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A Multi-Criteria Decision-Making Approach with Interval Numbers for Evaluating Project Risk Responses

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ABSTRACT

The aim of appropriate risk management in mega projects is to successfully deliver these projects for the lowest impacts at an acceptable level of risk. There is a need to develop and evaluate a set of risk response actions (RRAs) that reaches the lowest total project impacts under uncertainty while considering technical performance and schedule. Traditional techniques cannot effectively deal with the uncertainties of the risk response development. For this purpose, a new multiple criteria decision-making (MCDM) approach with interval numbers is introduced to evaluate the appropriate RRAs for higher risks of mega projects. Two decision-making techniques, known as decision tree (DT) and TOPSIS are improved versus multiple conflicting criteria by considering interval computations, a new utility function and similarity degree. Then, a real application in oil and gas projects is presented to demonstrate the applicability of the proposed approach under uncertainty, and the main advantages are reported.

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1. INTRODUCTION

Risk management in mega projects is introduced as a procedure to determine the level of risks, and to control and reduce their impacts. Generally, the steps are risk identification, risk assessment and risk response [1-4]. Also, a risk within the projects can be an uncertain event that has effects on the objectives, such as time, cost, quality and scope [5-7].

In the risk management process, risk response phase is the process of extending the alternatives and providing actions to enhance opportunities and mitigate threats to the project's objectives. It should be appropriate to the severity of the risk, cost effective in meeting the challenge, timely to be successful, realistic within the project context, agreed upon by all parties involved, and owned by a responsible person [8]. The risk response phase often contains the following actions [1]: (1) avoidance; (2) transference; (3) mitigation; and (4) acceptance.

In the risk management, the risk response phase starts from the judgment of whether to respond or not to the risk magnitude of a specific risky event computed at the risk assessment phase. It means the project risk threshold and the project risk comparison process that are considered at the risk management planning phase should be preceded. However, traditional techniques used in the risk response phase only recommend how to begin a strategy of simply responding to the risk [9, 10]. It is worth to note that at the risk response phase, all project risks cannot be mitigated to, and even further all risks cannot be responded at the same level.

In the related literature, there exist only limited researches that have considered the risk response phase for mega projects. Anderson [11] presented the use of several strategies in mitigating risk related to national defense projects. Baillie [12] considered a number of practical strategies to mitigate the risks and uncertainties inherent in R&D projects. DSMC [13] regarded examples of risk handling in weapon development projects, and Tsai [14] interviewed management in weapon development projects and presented seven risk-handling strategies.

Baker et al. [15] investigated the choice and application of the most commonly used techniques for the risk response phase within oil and gas industry, and

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compared them with the use of those selected by construction industry. Ben-David and Raz [16] proposed a decision-support model for the risk response phase in software development of electronic devices. Piny [17] built the response planning chart for threats and opportunities which was divided into six areas to define the overall strategy for each risk. Young [18] proposed a conceptual framework for the risk response phase on projects. Pan and Chen [19] presented an economic optimization model based on the model proposed by Ben-David and Raz [16] for selecting risk reduction actions in CMMI-based software projects with an example taken from a Chinese software industry. Fan et al. [20] provided a conceptual framework that defined the relationship between risk-handling strategy and relevant project characteristics, and described the quantitative relationships among all variables. Aaltonen and Sivonen [21] identified and regarded five different types of response strategies through an empirical analysis of four cases in emerging markets in global projects. Kutsch and Mark Hall [22] proposed the results of a qualitative study of IT project managers, considering their reasons for deeming certain known risks to be irrelevant.

The review of the literature shows that the risk response phase for mega projects has not received sufficient attention from researchers, whereas the phases of risk identification and assessment have been investigated properly. Indeed, they concentrated on the applications of different risk response strategies; however, they recommended scant guidelines for evaluating and selecting the best risk response actions (RRAs) which cope with the characteristics of mega projects. In addition, in the literature a single factor (i.e., cost factor) is only regarded for the evaluation of the RRAs. Other factors, including time, quality and scope, are not considered in the risk response phase for mega projects. Also, secondary risks are not discussed properly, which stem from the selection of preliminary responses for higher project risk.

On the other hand, lack of information, uncertain project environment and uniqueness in mega projects lead to benefiting from interval computations in the risk response phase. To the best of our knowledge, no decision-making approach under uncertainty was found regarding the risk response development for mega projects.

Decision-making process often involves the experts' subjective judgments and preferences regarding qualitative/quantitative criteria for mega projects [23-26]. This problem may result in imprecise and indefinite data being present, which makes the decision-making process complex and challenging. The decision-making process with interval computations can be recommended as an effective approach where the information available is uncertain.

This paper aims at introducing a new multiple criteria decision-making (MCDM) approach with interval computations to conquer the foregoing difficulties for mega projects. Two decision-making techniques, known as decision tree (DT) and technique for order preference by similarity to ideal solution (TOPSIS), are improved with interval numbers by considering the similarity degree of each alternative [27] from ideal solutions in order to evaluate the RRAs in the risk response phase for mega projects.

The proposed approach considers multiple criteria, including time, cost, quality and scope, for the first time in the literature in the risk response phase. In addition, it copes with the secondary risks that may happen after evaluating the first RRAs regarding a higher risk within a mega project in order to analyze precisely through sequential decision-making.

The rest of this paper is organized as follows. The proposed MCDM approach with interval numbers is presented in section 2. Section 3 explains the detail of the proposed approach through a real application in a gas refinery construction project, and discussion of results is also provided. Finally, conclusion and further research are given in section 4.

2. PROPOSED MCDM APPROACH WITH INTERVAL NUMBERS

In this section, a novel decision-making approach with interval computations is presented. This approach copes with subjective and objective information, described by linguistic variables or numerical values concurrently. The proposed MCDM approach is designed to evaluate RRAs for mega projects versus multiple criteria under uncertainty. The approach allows each expert or decision maker (DM) to make judgment in a conventional manner. Individual judgments or opinions are aggregated as a group judgment to reflect the inherent imprecision involved by interval numbers. The proposed approach is based on two improved decision-making techniques, namely DT and TOPSIS.

An improved DT with interval numbers versus multiple conflicting criteria is constructed to help the experts or DMs in order to measure the higher risks for mega projects, and provide a graphic approach for evaluations through sequential decision- making. Then, an improved TOPSIS method with interval computations is presented in order to process uncertain risk data and to perform an effective analysis. It is pointed out that this technique is chosen for evaluating the RRAs duo to its stability and ease of use with subjective and objective information [4, 23].

In a decision-making process, it is often difficult for the experts or DMs to estimate a precise performance rating for an alternative versus criteria and the weights of criteria. The main advantage of the proposed approach can be to assign the relative importance of the criteria by linguistic variables or interval numbers instead of precise numbers.

The steps of the proposed MCDM approach are provided below. This approach is on the basis of five main steps as illustrated in Figure 1.

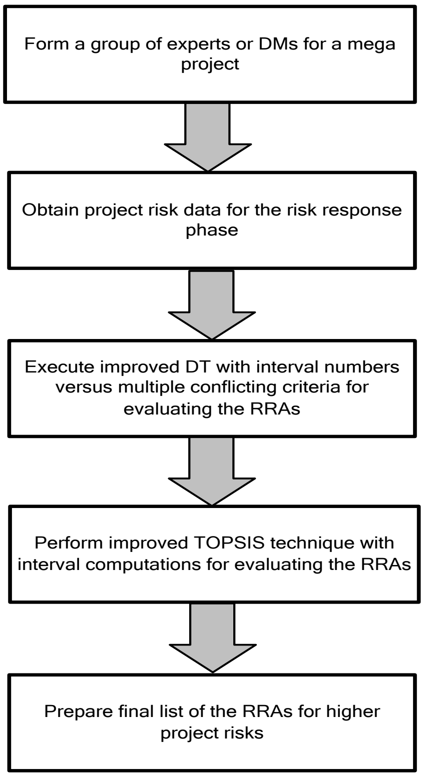


Figure 1. Proposed MCDM approach with interval computations for evaluating the RRAs in mega projects

Step 1. Form a group of experts or DMs for a mega project.

Step 2. Obtain project risk data for the risk response phase.

Step 2-1. Project risk response problem is defined for creating the RRAs.

Step 2-2. Project risks are collected by historical information and documents regarding the phases of risk identification and assessment.

Step 2-3. RRAs are determined by group decision techniques, including Brainstorming, Delphi and NGT.

Step 2-4. A list of potential RRAs is generated for higher risks.

Step 3. Execute improved DT versus multiple conflicting criteria for evaluating the RRAs based on sequential decision-making process.

Step 3-1. According to DT technique, the decision-making problem is defined versus multiple conflicting criteria under uncertainty.

Step 3-2. Multiple criteria (time, cost, quality and scope) are selected for evaluating the RRAs.

Step 3-3. A DT is structured versus the selected criteria.

Step 3-4. Probability of occurrence can be provided for each RRA versus each criterion by linguistic variables as presented in Table 1.

TABLE 1. Relations between linguistic variables and interval numbers

Linguistic variables	Interval numbers
Very low (VL)	[0, 10]
Low (L)	[10, 25]
Medium low (ML)	[25, 40]
Medium (M)	[40, 55]
Medium high (MH)	[55, 70]
High (H)	[70, 85]
Very high (VH)	[85, 100]

Step 3-5. The outcome is estimated for each RRA versus each criterion. It is worth to mention that experts' judgments can be expressed by linguistic variable for the outcome and then converted into numerical values.

Step 3-6. Expected value (EV) as well as the variance (Var) is calculated for each node (each RRA) versus each criterion when all outcomes and subsequent decisions are quantified.

Step 3-7. The utility function (UF) is calculated by:

$$UF(x) = E(x) \pm 2\,Var(x) \quad (1)$$

Step 4. Perform improved TOPSIS technique with interval computations for evaluating the RRAs.

Step 4-1. Choose the linguistic ratings or interval numbers $\left(x_{ij}^{L}, x_{ij}^{U}\ i = 1,2,\ldots,m,\ j = 1,2,\ldots,n\right)$ for alternatives (RRAs) versus conflicting criteria (time, cost, quality and scope), and the appropriate linguistic variables or interval numbers $\left(w_j^{L}, w_j^{U}, j = 1,2,\ldots,n\right)$ for the weight of the criteria. The normalized values are calculated by:

$$\bar{n}_{ij}^{\ L} = x_{ij}^{\ L} \Big/ \sqrt{\sum_{j=1}^{m} (x_{ij}^{\ L})^2 + (x_{ij}^{\ U})^2}\ , \quad j = 1,2,...,m,\ i = 1,...n, \quad (2)$$

$$\bar{n}_{ij}^{\ U} = x_{ij}^{\ U} \Big/ \sqrt{\sum_{j=1}^{m} (x_{ij}^{\ L})^2 + (x_{ij}^{\ U})^2}\ , \quad j = 1,2,...,m,\ i = 1,...n. \quad (3)$$

Step 4-2. Construct the weighted normalized interval decision matrix. The weighted normalized value is calculated by:

$$\bar{v}_{ij}^{\,L} = w_i \bar{n}_{ij}^{\,L}, \quad j = 1,...,m,\ i = 1,...,n, \tag{4}$$

$$\bar{v}_{ij}^{\,U} = w_i \bar{n}_{ij}^{\,U}, \quad j = 1,...,m,\ i = 1,...,n, \tag{5}$$

where, $\sum_{j=1}^{n} w_j = 1$.

Step 4-3. Identify the set of positive ideal solution (PIS) and negative ideal solution (PIS). The PIS ($\bar{A}^*$) and the NIS ($\bar{A}^-$) are shown as:

$$\bar{A}^* = \left(\bar{v}_1^*, \bar{v}_2^*, \ldots, \bar{v}_n^*\right) = \left\{\left(\max_j \bar{v}_{ij}^U \mid i \in I\right), \left(\min_j \bar{v}_{ij}^L \mid i \in J\right)\right\} \tag{6}$$

$$\bar{A}^- = \left(\bar{v}_1^-, \bar{v}_2^-, \ldots, \bar{v}_n^-\right) = \left\{\left(\min_j \bar{v}_{ij}^L \mid i \in I\right), \left(\max_j \bar{v}_{ij}^U \mid i \in J\right)\right\} \tag{7}$$

where I is associated with benefit criteria, and J is associated with cost criteria.

Step 4-4. Calculate the distance of each alternative from ($\bar{A}^*$) and ($\bar{A}^-$) by the following relations:

$$\bar{d}_i^* = \left\{\sum_{i \in I} (\bar{v}_{ij}^L - \bar{v}_i^*)^2 + \sum_{i \in J} (\bar{v}_{ij}^U - \bar{v}_i^*)^2\right\}^{\frac{1}{2}},\ i = 1, 2, \ldots, m \tag{8}$$

$$\bar{d}_i^- = \left\{\sum_{i \in I} (\bar{v}_{ij}^U - \bar{v}_i^-)^2 + \sum_{i \in J} (\bar{v}_{ij}^U - \bar{v}_i^-)^2\right\}^{\frac{1}{2}},\ i = 1, 2, \ldots, m \tag{9}$$

Step 4-5. The similarity degree of each alternative from PIS ($\bar{A}^*$) and fuzzy NIS ($\bar{A}^-$) as $\bar{S}_i^*$ and $\bar{S}_i^-$, can be currently calculated by:

$$\bar{S}_i^* = \frac{1}{1 + \bar{d}_i^*} = \frac{1}{1 + \left\{\sum_{i \in I} (\bar{v}_{ij}^L - \bar{v}_i^*)^2 + \sum_{i \in J} (\bar{v}_{ij}^U - \bar{v}_i^*)^2\right\}^{\frac{1}{2}}},\ i = 1, 2, \ldots, m \tag{10}$$

$$\bar{S}_i^- = \frac{1}{1 + \bar{d}_i^-} = \frac{1}{1 + \left\{\sum_{i \in I} (\bar{v}_{ij}^U - \bar{v}_i^-)^2 + \sum_{i \in J} (\bar{v}_{ij}^U - \bar{v}_i^-)^2\right\}^{\frac{1}{2}}},\ i = 1, 2, \ldots, m \tag{11}$$

Step 4-6. Calculate similarities to ideal solution. This step solves the similarities to an ideal solution by:

$$CC_i = \frac{S_i^+}{S_i^+ + S_i^-} \tag{12}$$

Step 4-7. Rank preference order. According to the similarities to ideal solution, the ranking order of all alternatives and the best one from among a set of feasible alternatives are determined.

Step 5. Prepare the final list of RRAs for higher risks. Then select the best RRA.

3. AN APPLICATION

This section illustrates the application of the proposed MCDM approach with interval computations for a mega project in Iran.

Experiences arisen from this real application in gas refinery construction projects have been used as input in the process of developing the proposed MCDM approach which is introduced in this section. The description of the gas refinery plant as a mega project is briefly introduced below.

Gas refinery plant is utilized to purify the raw natural gas extracted from underground gas fields, and brought up to the surface by gas wells. The processed natural gas, used as fuel by residential, commercial and industrial consumers, is almost pure methane. When processed and purified into finished by-products, these are collectively referred to natural gas liquids (NGL). The raw natural gas must be purified to meet the quality standards specified by the major pipeline transmission and distribution companies.

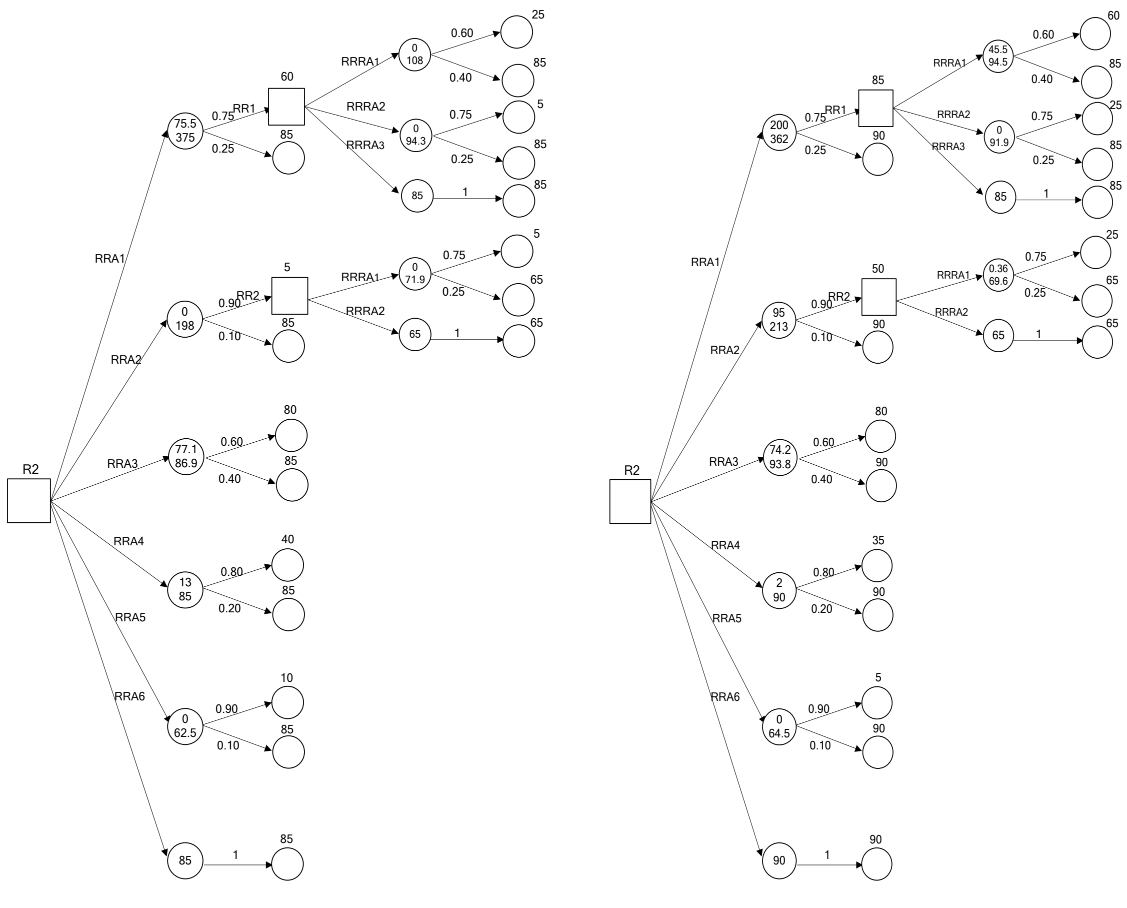
The contract type of foregoing project is MEPCC, namely management, engineering, procurement, construction and commissioning. In this contract, the MEPCC contractor agrees to deliver the keys of a commissioned plant to the owner for an agreed period of time. In this section, the risk response phase from general contractor's (GC) perspective is taken into account. GC receives work packages from the owner and delivers them to subcontractors by bidding and contracting. This contractor is in charge of monitoring the planning, engineering, designing and constructing phases. Moreover, the installation, leadership and the payment of the subcontractors are burdened by GC.

3.1. Computational Results The proposed MCDM approach with interval computations is elaborated for the gas refinery plant. For this purpose, a required decision committee of experts or DMs is formed. The team establishment step is needed to consider the organizational and project environment in which the risk response phase is taking place and to specify the main vision, goals, objectives and outcomes required. The main goal of the team is to mitigate the project risks to find their priorities for further measures. The list of experts in the project risk management process is provided, as below: (1) project manager and project team; (2) project sponsors and site representatives; (3) discipline engineers (e.g., civil, electrical, mechanical, and piping engineers); (4) experts with specific knowledge in particular areas of concern; (5) commercial specialists; (6) health, safety and environment (HSE) specialists; (7) experienced people in similar field of the project; (8) stakeholders; and (9) a consulting team outside of the project.

In *Step 1*, the risk management team is organized for the mega project for each activity in the risk response phase. Defining the purpose of the risk response planning is an essential step in the proposed MCDM approach, since this largely determines other factors in the development of the approach. This contains the selection of what is to be evaluated, the criteria for ranking, and the appropriate participants. To gather the project risk data, we utilize historical information, project records and documents regarding risk identification and assessment for the mega project risks in *Step 2*. Thus, higher risks are recognized for the risk response phase in the mega project as follows: (1) international relations (R_1); (2) design failures (R_2); (3) delay in paying and receiving project's invoices (R_3); (4) change in construction scope of work (R_4); and (5) HSE matters (R_5).

For the better understanding of potential RRAs, some group decision techniques are focused in the mega project [6, 28-30]. These main techniques are Brainstorming, Delphi, and NGT. Hence, risk data are offered based on foregoing resources and risk data gathering techniques. A list of the RRAs may consider potential responses, a list of risks requiring response in the near term, a list of risks for additional analysis and response, and trends in qualitative analysis results. Consequently, in *Step 2*, the list of RRAs is prepared for higher project risks.

In *Step 3*, the proposed improved DT technique is employed versus multiple criteria for the RRAs evaluation. The evaluation is structured using a DT diagram describing a situation under interval number consideration and the implications of each available alternative (RRA) versus four selected criteria (time, cost, quality and scope). It incorporates the effects of four criteria for each RRA, the probability of each possible scenario, and the outcome of each alternative logical path. In the studied mega project, objective information obtained by the professional experts copes with uncertain values. Then, the proposed improved DT technique is solved using EV method and variance with interval numbers based on the UF (Eq. (1)) for each alternative, when all outcomes and subsequent decisions are quantified for each higher risk in the risk response phase. For instance, the results of the second risk (design failures) and its RRAs versus time and cost criteria are depicted in Figure 2.



Time criterion Cost criterion

Figure 2. An improved DT technique versus time and cost criteria for the evaluation of RRAs for design failures risk (R_2)

TABLE 1. Normalized decision matrix according to the improved TOPSIS technique for the ranking of RRAs for design failures risk (R_2)

Criteria / Alternatives	Time criterion	Cost criterion	Quality criterion	Scope criterion
RRA 1	[0.159, 0.791]	[0.386, 0.698]	[0.181, 0.769]	[0.345, 0.718]
RRA 2	[0.000, 0.418]	[0.184, 0.410]	[0.246, 0.422]	[0.221, 0.397]
RRA 3	[0.163, 0.183]	[0.143, 0.181]	[0.000, 0.196]	[0.000, 0.230]
RRA 4	[0.027, 0.179]	[0.004, 0.173]	[0.000, 0.148]	[0.010, 0.172]
RRA 5	[0.000, 0.132]	[0.000, 0.124]	[0.116, 0.142]	[0.000, 0.130]
RRA 6	[0.179, 0.179]	[0.173, 0.173]	[0.148, 0.148]	[0.172, 0.172]

TABLE 2. Evaluation of RRAs according to the improved TOPSIS technique for design failures risk (R_2)

Risk ID	Risk Description	RRAs	Risk response actions (RRAs) Description	S_i^+	S_i^-	CC_i	Rank
R_2	Design failures	RRA 1	Contracting with licensor and third party authorities	1.4018	1.2459	0.5294	1
		RRA 2	Acquiring experts	1.2261	1.3470	0.4765	2
		RRA 3	Contracting with renown companies	1.1150	1.4302	0.4381	4
		RRA 4	Belief of international standards	1.0861	1.4677	0.4253	5
		RRA 5	Study of contract requirements	1.0707	1.4761	0.4204	6
		RRA 6	Risk acceptance response	1.1212	1.4081	0.4433	3

TABLE 3. Ranking of RRAs for five higher risks of the mega project in the risk response phase

Risk ID	Risk response actions	Proposed MCDM approach with interval computations CC_i	Ranking
R_1	RRA 1	0.5423	1
	RRA 2	0.5140	2
	RRA 3	0.4286	5
	RRA 4	0.4300	4
	RRA 5	0.4313	3
R_2	RRA 1	0.5294	1
	RRA 2	0.4765	2
	RRA 3	0.4381	4
	RRA 4	0.4253	5
	RRA 5	0.4204	6
	RRA 6	0.4433	3
R_3	RRA 1	0.5307	1
	RRA 2	0.4042	3
	RRA 3	0.3985	4
	RRA 4	0.4128	2
R_4	RRA 1	0.5386	1
	RRA 2	0.4222	4
	RRA 3	0.4204	5
	RRA 4	0.4230	3
	RRA 5	0.4416	2
R_5	RRA 1	0.4803	6
	RRA 2	0.5228	2
	RRA 3	0.5118	4
	RRA 4	0.4963	5
	RRA 5	0.5205	3
	RRA 6	0.5257	1

In *Step 4*, the proposed improved TOPSIS technique with interval numbers is performed for evaluating the RRAs. Also, the weights of four criteria provided by the experts or DMs by geometric mean are given as follows:

$$w_1 = \sqrt[5]{0.80*0.85*0.95*0.90*0.90} = 0.879$$
$$w_2 = \sqrt[5]{0.95*0.90*0.95*0.85*1} = 0.929$$
$$w_3 = \sqrt[5]{0.80*0.70*0.75*0.65*0.70} = 0.718$$
$$w_4 = \sqrt[5]{0.85*0.75*0.65*0.80*0.70} = 0.747$$

$$w = (0.879, 0.929, 0.718, 0.747)^T$$

Normalized decision matrixes are calculated for the ranking of the RRAs for each higher project risk. For instance, normalized decision matrix for R_2 is given in Table 1. Then, computational results of the proposed improved TOPSIS based on similarity measurement with interval number are provided for the second risk (R_2) in Table 2. In the last column of this Table, the ranking of the RRAs is obtained according to the MCDM approach (*Step 4*). The final list is recommended according to *Step 5* and the best alternative (RRA) is then evaluated for each higher risk in the mega project. The approach results in the studied project for five higher project risks are presented in Table 3.

3.2. Discussion of Results Computational results provided by the proposed MCDM approach with interval numbers concur the decision-making to choose the RRAs for higher risks in the mega project.

The higher risks were undertaken in the previous mega projects in oil and gas industry. The MCDM approach under uncertainty quantifies the ranking of each RRA which presents the experts or DMs with the needed insight on the potential RRAs for each higher risk. Thus, the best RRA for the five higher project risks in the gas refinery plant as the mega project is given as follows: (1) international relations (R_1): establishment of consortium with European countries; (2) design failures (R_2): contracting with licensor and third party authorities; (3) delay in paying and receiving project's invoice (R_3): taking advantages of strong financiers; (4) change in construction scope of work (R4): claim management system; and (5) HSE matters (R5): risk acceptance response.

Results of the proposed MCDM approach by interval computations have been discussed with the professional experts within some common meetings. Consequently, they confirmed that the results of the proposed approach are more appealing compared to the common techniques by considering experts' opinions. For example, results of the proposed MCDM approach for R_2 illustrate that contracting with licensor and third party authorities is the first rank among the potential RRAs to reduce the design failures risk in the studied mega project. When this RRA is discussed with the experts or DMs, they verify that the RRA for the project in Iran has higher ranking. Furthermore, the uncertainty matter in the proposed MCDM process with interval computation is much lower and the precision is much higher by regarding its advantages for mega projects.

Eventually, the main advantages of the proposed MCDM approach by interval computations within the risk response phase are described, as below: (1) for the first time in the literature, several conflicting criteria are presented for the assessments by considering objectives of the mega project, including time, quality and scope as well as cost, for the risk response phase; (2) the secondary risks matter taking place after evaluating the RRAs for the preliminary risk (e.g., R_2 in Figure 2) are considered in order to be analyzed more accurately through sequential decision-making; (3) an improved DT with interval computations based on a new UF is presented versus multiple conflicting criteria to deal with presentation and evaluation of RRAs for each higher risk of the mega project; (4) an improved TOPSIS with interval numbers is introduced by considering the concept of similarity measure to process uncertain risk data and to choose the best RRA for each higher risk of the mega project.

4. CONCLUSIONS AND FUTURE DIRECTIONS

Considering the fact that, in numerous cases, determining precisely the exact value of the RRAs in the risk response phase for mega projects is difficult and that, their performance values can be regarded as interval numbers; hence, in this paper a new MCDM approach for interval data was introduced for evaluating the RRAs in mega projects.

Two algorithms were developed to determine the most preferable RRA among all possible RRAs in the risk response phase, when data is uncertain. In the first improved technique by considering new effective criteria, including time, quality, scope and cost, the secondary risks taking place after assessing the RRAs for the preliminary higher risk is calculated in order to be analyzed more accurately through sequential decision-making by the improved DT. The proposed DT technique with new utility function under multiple conflicting criteria was a graphical mean of structuring a decision-making situation where the uncertain information could be characterized by interval numbers for the RRAs of mega projects. In the second improved technique, to make complex decisions for the most preferable RRAs, the TOPSIS with interval numbers was presented based on the concept of similarity measure. The distance of the RRA under evaluation from the positive ideal solution and the more, its distance from the negative ideal solution was taken into account for the ranking and evaluating.

A real application in an Iranian gas refinery construction plant was presented to demonstrate the suitability of the proposed MCDM approach with interval computations. Computational results showed the effectiveness of the proposed approach that can support the project manager and professional experts or DMs to properly identify and evaluate the RRAs of the mega project.

For the further research, it will be interesting to employ the proposed MCDM approach by a group of DMs through a decision support system (DSS) to facilitate the decision-making problem under uncertainty for mega projects.

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A Multi-Criteria Decision-Making Approach with Interval Numbers for Evaluating Project Risk Responses

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چکیده

هدف از مدیریت ریسک مناسب در پروژه های بزرگ، تحویل موفقیت آمیز این پروژه‌ها برای حداقل اثرات با سطح قابل قبول ریسک است. توسعه و ارزیابی فعالیتهای پاسخگویی به ریسک یک امر ضروری است که ما را به حداقل سطح از کل اثرات پروژه تحت شرایط عدم قطعیت با در نظر گرفتن عملکرد فنی و زمانبندی می‌رساند. روشهای سنتی نمی‌توانند با عدم قطعیتهای موجود در توسعه پاسخهای ریسک به طور موثر سر و کار داشته باشند. برای این منظور یک رویکرد جدید تصمیم گیری چند معیاره با اعداد بازه‌ای ارائه می شود تا بتوان فعالیتهای مناسب پاسخگویی به ریسکها را در پروژه‌های بزرگ ارزیابی نمود. دو روش تصمیم گیری مشهور به درخت تصمیم و تاپسیس برای چندین معیار با در نظر گرفتن محاسبات بازه‌ای و درجه تشابه توسعه داده می‌شوند. سپس یک نمونه کاربرد واقعی در پروژه های نفت و گاز به منظور نشان دادن قابلیت کاربرد رویکرد پیشنهادی تحت شرایط عدم قطعیت ارائه می‌شود و مزایای اصلی آن گزارش می‌گردد.

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