

# Simultaneous management and control on cost and time in the project development through fuzzy logic to risk management

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## Abstract

Projects are a series of unique activities defined in order to achieve a unique goal. Before implementation, project activities to be conducted in future are predicted and the initial timetable of the project is prepared. Given the fact that future is vague and unclear, risks and uncertainties will inevitably exist in the implementation of projects because human is unable to precisely foresee the future. Projects are planned according to estimations obtained from little information about the future conditions of projects. Considering the fact that the planning involve uncertainty, time delays and costs imposed by uncertainties are unavoidable. Risk management is a project management standard used extensively. The effects of the risk of time and cost were simultaneously investigated in one of the huge, national projects in Iran, namely the water supply project from Persian Gulf to the mineral industries of south eastern Iran, which involves the largest water desalination system in the Middle East. Information pertaining to risk management was gathered, and fuzzy number theory, fuzzy logic, software, and information analysis and combination were employed. A model was put forward including 7 stages and 20 steps in SPSS, and MATLAB was also utilized in civil projects for increasing planning accuracy. The results differed from those of existing, traditional methods, such as the method of probability of occurrence \* degree of impact, for risk management.

**Keywords:** Risk; Uncertainty; Fuzzy Logic; Probability of Occurrence.

## 1. Introduction

The presence of risk in every project is inevitable. Risk can be managed, transferred, or even is acceptable, but can't be ignored, because the time cost and the project quality are influenced by the consequences of project directly. The risk can cause the lack of correct and timely implementation of the project and too much drawback. Therefore, the risk management is a prominent implementation for coping with project risks; also it is a necessary condition for achieving the objectives of a project, which has a number of phases [1].

The risk management is a process, which aims to diminish the pernicious effects of an activity by proceeding consciously to anticipate the unwelcome accidents, and also plans to avoid them [1].

The time and cost management of a project is one of the fundamentals and also one of the most significant realms of project management. The surveys indicate, that the risks, which are related to the time and cost of development projects, considerably influence on the quality, implement circumstance and progress of a project, whenever they happen concurrently. frequently, It has been observed that the project execution activities Scrimmage with a variety of problems. The problems, which are mostly predictable and assessable and have a number of negative impact on the project, the stakeholders and also on societies directly and indirectly. Hence, by considering the importance of the studying risks and uncertainties, it is completely understandable that to proceed the aims as well as possible, they must be managed, so that gaining more efficiency. Accordingly, the risk management is important and is assessed highly verifiable. Heretofore many approaches

have been introduced to solve this matter, which have found an extensive usage in the third world, however it has been neglected, as many other matters, there. In fact, the third world is a situation, by considering the variety of management weaknesses, a number of uncertainties are ignored. Nevertheless the other management issues, the risk management have been disregarded, too [2].

Heretofore, many methods have been handled for this matter. The fuzzy logic theory, as a novel issue, is able to play an essential and useful role, by combination with management science, in the risk management. The fuzzy management science refers to the employment of classical management science. In the classical management, management problems are solved by using the rational and systematic approaches and benefits the managers to make decision by presenting some quantitative models. Since, it is based on accurate and certain data, so ambiguous and fuzzy ones doesn't have any credit in these methods. The classical management methods are manipulated by using of fuzzy management science in the fuzzy environment and can be used in many management tasks, for instance, planning and making decision and policy. The fuzzy management science can design such models, which are able to process the quantitative information wisely, as human. Therefore, the fuzzy management, whilst causing flexibility in model, takes the knowledge, experience and human judgments in account and provisions useable data. In 1992, the first international fuzzy system conference was held by the greatest engineering organization. In 1990s, a number of developments were generated in the fuzzy system, but yet many actions should be done, despite the clarification of fuzzy system illustration [2].

In this paper, it is attempts to make a relation between risk management and fuzzy logic and also defining a novel model, which

have sufficient implementation capability to promote the control and progress of the development projects.

## 2. Results

The project management considers the following fundamental process through the project implementation [3]:

- Risk management planning
- Risk identification
- Risk qualitative analysis
- Risk quantitative analysis
- Risk respond planning
- Risk prevention and control

After the surveys and expedition on the risk management issue, the circumstance of risk evaluation, the risk identification and awareness about fuzzy logic, by considering the membership of scholar in a part of a great Water supply project from Persian gulf to the south east mining industries of country and to some extent awareness about existent risks in this part, which is one of the most important projects of Iran in the last 30 years, the constructing of a penstock with a capacity of 2 million cubic meters, and for clarifying the existent risks and presenting a solution to reduce them also the procedure of encountering with the impacts, which are caused by the risk occurrence, and hereon promoting the implementation procedure of this massive project, it has been concluded to study on a part of this project, which is the tabulation of water pipeline from Hormozgan province to Kerman and Yazd [3].

The objective of this project is supplying the required water in an industrial region (Golgohar Siran Pelletizing and Steel Factory and also Sarcheshmeh Rafsanjan Copper Company), agricultural use sand supplying drinkable water for Keman, Yazd and Hormozgan citizens. A desalination plant with 1 million cubic meters per day, which is the second great desalination plant in the world [4].

After consulting with experts in this field and dear professors' advice, a model consisting of 7 steps and 20 sub-steps have been presented to be used in development projects to increase the planning accuracy .First, a questionnaire was provided to evaluate the risks and after authenticating by SPSS software, the outputs of questionnaire, which is the weighted average of occurrence probability, the risk impact on project cost, the risk impact on project time, were fed to the MATLAB software, as inputs, to analyze the risks by using the fuzzy logic and simultaneous analysis .After the fulfilment of processing steps, the score of each risk was calculated by "if... then" principles ,also required outputs and tables were provided [4].

In the rest, the implemented steps will be described separately. At first, the overall picture of this method has been exposed on (figure.1) .For a more exact view, each step has been turned to some smaller steps .Each step contains several inputs, which are obtained from previous steps and processed in different stages, as raw inputs .Finally, the outputs of the step or in the other word, the data and inputs of next step are introduced [4].

**Risk identification:**

In this step, the task of management group commences, whenever the achieved information about risk management is presented.

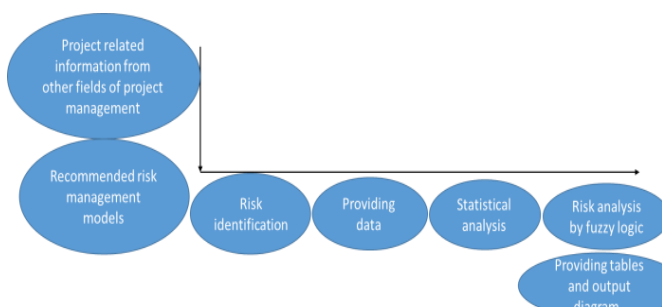


Fig. 1: Recommended Model for Project Risk Management.

Determining some experts by a project manager:

In this step, the experts of risk management group are determined by the project manager.

Holding risk identification sessions:

In this step, the list of identified risks, which are related to a project are revised by some professions to be used in the next steps.

Dividing the various realms of risk:

The realms of a risk are chosen and divided to variant groups, according to the nature of the project and involved bases, just as:

- Definition phase and the project implementation necessity.
- Consuler choosing step
- Job description writing and a project planning step
- Contractor choosing step
- Project implementation phase
- Project management
- Legal/ Contractual agents [5]

The responsibility for each risk is determined for the employer, consuler contractor groups and other agents.

Determining the range of risks occurrence probability:

Is assigned by using the combination of triangular and trapezoidal fuzzy numbers [5].

a) The reference set of probability consists of 5 ranges, means:

Occurrence probability  $U = \{VL, L, MO, H, VH\}$

And it is defined as following:

- 1) Very low range (very low)
- 2) low range (low)
- 3) Moderate range (moderate)
- 4) High range (high)
- 5) Very high range (very high)

b) Then, the membership functions of occurrence probability are described ,as following (equation.1) .For instance, triangular and trapezoidal fuzzy numbers are used in the VL and VH ranges and just triangular ones are used in the other ones.

Equations 1: Determining occurrence probability percentage by using the fuzzy numbers [5]

$$\text{Very low } \nabla \mu_{vl}(x) = \begin{cases} 1 & 0 \leq x \leq 10 \\ \frac{40-x}{30} & 10 \leq x \leq 40 \end{cases} \quad VL = (0,0,10,40)$$

$$\text{Low } \nabla \mu_l(x) = \begin{cases} \frac{x}{30} & 0 \leq x \leq 30 \\ \frac{60-x}{30} & 30 \leq x \leq 60 \end{cases} \quad L = (0,30,60)$$

$$\text{Moderate } \nabla \mu_{mo}(x) = \begin{cases} \frac{x-20}{30} & 20 \leq x \leq 50 \\ \frac{80-x}{30} & 50 \leq x \leq 80 \end{cases} \quad MO = (20,50,80)$$

$$\text{High } \nabla \mu_h(x) = \begin{cases} \frac{x-40}{30} & 40 \leq x \leq 70 \\ \frac{100-x}{30} & 70 \leq x \leq 100 \end{cases} \quad H = (40,70,100)$$

$$\text{Very high } \nabla \mu_{vh}(x) = \begin{cases} \frac{x-90}{30} & 60 \leq x \leq 90 \\ 1 & 90 \leq x \leq 100 \end{cases} \quad VH = (60,90,90,100)$$

c) Finally, the risk occurrence probability graph is plotted, Occurrence probability

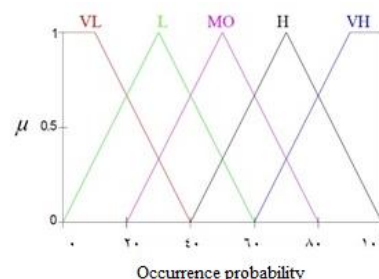


Fig. 2: The Probability Fuzzy Description.

d) The description of risk score is completely similar to the description of risk occurrence probability [5].

### 3. Determining the domain of risks impact

Domain of risk impact is studied for cost and time and eventually, it is decided to manipulate one of the fuzzy numbers; the triangular and trapezoidal ones [6].

a) First, the reference set is defined for cost and time impacts, just as the first part (2.1.4). Accordingly, we define the fuzzy function for risk impact on the time and cost of the project (Figures 3 and 4).

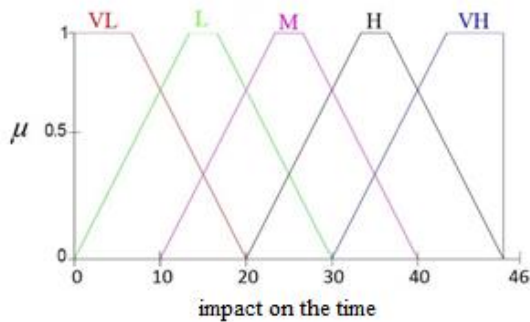


Fig. 3: The Fuzzy Description of Time Impact.

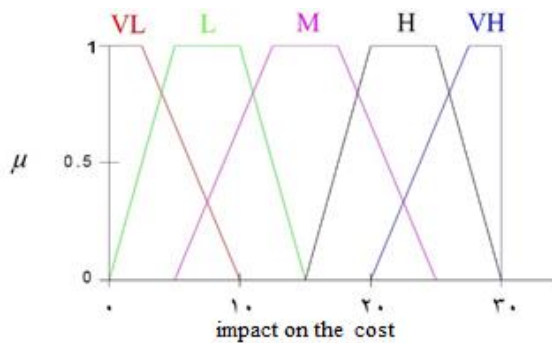


Fig. 4: The Fuzzy Description of Cost Impact.

#### Defining the "if...then" principles

In this paper, the combination of different feasible qualitative models are specified for the occurrence probability and each of the impacts, in qualitative description form of "if...then" principles. The matrix of probability impact is a 3-dimensional one, so 125 principles, corresponding to table 2, are defined, as following [6].

Principle 1. If the risk occurrence probability, the risk impact on cost and the risk impact on time are VL, then the risk score is VL.  
 Principle 2. If the risk occurrence probability, the risk impact on cost and the risk impact on time are VL, then the risk score is VL.  
 Principle 125. If the risk occurrence probability, the risk impact on cost and the risk impact on time are VH, then the risk score is VH.

Predicating the identified risks and providing raw data  
 Providing questionnaire:

The required questionnaire was codified to provide raw data, to be processed in the subsequent steps. It was done by considering the identified separated risks, according to realm and responsibility.

Determining some experts to answer the questionnaires:

9 of employer's experienced experts were opted to answer the risk management questionnaire. then; the questionnaires were distributed among them and collected after complete answering.

Specifying weight to each expert's questionnaire

It has been fulfilled by considering the experts' education, experience and management knowledge.

Table 1: Second Step; Predicating the Identified Risks and Providing Raw Data

Input	1-a list of risks and responsibilities	1.b the graphs of risks occurrence probability and the domain of impacts	1.c the table of qualitative description of "if...then" principles
predicating the identified risks and providing raw data	1-2 Codifying the questionnaire	2-2 determining some experts to answer the questionnaires	3-2 specifying sufficient weight to each expert's questionnaire
output	2-a Answered questionnaires		

### 4. Data statistical analysis by SPSS software

At first, the input data, the raw data of questionnaire is fed to the SPSS statistical analysis software. Then, the colmogrof-smerinof test is applied on them, so that their normality is asserted to be used in the following steps. for instance, normal graph of risk occurrence is depicted on Figure 6.

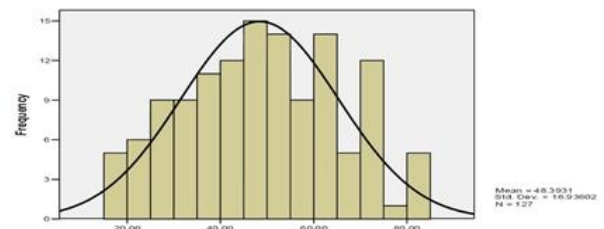


Fig. 5: Normal Graph of Risk Occurrence (Software Output).

#### Determining data frequency:

This step is necessary to calculate the weighted average. It is done by the SPSS software.

Weighting the data and determining the weighted average:

In this step, weighted average has been calculated for the center of categories by considering the each data frequency, the weight amount of each one, which is gained from step 2-3 and also each weight of expert's answer.

Analysis the risks by the fuzzy logic defining the membership functions and fuzzy plots in MATLAB software

First, the input data, the determined membership functions for risks occurrence probability and the impacts of cost and time on project, which are expressed in part (2-1-4) and (2-1-5), are fed to the software, then the principles of "if...then" table is defined, according to part (2-1-6). Also the output range is fed to the software, within the defined range of the software.

Determining the score of each risk in MATLAB software

In this part, the obtained weighted average of occurrence probability for each risk, the impact of each risk on the project time and cost, are fed. Then the score of each risk is calculated by software processing, according to the defined "if...then" principles.

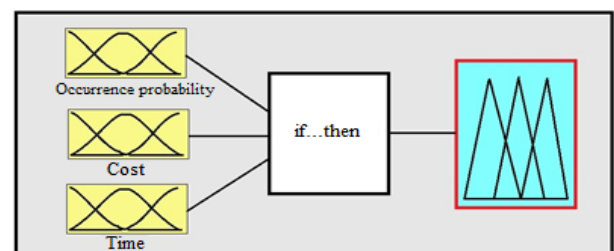


Fig. 6: The Circumstance of Calculating Risk Score in MATLAB Software.

Providing external tables and graphs  
 Risk prioritizing table:

Is provided by the weighted average values, gained from the risk occurrence probability questionnaire and also the risk impact on project cost and time and finally, the values obtained from score of

each risk by using MATLAB software and based on the fuzzy logic [6].

**Table 2:** Project Risk Ranking According to the Fuzzy Score

Risk oracle row code	Description	Risk causing agent	rence proba-Time impact	Cost impact	Risk score
1 49 F3	Imprecise geology surveys	Consulter	86% 29%	34%	78.9
2 119 L2	Inaccuracy for choosing the qualified contractor	Employer	68% 40%	28%	78.7
3 18 C8	incorrect Understanding the topography of mountainous regions	Consulter	85% 37%	24%	77.4
4 118 L1	Failure to obtain necessary approvals from the tribes and the environment	Employer	83% 41%	17%	76.2
5 64 G12	Great costs for mobilizing the workshop, owing to path	contractor	69% 42%	19%	75.7
6 87 I3	Impact of boycotting on cost growth and currency swing	other	86% 26%	28%	73.6
7 21 C11	Paradox and ambiguity in job description and technical characteristics	Consulter	66% 29%	26%	72.9
8 101 G14	Inaccurate project risks identification and assessment	contractor	71% 41%	16%	71.8
9 58 G6	Failure to supply the machinery according to the project requirements	contractor	51% 46%	21%	71.8
10 55 G3	The boss of workshop and technical office opinions frequent changes	contractor	54% 35%	28%	70.5
11 52 F6	Presenting anomaly and low rates by the contractor	contractor	72% 16%	30%	70
12 63 G11	Incomplete project execution team	contractor	66% 28%	24%	68
13 117 K13	Inaccurate project risks identification and assessment	Employer	72% 42%	26%	65.5
14 71 G19	Hesitating to make decision through the execution steps	contractor	53% 37%	21%	65.3
15 68 G16	Not doing material quality control testing during the execution steps	contractor	84% 34%	13%	64.8

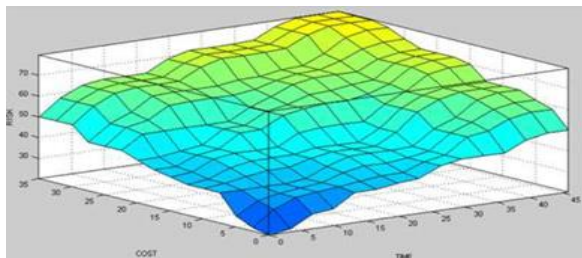
Table.2 indicates risk gained prioritized average values for the defined management realms, according to part 1.2.3 .Similarly, various tables can be obtained by using the fuzzy logic outputs to evaluate project risks by considering the available demands [6].

**Table 3:** Separated Realms Ranking, Based on Fuzzy Score

grade	Risk realm aver-age/ causing factor	Occurrence probability aver-age	Time impact average	Cost impact average	Risk score aver-age
1	Inscribing job description and designing project/consulter	56.77%	26.77%	15.77%	56.78
2	Contractor choosing process/ employer	67.33%	16.33%	18.17%	54.98
3	Project execution phase/ contractor	66%	21.33%	16%	54.1
4	Legal/ Contractual agents /employer	46.83%	23.83%	11.50%	50.48
5	Step of Defining and planning project/employer	43.32%	21.42%	17.74%	50.43
6	Consulter choosing process/ employer	43.16%	20.83%	13.50%	47.25
7	Project management/ contractor	52.38%	14.11%	10%	44.26
8	Contractor choosing process/ employer	42.86%	13.28%	11.86%	41.11
9	Project management/ employer	40.41%	14%	6.35%	39.95
10	Inscribing job description and designing project/employer	47.40%	14.30%	9%	39.58
11	Project execution phase/ employer	33.20%	15%	7.90%	39.53
12	Other agents	26%	10.50%	9.50%	32.12

### 5. D graphs of risk in MATLAB software

One of the output groups for the risk assessment are (occurrence probability- time impact- risk), (occurrence probability- cost impact- risk) and (time impact-cost impact- risk) 3- D graphs, which are plotted by using MATLAB software. For example, Figure 8 is a (time impact-cost impact- risk) 3- D graph.



**Fig. 7:** (Time Impact-Cost Impact- Risk) 3- D Graph.

### 6. Conclusion

a) In the research duration, it was denoted that the importance of risk management has not been heeded well in our country, Iran .It would be demanded to more surveys and notices be done on this issue, so that it finds a qualified position, also a significant development would be accomplished to promote

the executive agencies and organizations managers' notion and expectations about projects progression condition.

b) In this article, it has been shown that the fuzzy logic is able to become related to risk management. This method can be used for proceeding the future ambiguities, to control and manage cost and time in the development projects.

In this article, the constructing of water supplying project from Persian gulf to the south east mining industry of country was surveyed, identified, classified and prioritized .In addition, this research gives this opportunity to executive agencies to have a correct management on controlling and pursuing the reasons of risks occurrence.

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