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A hybrid risk management and value management model based on MCDM in contractor selection

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Abstract

In this research, an hybrid approach based on risk management and value engineering has been developed to select contractors in construction projects. This model is designed based on some criteria and sub-criteria derived from the literature whose importance is evaluated by the bestworst method. The contractors were then prioritized using VIKOR methods and Gray Relationship Analysis. According to the computational results, it can be observed that the local risk strategic (0.348) has the highest score among the criteria and the other risk weighted local scale (0.080) has the lowest score among the criteria. In terms of operational risk, the technical error sub-criterion had the highest local weight (0.477) and the cheaper sub-criterion the lowest local weight (0.165). In the strategic risk dimension, the social dissatisfaction sub-criterion reported the highest local weight (0.380) and the environmental dissatisfaction sub-criterion the lowest local weight (0.136). In terms of human resource risk, the sub-criterion has the highest local weight (0.470) and the lowest local technical risk (0.149). In the other risk dimension, financial risk sub-criterion has the highest local weight (0.517) and external risk sub-criterion has the lowest local weight (0.096). In the engineering dimension, the value of turnover volume sub-criterion has the highest local weight (0.469) and the financial saving sub-criterion has the lowest local weight (0.251). Finally, the prioritization of contractors based on the comparison of the results obtained from the solution of VIKOR methods and the analysis of gray relations is reported. It is noteworthy that a Monte Carlo simulation-based approach is used to compare the performance of these methods.

1. Introduction

In this research, the titles of risk management and value engineering and BOT construction, operation and transfer projects are considered as three important topics. Therefore, first, some topics have been stated about these topics and their concepts, and then what is considered in this research, namely the combination of risk management and value engineering and its application in the best way in the implementation of construction, operation and transfer projects. Risk management or risk management is the systematic application of management policies, procedures and processes related to risk analysis, assessment and control activities. Risk management is the process of documenting the final decisions made and identifying and applying criteria that can be used to bring the risk to an acceptable level. According to the definitions provided, the risk management process has two stages, which are recognizing the risk in the desired area and planning for the remaining processes. Risk management is one of the central parts of the strategic management of any organization. This method includes processes through which organizations can methodically identify risks associated with their activities. A successful risk management approach should be commensurate with the level of risk in the organization and in line with other activities of the organization. Other characteristics of successful risk management include comprehensiveness of work, engagement with daily activities, and dynamism in responding to situations. Many projects that are assumed to be under control take risks as an unrecognized event and try to control it. With this in mind Basic concepts, it is possible to deal with risk; Therefore, first, the potential risks of the project should be identified. This is possible by categorizing the task structure and asking a few questions of oneself or the members of the project team. The following suggested values can be used to assign potential values to risks. From 85 ٪ upwards Immediate - 85 % probable - 6 % medium - 50 % possible - 40 % low - 15 % unlikely. The probability of each risk now being calculated can be calculated. Another way is to assign a weight percentage to each of the risks. The main problem with this method is that there is not always enough experimental data available to do this accurately. This method is usually done by experienced people.

They work to gain comprehensive experience of a variety of events in different projects. In the next step, they assign a value to each risk. This amount can be in terms of cost or time if needed; For example, if the goal is to determine when the project will be completed, any ideas about the duration of the activities can be considered a risk scenario. At this stage, the true amount of risk can be obtained by calculating the product of the values assigned to the risk and the probability of its occurrence, and according to the results can be decided to take action or postpone it. Therefore, in the first stage, the project risks are identified at the highest level of WBS, and after doing this several times, the issue will become much clearer. Value management is a management model in the value approach that emphasizes motivating people, developing skills and promoting synergy and innovation with the aim of maximizing the overall performance of the organization. Value management at the organizational level relies on a value-based organizational culture that values both the interests of stakeholders and customer satisfaction (internal / external) that at the operational level, the use of appropriate tools and methods puts. Value management through the senior manager tries to meet the expectations of stakeholders and customers to get the best output from inputs such as assets, property, materials and manpower. Value management creates a focus on value throughout the organization by integrating the efforts of operations managers and senior managers. This is made possible by focusing on outputs that are in line with the overall goals of the organization. The principles of value management

include the model of teamwork management and effective communication, which includes the use of value culture in the organization and focus on the function of paying attention to what it does to what it is and creating a platform for creativity and innovation and using creative techniques. The need for quantitative evaluation is the definition of measurement tools for accurate and correct comparison and the next issue is the dynamics of individuals, which includes encouraging people to work in groups to create solutions and prevent confrontation and satisfaction and recognition of cooperation with individuals and team results. And creating mutual understanding and better support of team decisions and encouraging change in the expression of conditions to make changes is useful and effective.

Asgharizadeh and Nasrollahi (2008) in a study entitled "Identifying and determining the weight of effective indicators in selecting contractors for construction projects" in addition to identifying indicators affecting the selection of contractors, the importance and priority of these indicators has been determined using the AHP model in group decision making. The most important indicators obtained based on pairwise comparisons made by experts are: technical; Skill-ability; Economic-financial; Management-specialized staff; Equipment; Credibility and good record. Elahi et al. (2010) in a study entitled "Design of a fuzzy expert system for contractor selection.

Appropriate in IT outsourcing "Identify important criteria for selecting a contractor and provide its framework and determine the importance of criteria and finally design a fuzzy expert system to select the appropriate contractor in in-house IT outsourcing. Method of obtaining knowledge from experts including technology experts and managers Information is a questionnaire and its use in an information technology company has been used to validate the system and the results indicate the optimal performance of the system.

2. Research Method

The research method is in fact the action plan and implementation of a research. The choice of research method depends on the goals and nature of the research subject and its implementation possibilities, and sometimes it is possible to research the research method.
It was decided that the mentioned factors be known. According to the objectives and questions of the current research, the research method used in this research is in terms of nature and analytical-communication method and in terms of purpose is applied and in terms of collecting survey information. A survey because in this research, a questionnaire has been designed to select the desired factors in the implementation of construction and operation projects. Considering that in multi-criteria decision-making models, the optimal decision in three-dimensional space must be made based on a series of criteria. This study is from the perspective of examining and evaluating the factors affecting the ranking of factors affecting the implementation of construction and operation projects and its role
Factors in the process of improving the current situation are analytical-communicative and because the research results can be used to improve the evaluation process; It is practical. Therefore, hypothesis and subsequent hypothetical test are not discussed in this study; The purpose is to provide a method for "evaluating the factors affecting the implementation of construction and operation projects."

3. Society and Statistical Sample

In this research, in order to collect information, the opinions of research experts in various fields of industry and universities have been used. Therefore, through a semi-guided free interview, the opinions of three groups of people were used in the research. These three categories are:
1- University professors: This part of the society consists of people who are familiar with the evaluation and management of executive risks or evaluation of technology in theory and practice.
2- Managers, supervisors and experts of the construction industry: In order to make the research results more practical, the opinions of this group of experts, especially in the construction industry, have been considered.
3- Consultants, teachers and experts in the field of consulting and training services: This group of specialists have been selected due to their close relationship and familiarity with different industries.

In order to collect information and conduct interviews about the features of the model, a sample of 40 experts in the three categories mentioned above was selected. Among these 40 people, 30 questionnaires that have the best level of response for the validation of criteria have been selected. Finally, in order to complete the questionnaire related to scoring criteria and sub-criteria, 5 highly experienced experts have been used.

4. Conceptual model of research

This section presents a conceptual research model that is a combination of risk management and value engineering models. It should be noted that the use of value engineering with the usual method for the following reasons increases or decreases risk.

4.1. Descriptive findings

In order to investigate the characteristics of the statistical population,descriptive statistics have been used. Information about the demographic characteristics of the research sample is shown in Table 1.

Table 1. Descriptive findings

Property	Response	Relative frequency
gender	man	87
	woman	13
age	30-40 years	57
	40-50	30
	50 and up	13
work experience	10-15	45
	15-20	35
	20 and up	20
degree of education	Bachelor	20
	Master	67
	Phd	13

Description of data by gender:

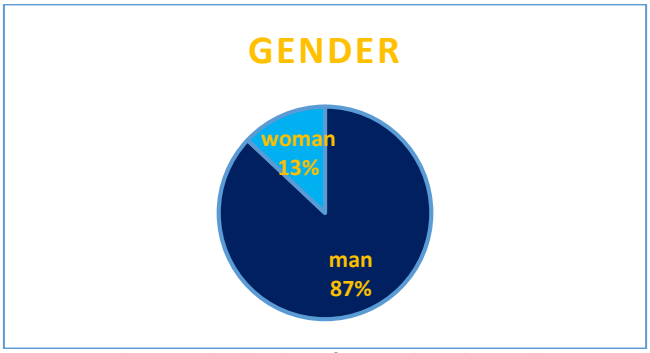

Figure 1. Distribution of respondents by gender

Description of data by age:

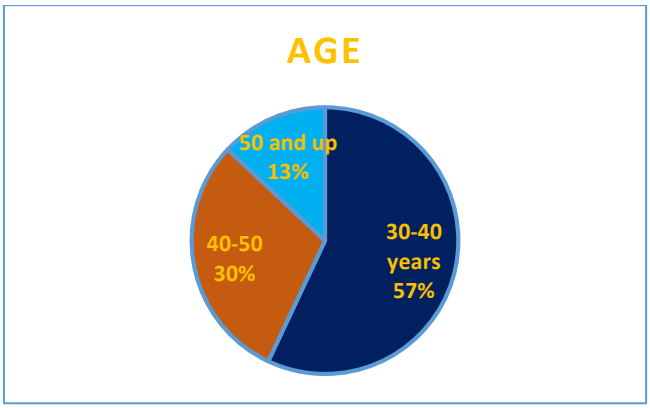

Figure 2. Distribution of respondents based on the age of the respondents

5. Numerical analysis

In order to achieve valid results, a consensus method has been used in this research. In order to collect information, a committee of experts was invited to participate in the meetings and they were asked to evaluate the performance of the options in relation to the criteria presented in Table 3 using the scales mentioned in Table 2.

Table 2. Pair comparison of BWM and VIKOR and GR techniques

BWM								
Extremely more important	Very strongly to extremely more important	Very strongly more important	Strongly to very strongly more important	Strongly more important	Moderately to strongly more important	Moderately more important	Equal to moderately more important	Equally important
9	8	7	6	5	4	3	2	1
GRA & VIKOR								
Degree of importance for the positiveon	Degree of importance for the negative criterion							
	5					Least Important		
2	4					Moderately Important		
3	3					Strongly Important		

6. Ranking options

6.1. Ranking options using the GRA technique

After achieving the weights of the criteria, in the next step, the potential options are prioritized based on the weights of these factors and using VIKOR and GRA methods. Using the verbal scale presented in Table 3 of the ranking, all experts were asked individually to evaluate the options for these criteria. After achieving the priority level of each expert, in the next step, the average of the grades is calculated and the average decision matrix is obtained according to Table 4.

Table 6. Average Option Scores

	Ec۱	Ec۲	Ec۳	Te۱	Te۲	Te۳	Te٤	En۱	En۲	En۳	So۱	So۲	So۳	Ri۱	Ri۲	Ri۳
A_1	3.4	2.8	2.8	2.0	3.0	2.2	3.0	3.2	3.4	3.6	3.2	2.4	2.6	3.6	4.4	2.6
A_2	3.6	3.4	3.0	3.2	2.8	2.6	2.8	3.6	3.2	2.8	2.6	3.4	2.8	2.6	3.6	3.2
A_3	3.0	3.0	2.8	4.4	3.8	4.2	3.0	3.0	2.8	3.4	4.4	4.8	2.8	3.2	3.4	2.4
A_4	2.6	2.8	2.8	4.4	3.2	3.6	3.0	3.2	2.6	3.2	2.0	2.8	2.2	2.8	3	4.2
A_5	2.6	3.6	2.6	3.8	4.4	3.0	4.0	2.8	3.2	2.2	3.4	3.4	2.2	3.8	2.6	2.6

Table 7. Normalized decision matrix

	Ec۱	Ec۲	Ec۳	Te۱	Te۲	Te۳	Te٤	En۱	En۲	En۳	So۱	So۲	So۳	Ri۱	Ri۲	Ri۳
A_1	0.13	0.75	0.50	1.00	0.30	0.00	0.33	0.75	0.33	0.25	0.40	0.00	0.67	0.14	0.00	0.82
A_2	0.00	0.50	0.40	0.50	0.20	0.14	0.22	1.00	0.50	0.67	0.20	0.40	0.50	0.86	0.40	0.50
A_3	0.38	0.63	0.50	0.00	0.70	0.91	0.33	0.63	0.83	0.33	0.90	1.00	0.50	0.43	0.50	0.91
A_4	0.63	0.75	0.50	0.00	0.40	0.64	0.33	0.75	0.33	0.75	0.00	0.70	0.00	1.00	0.70	0.00
A_5	0.63	0.38	0.60	0.25	1.00	0.36	0.89	0.50	0.00	0.00	0.50	0.20	1.00	0.00	0.90	0.82
x_i	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

6.2. Ranking options using the VIKOR technique

Similarly, the mean decision matrix for the vikor technique is as shown in Table 8. In the next step, the maximum and minimum values of the criteria are obtained using the equation presented in the previous chapter. In addition, the values of R, S and Q were calculated using the related equations by Vikor method, which are shown in the table below. Options are prioritized based on Q values and the option with the lowest Q value is selected as the best option.

Table 3. Maximum and minimum values of criteria

	Ec۱	Ec۲	Ec۳	Te۱	Te۲	Te۳	Te٤	En۱	En۲	En۳	So۱	So۲	So۳	Ri۱	Ri۲	Ri۳
f_j^*	2.0	2.2	1.8	2.0	4.4	4.4	4.2	3.6	2.6	2.0	4.6	4.8	2.2	2.4	2.4	2.2
f_j^-	3.6	4.8	4.0	4.4	2.4	2.2	2.4	2.0	3.8	4.2	2.0	2.4	3.4	3.8	4.4	4.4

Table 4. Ranking of options based on R, S and Q values

	S	Ranking	R	Ranking	Q	Ranking
A_5	0.382	1	0.060	1	0.000	1
A_3	0.407	2	0.078	3	0.130	2
A_4	0.444	3	0.075	2	0.189	3
A_1	0.419	4	0.121	10	0.355	4
A_{13}	0.506	8	0.093	4	0.392	5

In general, the final ranking of the options using GRA and VIKOR methods is presented in the above sections, respectively. As can be seen, the main difference between the two methods is the first and second options, respectively. In fact, the third to fifth options are equal in both methods, but the order of the first and second options is different, and this can be due to the very different points of the first and second options with the other options and, of course, the proximity of the scores of these two options to each other. To know. Therefore, it seems necessary to use sensitivity analysis to report the best method and report the final result.

7. Discussion

Considering that more than 90% of the credit of construction projects is spent in the construction stage and the quality of a project largely depends on this stage. Therefore, conducting extensive studies to identify all the factors affecting the successful implementation of a project is very important. In general, the issue of risk management in the implementation of a project has always been one of the most important concerns of managers of various departments of organizations responsible for the implementation of this project. In fact, it is these risks that in many cases increase costs and reduce the effectiveness of some projects. At the result will definitely be one of the dimensions studied in this research is risk management. On the other hand, value creation in a project is so important that researchers in this field of research have introduced a concept called value engineering in the study and implementation of industrial and service projects. Therefore, in this research, in addition to risk management, the concept of value engineering has also been studied. In fact, it can be said that the integrated model of this research is based on the dimensions of risk management and value engineering.

Given that this study seeks to answer questions such as how can th most important effective criteria related to risk management in project implementation be identified and validated? How can the most influential criteria related to value engineering in project implementation be identified and validated? How can the weight of criteria and sub-criteria related to risk management be determined? How can the weight of criteria and sub-criteria related to value engineering be determined? And what is the final prioritization of the most important options in project success based on criteria and sub-criteria related to risk management and value engineering? Necessary calculations need to be made using efficient methods. For this purpose, in this research, the best-worst multi-criteria decision-making methods to determine the importance of criteria related to risk management and value engineering and Vickor methods and analysis of gray relationships to prioritize the options including "technology absorption", "financing by the contractor" "," Reducing disputes "," Reducing the employer's responsibilities and obligations "and" Risk transfer the executive structure of the research is as follows: First, important criteria and sub-criteria are extracted from the research literature, and then, using the method of validation, the criteria that have the highest level of importance are scored by 30 experts. Questionnaires based on the best-worst method, final score of criteria and sub-criteria were presented by 5 experts who have higher work experience and executive position than other people. These scores as input of the best-worst method help to determine the final weight of criteria. Using Vickor methods and analysis of gray relations and in accordance with the weight obtained from the implementation of the best-worst method, the final prioritization of options is done.According to the computational results, it can be seen

that the strategic risk criterion has the highest local weight (0.348) Value engineering criteria also have the lowest local weight (0.127) among all criteria, considering that compared to other sub-criteria and technical risk sub-criteria, it has the lowest local weight (0.149) among all sub-criteria. Sub-criteria Other risks It can be said that the financial risk sub-criterion has the highest local weight (0.517) compared to other sub-criteria and the external risk sub-criterion also has The lowest local weight (0.096) is 0. Among all sub-criteria. Regarding the sub-criteria of value engineering, it can be said that the sub-criterion of turnover volume has the highest local weight (0.469) compared to other sub-criteria. And the financial savings sub-criterion has the lowest local weight (0.251) among all sub-criteria. Regarding the final ranking of options, it can be said that the option of "financing by the contractor" has the highest priority and "the possibility of absorbing technology" has the least importance. The options of "reducing the employer's responsibilities and obligations", "transferring risk to the contractor" and "possibility of absorbing technology" are in the second to fourth ranks, respectively.

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