An integrated method for ranking of risk in BOT projects

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Abstract

In BOT approach, the private sector is granted a concession to plan, design, construct, operate and maintain a project in a certain period of time and after that it should be transferred to the government.

In this paper, at first the risks of the BOT projects are identified, then we rank the risks based on their severity and effect on project objectives (time, cost, quality, safety and environmental) by two methods, namely FTOPSIS and FSAW. In the next stage obtained results by NGT method are integrated. After wise the occurrence and detection values of each risk are determined by experts and ultimately the risks are evaluated according to risk priority number (RPN) of failure mode and effect analysis (FMEA) technique. Finally, an example is shown to highlight the procedure of the proposed method at the end of this paper.

Keywords: BOT projects, Risk ranking, FMADM, NGT, FMEA

1. INTRODUCTION

Development of infrastructures and assets is very essential because of the rapid growth of the economy. This brings opportunities to BOT project stakeholders. Employing effective risk management techniques is very important to cope with risks associated with variable activities, so we can implement the BOT projects aligning with project objectives including time, cost, quality, safety and environmental.

1.1. BOT projects definition

BOT- type schemes are attracting increasing interest with the growing thrust towards privatizing infrastructure projects in both developing and developed countries.[1],[2] . Kumaraswamy and Zhang (2001) identified and discussed various issues that governments need to deal with, for the BOT mechanism to work smoothly.

The main objective of BOT is to lower the role of government in the execution and implementation of infrastructure projects in which the financial risks are divided among different sectors through a strong organization and, at the same time, the national interests of host government are protected as well [1],[3],[4] .

1.2. BOT projects risk

Chen and Doloi (2008) in their study identified the driving and impeding factors about BOT application in China, and a survey of experienced practitioners indicated that the most significant driving factors are Needing infrastructure development capital; the most significant general impeding factors include complex financial arrangement, complex contractual arrangement, high up-front cost, complex process, and high risk.

Kanga and Feng (2009) identified and assessed the potential risks faced by private sectors in holding BOT projects through the risk assessment model developed in their paper.

Ebrahimnejad et al. (2010) mentioned that BOT project risks have two distinctive aspects: first, they have initiating process risks (technical and financial studies), financing and operation process risks because of the nature of BOT approach; and second, they have political, regulatory and economical risks because of the fact that they are mega projects.

1.3. Project Risk Management

Risk management is the art and science of identifying, analyzing and responding to risk factors throughout the life cycle of the project, so that a conscious decision can be taken on how to manage the risks [8],[9].

It is commonly accepted in the risk management literature that part of the project risk management process requires the analysis of identified risks in terms of their potential impacts and probability of occurrence [10] .

Aloini et al. (2007) collected and analyzed a number of key articles discussing and analyzing ERP implementation and compared different approaches taken in the literature of this type projects from a risk management point of view to highlight the key risk factors and their impact on project success.

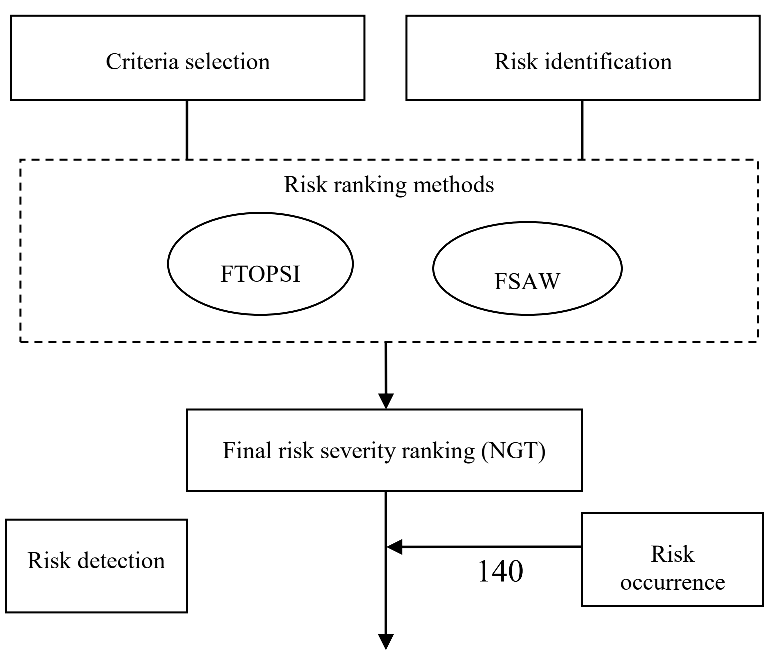
Bannerman (2008) in his paper reconsidered the status of risk and risk management in the literature and practice. This analysis was supported by a study of risk practices in government agencies in an Australian State, contributing to a gap in research in the public sector.

Lee et al. (2009) proposed a scheme for large engineering project risk management using a Bayesian belief network and applied it to the Korean shipbuilding industry.

The paper is organized as follows: In Section 2, we present our proposed model and theoretical descriptions. In Section 3 investigates a case study using the proposed model. Finally, conclusions are offered in Section 4.

2. Proposed model

In this part we present our proposed model. At first the risks of the BOT projects are identified, and then we rank them according to the project objectives as criteria by three methods, namely FTOPSIS and FSAW. Then, we integrate the obtained results by NGT method. The probability of each risk occurrence is determined by experts and ultimately the risks are being final ranked according to factors of severity, occurrence and detection of risks by FMEA technique.



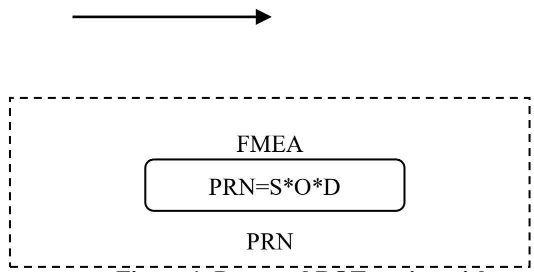


Figure.1. Proposed BOT project risk ranking model.

2.1. Risk identification

Recognition process of possible risks in BOT projects and determination of their characteristics is an effective step in risk identification. This process is carried out by assistance and cooperation of project group, risk management group and experts of this field out of the organization.

2.2. Suitable criteria for risk ranking

A direct relationship between risk management and BOT project success is acknowledged since risks are assessed by their potential impact on the project objectives [14]. Previous researches have done up to now, has mainly focused on examining the impacts of risks on one or two aspects of project strategies with respect to the project objectives, namely cost, time, quality, safety and environmental sustainability [15]. Because of the importance of these five objectives, in this paper, we use five objectives (cost, time, quality, safety and environmental) as decision making criteria for risk ranking.

Linguistic variables as shown in table1 are used scoring the risks that determined in previous part according to each of the above objectives.

Table.1. Linguistic variables and related triangular fuzzy numbers .

Linguistic variables	Triangular fuzzy numbers
Very Low (VL)	(0,0,0.1)
Low (L)	(0,0.1,0.3)
Medium Low (ML)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
Medium High (MH)	(0.5,0.7,0.9)
High (H)	(0.7,0.9,1)
Very High (VH)	**(0.9,1,1)**

2.3. Risk ranking methods

two methods, namely Fuzzy TOPSIS and Fuzzy SAW are used in this paper for ranking risks, they are described as follows.

2.3.1. Fuzzy TOPSIS method

A. Determine the alternatives. m possible alternatives: $A = \{A_1, A_2, \dots, A_m\}$

B. Define and describe a finite set of relevant attributes and their weight.
n Criteria: $C = \{C_1, C_2, \dots, C_n\}$; <u>B</u>enefit criteria (C_1), <u>C</u>ost criteria (C_2) where $C_1 \cup C_2 = C$ & $C_1 \cap C_2 = \emptyset$.

C. Establish a decision matrix for alternatives performance

$$\tilde{x}_{ij} = (\alpha_{ij}, \beta_{ij}, \theta_{ij})$$

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} x_1 & x_2 & \dots & x_j & \dots & x_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{ij} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2j} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \dots & \vdots & \dots & \vdots \\ \tilde{x}_{i1} & \tilde{x}_{i2} & \dots & \tilde{x}_{ij} & \dots & \tilde{x}_{in} \\ \vdots & \vdots & \dots & \vdots & \dots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mj} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{array}$$

D. Establish the normalized decision matrix

$$\tilde{r}_{ij} = \left(\frac{\alpha_{ij}}{\theta_j^*}, \frac{\beta_{ij}}{\theta_j^*}, \frac{\theta_{ij}}{\theta_j^*}\right);\ j \in B\ ;\ \theta_j^* = \max_i\{\theta_{ij}\},\ \ \tilde{r}_{ij} = \left(\frac{\alpha_j^-}{\theta_{ij}}, \frac{\alpha_j^-}{\beta_{ij}}, \frac{\alpha_j^-}{\alpha_{ij}}\right); j \in C\ ;\ \alpha_j^- = \min_i\{\alpha_{ij}\} \quad (1)$$

E. Construct weighted normalized decision matrix

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes w_j \quad (2)$$

F. Determine FPIS and FNIS as follow

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \tilde{v}_3^*, \dots, \tilde{v}_n^*) = \{(\max_i v_{ij} \mid i = 1,2,\dots,m), j = 1,2,\dots,n\} \quad (3)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \tilde{v}_3^-, \dots, \tilde{v}_n^-) = \{(\min_i v_{ij} \mid i = 1,2,\dots,m), j = 1,2,\dots,n\} \quad (4)$$

G. Calculate the distance of each alternative from FPIS and FNIS

$$d_i^+ = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^*)\ \ ;\ d_i^- = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^-)\ \ ;\quad i = 1,2,\dots,m \quad (5)$$

Assuming that: $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ then the distance between them is:

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{6}[(a_1 - b_1)^2 + 4(a_2 - b_2)^2 + (a_3 - b_3)^2]} \quad (6)$$

H. Calculate the relative closeness to the ideal solution

$Cc_i = \frac{d_i^-}{d_i^+ + d_i^-}$ where Cc_i range belongs to the closed interval [0, 1] and i = 1, 2,…, m (7)

K. Rank the alternatives in descending order

A set of alternatives can now be preference ranked according to the descending order of Cc_i, and the one with the maximum value of Cc_i is the best.

2.3.2. FSAW (Fuzzy simple-additive-weighting) method

A fuzzy MCDM model is used to evaluate alternatives versus selected criteria through a committee of decision makers, where suitability of alternatives versus criteria, and the importance weights of criteria, can be evaluated in linguistic values demonstrated by fuzzy numbers. The simple additive weighting (SAW) method is one of the most useful and widely used MCDM approaches and used to aggregate the alternative‘s scores into one score based on the criteria weights.

At first, the scores are normalized by the formulas:

$$r_{ij} = \frac{x_{ij}}{x_i^{max}} \quad (9)$$

$$r_{ij} = \frac{x_j^{min}}{x_{ij}} \quad (10)$$

Where x_{ij} is the score for the criterion. When criteria are maximized, formula (9) has to be used, and formula (10) has to be used when criteria are minimized. Then the scores are aggregated into one score:

$$R^* = \left\{ R_i \,\middle|\, \max_i \frac{\sum_j w_j . r_{ij}}{\sum_j w_j} \right\} \quad (11)$$

Where R^* is the total score, n is the number of criteria, w_j is the weight of the criterion, and r_{ij} is the normalized score for the criterion.

2.4. Nominal group technique (NGT)

One approach for improving decision outcomes is to use structured group processes. The nominal group technique NGT is probably the most widely used structured group process. The NGT is designed to elicit ideas from all members of the group, and encourage consensus in the final decision making. Because it reduces process losses that can occur with groups, it generally improves decision outcomes. However, it also requires group members to meet at the same time and in the same place.

2.5. Failure mode and effect analysis (FMEA)

Failure mode and effect analysis (FMEA) is a systematic technique for identifying, prioritizing and acting on potential failure modes before the failures occur. A conventional form of FMEA includes (i) the design function of parts, (ii) the potential failure mode (categories of failure), (iii) the potential effects of failure (measured by the severity index), (iv) the potential causes of failure (measured by the occurrence (frequency) index), (v) the detection method (measured by the detect ability index), and (vi) the risk priority number (RPN). The RPN is used to evaluate the risk level of a part‘s failure mode in design stage, and is determined by the multiplication of three characteristic failure mode indexes, i.e., the severity of the potential failure (S), the occurrence of potential failure (O), and the detect ability index (D), respectively, as

$$RPN = S * O * D \quad (12)$$

The three indices S, O and D in (12) are defined in tables 2-4 to identify the various levels of risk situation in BOT projects.

Table.2. Traditional ratings for risk occurrence.

Rating	Probability of occurrence		Possible risk rate
10 9	Very high: risk is almost inevitable	VH	$\geq 1/2$ 1/3
8 7	High: repeated risks	H	1/8 1/20
6 5 4	Moderate: occasional risks	M	1/80 1/400 1/2000
3 2	Low: relatively few risks	L	1/15,000 1/150,000
1	Remote: risk is unlikely	R	$\leq 1/1{,}500{,}000$

Table.3.Traditional ratings for severity of a Risk

Rating	Effect
10	Hazardous without warning
9	Hazardous with warning
8	Very high
7	High
6	Moderate
5	Low
4	Very low
3	Minor
2	Very minor
1	None

Table.4. Traditional rating for risk detection .

Rating	Detection	
10	Absolutely impossible	AI

9	Very remote	VR
8	Remote	R
7	Very low	VL
6	Low	L
5	Moderate	M
4	Moderately high	MH
3	High	H
2	Very high	VH
1	Almost certain	AC

3. Case study

Absorbed Investment provide fundamental help for increasing Iran's power in conducting infrastructure projects such as roads, railways, sanitation and also increase employment rate. In this direction, BOT approach has been introduced in power generation industry for many years in Iran, which can be mentioned to one of completed project like 954MW South Isfahan project. Moreover, other projects can be listed such as, Fars, Pareh sar, Heris and Zanjan. The objective in the BOT project in Iran power industry is to use the private sector's financing power in the power generation sector and decrease the financial burden on governmental organizations.

All mandatory expenses and finance provisions are done by the private sector. In return, the private sector acquires the operation right for a certain period beginning from the day of power plant commissioning. During this period, it sells the electricity that it has generated to TAVANIR (Iran power generation, transmission and distribution management company), and at the end of the period, it transfers the power plant to TAVANIR. In this section, the experiences of the private sector in the successful implementation of power plant project (South Isfahan project) have been used. Then, experts (DMs) have been selected to establish BOT projects risk ranking team.

3.1. & 3.2. Risk identification and criteria determination for risk ranking

By using Brain storming technique, at first 28 events or risks that affect on BOT projects have been recognized. Then by using Delphi method, number of these technical risks was decreased to 10. The finalized risks are presented in Table 5.

Table.5. Final risks .

Final	Description
R1	Expropriation
R2	Management
R3	Construction
R4	Procurement
R5	Maintenance
R6	Performance
R7	Force major event
R8	Financing
R9	Conflict of laws
R10	Delay or incompletion

As we mentioned before (section 2.2.), we use time, cost, quality, safety and environmental as decision making criteria for risk ranking.

3.3. FTOPSIS & FSAW for risk ranking

3.3.1. FTOPSIS method

In this part, we consider decision matrix by assuming the finalized risks (table 5) as alternatives and five mentioned objectives as our criteria. As we showed in table 6 the weights of these objectives and the effects of each risk on them are determined according to Linguistic variables by experts. Table 8 shows the quantity values of table 6 contents.

Table.8. Fuzzy decision matrix.

	TIME			COST			QUALITY			SAFETY			ENVIRONMENTAL		
R1	0.5	0.7	0.9	0.7	0.9	1	0.5	0.7	0.9	0.3	0.5	0.7	0.5	0.7	0.9
R2	0.3	0.5	0.7	0.5	0.7	0.9	0.5	0.7	0.9	0.3	0.5	0.7	0.7	0.9	1
R3	0.7	0.9	1	0.7	0.9	1	0.3	0.5	0.7	0.5	0.7	0.9	0.3	0.5	0.7
R4	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.7	0.9	1
R5	0.1	0.3	0.5	0.1	0.3	0.5	0	0.1	0.3	0	0.1	0.3	0.5	0.7	0.9
R6	0.3	0.5	0.7	0.7	0.9	1	0	0.1	0.3	0	0.1	0.3	0.5	0.7	0.9
R7	0.1	0.3	0.5	0.3	0.5	0.7	0	0.1	0.3	0.3	0.5	0.7	0.3	0.5	0.7
R8	0.3	0.5	0.7	0.3	0.5	0.7	0.5	0.7	0.9	0.7	0.9	1	0.3	0.5	0.7
R9	0.1	0.3	0.5	0.5	0.7	0.9	0.3	0.5	0.7	0.7	0.9	1	0.5	0.7	0.9
R10	0.5	0.7	0.9	0.5	0.7	0.9	0.1	0.3	0.5	0.3	0.5	0.7	0.5	0.7	0.9

Table 9 shows the normalized decision matrix which obtained from equation (1).

Table.9. Normalized decision matrix.

	TIME			COST			QUALITY			SAFETY			ENVIRONMENTAL		
R1	0.27	0.38	0.49	0.31	0.40	0.45	0.31	0.43	0.56	0.16	0.26	0.37	0.14	0.20	0.26
R2	0.16	0.27	0.38	0.22	0.31	0.40	0.31	0.43	0.56	0.16	0.26	0.37	0.20	0.26	0.29
R3	0.38	0.49	0.55	0.31	0.40	0.45	0.19	0.31	0.43	0.26	0.37	0.47	0.09	0.14	0.20
R4	0.27	0.38	0.49	0.22	0.31	0.40	0.31	0.43	0.56	0.26	0.37	0.47	0.20	0.26	0.29
R5	0.05	0.16	0.27	0.04	0.13	0.22	0.00	0.06	0.19	0.00	0.05	0.16	0.14	0.20	0.26
R6	0.16	0.27	0.38	0.31	0.40	0.45	0.00	0.06	0.19	0.00	0.05	0.16	0.14	0.20	0.26
R7	0.05	0.16	0.27	0.13	0.22	0.31	0.00	0.06	0.19	0.16	0.26	0.37	0.09	0.14	0.20
R8	0.16	0.27	0.38	0.13	0.22	0.31	0.31	0.43	0.56	0.37	0.47	0.53	0.09	0.14	0.20
R9	0.05	0.16	0.27	0.22	0.31	0.40	0.19	0.31	0.43	0.37	0.47	0.53	0.14	0.20	0.26
R10	0.27	0.38	0.49	0.22	0.31	0.40	0.06	0.19	0.31	0.16	0.26	0.37	0.14	0.20	0.26
W	0.7	0.9	1	0.9	1	1	0.5	0.7	0.9	0.5	0.7	0.9	0.1	0.3	0.5

Table 10 shows the weighted normalized decision matrix which obtained from equation (2).

Table.10. Weighted normalized decision matrix.

R1	0.19	0.35	0.49	0.28	0.40	0.45	0.16	0.30	0.50	0.08	0.18	0.33	0.01	0.06	0.13
R2	0.12	0.25	0.38	0.20	0.31	0.40	0.16	0.30	0.50	0.08	0.18	0.33	0.02	0.08	0.14
R3	0.27	0.45	0.55	0.28	0.40	0.45	0.09	0.22	0.39	0.13	0.26	0.43	0.01	0.04	0.10
R4	0.19	0.35	0.49	0.20	0.31	0.40	0.16	0.30	0.50	0.13	0.26	0.43	0.02	0.08	0.14
R5	0.04	0.15	0.27	0.04	0.13	0.22	0.00	0.04	0.17	0.00	0.04	0.14	0.01	0.06	0.13
R6	0.12	0.25	0.38	0.28	0.40	0.45	0.00	0.04	0.17	0.00	0.04	0.14	0.01	0.06	0.13
R7	0.04	0.15	0.27	0.12	0.22	0.31	0.00	0.04	0.17	0.08	0.18	0.33	0.01	0.04	0.10
R8	0.12	0.25	0.38	0.12	0.22	0.31	0.16	0.30	0.50	0.18	0.33	0.47	0.01	0.04	0.10

R9	0.04	0.15	0.27	0.20	0.31	0.40	0.09	0.22	0.39	0.18	0.33	0.47	0.01	0.06	0.13
R10	0.19	0.35	0.49	0.20	0.31	0.40	0.03	0.13	0.28	0.08	0.18	0.33	0.01	0.06	0.13

We obtain FPIS and FNIS from equation (3) and (4). These results are presented in table 11.

Table.11. FPIS and FNIS.

FPIS	0.04	0.15	0.27	0.04	0.13	0.22	0.00	0.04	0.17	0.00	0.04	0.14	0.01	0.04	0.10
FNIS	0.27	0.45	0.55	0.28	0.40	0.45	0.16	0.30	0.50	0.18	0.33	0.47	0.02	0.08	0.14

Table 12 shows the distance of each alternative from FPIS according to equation (5).

Table.12. The distance of each alternative from FPIS .

D1+	0.20	0.26	0.26	0.15	0.02
D2+	0.10	0.18	0.26	0.15	0.03
D3+	0.28	0.26	0.17	0.22	0.00
D4+	0.20	0.18	0.26	0.22	0.03
D5+	0.00	0.00	0.00	0.00	0.02
D6+	0.10	0.26	0.00	0.00	0.02
D7+	0.00	0.09	0.00	0.15	0.00
D8+	0.10	0.09	0.26	0.29	0.00
D9+	0.00	0.18	0.17	0.29	0.02
D10+	0.20	0.18	0.09	0.15	0.02

The distance of each alternative from FNIS according to equation (5) is presented in table 13.

Table.13. The distance of each alternative from FNIS .

D1-	0.09	0.00	0.00	0.14	0.02
D2-	0.19	0.08	0.00	0.14	0.00
D3-	0.00	0.00	0.09	0.07	0.03
D4-	0.09	0.08	0.00	0.07	0.00
D5-	0.28	0.26	0.26	0.29	0.02
D6-	0.19	0.00	0.26	0.29	0.02
D7-	0.28	0.17	0.26	0.14	0.03
D8-	0.19	0.17	0.00	0.00	0.03
D9-	0.28	0.08	0.09	0.00	0.02
D10-	0.09	0.08	0.18	0.14	0.02

The relative closeness to the ideal solution according to equation (7) and the final risk ranking are shown in table 14.

Table.14.The final result of risk ranking by FTOPSIS method.

		ranking	risk ranking
CL1+	0.22	8	R3
CL2+	0.36	6	R4
CL3+	0.17	10	R2
CL4+	0.21	9	R8
CL5+	0.98	1	R9
CL6+	0.67	3	R10
CL7+	0.79	2	R1

CL8+	0.35	7	R6
CL9+	0.42	5	R7
CL10+	0.45	4	R5

3.3.2. FSAW method

Table 15 shows the results of equation (9-11) according to tables 8-10. We used equation (14) for obtaining real-valued numbers from corresponding fuzzy numbers. The final risks ranking are also represented in the last column of this table.

Table.15 .The final result of risk ranking by FSAW method .

SUM				DF	Ranking
R1	0.72	1.29	1.9	1.30	R3
R2	0.58	1.12	1.75	1.14	R4
R3	0.78	1.37	1.92	1.36	R1
R4	0.7	1.3	1.96	1.32	R8
R5	0.09	0.42	0.93	0.47	R2
R6	0.41	0.79	1.27	0.82	R9
R7	0.25	0.63	1.18	0.67	R10
R8	0.59	1.14	1.76	1.16	R6
R9	0.52	1.07	1.66	1.08	R7
R10	0.51	1.03	1.63	1.05	R5

Table 16 shows the final risks ranking results obtained by FSAW and FTOPSIS methods.

Table.16. Final risk ranking results obtained by FSAW and FTOPSIS methods.

Final risks	Ranking by FTOPSIS	Ranking by FSAW
R1	R3	R3
R2	R4	R4
R3	R2	R1
R4	R8	R8
R5	R9	R2
R6	R10	R9
R7	R1	R10
R8	R6	R6
R9	R7	R7
R10	R5	R5

3.3.3. Risk ranking by NGT (nominal group technology) method

First, we rank the obtained results of each method within the values of 1and 10. Then we give zero score to grade 10, one score to grade 9, etc, so the grade 1 take 9 score. Thereafter, we add the scores that are obtained from three methods together for each risk, namely N_i (for example for R1 the calculation of N_1 is as 3+7+7=17) and then according to the N_i s, we ranked the values again, as shown in table 17.

Table.17. The integrating of three methods results by NGT method.

N_i	Values of N_i	Ranking by NGT method (Risk severity)
N_1	17	R3
N_2	17	R4
N_3	27	R8
N_4	24	R2
N_5	0	R1
N_6	6	R9
N_7	3	R10
N_8	18	R6
N_9	13	R7
N_{10}	10	R5

3.3.4. FMEA

The occurrence and detection values of each risk are determined by experts in tables 18, 19 according to tables 2, 4 and ultimately the risks are evaluated according to risk priority number (RPN) of failure mode and effect analysis (FMEA) technique.

Table.18. primal evaluation results of FMEA.

Finalized risks	Risk severity	Risk occurrence	Risk detection
R1	17	H	VH
R2	17	M	M
R3	27	VH	AC
R4	24	H	MH
R5	0	L	R
R6	6	M	H
R7	3	L	VL
R8	18	M	VR
R9	13	R	M
R10	10	H	MH

We obtain RPN results from equation (12). These results are presented in table 19.

Table.19. RPN calculation stages.

Final risks	I	O	D	RPN
R1	17	8	2	272
R2	17	6	5	510
R3	27	10	1	270
R4	24	7	4	672
R5	0	3	8	0
R6	6	5	3	90
R7	3	2	7	42
R8	18	4	9	648
R9	13	1	5	65
R10	10	8	4	320

4. Conclusion

Risk Management has been recognized as a very important process in BOT projects. In this paper we ranked the risks according to the project objectives, namely time, cost, quality, safety and environmental. In order to decision making for risk ranking two methods (FTOPSIS and FSAW) are used and finally the results of these two methods merge together by NGT method, A NGT is a way to improve the communications between members of an implementation team as well as between the team and top management. The process is robust in the sense that a group can come together for the first time and produce some useful information in less than three hours. The information generated has validity because it comes from the whole group and there are rankings of the importance of the various ideas. The results of the NGT can generate further discussions and can be the focus of a dialogue on how to improve the implementation. so we showed the final risks ranking results obtained by NGT method as below:

$R_3>R_4>R_8>R_2>R_1>R_9>R_{10}>R_6>R_7>R_5$

Ultimately the risks are evaluated according to risk priority number (RPN) of failure mode and effect analysis (FMEA) technique. Several issues could be further investigated to enhance the practicality of the proposed method. For example, project selection, supplier selection, a better fuzzy clustering algorithm, discussed in Section 3.3.4 and 3.3.5, could be developed. Finally, a user-friendly and intelligent decision support system could be developed based on the proposed method.

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