Journal of Optimization in Industrial Engineering 9 (2011) 47-55

Using Hybrid Fuzzy PROMETHEE II and Fuzzy Binary Goal Programming for Risk Ranking: A Case Study of Highway Construction Projects

Samareh Moradpour[a], Sadoullah Ebrahimnejad[b,*], Esmaeil Mehdizadeh[c], Arash Mohamadi [d]

[a] *MSc, Department of industrial engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*

[b] *Assistant Professor, Department of Industrial Engineering, , Karaj Branch, Islamic Azad University, Karaj , Iran*

[c] *Assistant Professor, Department of industrial engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*

[d] *MSc, Department of Industrial Engineering, Tehran South Branch, Islamic Azad University, Tehran , Iran*

Received 10 March, 2011; Revised 21 April, 2011; Accepted 23 May, 2011

Abstract

Multi attribute decision making methods are considered as one of the most useful methods for solving ranking problems. In some decision making problems, while the alternatives for corresponding criteria are compared in a pairwise comparison manner, if the criteria are inherently fuzzy, debates will arise in ranking alternatives due to the closeness of the values of the criteria. In this research, the fuzzy PROMETHEE II is proposed as a solution in such conditions. First, using the ANP method, the criteria are weighted. Then, the ranking process is accomplished both by the fuzzy PROMETHEE II and the fuzzy TOPSIS methods. Finally, calculating Spearman correlation coefficient, the results of these two approaches are compared. Then, the most important risks are selected via the fuzzy binary goal programming and ranked again through the fuzzy PROMETHEE II and fuzzy TOPSIS methods finally, in the last step, these ranking two are compared. As a case study, highway construction risks are ranked through this method.
Keywords: Fuzzy PROMETHEE II; Fuzzy TOPSIS; ANP; Risk Management.

1. Introduction

Different multi attribute decision making methods are used in many practical problems for ranking and selecting many alternatives. A suitable multi attribute decision making method should be able to indicate the internal relationships between different criteria and also preference of each alternative corresponding to each criterion correctly.

Rezaifar and et al.(2005) stated decision making problems cover a vast area of management activities. Actually, it is the issue of dealing with decision making problems while trying to identify, classify, ranking or selecting alternatives. Ranking of risks of a certain project is one of the main steps in the risk management which is in turn one of the most significant divisions in project management. Using ranking approaches makes it possible to determine the relative importance of risks and, as a consequence, enables the decision maker to manage the dominant ones.

Tavakoli and et al. (2003) reported selecting an appropriate method for decision making is regarded as one of the most significant phases of decision making process. Being divided into the main categories of compensatory models and non compensatory ones, a large number of models are usually used for ranking procedure. The models that do not allow trade off between criteria are called non compensatory. This means that is not possible to compensate the deficiency of a criterion using the advantage of the other ones. On the other hand, we are allowed to trade off between different criteria in compensatory models. For instance, even in the case of minor changes, it is possible to compensate the changes corresponding to a criterion using the changes in the others.

Rezaifar and et al. (2005) stated since the trade off between criteria is possible in risk ranking problems, compensatory models are used for ranking project risks. Probability of occurrence and intensity may be considered as examples of these compensatory criteria.

There usually exist little differences between the points of alternatives in fuzzy environments, which results in uncertainties in preferences as such choices. In many decision making problems, in which alternatives

*Corresponding author e-mail: ibrahimnejad@kiau.ac.ir

corresponding to various criteria are compared in a pairwise manner, debates raise. As an example, Aousam and et al. (2003) suggested a multi attribute fuzzy decision making method for outranking problems which resulted in uncertainties in preference of alternatives in the case of closeness of the results. In order to make a certain decision about the preference of these closed alternatives, he applied a fuzzy outranking function.

In order to solve this problem, a hybrid multi objective and multi criteria decision making methods is used. First, the alternatives are ranked using the fuzzy PROMETHEE II method. Then, fuzzy TOPSIS is used for ranking the alternatives again and the results of the two methods are compared using the Spearman method. Then, using the fuzzy binary goal programming, the most important risks are selected and finally ranked via the fuzzy PROMETHEE II and fuzzy TOPSIS methods.

In what follows, in the second section, the PROMETHEE II, goal programming and TOPSIS methods are briefly explained. The third section of this paper addresses the risks of highway construction in Iran. Results are shown in the fourth section and, finally, conclusions are presented in the fifth section.

2. Decision Making

2. 1. PROMETHEE II

PROMETHEE is one of the methods commonly used for ranking and selecting limited alternatives among usually conflict criteria. The method is considered as a simple one among the multi criteria analysis methods. Consequently, this method is increasingly used by decision makers.

The PROMETHEE family of outranking methods, includes the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for complete ranking of the alternatives, PROMETHEE III for ranking based on interval, PROMETHEE IV for complete or partial ranking of the alternatives when the set of viable solutions is continuous, PROMETHEE V for problem with segmentation constraints, PROMETHEE VI for the human brain representation ,PROMETHEE GDSS for group decision making, the visual interactive module GAIA for graphical representation, PROMETHEE TRI for dealing with sorting problems and PROMEETHEE CLUSTER for nominal classification.

Behzadian and et al.(2010) stated the success of these methods is basically due to their mathematical properties and Their user friendly.

Two PROMETHEE software packages, including PROMCALC and DECISION LAB, have been developed to facilitate the PROMETHEE process. PROMCALC was provided for all type of multi criteria problems, the PROMETHEE I, II, V, VI and GAIA visual module. DECISION LAB is the current software implementation of the PROMETHEE and GAIA methods. By using DECISION LAB, decision makers can improve the quality and reliability of the decision making processes, because of the structured procedure, accompanied by computational help, and the analytical aids.

PROMETHEE II is fundamental to implement the other PROMETHEE methods and a great majority of researchers have referred to this version of the PROMETHEE methods. Behzadian and et al. (2010) stated the basic principle of PROMETHEE II is based on a pairwise comparison of alternatives corresponding to each criterion.

The implementation of the PROMETHEE II requires two additional types of information:

1- The weight:

Determination of the weights is an important step in most multi criteria methods. PROMETHEE II assumes that the decision maker is able to weight the criteria appropriately, at least when the number of criteria is not too large.

2-The preference function:

For each criterion, the preference function translates the difference between the evaluations obtained by two alternatives into a preference degree ranging from zero to one.

In order to facilitate the selection of a specific preference function, Vincke and Brans, proposed six basic types:

3. Usual criterion
4. Quasi- criterion
5. Criterion with linear preference
6. Level criterion
7. Criterion with linear preference and indifference area
8. Gaussian criterion.

Zhang and et al. (2009) considered the linear preference function Type III for ranking goals that is reasonable and is defined as follows:

$$P_k = \begin{cases} \frac{d_k}{p_k} & if \quad 0 \le d_k \le p_k \\ 1 & if \quad\quad p_k \ge p_k \end{cases} \quad (1)$$

Where $d_k = f_k(a_i) - f_k(b_j)$

a_i and b_j are values of i th and j th alternative corresponding to k th criterion.

For ranking goals, the parameter p_k can be set as:

$$p_k = f_k(.)_{max} - f_k(.)_{min} \quad (2)$$

Where $f_k(.)$ is the evaluation of all alternatives for criterion K .

Concerning advantages and disadvantages of such multi criteria decision making methods such as PROMETHEE, extensive research has been conducted. In a nutshell, the following points have been put forward regarding the advantages and disadvantages of the PROMETHEE method.

Advantages:

1. Despite being a compensatory method, this method is easy to use.
2. The possibility of changing parameters (classification of criteria and alternatives)
3. Stability of results
4. Easy senility analysis
5. The possibility of graphical simulation (GAIA)
6. Supporting group decision making
7. The possibility of imposing limitations in decision making.

Disadvantages:

1. Loosing information in analyzing alternative differences(the preference difference of two alternatives)
2. Weakness in evaluating qualitative criteria, comparing with such methods as AHP
3. Difficulties in defining preference functions (especially for armature users),Hanafi(2010).
4. Conflicts in ranking results can occur, Macharis and et al. (2004).

2. 2 Fundamentals of fuzzy set theory

The goal of decision making problems is to select just one from many choices but, in the case of conflict alternatives, the decision maker has to analyze uncertain and vague information. Gelderman and et al. (2000) stated the aim of fuzzy theory is to make decision in these conditions. This method was first used by Bellman and Zadeh. Since then, a plethora of research into fuzzy optimization problems has been carried out.

Trapezoidal fuzzy numbers:

The fuzzy number A will be defined as trapezoidal fuzzy in the real numbers domain R if the membership function f_A is defined as below:

$f_A: R \to [0,1]$

$$f_A(x) = \begin{cases} \dfrac{(x-c)}{a-c}, & c \le x \le a \\ 1, & a \le x \le b \\ \dfrac{x-d}{b-d}, & b \le x \le d \\ 0, & otherwise \end{cases} \quad (3)$$

Where

$-\infty < c \le a \le b \le d < \infty$.

The trapezoidal fuzzy number is depicted in the form of (a, b, c, d). The x value in range [a, b] has the greatest membership degree of f_A=1 and is the most pobable area. C and d are defined as the highest and the lowest levels of data and are corresponding to the lowest membership value of zero.

2. 3. FUZZY PROMETHE II

Goumas and Lygerou extended the promethee methods to consider fuzzy inputs along with crisp weights. Gelderman and et al. (2000) made further enhancements and used fuzzy preference and fuzzy weights to obtain fuzzy scores. Zhang and others used the comparative approach for ranking contaminated sites based on the Promethee and fuzzy Promethee methods.

The fuzzy Promethee II algorithm is given below:

1. Choose linguistic ratings for alternatives with respect to each criterion for preference function.
2. Choose linguistic ratings for each criterion.
3. Translate linguistic ratings to fuzzy numbers with regard to table 1.

Table 1
Linguistic terms and their corresponding generalized fuzzy numbers

Linguistic terms	Generalized fuzzy numbers
Absolutely low	(0,0,0,0;1)
Very low	(0,0,.02,.07;1)
low	(.04,.1,.18,.23;1)
Fairly low	(.17,.22,.36,.42;1)
Medium	(.32,.41,.58,.65;1)
Fairly high	(.58,.63,.8,.86;1)
High	(.72,.78,.92,.97;1)
Very high	(.93,.98,1,1;1)
Absolutely high	(1,1,1,1;1)

4. Calculate criteria weights.
5. Calculate the fuzzy preference relation for each criterion.

$$\pi(a_i, b_j) = \sum_{j=1}^{m} w_k \times p_k\left(f_k(a_i) f_k(b_j)\right) \quad (4)$$

Calculate the degree of preference for the comparison of alternatives a_i and a_j with regard to criteria f_k

$$w_k \times p_k[f_k(a_i) - f_k(b_i)] = \quad (5)$$
$$w_k \times p_k(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1)$$

6. Calculate the fuzzy positive outranking flow for each alternative.

$$\varphi^+(a_i) = 1/(n-1)\sum_{j=1}^{n}(a_i, b_j) \quad (6)$$

7. Calculate the fuzzy negative outranking flow for each alternative.

$$\varphi^-(a_i) = 1/(n-1)\sum_{j=1}^{n}(a_i, b_j) \quad (7)$$

8. Calculate the fuzzy net outranking for each alternative.

$$\varphi(a_i) = \varphi^+(a_i) - \varphi^-(a_i) \quad (8)$$

9. Defuzzy the net flow then rank alternatives. Choose alternative with maximum defuzzy net flow or rank alternatives according to defuzzy net flows in descending order, Aousam and et al. (2003) and Chen and et al.(2009).

$x_{defuzzy} = a_1a_2 + a_3a_4 + \frac{1}{3}(a_4 - a_3)^2 - \frac{1}{3}(a_1 - a_2)^2)/(-a_1 - a_2 + a_3 + a_4)$ (9)

2. 4. Goal Programming Method

Goal programming was originally proposed by Charnes and Cooper, and further development was carried out by Lee, Ignizio, Tamiz and Romero. It has been applied to many real world problems in many areas such as accounting, agriculture, economic, engineering, transportation, finance, government, international context and marketing. Chen and et al. (2009) stated, goal programming is an important technique for decision makers to consider simultaneously several objectives in finding a set of acceptable solutions.

In a conventional goal programming formulation, goals are precisely defined. That is, the formulation assumes that the decision maker is able to determine accurately goal values for their decision making problems. In fact, many imprecise aspiration levels may exist in decision making problems such as" somewhat larger than", "substantially lesser than" or "around" the vague goal due to decision makers ambiguous understanding of their nature. Thus, the decision maker may find it is impossible to state precisely exact aspiration levels to the goals for their problems.

Binary Fuzzy Goal Programming is a suitable method for problems with imprecise objective values. Chang (2009) formulated it as follows:

$$d_k^- \quad , k = 1, \dots, n \tag{10}$$

$$L_k f_k(X) b_k - \mathring{L}_k b_k + d_k^- - d_k^+ = 1$$
$$k = 1,2, \dots, n, for\ f_k(X) \gtrsim g_k$$

$$\mathring{I}_k b_k - I_k f_k(X) b_k + d_k^- - d_k^+ = 1$$
$$k = 1,2, \dots, n, for\ f_k(X) \lesssim g_k$$

$$X \in F$$
$$b_k \in R_k(X), k = 1, \dots, n$$

Where

$$L_k = \frac{1}{g_k - l_k} \tag{11}$$

$$\mathring{L}_k = L_k l_k \tag{12}$$

$$I_k = \frac{1}{u_k - g_k} \tag{13}$$

$$\mathring{I}_k = I_k u_k \tag{14}$$

b_k : Binary decision variable for k^{th} goal

l_k: Lower limit for k^{th} goal (9)
u_k: Upper limit for k^{th} goal
g_k: Aspiration level for k^{th} goal, Kara and et al. (2009).

In this problem, the values corresponding to alternatives are normalized firstly. The normalized values multiplied by the weight of each criterion are used due to the difference of the weights of deferent criteria in each of problems constraints.

2. 5. Fuzzy TOPSIS

TOPSIS method is presented in Chen and Hwang. The basic principle is that the chosen alternative should have the shortest distance from the ideal solution and the farthest distance from the negative ideal solution.
Fuzzy TOPSIS procedure is defined as follows:

1. Choose linguistic ratings for alternatives with respect to each criterion for preference function.
2. Choose linguistic ratings for each criterion.
3. Translate linguistic ratings to fuzzy numbers regard to Table 1.
4. Construct the weighted normalized fuzzy decision matrix.
5. Identify positive ideal and negative ideal solutions.

$$A^* = \{\tilde{V}_1^*, \dots, \tilde{V}_n^*\} = \{(max_j V_{ij} | i \in \acute{I}), (min_j V_{ij} | i \in I'')\} \tag{15}$$

$$A^- = \{\tilde{V}_1^-, \dots, \tilde{V}_n^-\} = \{(min_j V_{ij} | i \in \acute{I}), (max_j V_{ij} | i \in I'')\} \tag{16}$$

Where is associated with benefit criteria and is associated with cost criteria.

6. Calculate separation measures. The distance of each alternative from positive ideal solution is defined as below:

$$D_j^* = \sum_{j=1}^{m} d(\tilde{V}_{ij}, \tilde{V}_j^*) , j = 1, \dots, J \tag{17}$$

The distance of each alternative from negative ideal solution is defined as below:

$$D_j^- = \sum_{j=1}^{m} d(\tilde{V}_{ij}, \tilde{V}_j^-) , j = 1, \dots, J \tag{18}$$

7. Calculate similarities to ideal solution.

$$C_j^* = \frac{D_j^-}{(D_j^- + D_j^*)} , j = 1, \dots, J \tag{19}$$

8. Rank alternatives according to C_j^* in descending order. The best alternative has the minC_j^*, Ebrahimnejad and et al. (2010).

The proposed research procedure is depicted in Figure 1.

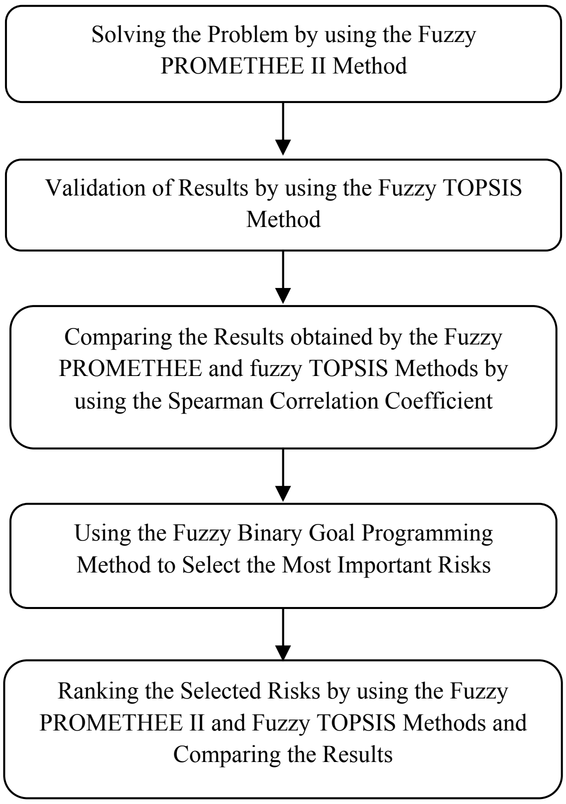

Fig. 1. Research Procedure

3. Highway Construction Projects Risk

Sayady and et al. (2011) stated experience reveals the fact that ignoring the risks and uncertainties may be regarded as one of the causes of failure in many projects. Besides, many projects are not accomplished within the predicted time table or with the allocated budget .Trying to eliminate all risks in construction projects is impossible. Thus, there is a need for a formal risk management process to manage all types of risks. Kartam (2001) stated one of the major steps in project risk management is to identify and assess the potential risks in the project. El-sayegh (2008) reported some researchers describe risk in relation to construction as a consideration in the process of a construction project whose variation results in uncertainty in the final cost, duration time and quality of the project.

In the present study, three approaches are used for identification of risks of highway construction projects. These approaches consist of surveying the literature, asking the experts' viewpoints and using the existing documents of the ongoing project. Makui and et al. (2007) studied risk breakdown structures formed after the risks are identified and risk categories, classifications and risk events are depicted at the lowest level.

3. 1. Project Documents

Considering the point that the goal of this research is to rank the risks of highway construction projects in Iran, the documents of these projects are used as an important source of information. In what follows, some of these projects are introduced briefly:
Meybod-Ardakan road is 120 km long.

Isfahan- Shiraz freeway with the length of 210 km which is being constructed to minimize the distance between these two cities.

The first part of the Fariman– Torbate jam road which is 20 km long.

Hamadan-Bijar road which is approximately 30 km long.

Zarch-Ashkzar highway that extends the Tehran-Bandar abbas highway with 26 km length in two tracks.

The second part of the northern highway of Arak-Andimeshk as a part of Arak free way with the length of 25 km.

3. 2. Developing the Questionnaire

With regard to the documents of the mentioned projects, interviewing the experts and reviewing the related literature, two types of questionnaires were developed. Although more than 80 experts were asked to fill the questionnaires, only 63 of them returned the questionnaires. It is worth mentioning that interviews were planned to ensure the credibility of questionnaires data which in turn may result in obtaining comprehensive information.

Using SPSS software, the value of Coronbach's alpha was calculated. The obtained value of .83 proved the justifiability of the questionnaires.

Table 2
Questionnaire No.1- experts' ideas about criteria weight

No.	Description	Relative Scale									Description
1	Effect of cost of the project	9	7	5	3	1	3	5	7	9	On duration of project
2	Effect of cost of the project	9	7	5	3	1	3	5	7	9	On quality of project
3	Effect of duration of the project	9	7	5	3	1	3	5	7	9	On cost of project
4	Effect of duration of the project	9	7	5	3	1	3	5	7	9	On quality of project
5	Effect of quality of the project	9	7	5	3	1	3	5	7	9	On duration of project
6	Effect of quality of the project	9	7	5	3	1	3	5	7	9	On cost of project

	Risk	affect on project goals															probability of occurance				
		quality					cost					time									
		not usable	not accepted by owner	owner may accept it	little decrease in quality	no decrease in quality	more than 20% increase	10% to 20% increase	5% to 10% increase	less than 5% increase	no increase in costs	more than 20% delay	10% to 20% delay	5% to 10% delay	less than 5% delay	no delay	very low	low	medium	high	very high
1	In appropriate method of select the contractor																				
2	Mistakes in determining the corridor																				
3	Disrupting the corridor limits																				
4	Changeing in scope definition																				
5	Land ownership problems																				
6	Improper intervention																				
7	Incorrect prediction of project duration																				
8	Change in design																				
9	Incorrect technical design																				
10	Misunderstanding the laws and codes																				
11	Delayed payement to contractors																				
12	Inadequate estimating the costs																				
13	Incorrect traffic estimation																				
14	Poor performance																				
15	Contraction accidents																				
16	Mistakes inperforming activities																				
17	Usage of new technology																				
18	Contractors mismanagement																				
19	Construction Method																				
20	Incorrect scheduling																				
21	Subcontractors																				
22	Lack of machines																				
23	Qualified staff																				
24	Material quality																				
25	Delay in material supply																				
26	Inflation																				

Fig. 2. Questionnaire No.2

4. Results and Discussion

The criteria are weighted through the ANP method and using the questionnaire 1. The weight vector equals to W= (.384619,.331426,.283956). After defuzzification the net flow values, as shown in Table 2, the values obtained using the PROMETHEE II method are found to be close to each other which in turn causes uncertainties in ranking the choices.

So the fuzzy TOPSIS approach was used for ranking the risks as an alternative because of the different algorithm used in this method. It should be noted that through the fuzzy PROMETHEE II method, ranking is carried out on the basis of pairwise comparison approach. On the contrary, closeness to the ideal solution will be considered as the basic rule as the fuzzy TOPSIS. Results of both methods are included in Tables 3 and 4. Comparing these results it is concluded that they are not similar and there exists a little difference in rankings.

Table3
Ranking project with fuzzy PROMETHEE II

Alternative	X defuzzy	RANK	Alternative	X defuzzy	RANK
1	-0.204012	18	14	-0.429651	23
2	-0.092069	13	15	0.2108528	5
3	-0.357648	22	16	0.3902858	2
4	-0.186146	16	17	0.083465	8
5	-0.250435	19	18	0.0135654	10
6	-0.292162	21	19	0.1771677	6
7	0.1429804	7	20	0.4125537	1
8	-0.022551	12	21	-0.118315	14
9	-0.01227	11	22	0.0317441	9
10	-0.186146	16	23	0.2108528	5
11	0.3065786	4	24	-0.266054	20
12	0.4125537	1	25	0.3800073	3
13	-0.163691	15	26	-0.200803	17

Table 4
Ranking project with fuzzy TOPSIS

Alternative	c	Rank	Alternative	c	Rank
1	0.280513	19	14	0.094761	23
2	0.38364	14	15	0.674307	5
3	0.169483	22	16	0.809595	2
4	0.293017	18	17	0.512188	8
5	0.268957	20	18	0.441336	11
6	0.192747	21	19	0.598334	6
7	0.541376	7	20	0.859104	1
8	0.417088	13	21	0.361719	15
9	0.488394	9	22	0.446932	10
10	0.293017	18	23	0.674307	5
11	0.73342	4	24	0.304798	17
12	0.859104	1	25	0.775082	3
13	0.431755	12	26	0.323343	16

We can compare these methods by calculating the spearman rank correlation coefficient.

$$r_s = 1 - \frac{6\sum D^2}{N(N^2-1)} \tag{20}$$

Where

: Spearman rank correlation coefficient

D: different in ranking

N: number of variables (risks)

The r_s value is 0.98 that indicates a stronger association between the two sets of ranking.

It is a generally accepted idea that in risk ranking problems, those with the highest ranks are considered as the most significant ones. According to the PMBOK standards, the risks with high or average ranking are candidates for more analysis including qualitative risk analysis and risk management activities. Because of their considerable impacts on projects, our goal is to mark these risks. So the decision maker will be allowed to find solutions for them. In order to control the accuracy of ranking, the most effective risks are chosen via the fuzzy binary goal programming method. The selected risks are ranked through the fuzzy PROMETHEE II and fuzzy TOPSIS methods and the results are compared again.

It should be noted that while there are many alternatives, goal programming is used as the primary phase of the multi criteria process. Ranking the risks of a highway construction project is a good example of these problems. So, using the Lingo software, the most effective risks of this project are selected through the binary fuzzy goal programming. These risks are illustrated in Table 5 below. The selected risks are as follows:

Table 5
Selected alternatives with BFGP

Alternative	Risk
11	Delayed payment to contractors
12	Inadequate estimating the costs
16	Mistakes in performing activities
20	Incorrect scheduling
25	Delay in procurement

- Delayed payment to contractors: payment from owner is the main source of revenue for construction contractors. When the owner delays payments to contractors, a financial hardship is played on the contractors.

- Incorrect prediction of project costs: shortages may be traced back to the inappropriate prediction of project costs.

.

- Mistakes in performing activities: This risk includes the probability of accomplishing the activities of construction phase in a false manner.

- Incorrect scheduling: in many cases, projects are scheduled in a manner that is not easily reachable.

- Delay in procurement: Delay in material supply by supplier is one of the risks results in the prolongation of project.

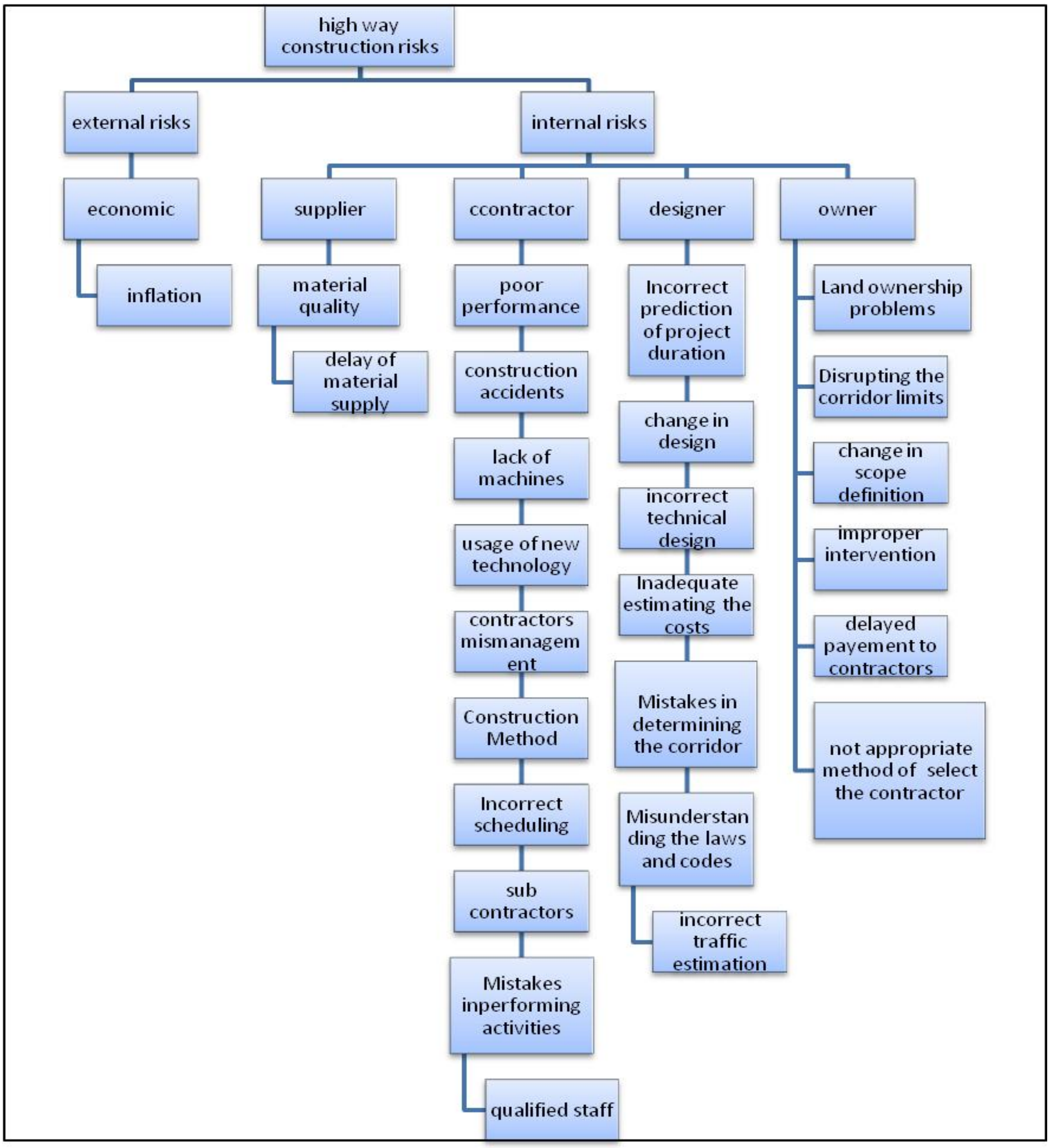

Fig.3. Risk breakdown structure

As it is shown in Table 6, results of ranking the risks through both of the methods of fuzzy PROMETHEE II and fuzzy TOPSIS are similar.

Table 6
Ranking with fuzzy PROMETHEE II and fuzzy TOPSIS

Alternative	Rank in fuzzy PROMETHEE II	TOPSIS Rank in fuzzy
11	4	4
12	1	1
16	2	2
20	1	1
25	3	3

The basic principle of PROMETHEE II is based on a pairwise comparison of alternatives along each recognized criterion. Alternatives are evaluated according to different criteria, which have to be maximized or minimized.

The TOPSIS method is based on the idea that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution for solving multi criteria decision making problems. In short, the ideal solution is composed of all the best criteria, whereas the negative ideal solution is made up of all the worst attainable criteria.

5. Conclusion

Ranking the risks of a certain project may be considered as one of the most important challenges of a project manager. But, in some cases of decision making problems, while one is trying to make pairwise comparisons between alternatives on the basis of the corresponding criteria, debates may arise regarding values of criteria in fuzzy conditions.

In order to solve this problem, the ranking process was accomplished using the fuzzy PROMETHEE II as a multi criteria decision making method. Besides, using the fuzzy TOPSIS method, alternatives were ranked again. Spearman correlation coefficient was calculated and the coefficient of .98 reveals the similarity of ranking by these two approaches.

As it was stated in previous section, in risk ranking problems, those risks that are ranked as most important ones have the greatest effects on the goals of a project. So these risks will be of great importance for the decision makers. Accordingly, in the first step, the most effective risks are selected through the binary fuzzy goal programming approach. Then, these risks are ranked via the fuzzy PROMETHEE II and the fuzzy TOPSIS methods. Considering what is obtained in the two methods, results as ranking the outputs of the fuzzy binary goal programming using both methods (fuzzy PROMETHEE II and fuzzy TOPSIS) are equals the calculated value of the Spearman Correlation coefficient which equals to 0.98 may be a proof for this claim.

6. References

[1] Rezaifar, A., Jabalameli, MS., Chaibakhsh, A.(2005). Using multi criteria decision making models for project risk ranking. Proceeding of the 2nd Iranian international conference on project management,125-135.

[2] Tavakoli, A., Aliahmadi, A.(2003). Modeling of select and rank the ways of technology transition. Proceeding of the 1st Iranian conference on technology management, 276-290.

[3] Aousam, T., Chang, S.I., Lee, E.(2003). Fuzzy MADM: An outranking method. European Journal of Operational Research, 145, 317-328.

[4] Behzadian, M., Kazemzadeh R.B., Albadvi, A. and Aghasi, M.(2010). PROMETHEE: A comprehensive literature review on methologies and applications. European Journal of Operational Research, 200, 198-215.

[5] Zhang, K., Kluck, C., and Achari, G.(2009). A Comparative Approach for Ranking Contaminated Sites Based on the Risk Assessment Paradigm Using Fuzzy Promethee. Environment Management, 44,.952-967.

[6] Hanifi, J. (2010). Solving problem of selecting C.N.C machines based on multi indicator decision making method. Thesis of M.S.c.Islamic Azad University, Tehran South Branch.

[7] Macharis, C., Speringeal, J., DeBrucker, and Verbeke., A.(2004).PROMETHEE and AHP: The design of operational synergies in multi criteria analysis. Strengthening PROMETHEE with ideas of AHP. European Journal of Operational Research, 153, 307-317.

[8] Geldermann, J., Spengler, T., Rentz, O.(2000). Fuzzy Outranking for environmental assessment. Case study: iron and steel making industry. Fuzzy sets and Systems 115, 45-65.

[9] Chen, S.M., Chen, J.H. (2009).Fuzzy risk analysis based on ranking generalized fuzzy numbers with different heights and different spread. Expert systems with Applications, 36, 6833-6842.

[10] Chang, C.T. (2009). Binary fuzzy goal programming. European Journal of Operational Research, 180, 29-37.

[11] Kara, Y., Paksoy, T., Chang, C.T.(2009). Binary fuzzy goal programming approach to single model straight and U-shaped assembly line balancing. European Journal of Operational Research, 195, 335-347.

[12] Ebrahimnejad, S., Mousavi, S.M., Seyrafianpour, H. (2010) Risk identification and assessment for build-operate-transfer projects: A fuzzy multi attribute decision making model. Expert systems with Applications, 37, 575-586.

[13] Sayady, A., Hayaty, M., Azar, A.(2011) Assessment and ranking risks in tunnel construction projects by Linear Assignment method. International journal of industrial engineering and production management, 1, 22, 28-38.

[14] Kartam, N.A. (2001). Risk and its management in the Kuwaiti construction industry: a contractor's perspective. International Journal of Project Management, 19, 325-335.

[15] El-Sayegh, S.M. (2008). Risk assessment and allocation in the UAE in the construction industry. International Journal of Project Management, 26, 431-438.

[16] Makui, A., Mojtahedi, S.M.H., Mousavi, S.M.(2007). Introduce the new and applicable methods for identification of project risks. Proceeding of the1st international conference on risk management, 150-165.