industry regarding the renewal of the car fleet continues with the performance matrix necessary to choose the optimal variant according to the data listed in table no. 3.

Table no. 3. Fixed asset matrix

Criteria / Alternative	C_1	C_2	C_3	C_4	C_5
A_1	20.000	125	7	800	4
A_2	23.000	140	9	900	5
A_3	27.000	160	8	1100	5

Source: own processing

The data in Table no. 3 analyzes the performance of the three variants of vans after each previously described criterion (price, power, consumption, maintenance cost and appearance). It can be seen that all these criteria are measured in cardinal numbers, although the fifth criterion is qualitative.

Following the logic of maintenance costs in the performance matrix, we can assume that A1 is a viable option because it meets the requirements of the advanced budget within the investment program.

The initial multicriterial analysis reveals that the performance matrix may represent the final stage of the analysis. The data recorded in the performance matrix determines the organization's decision-makers to quickly and efficiently assess to what extent their objectives are met, but unjustified assumptions can be obtained by obtaining a vicious ranking of the options under consideration.

Once the performance matrix has been compiled, the assignment of numerical weights to each criterion is given as the decision criteria acquire a relative weight relative to each other. The weight of a criterion highlights the range of differences between alternatives and the difference.

An expert group has been appointed at the organization level to review the selection criteria for the proposed options and consult stakeholders interested in purchasing the vans: senior management, mining sector leaders and employees' representatives. It has been decided at the level of the working group that the price of the vans is the most important criterion and that its share should be 50%, the engine performance and aspect are the least important criteria with a weight of 5%, while the economy and maintenance costs have an average relevance and weight of 20%, the weights being shown in Table no. 4.

Table no. 4. Estimated direct weighting of the analyzed criteria

Criteria	C_1	C_2	C_3	C_4	C_5
Weight	0.50	0,05	0,2	0,2	0,05

Source: own processing

The next step after assigning the weights of each analyzed criterion is to standardize the performance matrix according to a specific working methodology. The standardization process refers to the transformation of the values specific to the criteria expressed in units of measurement into a common scale that makes comparisons between them.

We initiated a normalization procedure on the performance matrix described in Table no. 3, vector normalization being applied by means of the formula:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} x100 \qquad (1)$$

where rj is the standard scores and aij represents the scores resulting from the weighting process, the results being listed in Table no. 5.

Table no. 5. Standardized performance matrix (vector normalization)

Criterii / Alternative	C_1	C_2	C_3	C_4	C_5
A_1	0.51	0.47	0.53	0.47	0.41
A_2	0.56	0.51	0.56	0.51	0.56
A_3	0.61	0.57	0.57	0.54	0.70

Source: own processing

From Table no. 5 it follows that Option 1 obtains the best scores used to substantiate the decision to purchase the vans according to the approved purchase program.

5. Methods of multicriterial evaluation of the investment project

5.1. Direct analysis of the performances of options (alternatives)

Multicriterial analysis is sometimes limited to a direct analysis of the performance matrix. In this case, information about the attributes of the options is obtained by direct analysis of the performances of the alternatives.

The method focuses on verifying the dominant position of some criteria against other criteria. The dominant position occurs when the performances of an alternative (options) are at least as satisfactory as the other, similar for all the criteria being pursued, being better than the other for at least one criterion. It can be said that one principle can dominate all the others, which is unlikely to happen in practice.

The method is recommended in the initial analysis of a product prior to issuing the financing decision because the financing of a project requires the application of the more complex multicriteria analysis methods described throughout this subchapter.

5.2. Weighting Method (Cumulative Linear Models)

The weighting method known in the literature as cumulative linear models is very widespread in the multicriterial decision-making process.

According to the same author (Roman M., 2012) [8] the weighting method "is applied taking into account that all criteria are preferentially independent of one another as uncertainty is not formally embedded in the multicriteria analysis model, so the model shows how the values of an option for several criteria can be combined into an overall value. "

This desideratum is achieved by multiplying the standardized scores of each analyzed criterion with the weight of wj, then proceeding to sum up the scores we have weighed for all criteria. The total score for each Ai or ASi option is calculated by the following equation:

$$AS_i = \sum_{j=1}^{n} W_j * r_{i,j} \quad (2)$$

This type of model provides assistance to decision makers in various circumstances. The authors of Beinat E and Nijkamp P., 1998 [2], questioned the Dutch model in the Environmental Impact Assessment (EIA) commission, recommending the application of weighting to assess alternative solutions as applied in other countries.

Applying this method to select a van model within the organization involves establishing scores based on a normalized performance matrix (Table no. 5) and weights directly entered by the above-mentioned working group (Table no. 4). The results obtained are shown in Table no. 6.

Table no. 6. Weighting method in multicriteria analysis

Alternatives	C_1	C_2	C_3	C_4	C_5	AS_i
A_1	0.51	0.47	0.53	0.47	0.41	0,50
A_2	0.56	0.51	0.56	0.51	0.56	0,54
A_3	0.61	0.57	0.57	0.54	0.70	0,59
Weighting Working Group	0.50	0,05	0,2	0,2	0,05	

Source: own processing

Table no. 6 shows that the necessary viable alternative to the investment project is A1 because it obtains the best score and ensures the lowest purchase price. The alternative score for A1 is 0.50, the other two scores achieving an unfavorable score of 0.59 for A3 and 0.54 for A2 respectively.

It is worth mentioning in this method that the evaluation methodology is affected by subjectivism. The detailing strengths and weaknesses in a project through careful analysis of each alternative are important steps in presenting the results obtained.

5.3. Method Process of Analytical Hierarchy

This method was developed by Saaty T., 1980 [10], which aimed at "analyzing decisions based on a hierarchy of decision components". According to the observations of Gissel G. and Leleur S., 2004 [4], the Process of Analytical Hierarchy is considered one of the most applied methods of multicriterial analysis being mentioned in most of the specialized papers "[7].

The method is interactive in which the decision-makers in the organization communicate their preferences to the working group and can discuss various opinions and outcomes, focusing on the characteristics of human behavior in all its aspects.

The Process of the Analytical Hierarchy (PIA) allows the construction of a series of matrices called "pair comparisons" that compare criteria to each other in order to rank or weigh each criterion that contributes to the overall goal. If the criteria are subdivided into sub-criteria, the pair comparisons are repeated within the given hierarchy.

Considering the multitude of the analyzed criteria, the construction of the pair comparison determines the influence of each objective on the criterion by which it is necessary to construct a matrix on "n" (C) which faithfully returns the dominating position of a criterion from the left column to each criterion from the top row:

$$C= \begin{array}{c|ccc} & C_1 & \cdots & C_n \\ \hline C_1 & c_1/c_1 & \cdots & c_1/c_n \\ \vdots & \vdots & \ddots & \vdots \\ Cn & c_n/c_1 & \cdots & c_n/c_n \end{array} \qquad (3)$$

Each item C represents a measure of the ratio between the representative weights assigned to each criterion. In this respect, Saaty T. elaborated the nine-point Intensity Importance Scale from psychological experiences, being designed to accurately reflect the priorities of the comparisons between the two elements, minimizing the inherent difficulties in the work carried out, (Table no. 7).

Table no. 7. The PIA Scale of Intensity of Importance

The intensity of importance	Definition
1	Similar importance of competing elements.
3	Reflects less importance of one element than another.
5	It reflects a significant importance of one element over another.
7	Reflects a proven importance of one item to another.
9	Reflects an absolute importance of one element over another.

Source: Saaty T., *Decision-making for Leaders*, Wadsworth, California, 1982

We mention that values 2.4, 6 and 8 are intermediate values used to represent the personal judgment aspects in addition to the five assessments analyzed.

The calculations required to implement this method are rather complex, and a PCA computer application is required in practice. The necessary steps in this respect are the following:
- Determination of the geometric mean for each criterion in the matrix;
- Summing of previously determined geometric environments;
- Normalization of the geometric mean in relation to the total obtained.

The result reflects the determination of the weight to be assigned to each criterion, wj.

The last step is to determine the Alternative Score (ASi) for each analyzed option taking into account all the known criteria, being estimated from the perspective of the cumulative linear model according to the following systematization:

$$AS_1 = a_{11}(w_1) + a_{21}(w_2) + \ldots + a_{N1}(w_N)$$

$$AS_2 = a_{12}(w_1) + a_{22}(w_2) + \ldots + a_{N2}(w_N)$$

$$\vdots$$

$$AS_m = a_{1m}(w_1) + a_{2m}(w_2) + \ldots + a_{Nm}(w_N) \qquad (4)$$

The application of this method in the organization regarding the purchase of the vans is carried out in order to elaborate the weights for the five criteria listed above, using these weights to calculate the alternative scores as shown in Table no. 8.

Table no. 8. Weights of derived criteria using PIA within the organization

	C_1	C_2	C_3	C_4	C_5	Geometric media	$Weight_{mg}$
C_1	1	3	6	3	7	3.28	0.52
C_2	0.3	1	0.3	0.1	3	0.49	0.08
C_3	0.1	3	1	3	3	1.22	0.19
C_4	0.3	4	0.3	1	4	1.08	0.17
C_5	0.11	0.15	0.15	0.15	1	0.21	0.03
Sum of geometric environments						6.26	

Source: own processing

Under the first four criteria in Table no. 8, the weights are somewhat close to the directly estimated weights. Significant differences are noted in the fifth criterion, as according to the PIA it has a weight of 3%, compared to 5% determined by the previous method.

Next, we proceed to calculate the Alternate Score (AS_AHP) described above for selecting the best score option (Table no. 9).

Table no. 9. Weights of derived criteria using the PIA method

Alternatives	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**AS_AHP**
A_1	0.51	0.47	0.53	0.47	0.41	0.49
A_2	0.56	0.51	0.56	0.51	0.56	0.54
A_3	0.61	0.57	0.57	0.54	0.7	0.58
weighting mg	0.52	0.08	0.19	0.17	0.03	

Source: own processing

Table no. 6 illustrates that, using the PIA method, the best option is A1 and its score of 0.49 is close to the one obtained using the weighting method, which means the lowest budget effort on the part of the organization to purchase the vans stipulated in the plan investment. The next option is A2 and the least attractive option is A3.

Therefore, the application of the three multicriteria assessment methods recommends that the organization acquire option A1, represented by the Volkswagen Transporter, because it obtains the best score for multicriterial assessment.

6. Conclusion

The research on the analysis of a multicriterial investment project allows the enterprise's management to achieve the budgeted cost target.

In the initial phase of the multicriterial evaluation the options (alternatives) are determined by the decision-makers in order to determine the ways of achieving the objectives pursued. The assessment continues with the analysis of the criteria against which the previously available options are analyzed. Multicriterial analysis requires the investment project by assigning weights to each criterion standardization of performance by the transformation matrix to each criterion values in units according to a pre-defined procedure in order to achieve normalization of comparisons between them. Thus, the analysis of the existing options is based and an investment decision is made by selecting the best score option.

The finding required application specific multicriterial analysis methods within the organization considered as options in the portfolio in order to achieve a qualitative assessment of the investment project of multicriterial perspective which led to choosing the best performance.

References

[1] Baker D., Bridges D., Hunter R., Johnson G., Krupa J., Murphy J., Sorenson, K., *Guidebook to Decision-Making Methods*, Department of Energy, USA, 2002;

[2] Beinat E., Nijkamp P., *Multicriterial analysis for land-use management*. Kluwer, Dordrecht, 1998;

[3] Beria P., Maltese I., Mariotti I., *Comparing cost benefit and multicriterial analysis: the evaluations of neighbourhoods' sustainable mobility,* Società Italiana degli Economisti dei Trasporti - XIII Riunione Scientifica –Messina, 2011;

[4] Gissel G., Leleur S., *Cost-Benefit Analysis and alternative approaches from the Centre for Logistics and Goodds*. Study of evaluation techniques, 2004;

[5] Keeney R.L., Raiffa H., *Decisions with multiple objectives*, John Wiley & Sons, 1976;

[6] Köksalan M., Wallenius J., Zionts S., , *Multiple Criteria Decision Making: From Early History to the 21st Century*. Singapore: World Scientific, 2011;

[7] Multicriterial analysis of Department for Communities and Local Government: London; *Methodology for multicriterial Analysis of Agri Environmental Schemes*; Sourcebook 2: Methods & Techniques, 2009;

[8] Roman M., Multicriterial Analysis - Manual, ERDF funded project through the POAT "Capacity development for Cost - Benefit Analysis", pp. 17-27, 2012;

[9] Roman M., Multicriterial Analysis - Manual, ERDF funded project through the POAT "Capacity development for Cost - Benefit Analysis", pp. 7-49, 2012;

[10] Saaty T., *The Analytic Hierarchy Process*, McGraw-Hill, New York, 1980.