A VIKOR Approach for Project Selection Problem

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Abstract: Profitable investments lead to the growth and prosperity of each corporation. Various objectives are usually taken into account when projects are analyzed, including economic desirability, technical issues, and environmental and social factors. Many conflicting criteria should be considered when comparing projects to choose among or rank them. The merit of MCDM techniques is that they consider both qualitative parameters as well as the quantitative ones. In this article, a MCDM project selection problem found in real-life international company is presented. The technique used named *Vlse Kriterijumska Optimizacija I Kompromisno Resenje* in Serbian (VIKOR) is applied for ranking the projects.

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1. Introduction

Decision of selecting an engineering, construction or R&D project is often fundamental for business survival. Such decisions usually involve prediction of future outcomes considering different alternatives. Selection of a project or a portfolio of projects constitutes one of the main problems that managers are faced with. As the decision maker tries to maximize or minimize outcomes associated with each objective depending on its nature, so a Multi-Criteria Decision Making (MCDM) problem arises. It should be noticed that evaluation criteria could be of various nature. While financial measures (Net Present Value, Rate of Return, Payback Period, and Project Risk) are of quantitative type, the ones that reflect technical, environmental or social objectives are usually of qualitative nature [7].

MCDM includes many solution techniques such as Simple Additive Weighting (SAW), Weighting Product (WP) [5], and Analytic Hierarchy Process (AHP) [9]. In this paper, a project selection problem existing in a multi-national company is presented. The technique used in this paper named *Vlse Kriterijumska Optimizacija I Kompromisno Resenje* in Serbian (VIKOR) is applied for ranking the projects. The rest of this paper is organized as follows: Section 2 is made for the VIKOR approach, the project selection problem is illustrated in section 3, in section 4 the case study is described, and finally section 5 is made for conclusion.

2. VIKOR

A MCDM problem can be concisely expressed in a matrix format, in which columns indicate criteria (attributes) considered in a given problem; and in which rows list the competing alternatives. Specifically, a MCDM problem with m alternatives ($A_1, A_2, \ldots, A_m$) that are evaluated by n criteria ($C_1, C_2, \ldots, C_n$) can be viewed as a geometric system with m points in n-dimensional space. An element x_{ij} of the matrix indicates the performance rating of the i^{th} alternative A_i, with respect to the j^{th} criterion C_j, as shown in Eq. (1):

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

The VIKOR method was introduced as an applicable technique to implement within MCDM [8]. It focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. The compromise solution, whose foundation was established by Yu [13] and Zeleny [14] is a feasible solution, which is the closest to the ideal, and here "compromise" means an agreement established by mutual concessions.

The VIKOR method determines the compromise ranking list and the compromise solution by introducing the multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution. The multi-criteria measure for compromise ranking is developed from the *Lp-metric* used as an aggregating function in a compromise programming method. The levels of regret in VIKOR can be defined as:

$$L_{p,i} = \{\sum_{j=1}^{n} [w_j (x_j^* - x_{ij}) / (x_j^* - x_j^-)]^p\}^{1/p}, \; 1 \le p \le \infty, \quad (2)$$

where $i = 1,2,\ldots,m$. $L_{1,i}$ is defined as the maximum group utility, and $L_{\infty,i}$ is defined as the minimum individual regret of the opponent.

The procedure of VIKOR for ranking alternatives can be described as the following steps [3]:

Step 1: Determine that best x_j^* and the worst x_j^- values of all criterion functions, where $j = 1, 2,\ldots, n$. If the *jth* criterion represents a benefit then $x_j^* = \max_i f_{ij}$, $f_j^- = \min_i f_{ij}$.

Step 2: Compute the S_i (the maximum group utility) and R_i (the minimum individual regret of the opponent) values, $i = 1, 2,\ldots, m$ by the relations:

$$S_i = L_{1,i} = \sum_{j=1}^{n} w_j (x_j^* - x_{ij}) / (x_j^* - x_j^-) , \quad (3)$$

$$R_i = L_{\infty,i} = \max_j [\sum_{j=1}^{n} w_j (x_j^* - x_{ij}) / (x_j^* - x_j^-)] , \quad (4)$$

where w_i is the weight of the j^{th} criterion which expresses the relative importance of criteria.

Step 3: Compute the value Q_i, $i = 1,2,\ldots,m$, by the relation

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*) , \quad (5)$$

where $S^* = \min_i S_i$, $S^- = \max_i S_i$, $R^* = \min_i R_i$, $R^- = \max_i R_i$, and v is introduced weight of the strategy of S_i and R_i.

Step 4: Rank the alternatives, sorting by the *S, R,* and *Q* values in decreasing order. The results are three ranking lists.

Step 5: Propose as a compromise solution the alternative (A') which is ranked the best by the minimum *Q* if the following two conditions are satisfied:

C1. "Acceptable advantage":

$Q(A'') - Q(A') \geq DQ$, where A'' is the alternative with second position in the ranking list by *Q*, $DQ = 1/(m - 1)$ and *m* is the number of alternatives.

C2. "Acceptable stability in decision making":

Alternative A' must also be the best ranked by *S* or/and *R*. This compromise solution is stable within a decision making process, which could be: "voting by majority rule" (when $v > 0.5$ is needed), or "by consensus" ($v \approx 0.5$), or "with vote" ($v < 0.5$). Here, v is the weight of the decision making strategy "the majority of criteria" (or "the maximum group utility"). $v = 0.5$ is used in this paper. If one of the conditions is not satisfied, then a set of compromise solutions is proposed [3].

Recently, VIKOR has been widely applied for dealing with MCDM problems of various fields, such as environmental policy [10], data envelopment analysis [11], and personnel training selection [2].

3. Project Selection Problem

Numerous techniques have been proposed in recent years for solving project selection problems. Heidenberger and Stummer give a survey of quantitative techniques for R&D project selection and resource allocation problems [4]. Most of procedures listed in that paper can be applied for evaluating construction and engineering projects as well. Utility function approach is often employed for solving such a problem. E.g., in [6] and [12] this methodology is used.

Project selection problem is a typical MCDM problem which involves both quantitative and qualitative criteria to be considered. In the rest of this section, some of the quantitative criteria will be illustrated. Also, in our case study, we will limit comparison to these four criteria. The considered criteria are described in brief as following [1]:

First Net Present Value

The Net Present Value (NPV) is defined as the sum of the present values (PVs) of the individual cash flows. Actually, NPV is an indicator of how much value a project adds to the organization. Therefore, it is treated as the benefit criteria of the project. In financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the highest NPV should be selected.

Second Rate of Return

Rate of Return (ROR) is the ratio of money gained or lost on a project relative to the amount of money invested. ROR is usually expressed as a percentage. Therefore, ROR is also the benefit criteria for any project selection.

Third Payback Period

Payback period (PB) is the period required for the return on an investment or project. Any project yielding the quickest Payback Period should be selected.

Fourth Project Risk

There may be some external circumstances or event that cannot occur for the project to be successful. The external events are called Project Risks (PR). If such type event were likely to happen, then it would be a risk. The aim of project selection is to minimize the risk criteria. In the problem considered the risks associated to projects are scaled from 1 to100.

4. Case Study

In this section, a real-life project selection problem existing in multi-national company will be illustrated and solved by VIKOR method. The company's management limited the criteria compared to be eight. All the criteria are from the quantitative type (illustrated before in section 3), also have financial aspects. The company made market research and feasibility studies to stand over the values and performance ratings with respect to the considered criteria. Some values are extracted from the company financial statements (like cash flow statement, balance sheet). The values of fourth criterion (project risk) are analyzed by specialized organization. The problem has eight projects to be ranked through comparing four criteria. As shown in Table 1, the considered criteria, their computational units, their utility type (Max or Min), and their relevant weights assigned by management are presented. After, Table 2 shows the eight projects and their performance ratings with respect to all criteria.

Table 1. Criteria and their computation units

Criterion Index	Criterion Description	Units	Utility Type	Weight
C_1	Net Present Value (NPV)	L.E (Millions)	Max	0.5
C_2	Rate of Return (ROR)	L.E (Millions)	Max	0.1
C_3	Payback Period (PB)	Months	Min	0.25
C_4	Project Risk (PR)	Points (1-100)	Min	0.15

Table 2. Decision matrix

	C_1	C_2	C_3	C_4
Project 1	3.6	0.5	5	32
Project 2	4	0.8	8	25
Project 3	2.3	0.6	10	20
Project 4	1.5	0.2	16	15
Project 5	2.9	0.7	12	52
Project 6	4.5	1.2	30	60
Project 7	3.9	1.9	15	71
Project 8	1.5	0.3	7	8

By applying the procedure of VIKOR, we can calculate the S, R and Q values as shown in Table 3 to derive the preference ranking of the projects. Management should implement the second project. The second project has the minimum S, R, and Q values; also, the two conditions mentioned earlier in section 2 are satisfied.

Table 3. Ranking lists and scores

	S	R	Q	Rank
Project 1	0.2895	0.1500	0.149842	2
Project 2	0.2185	0.0833	0	**1**
Project 3	0.5217	0.3667	0.63833	6
Project 4	0.7267	0.5000	1	8
Project 5	0.5120	0.2667	0.508793	5
Project 6	0.4150	0.2500	0.393319	4
Project 7	0.3500	0.1500	0.209375	3
Project 8	0.6141	0.5000	0.889256	7

5. Conclusion

In this paper, the VIKOR method is presented and illustrated. A real-life project selection problem of a new manner existing in multi-national company is introduced. The VIKOR method is employed to rank the projects. It might be combined to other techniques in further research. The MCDM problem should be reformulated and solved if any parameter or alternative is added or deleted because of its sensitivity to any changes.

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References

1. Bakshi, T., Sinharay, A. and Sarkar. B. (2011), "*Exploratory Analysis of Project Selection through MCDM*", In the Proceedings of the 10th International Conference on Operations and Quantitative Management (ICOQM-10), June 28–30, 2011, Nashik, India, pp. 128–133.
2. El-Santawy, M. F. (2012), "*A VIKOR Method for Solving Personnel Training Selection Problem*", International Journal of Computing Science, ResearchPub, 1(2): 9–12.
3. Huang, J. J., Tzeng, G. H. and Liu, H.H. (2009), "*A Revised VIKOR Model for Multiple Criteria Decision Making - The Perspective of Regret Theory*", Communications in Computer and Information Science, 35 (11): 761–768.
4. Heidenberger, K. and Stummer, Ch. (1999), "*Research and Development Project Selection and Resource Allocation: a Review of Quantitative Modelling Approaches*", International Journal of Management Reviews, 1: 197–224.
5. Hwang, C.L. and Yoon, K. (1981), Multiple Attributes Decision Making Methods and Applications, Heidelberg: Springer, Berlin.
6. Moselhi, O. and Deb, B. (1993), "*Project Selection Considering Risk*", Construction Management and Economics, 11: 45–52.
7. Nowak, M. (2005), "*Multicriteria Technique for Project Selection under Risk*", In the Proceedings of the 5th International Conference Reliability and Statistics in Transportation and Communication (RelStat'05), 13–14 October 2005, Riga, Latvia, Part 1: 85–91.
8. Opricovic, S. (1998), Multicriteria optimization of civil engineering systems, PHD Thesis, Faculty of Civil Engineering, Belgrade.
9. Saaty, T.L. (1980), The Analytic Hierarchy Process, McGraw-Hill, NewYork.
10. Tzeng, G.H., Tsaur, S.H., Laiw, Y.D. and Opricovic, S. (2002), "*Multicriteria Analysis of Environmental Quality in Taipei: Public Preferences and Improvement Strategies*", Journal of Environmental Management, 65: 109–120.
11. Tzeng, G.H. and Opricovic, S. (2002), "*A comparative analysis of the DEA-CCR model and the VIKOR method*", Yugoslav Journal of Operations Research, 18: 187–203.
12. Wong, E.T.T., Norman, G. and Flanagan, R. (2000), "*A Fuzzy Stochastic Technique for Project Selection*", Construction Management and Economics, 18: 407–414.
13. Yu, P.L. (1973), "*A class of solutions for group decision problems*". Management Science, 19: 936–946.
14. Zeleny, M. (1982), Multiple criteria decision making, McGraw-Hill, New York.

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