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Risk assessment model selection in construction industry

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ABSTRACT

Construction industry faces a lot of inherent uncertainties and issues. As this industry is plagued by risk, risk management is an important part of the decision-making process of these companies.

Risk assessment is the critical procedure of risk management. Despite many scholars and practitioners recognizing the risk assessment models in projects, insufficient attention has been paid by researchers to select the suitable risk assessment model. In general, many factors affect this problem which adheres to uncertain and imprecise data and usually several people are involved in the selection process. Using the fuzzy TOPSIS method, this study provides a rational and systematic process for developing the best model under each of the selection criteria. Decision criteria are obtained from the nominal group technique (NGT). The proposed method can discriminate successfully and clearly among risk assessment methods. The proposed approach is demonstrated using a real case involving an Iranian construction corporation.

1. Introduction

The research on projects has expanded during the last decades (Naaranoja, Haapalainen, & Lonka, 2007). A project is an organization of people dedicated to the deployment of a set of resources for a specific purpose or objective (Steiner, 1969). Project management is defined as planning, directing, and controlling resources to achieve specific goals and objectives of the project (Fan, Lin, & Sheu, 2008). Managers need to ensure delivery of projects to cost, schedule and performance requirement. To achieve this involves identifying and managing the risks to the project at all project stages from the initial assessment of strategic options through the procurement, fabrication, construction and commissioning stage (Tah & Carr, 2001). The less "predictable" nature of projects makes them riskier than day to day business activities (Elkington & Smallman, 2002). Risk is a possible undesirable and unplanned event that could result in the project not meeting one or more of its objectives (Teneyuca, 2001). As the underlying concept of risk management is to manage risks effectively, risk management is a critical part of project management (Lyons & Skitmore, 2004).

Construction industries, face a lot of inherent uncertainties and issues like company's fluctuating profit margin, competitive bidding process, weather change, productivity on site, the political situation in a country, inflation, contractual rights, market competition, etc. Thus the construction industry, more than others, has been plagued by risk (Carr & Tah, 2001) and there is no construction project with risk free (Lam, Wang, Lee, & Tsang, 2007).

With the rapid advancement in the construction industry, an increased number of uncertainties are bound to occur (Thevendran & Mawdesley, 2004). It is essential that the construction companies conquer these risks and uncertainties in order to assess the effect of these sources in order to decide which of the projects is more risky, plan for the potential sources of risk in each project and manage each source during construction (Zayed, Amer, & Pan, 2008). Therefore it is paramount for construction companies to be sensitive to the issue of embracing and managing uncertainty and risk discussed above.

Project related risk management has attracted steady stream of interest in the academic literature (Bannerman, 2008). One of the major steps in project risk management is to identify and assess the potential risks (El-Sayegh, 2008). Despite many scholars and practitioners recognizing the risk identification methods and assessment models in projects insufficient attention has been paid by researchers to select a suitable risk assessment model. This paper attempts to address this limitation and the gap in the current literature and provide a framework for determining optimal risk assessment model.

In Section 2, some relevant literature is described. In Section 3, the problem of the risk assessment model selection is introduced. Section 4 concentrates on the proposed model. A real case study is presented to illustrate the application of the proposed method in Section 5. In the final section some conclusions are drawn.

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2. Literature review

2.1. Risk

The concept of risk became popular in economics during the 1920s. Since then, it has been successfully used in theories of decision making in economics, finance, and the decision science (Ngai & Wat, 2005). Risk has different meaning to different people; that is, the concept of risk varies according to viewpoint, attitudes and experience. Engineers, designers and contractors view risk from the technological perspective; lenders and developers tend to view it from the economic and financial side (Baloi & Price, 2003).

The traditional view of risk is negative, representing loss, hazard, harm and adverse consequences. But some current risk guidelines and standards include the possibility of upside risk or opportunity, i.e. uncertainties that could have a beneficial effect on achieving objectives (Hillson, 2002). Project risk is defined by Project Management Body of Knowledge (PMBOK) published by the Project Management Institute (PMI) as an uncertain event or condition that, if it occurs, has a positive or a time, cost, span or quality, which implies an uncertainty about identified events and conditions. PMBOK describes risk through the notion of uncertainty; however, these two phenomena are not synonymous (Perminova, Gustafsson, & Wikstrom, 2008). According to the Olsson (2007) and Hillson (2004) attempts to link risk with uncertainty based on the distinction between aleatory and epistemic uncertainty in the following couplet:

- Risk is measurable uncertainty.
- Uncertainty is immeasurable risk.

This implies that, when measurable, an uncertainty is to be considered a risk. PMBOK's definition of risk and uncertainty is the considered definition through the entire paper because this definition implies that risk is quantifiable and lends itself to assessment.

2.2. Risk management

If a risk is not identified it cannot be controlled, transferred or otherwise managed (Bajaj, 1997) and trying to eliminate all risks in projects is impossible. Thus, there is need for a formal risk management process to manage all types of risks. The project success usually depends on the combination of all risks, response strategies used to mitigate risks and a company's ability to manage those (Dikmen, Birgonul, & Han, 2007). Hence, the underlying concept of risk management is to manage risks effectively (Thevendran & Mawdesley, 2004). Risk management can lead to a range of project and organizational benefits including: (Bannerman, 2008)

- Identification of favorable alternative courses of action.
- Increased confidence in achieving project objectives.
- Improved chances of success.
- Reduced surprises.
- More precise estimates (through reduced uncertainty).
- Reduced duplication of effort (through team awareness of risk control actions).

PMBOK included risk management as one of the nine focuses in project management and described it as the process concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project (Zou, Zhang, & Wang, 2007). Risk management in construction is a tedious task as the objective functions tend to change during the project life cycle, and the scenarios are numerous due to sensitivity of projects to uncontrollable risks stemming from the changes in the macro-environment, existence of high number of parties involved in the project value chain, and one-off nature of the construction process (Dikmen, Birgonul, Anac, Tah, & Aouad, 2008).

Project risk management is an integrated process which includes activities to identify project uncertainty, estimate their impact, analyze their interactions, control them in the execution stage, and even provide feedback to the maintenance of collective knowledge asset (Williams, 1995). Risk management based on consensus in the literatures, used the following three-step approach (Zayed et al., 2008):

- Risk identification.
- Risk assessment.
- Risk mitigation.

The first step in risk management is risk identification. Before risks can be managed, they must be identified. Identification surfaces risks before they become problems and adversely affect a project. It refers to the evidences from previous experience or similar cases which would apply to the current project, in order to avoid or ameliorate the probability of compromising the project's success.

Construction risks can be categorized in a number of ways based on the source of risk, impact of risk or by project phase (Klemetti, 2006). In the most reference one, project risks are divided into two groups, according to their source, into internal and external. Internal risks are initiated inside the project while external risks originate due to the project environment (El-Sayegh, 2008). In risk identification step all internal and external risks must be identified. After the establishment of a list of risk events that had actually occurred in the process of project performance, these risks must be assessed.

The primary objective of risk assessment is to estimate risk by identifying the undesired event, the likelihood of occurrence of the unwanted event, and the consequence of such event. Risk assessment involves measures, either conducted quantitatively or qualitatively, to produce the estimation of the significance level of the individual risk factors to the project, so as to produce the estimation of the risk of the potential factors to project success. However, this step results will become the input to the determination of the optimum decision. With a better quantification measuring result, the managers can recognize which risks are more important and then deploy more resources on it to eliminate or mitigate the expected consequences.

The identification and assessment of project risk are the critical procedures for projecting success, and they usually become the essential factors in the decision-making process (Williams, 1995). Most authors refer to the processes which include risk identification and assessment, as the stage called "risk analysis". Risk analysis can provide insight to the specific sources of project risk and enable management to devise targeted remedial action.

Several methods have been proposed and utilized thorough research by a lot of scholars to help contractors and subcontractors to evaluate and select the best projects in order to decide which projects are more risky. And so these models help to plan for the potential sources of risk in each project and manage each source during construction. Currently project management teams have more options from which to choose.

Risk assessment methods have ranged from simple classical methods to fuzzy approach mathematical models. Many construction project risk assessment techniques currently used are comparatively mature tools (Zeng, An, & Smith, 2007).

Monte Carlo Simulation (White, 1995), Sensitivity Analysis (White, 1995), Critical path method (Kaufmann & Gupta, 1988), Fault tree analysis (Terano, Asai, & Sugeno, 1992), Event tree analysis (Huang, Chen, & Wang, 2001), Failure mode, effects and criticality analysis (Bowles & Pelaez, 1995) are the classical quantitative methods, used in construction industry for risk assessment. These methods only use data that are quantitative so, for effective application of these sophisticated quantitative techniques high quality data are a prerequisite (Zeng et al., 2007). Only on a few projects and contracts are risk considered in a consistent and logical manner; much assessment is too subjective (Mills, 2001). So, some other models suggested, involve both quantitative and qualitative ones.

Fuzzy risk assessment methods have also been deployed with some scholars too.

Mustafa and Al-Bahar (1991) investigated the subject of risk assessment and developed a scheme of classifying the various sources of risk in construction projects. They applied Analytical Hierarchical Process (AHP) in assessing the riskiness of a real-life constructing project (Mohammad & Al-Bahar, 1991). Sadiq and Husain (2005) developed a three-stage hierarchical structure aggregative risk model for grouping of risk items. For this grouping, an analytical hierarchy process was used for assessment. Another hierarchical risk breakdown structure is described to represent a formal model for qualitative risk assessment by Carr and Tah (2001). In their paper, using fuzzy approximation and composition, the relationships between risk sources and the consequences on project performance measures were identified and quantified. Cho, Choi, and Kim (2002) proposes another methodology for incorporating uncertainties using fuzzy concepts into conventional risk assessment frameworks in construction industry. Choi, Cho, and Seo (2004) presents fuzzy risk assessment methodology for underground construction projects. A formalized procedure and associated tools were developed to assess and manage the risks involved in underground construction. The suggested risk assessment procedure is composed of four steps of identifying, analyzing, evaluating, and managing the risks inherent in construction projects. Zeng et al. (2007) developed a methodology to deal with risks associated with the construction projects in the complicated situations. This model can handle with the expert knowledge, engineering judgment and the historical data for risk assessment and in this model the risk can be evaluated directly using linguistic terms which are employed in risk assessment. Zayed et al. (2008) introduces a model, based on AHP to help practitioners to assess Chinese highway risk projects and prioritize them. This methodology quantifies the qualitative effect of subjective factors of risk.

These methods differ in a variety of ways and they have their own advantages and disadvantages. So an ideal risk assessment method which would suit all organizations does not exist, as each of the organizations and projects possesses its own unique characteristics (Lichtenstein, 1996), so, an organization and project management team need to select the most appropriate methodology on its specific. This problem labeled as the risk assessment model selection.

3. Risk assessment model

According to Lichtenstein (1996) selecting which model is suitable for the organization or project is affected by many factors.

The cost of employing the technique, the level of external party's approval, Organizational structure, Agreement, Adaptability, Complexity, Completeness, Level of risk, Organizational size, Organizational security philosophy, Consistency, Usability, Feasibility, Validity, Credibility and Automation are factors to be considered in the selection of a risk assessment method (Lichtenstein, 1996).

Owning to several quantitative and qualitative factors, some of which them may be in conflict with the others, the risk assessment technique selection is complicated.

Risk assessment model involves two other key modeling aspects: First, construction is described as a collaborative teamwork process where parties with different interests, functions, and objectives, share a common goal, which is successful completion of a project. Thus in this problem solving it is vital to involve several people from different parties.

A second important consideration of the risk assessment model selection is that much knowledge in the real world is imprecise than precise (Olcer & Odabasi, 2005), thus the preference information provided to model selection may be imprecise or incomplete.

As a result, multiple factors, which are either quantitative or qualitative and may be in conflict with each other, impact the risk assessment model selection problem and problem arises in group setting with incomplete, vague and uncertain information.

In line with the multidimensional characteristics of the risk assessment model selection, the problem is a kind of multi-criteria decision-making (MCDM) problem, which requires MCDM methods for an effective problem solving.

MCDM refers to screening, prioritizing, ranking or selecting a set of alternatives under usually independent, incommensurate or conflicting attributes (Hwang & Yoon, 1981). It can rank different methods when they are compared in terms of their overall performance.

Over the years, a variety of MCDM theories and techniques have been proposed by different behavioral scientists, operational researchers and decision theorists. The methods differ in many areas of theoretical background, type of questions asked and the type of results given (Hobbs & Meier, 1994). The availability and selection of such a method depends on the structure of the model and the information that can be collected. For brevity, a short introduction to TOPSIS is provided and the reader is referred to Saremi, Mousavi, and Sanayei (2009) and Shih, Syur, and Lee (2007) for a more in-depth treatment.

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), proposed by Hwang and Yoon (1981), referring to the positive and negative ideal solutions as the ideal and anti-ideal solutions is a widely used MCDM method. It based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative-ideal solution (NIS) for solving a multiple criteria decision-making problem. According to the simulation comparison of Zanakis, Solomon, Wishart, and Dublish (1998), this technique has the fewest rank reversals among the eight methods of MCDM (Shih, 2008).

Chen (2000) extended TOPSIS to fuzzy environments; this extended version used fuzzy linguistic value (represented by fuzzy number) as a substitute for the directly given crisp value in grade assessment. This modified TOPSIS is a practical method and fits human thinking under actual environment (Wang, Cheng, & huang, 2009).

The difference between TOPSIS and fuzzy TOPSIS chiefly lies in rating approaches. The merit of fuzzy TOPSIS is using fuzzy numbers instead of precise numbers (Chen & Tsao, 2008).

Fuzzy TOPSIS is flexible and efficient method that is easily understood by practitioners and researchers. Fuzzy TOPSIS method is extended in this paper for selecting a proper risk assessment model.

4. Proposed method

A systematic approach to extend the TOPSIS is proposed to solve the risk assessment model selection problem under a fuzzy environment in this section.

Assume that there is a committee of k decision makers $K = (1, 2, \ldots, k)$ who are responsible for assessing the project risks. Once the set of possible models are selected, the committee determines the best of these models. Model selection first requires identification of decision attributes (criteria). Various techniques exist in order to reach a consensus among the experts (Bryson, Mobolurin, & Joseph, 1997). Nominal Group Technique (NGT), Delphi (Van De Ven & Delbecq, 1974), Focus Groups and Brainstorming (Stewart & Shamdasani, 1990) are formal and more useful group management techniques. When comparing the NGT with other group processes the NGT has a number of advantages over other group processes (Potter, Gordon, & Hamer, 2004) thus the NGT technique is suggested to obtain decision criteria/factors. Selected criteria can be classified into two types: benefit factors (C^1) and cost ones (C^2).

After this, members in the risk assessment group are required to provide their judgment on the basis of their knowledge and expertise for each model.

Decision makers make decisions on the basis of their knowledge of the facts and personal experience. Their judgments and preferences are often vague, inexact, imprecise and uncertain by nature which makes it difficult to estimate their preference with an exact numerical value since crisp data are inadequate to model real-life situations. Decision makers describe their preference with words or sentences in a natural or artificial language. In these circumstances values are not numbers but linguistic terms. A linguistic variable is a variable whose values (namely linguistic values) have the form of phrases or sentences in a natural language (Von Altrock, 1996). Linguistic values can be represented by fuzzy numbers. A fuzzy number is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1 (Wang & Elhag, 2006).

In the following, some basic definitions of fuzzy sets theory will be reviewed briefly from Cheng and Lin (2002), Kaufmann and Gupta (1985), and Raj and Kumar (1999).

A real fuzzy number A is described as a fuzzy subset of the real line R with member function f_A that represents uncertainty. A membership function is defined from universe of discourse to [0,1] (see Fig. 1).

A triangular fuzzy number can be defined as a triplet (a,b,c); the membership function of the fuzzy number A is defined as:

$$f_A = \begin{cases} 0, & x \leqslant a, \\ \frac{x-a}{b-a}, & a \leqslant x \leqslant b, \\ \frac{c-x}{c-b}, & b \leqslant x \leqslant c, \\ 0, & x \leqslant c. \end{cases} \quad (1)$$

This representation is useful for arithmetic operation on fuzzy numbers. With this notation, the arithmetic operations on fuzzy numbers are defined as follows:

$$(a_1,b_1,c_1)(+)(a_2,b_2,c_2) = (a_1+a_2, b_1+b_2, c_1+c_3), \quad (2)$$

$$(a_1,b_1,c_1)(-)(a_2,b_2,c_2) = (a_1-c_2, b_1-b_2, c_1-a_2), \quad (3)$$

$$(a_1,b_1,c_1)(\times)(a_2,b_2,c_2) = (a_1\times a_2, b_1\times b_2, c_1\times c_2), \quad (4)$$

$$(a_1,b_1,c_1)(\div)(a_2,b_2,c_2) = (a_1\div c_2, b_1\div b_2, c_1\div a_2), \quad (5)$$

$$(a_1,b_1,c_1)^{-1} = \left(\frac{1}{c_1}, \frac{1}{b_1}, \frac{1}{a_1}\right), \quad (6)$$

$$k\times(a_1,b_1,c_1) = (ka_1, kb_1 + kc_1). \quad (7)$$

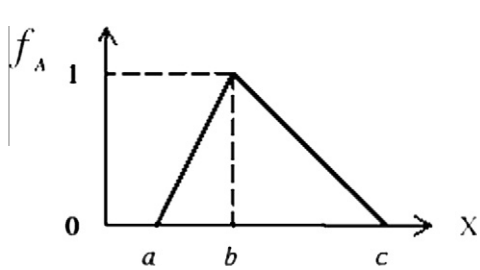

Fig. 1. A triangular fuzzy number.

According to the vertex method stated by Chen (2000), the distance between fuzzy numbers (a_1,b_1,c_1) and (a_2,b_2,c_2) is calculated as:

$$d(A_1,A_2) = \sqrt{\frac{1}{3}\left[(a_1-a_2)^2 + (b_1-b_2)^2 + (c_1-c_2)^2\right]}. \quad (8)$$

Obviously, in the risk assessment model selection problem the models and the factor set $C_j = (j = 1,2,\ldots,j)$ are finite, so it is very convenient to denote the rating of models on factors by f_{ij}.

Then a decision problem can be concisely expressed as the following decision matrix:

$$D^k = [f_{ij}^k]_{m\times n},$$

$f_{ij}^k = (a_{ij}, b_{ij}, c_{ij})$ is a linguistic variable, indicating the rating of each ith method with respect to each jth factor respect to kth DM. These linguistic variables can be described by triangular fuzzy numbers as shown in Table 1.

In the decision making process, different attributes have different importance. Suppose $w_i = (i = 1,2,\ldots,m)$ is the relative weight of factor C_i, where $w_i \geqslant 0$ and $\sum_{i=1}^{i=n} w_i = 1$. Denote a weight vector by $w = (w_1,w_2,\ldots,w_6)^T$. Establishing the relative importance of factors can be obtained by either directly assigning or indirectly using pair-wise comparisons (Cook, 1992). In many real-life cases, a decision maker cannot generally specify exact attribute weights but can provide value ranges (Xu & Chen, 2007) thus it is suggested in this paper that linguistic variables are used for assigning the priority weights of factors. The linguistic variable schemes in the rating set and weighting set, shown in Tables 1 and 2, respectively, are used in this study to evaluate the ratings of strategies with respect to different factors and the importance of the factors.

If there is consensus among DMs with respect to rating and importance of factors suppose $k = 1$ in proposed procedure.

The procedure of the TOPSIS method consists of the following steps:

4.1. Establish a normalized matrix

The decision matrix must first be normalized so that the elements will be unit-free. The structure of the normalized matrix for the kth decision maker can be expressed as follows:

Table 1
Linguistic variables for the ratings.

Linguistic variables	Fuzzy triangular
Very low/very poor	(0, 0, 1)
Low/poor	(0, 1, 3)
Medium low/medium poor	(1, 3, 5)
Medium/fair	(3, 5, 7)
Medium high/medium good	(5, 7, 9)
High/good	(7, 9, 10)
Very high/very good	(9, 10, 10)

Table 2
Linguistic variables for the importance weight of each criterion.

Linguistic variables	Fuzzy triangular
Very low	(0, 0, 0.1)
Low	(0, 0.1, 0.3)
Medium low	(0.1, 0.3, 0.5)
Medium	(0.3, 0.5, 0.7)
Medium high	(0.5, 0.7, 0.9)
High	(0.7, 0.9, 1)
Very high	(0.9, 1, 1)

$$R^k = [r_{ij}^k]_{m\times n}, \quad k = 1,2,\ldots,K;\ i = 1,2,\ldots,\ m;\ j = 1,2,\ldots,n, \tag{9}$$

where the r_{ij}^k is the normalized value of $f_{ij}^k = (a_{ij}, b_{ij}, c_{ij})$ which be calculated by the following relations:

- If jth criterion is a benefit one:

$$r_{ij}^k = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \tag{10}$$

where $c_j^* = \max c_{ij}$.

- And if jth criterion is a cost one:

$$r_{ij}^k = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \tag{11}$$

where $a_j^- = \min a_{ij}$.

4.2. Construct the weighted normalized decision matrix

The columns of the normalized decision matrix for kth decision maker by the associated priority weights of factors are multiplied to construct the weighted normalized decision matrix as follows:

$$V^k = [v_{ij}^k]_{m\times n}, \quad k = 1,2,\ldots,K;\ i = 1,2,\ldots,m;\ j = 1,2,\ldots,n, \tag{12}$$

where $v_{ij}^k = r_{ij}^k(\times)w_j^k$ and $v_{ij}^k = (v_{ij1}, v_{ij2}, v_{ij3})$ is a triangular fuzzy number.

4.3. Calculate the separation measure from the ideal and the negative ideal solutions for each decision maker

The positive ideal solution indicates the most preferable alternative, and the negative ideal solution indicates the least preferable alternative. So determine the fuzzy positive ideal solution (FPIS, A^+) and fuzzy negative ideal solution (FNIS, A^-) as follows (Chen, Lin, & Huang, 2006):

$$A^+ = (v_1^+, v_2^+, \ldots, v_n^+), \quad A^- = (v_1^-, v_2^-, \ldots, v_n^-), \tag{13}$$

where $v_j^+ = \max_i(v_{ij3})$ and $v_j^- = \min_i(v_{ij1}), i = 1,2,\ldots,m; j = 1,2,\ldots,n$.

For kth, the distance of each alternative from A^+ and A^- can be currently calculated as:

$$d_i^{k+} = \sum_{j=1}^{n} d(v_{ij}^k, v_j^+), \quad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \tag{14}$$

and

$$d_i^{k-} = \sum_{j=1}^{n} d(v_{ij}^k, v_j^-), \quad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n, \tag{15}$$

where $d(*,*)$ represented the distance measurement between two fuzzy numbers.

4.4. Calculate the overall separation measure from the ideal and the negative ideal solutions

To derive group preferences provided by multiple decision makers and combine the group synthesis and prioritization stages into a single integrated stage, the geometric mean with the modified TOPSIS approach is employed.

The overall separation measure calculated as:

$$\bar{d}_i^+ = \left(\prod_{k=1}^{K} d_i^{k+}\right)^{\frac{1}{k}}, \quad i = 1,2,\ldots,m \tag{16}$$

and

$$\bar{d}_i^- = \left(\prod_{k=1}^{K} d_i^{k-}\right)^{\frac{1}{k}}, \quad i = 1,2,\ldots,m. \tag{17}$$

4.5. Calculate the relative closeness to the ideal solution

The relative closeness of the alternative A_j with respect to ideal solution A^+ is defined as:

$$\overline{C}_i = \frac{\bar{d}_i^-}{\bar{d}_i^+ + \bar{d}_i^-}, \tag{18}$$

where $\overline{C}_i$ range belong to the closed interval [0,1] and $i = 1,2,\ldots,m$.

4.6. Rank the alternatives

A set of alternatives can now be preference ranked according to the descending order of $\overline{C}_i$. The one with the maximum value of $\overline{C}_i$ is the best.

5. Numerical example

To illustrate the group based fuzzy TOPSIS approach introduced above; risk assessment model selection problem faced by XYZ is presented. The case company XYZ is one of the Iranian construction companies.

Recently FNP Co. has taken a huge project in road construction. Risk management team is formed to manage risks in the project. Three experts with high qualification regarding project risks are selected to form a group. Risk assessment model selection is one of the fundamental tasks of the team. The proposed method commonly taken decides among a three possible models. After the NGT technique is employed, the group identifies four criteria, for the risk assessment model selection, as follows:

- Implementation cost.
- External party's approval.
- Complexity.
- Usability.

The group, respectively, compares the four criteria and evaluates their degree of satisfaction with every model. The compared and evaluated grades are shown in Table 3 (see Tables 1 and 2 for the linguistic value and degree of importance).

The ratings of the three consultants by the decision makers against the various criteria are shown in Tables 4. The linguistic evaluations are shown in Tables 3 and 4 are converted into triangular fuzzy numbers. After establishing a normalized matrix, the weighted normalized fuzzy decision matrix is calculated. To save space the other matrixes are omitted and only the separation from the ideal and the negative ideal solutions for each DM is shown in Table 5. Next, to derive group priorities, the group's aggregated separation distances are generated by its geometric mean.

Table 3
Importance weight of criteria from three decision-makers.

	DM_1	DM_2	DM_3
C_1	MH	M	M
C_2	VH	H	H
C_3	L	VL	VL
C_4	H	MH	VH

Table 4
Ratings of the 3 consultants by the DMs under the various criteria.

		C_1	C_2	C_3	C_4
DM_1	A_1	M	L	ML	ML
	A_2	H	VL	VH	L
	A_3	MH	VH	M	VH
DM_2	A_1	ML	ML	M	L
	A_2	VH	VL	VH	VL
	A_3	M	VH	ML	VH
DM_3	A_1	ML	M	ML	L
	A_2	H	L	VH	VL
	A_3	M	VH	M	VH

Table 5
The distance measurement.

	DM_1		DM_2		DM_3	
	d_1^-	d_1^+	d_1^-	d_1^+	d_1^-	d_1^+
A_1	2.33	1.1	2.11	0.9	2.02	1.1
A_2	2.78	0.4	2.58	0.1	2.58	0.3
A_3	1.18	2.1	1.17	1.7	1	1.9

Table 6
The final closeness coefficient of each model.

Model	Overall
A_1	0.441
A_2	0.321
A_3	0.545

Table 6 represents the result. At last according to the closeness of the 3 consultant the A3 is the best.

6. Conclusion

Despite its importance to the success of project management, risk management is rarely approached with the same rigor as other project management processes such as project scope and scheduling. A process of risk management has involved risk identification, risk assessment and risk mitigation. The identification and assessment of project risk are the critical procedures for projecting success. Many construction project risk assessment techniques are currently used in the construction industry but insufficient attention has been paid by researchers to a select suitable risk assessment model. To address this decision problem, in this paper a group based fuzzy TOPSIS approach is developed with an effective algorithm to improve the quality and effectiveness of decision making. TOPSIS provides good evaluations and it appears to be more appropriate than other MCDM methods.

Construction project would require interaction between dissimilar, yet contractually integrated parties, owners, designers, contractors, sub-contractors, suppliers, manufacturers, and others. As a result, construction is described as a collaborative teamwork process where parties with different interests, functions, and objectives, share a common goal, which is successful completion of a project. In line with a group decision environment of the problem, the approach provides a simple and effective mechanism to make comparative and absolute judgments in a conventional manner. The proposed method can discriminate successfully and clearly among risk assessment methods.

Further research can apply this method to other decision situations in construction industry, like project selection, performance selection, vendor selection, etc.

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