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Identify and Prioritize Risks of Construction Projects Based on Fuzzy Logic (Case Study: Construction Project of Iranian Investment and Sustainable Development Company)

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Abstract

The purpose of the research was to identify and rank risks in construction projects of Iranians investment and Sustainable Development Company. This descriptive study based on purpose and on the basis of data collection is the survey. The study society consisted of 25 experts in construction projects. The data collected through a questionnaire which is then used to calculate the reliability and validity researcher.

Thus, using literature review and interviews with experts, more than 100 risks were identified and were divided based on risk factors and risk breakdown structure, for weighting criteria, network analysis process which is used to obtain the internal relationship between the criteria of DIMATEL fuzzy method is used, then rankings risks were done using fuzzy TOPSIS algorithm. The results showed that, given the vague nature of the data in most projects, the proposed model is suitable for the real world.

Keywords: risk management, dimatel fuzzy, civil projects

1. Introduction

Risk management is one of 10 areas of project management knowledge that is particularly important in terms of theory and practice and despite the publication of numerous articles on the subject, little and substantial deficiencies are in this area in the real world.

Effective risk management project guides manager to achieve the desired benefits such as identifying options activity, increasing the likelihood of achieving the project objectives, to improve the chances of success, reduce unexpected events, achieving accurate estimates (by reducing uncertainty), and the effects of reducing the frequency. (Bannerman, 2008) On the other hand, project management, application of knowledge, skills, tools and techniques related to project activities to meet project requirements. (PMI, 2013)

Of the year 1990, several models have been presented for risk management projects with the aim of increasing their success, such as SHAMPU model (Chapman & Ward, 1997), ALARM (2002), the PRMA (2004), the PRAM (1997), Smith model (2002), Leach model (2000), etc. The most famous and most widely recognized standard among standards is Body of Knowledge of the Project Management (PMBOK). This standard describes all the necessary processes for project management process in the form of 47.

According to the definition of knowledge management guide (2013) risk is said to events have occurred in the future that is uncertain and in case of a positive or negative effect on the project. Risks with positive impact called desired or opportunities risk, and the risks with negative impact is called or threat or undesirable risk. According to Mark research et al. (2004) risk is the potential against complexities and difficulties with regard to complete project activities and achieve the project objectives.

Risk is inherent in all projects. Risk cannot be completely removed or destroyed, but with effective management can affect the project. Project risk is an integral part of any project, it must be managed. In fact, systematic project risk management process involves planning for the identification, analysis, response and risk monitoring project. This includes management processes, tools and techniques that help project managers to maximize likelihood of positive events and minimizing the likelihood of adverse events. (Azar, 2010)

PMBOK standard summarized risk management process as below:

1. Identifying risks

2. Analysis of risks

3. Responding to risks

4. Risk Control

With a general, the risk management process is divided into two main stages of risk assessment (including identification and risk analysis) and respond to them. (Miller, 2005) According to Kunero (2003), all equally important step risk management process and may be incomplete each of the steps leading to ineffective risk management.

Because the success of the project, the different metrics to measure stakeholders to assess the success of the project is difficult. (Yon Chang et al., 2009) For construction companies face the risk of uncertainty, by evaluating their impact on the objectives of the project are important. Because of this it can be concluded that with a bit of a risk which is more risky projects and we can plan for potential sources of risk in any project and any source (origin) to manage the construction period. (Zayed et al., 2008)

In the meantime, use of fuzzy theory because of the uncertainty in risk management concept, widely used in the research area in construction management. Using fuzzy set theory, data can be defined vaguely and phrases such as low probability, high impact or high risk.

These statements may be significantly showed a number, but the fuzzy set theory provides a tool that can define this expression with mathematical logic. (Jafari, 2001) The theory is applied in confusion and uncertainty. This theory has not been capable to express many of the concepts and mathematically precise and provide reasoning, inference, control and decision-making under uncertainty. (Aydin, 2004)

According to the studies that have been done in the field of risk assessment and ratings, can be found to various aspects of the issue. Perry and Hayes (1985) gave a list of factors, risks and resources it into 3 parts: contractors, consultants and employers. Cooper and Chapman (1987) Classified the risks according to their importance and the nature and risks divided have into two groups: primary and secondary. (Abdou, 1996)

Risk is classified into 3 groups: financial, time and design. Zhang et al. (2007) classified risk factors as: human, sites, material and equipment. In general, project risks, there are several ways to classify and select a logical method depends on the specific objectives of the research. (Zou et al., 2007)

Also, several research have been conducted to rank risk projects, including Bakarini and Archer (2001) describes a method of using the grading process for ranking project risk project risk associated with contract services department, Western Australia is the government agency's management. Due to the fact that at each stage of the project risk management process different tools can be used.

Ebrahimnejad et al. (2010) used Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) and Fuzzy Linear Programming Technique for Multidimensional analysis of Preference (FLINMAP) in projects to build, operate and transfer. They are in their proposed model, the risk of project construction, implementation and transfer of Iran's power plants identify and evaluate and rank the most important risks.

In research was conducted by Olfat and Jalali, (2010) project risks interchange construction projects in the province were identified based on the standard of knowledge of project management, then fuzzy hierarchical analysis and fuzzy TOPSIS methods were used for prioritization.

Also similar studies by other Mojtahedi et al. (2010), Mousavi et al. (2011), Azari Karimi et al. (2011), Sayyadi et al. (2011) conducted that several criteria were determined based on likelihood and impact of risks on project objectives with different weights.

Therefore, taking into account the research literature, this paper aims to identify, assess and respond to risks in a timely manner in order to reduce adverse impacts and increase the desired effects. This study was conducted at the investment company of Iranian civil and sustainable development. In short, looking for an analytical model fits into the project risk management is evaluated.

In this regard, researchers sought to answer the following questions:

What are the major risks in construction projects?

What factors affect the risk of the project?

What is the appropriate method of risk categories?

How is the effect of risk on the project objectives?

How risks should be prioritized?

Which is a better fuzzy logic techniques cannot risk modeling?

2. Research Methodology

The research method, due to the nature of the subject was a case study. Also, by purpose and by way of data collection is descriptive - is. In this study of 25 experts in different times and levels to fill out questionnaires, validity and reliability of questionnaire was used.

In this study, consistent approach using fuzzy logic to identify and rank the risks presented that eventually can help to control risk. Appropriate plan to reduce and control risks to the project, the proposed approach for the steps given below. Thus, initially, to choose effective measures in the process of evaluating the risks involved in the construction projects of the study will be discussed. The criteria used for this purpose are taken from the PMBOK standard.

The purpose of this step is a complete set of risks in construction projects. In the second step, to test reliability Theta sequential method was used to test reliability. Then using network analysis process and selection criteria will be weighted fuzzy DIMATEL, weighting process is carried out in three phases due to the interdependence between the criteria, the network process and live and then use the first technique the risks involved in construction projects were assessed and ranked.

3. Research Findings

In this section, the proposed model in construction projects is provided in the following stages:

After a theoretical study in several meetings with leaders of the companies and experts, some risks were identified by experts of the organization, then appropriate structure for risk breakdown was provided. Figure 1 shows risk breakdown structure proposed for the projects.

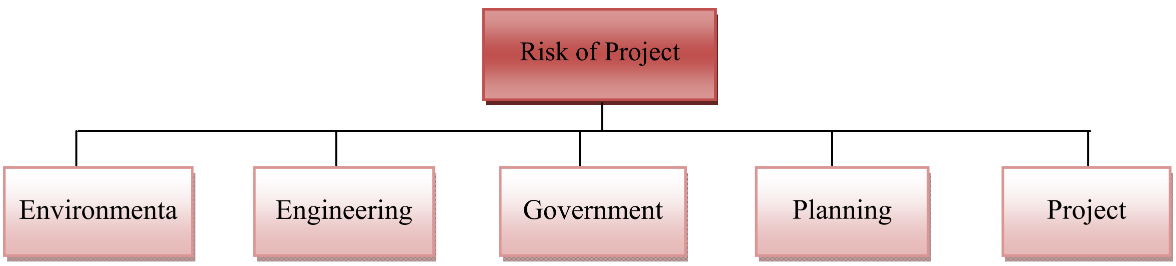

Figure 1. Breakdown Structure Risk

In the proposed structure, categories of risk so that all risks of construction projects will be included in the study, 110 risks associated with the risk factors and the area was listed in table format category, (which is short for limits on paper, is bringing your own table.) and in the next stage of construction risks in the company's investment rating by the Iranian Civil and sustainable development approach based on network analysis process, DIMATEL and TOPSIS were:

First step: In this step the selection and ranking criteria and identify the risks involved and influential mining will be discussed. PMBOK standards have been used for this purpose. So five evaluation criteria and ranking are: cost, time, quality, range and performance. Then, using the experience of experts and historical events in the organization, risks were detected.

Step two: Referring to experts to test the validity and approved. Experts were to examine the reliability of the questionnaire and they were asked to respond to questionnaires. (Appendix "A") To check the reliability of this questionnaire the ordinal theta is used. R software output for the Inventory is shown in Table (1). As is clear from the table, reliability of all questions is approved in the acceptable level and higher. As well as the overall reliability of the questionnaire with ordinal theta 0.812303 was approved, that this level of Theta represent the confirmation is at a good level.

Table 1. Output of program R

$ Ordinal Theta if a Question Deleted	New Theta
Without Question 1	0.813298
Without Question 2	0.811141
Without Question 3	0.825389
Without Question 4	0.851330
Without Question 5	0.807052
$ Ordinal Theta for all Question= 0.812303	

Step Three: In this step, using the seven expert organization, to weighting of the criteria and ranking risks were discussed. This process is given below:

First step: In this step, weighting criteria will be discussed. Because, according to experts, there is interdependence between the criteria and network analysis process will be used for that interrelation between them, DIMATEL fuzzy method is used. This process is given below:

First step - first stage: In this phase, we assume that there is no dependence between criteria. From experts want to use the words of a language table 2 between their judgment. Output of the questionnaire fuzzy numbers in Table 3 below.

Table 2. Linguistic scale to determine the significance of paired comparisons

Reverse triangular fuzzy scale	triangular fuzzy scale	Linguistic scale
(1 , 1 , 1)	(1 , 1 , 1)	Exactly equal (JE)
(2.3 , 1 , 2)	(1.2 , 1 , 3.2)	Most importantly very low (ED)
(1.2 , 2.3 , 1)	(1 , 3.2 , 2)	Least important (WMD)
(2.5 , 1.2 , 2.3)	(3.2 , 2 , 5.2)	Most importantly (SMD)
(1.3 , 2.5 , 1.2)	(2 , 5.2 , 3)	Very important (VSMD)
(2.7 , 1.3 , 2.5)	(5.2 , 3 , 7.2)	Absolutely important (AMD)

Table 3. Table pairwise comparisons completed by the group of experts

Criteria	Time	Cost	Quality	Limit	Performance
Time	(1,1,1)	(1.2,1,3.2)	(1,3.2,2)	(3.2,2,5.2)	(2,5.2,3)
Cost	(2.3,1,2)	(1,1,1)	(1.2,1,3.2)	(1,3.2,2)	(3.2,2,5.2)
Quality	(1.2,2.3,1)	(2.3,1,2)	(1,1,1)	(1.2,1,3.2)	(1,3.2,2)
Limit	(2.5,1.2,2.3)	(1.2,2.3,1)	(2.3,1,2)	(1,1,1)	(1.2,1,3.2)
Performance	(1.3,2.5,1.2)	(2.5,1.2,2.3)	(1.2,2.3,1)	(2.3,1,2)	(1,1,1)

Then, using a method developed by Bezbora and Beskes (2007), weight of criteria is given in Table 4. Because the process is very time consuming calculations by this method, it was coded using MATLAB software.

Table 4. Weight criteria regardless of interdependence

Criteria	Time	Cost	Quality	Limit	Performance
Weight	0.2949	0.2473	0.1979	0.1502	0.1098

First step - second stage: In this stage the following 5 steps, calculating the matrix interdependence through DIMATEL phase.

The impact of the measures on each other using the experience of experts was drawing schematically shown in

Figure 4-3.

In this step, using the table 5 Effect of criteria on each other using expert opinion to be obtained. Table 6 shows the effect on each criteria.

Table 5. Scale to determine the effect criteria

Triangular fuzzy scale	Linguistic scale
(0,0,0.1)	Affectless
(0.1,0.2,0.3)	Effect of very low
(0.2,0.3,0.4)	Low impact
(0.3,0.4,0.5)	Low-medium impact
(0.4,0.5,0.6)	Effect of average
(0.5,0.6,0.7)	The impact of average high-
(0.6,0.7,0.8)	High Impact
(0.7,0.8,0.9)	A huge effect
(0.8,0.9,1)	Absolutely effective

Table 6. Matrix effect of criteria on each other

	Performance	Limit	Quality	Cost	Time
Time	-	(0.7,0.8,0.9)	(0.5,0.6,0.7)	(0.3,0.4,0.5)	(0.4,0.5,0.6)
Cost	(0.7,0.8,0.9)	-	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.5,0.6,0.7)
Quality	(0.2,0.3,0.4)	(0.4,0.5,0.6)	-	(0.1,0.2,0.3)	(0.5,0.6,0.7)
Limit	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.4,0.5,0.6)	-	(0.3,0.4,0.5)
Performance	(0.4,0.5,0.6)	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.1,0.2,0.3)	-

In this step, to normalization matrix of the previous step is done. For this purpose the relationship introduced in First step - second stage from the third quarter are used. Table 7 is version of the matrix phase to obtain normal.

Table 7. Normalized matrix effect of criteria on each other

	Time	Cost	Quality	Limit	Performance
Time	-	(0.25,0.286,0.321)	(0.179,0.214,0.25)	(0.107,0.143,0.179)	(0.143,0.179,0.214)
Cost	(0.25,0.286,0.321)	-	(0.143,0.179,0.214)	(0.143,0.179,0.214)	(0.179,0.214,0.25)
Quality	(0.071,0.107,0.143)	(0.143,0.179,0.214)	-	(0.036,0.071,0.107)	(0.179,0.214,0.25)
Limit	(0.179,0.214,0.25)	(0.214,0.25,0.286)	(0.143,0.179,0.214)	-	(0.107,0.143,0.179)
Performance	(0.143,0.179,0.214)	(0.179,0.214,0.25)	(0.214,0.25,0.286)	(0.036,0.071,0.107)	-

In this step, the fuzzy relationship matrix earned and converted for this purpose into three matrix.

Finally interdependence of the De fuzzy matrix of matrices obtained the previous step achieved.

$$Defuzzy(t_{ij}) = \begin{bmatrix} 0.6768 & 0.9854 & 0.8742 & 0.5719 & 0.8135 \\ 0.9259 & 0.7928 & 0.8776 & 0.6134 & 0.8598 \\ 0.5970 & 0.7108 & 0.5198 & 0.3968 & 0.6682 \\ 0.8358 & 0.9425 & 0.8288 & 0.4370 & 0.7672 \\ 0.7400 & 0.8413 & 0.8173 & 0.4596 & 0.5841 \end{bmatrix}$$

$$Normalized\ defuzzy(t_{ij}) = \begin{bmatrix} 0.1793 & 0.2306 & 0.2231 & 0.2307 & 0.2203 \\ 0.2452 & 0.1855 & 0.2240 & 0.2475 & 0.2328 \\ 0.1581 & 0.1663 & 0.1327 & 0.1601 & 0.1809 \\ 0.2214 & 0.2206 & 0.2115 & 0.1763 & 0.2078 \\ 0.1960 & 0.1969 & 0.2086 & 0.1854 & 0.1582 \end{bmatrix}$$

First step - third stage: In this step interdependence matrix obtained from the first phase of the second phase of the weight factors is applied.

Thus weighting of criteria taking into account the interdependence between them is obtained. The result of this calculation is given below:

$$\begin{bmatrix} 0.1793 & 0.2306 & 0.2231 & 0.2307 & 0.2203 \\ 0.2452 & 0.1855 & 0.2240 & 0.2475 & 0.2328 \\ 0.1581 & 0.1663 & 0.1327 & 0.1601 & 0.1809 \\ 0.2214 & 0.2206 & 0.2115 & 0.1763 & 0.2078 \\ 0.1960 & 0.1969 & 0.2086 & 0.1854 & 0.1582 \end{bmatrix} \times \begin{bmatrix} 0.2949 \\ 0.2473 \\ 0.1979 \\ 0.1502 \\ 0.1098 \end{bmatrix} = \begin{bmatrix} 0.212901 \\ 0.225273 \\ 0.157937 \\ 0.210989 \\ 0.192999 \end{bmatrix}$$

Second step: In this step using Table 8 experts want to each index score for each criteria using words in their language. This is done by eight experts.

Table 8. Linguistic variables and fuzzy rating criteria

fuzzy rating criteria	**linguistic variables**
(0,0,1)	Very weak
(0,1,3)	Weak
(1,3,5)	Average- weak
(3,5,7)	Average
(5,7,9)	Average - high
(7,9,10)	High
(9,10,10)	Very high

Then average expert opinion from the formula provided in the third quarter was the second step.

Third step: In this step, the normalized decision matrix was used make weight. For this purpose, weigh criteria we applied to consider the interdependence between them.

Step Four: In this step the ideal solution (A^*) and anti-ideal (A^-) is specified. The results of the calculations in Table 9 below.

Table 9. Ideal solution and anti-ideal solution

Criteria	ideal solution	anti-ideal solution
Time	(0.2129, 0.2129, 0.2129)	(0.0679, 0.0679, 0.0679)
Cost	(0.2253, 0.2253, 0.2253)	(0.0509, 0.0509, 0.0509)
Quality	(0.1579, 0.1579, 0.1579)	(0.0127, 0.0127, 0.0127)
Limit	(0.211, 0.211, 0.211)	(0, 0, 0)
Performance	(0.193, 0.193, 0.193)	(0.0116, 0.0116, 0.0116)

Step Five: In this step, ideal and anti-ideal items are distinguished.

Step Six: In this step close to each risk factor using the formula provided in the table is determined in Step sixth of Chapter III (10) is given.

Table 10. Proximity risk coefficient (option)

option	proximity
The delay in the delivery of land	0.196614
Delays in licensing	0.205858
Lack of adequate funding	0.324943
The delay in accreditation	0.25231
Problems or lack of satisfaction with the natives and locals collective, social and cultural	0.318415
Potential difficulties in interacting with government agencies (municipal engineering organization, etc.)	0.324686
Human error work method	0.368655
Non-performance of obligations under the contract and the provisions for meetings	0.370199
Improper estimation of performance work statement	0.344487
Changes in project schedule	0.212106
Delays in settling the contract	0.353447
Changes in the design specification and scope of work	0.419344
The complexity of the project	0.394823
Business interruption (suspension etc.)	0.25745
Incomplete of maps	0.348639
Lack of appropriate technical schedule due to project location	0.31585
Lack of welcome customers from project	0.442393
A chance encounter with infrastructure projects such as water, electricity, etc. and various problems in addressing these rebels	0.304376
Change managers and officials associated with the project	0.437283
Non-approval of the plans, the proposed amendments in the project execution	0.295018

Step Seven: In this step, based on the coefficient value, proximity to risks is ranked. The risk that the proximity coefficient is the highest priority is higher.

In the following risks listed in order of importance:

Table 11. Prioritize risks (options)

risks	Rank
Failure to welcome customers from project	1
Change managers and officials associated with the project	2
Changes in the design specification and scope of work	3
The complexity of the project will be implemented	4
Non-performance of obligations under the contract and the provisions for meetings	5
Human error procedure	6
Delays in settling the contract	7
Lack of maps	8
Improper estimation of performance work statement	9
Lack of adequate funding	10
Potential difficulties in interacting with government agencies (municipal engineering organization, etc.)	11
Problems or lack of satisfaction with the natives and locals collective, social and cultural	12
Lack of appropriate technical schedule due to project location	13
A chance encounter with infrastructure projects such as water, electricity, etc. and various problems in addressing these rebels	14
Non-approval of the plans, the proposed amendments in the project execution	15
Business interruption (suspension etc.)	16
The delay in accreditation	17
Changes in project schedule	18
Delays in licensing	19
The delay in the delivery of land	20

According to the ranking of risks, it provides managers and decision makers prioritize them according to priority to manage organizational risks. This ranking is important in the sense that if an organization to meet, confront and promotion of these risks are the limited resources available, should act on the basis of risks to prevent the deviation from the objectives of the project. According to Pareto's 80-20 rule, it is recommended to focus on the 20 percent of major risks, should be avoided up to 80 percent of the deviation from the objectives of the project.

4. Analysis of Research Results

In this study, a model was presented for risk management projects in conditions of uncertainty regarding the conditions in the country and the status of construction projects. The most important aspect of research innovation models that are consistent with real world conditions. However, in the analysis and solution models were presented as well as new approaches.

In this study, an appropriate structure are presented for classification of risks in construction projects and risk analysis helps to identify risks. With the addition of library studies, the most common risks in construction projects of the country were identified that a few changes can be used to the country's other building projects.
In the next step was to develop new models for risk assessment taking into account the preferences of decision-makers the ability to systematically. The proposed model for the evaluation and selection of timely and appropriate responses to risks also considers the different targets and selects the appropriate measures to be effective....

In short, research and analysis in the areas of innovation is that the model has to mention some of them:

- ✓ Development of a hierarchical structure in order to consider the different criteria in risk assessment tailored to the preferences of decision-makers
- ✓ Given the interdependence between the various criteria of risk assessment
- ✓ Compatibility index calculated paired comparisons in terms of fuzzy
- ✓ Taking into account the standards of the time, cost, quality, range and performance risk assessment
- ✓ Innovative methods for risk assessment
- ✓ Using fuzzy logic in risk assessment and response to further correspondence with the real world

In terms of applications using different methods, the most common risks in construction projects were identified. Also, suitable structural failure risks in construction projects were presented and finally a model for ranking risks according to different preferences of decision-makers was developed. Therefore, we see a practical sense, this research suitable for deployment provides risk management in construction projects.

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