Resistive Economics
International Journal

**The Open Access Journal of Resistive Economics (OAJRE)/**
Volume 5, Number 1, 2017 Published Online January 01
E-ISSN: 2345-4954 http://oajre.ir

**Original Article**
Pages: 17-33

# Prioritizing Risk Treatments on a Given Subterranean Oil Pipeline Project Using Fuzzy Decision Making Technique

Nafiseh Falahi[1], Farshid Abdi[2] and Sadigh Raissi[3]

Received: 2016/06/24 Revised: 2016/10/01 Accepted: 2016/11/25

**ABSTRACT:** Following dangers limitation strategies to reduce incidence possibility, intensity traces, and increase assessment capability happens in oil and gas industries have kept on focus by managers. The scope of this project is choosing the most suitable cases which reduce expenses of risks in Ilam-Ahvaz transmit pipe line reparation project. Firstly, by using the three-point Delphi method, these were recognized the most criticism dangers, and then with the help of smarts' ideas, several choices were identified against them, and finally based on fuzzy TOPSIS method, many preference strategies were introduced. Research results show that "preparation of article and equipment by go-betweens for risk prohibition", "installation control valves for earthquake risk", "quarrel resolve group prediction at the start of the agreement for deferment risk to resolve opponent pension cases", "payment credit security of external stuff to change the amount of payment", "amendment written safety recipes at the start of the project to explore and fire risks", " forecast for torrent and water eclipse", are the most important policies that following them can cause noticeable reduction in crisis dangers.

**KEYWORDS:** Risk Reduction Strategy, Oil and Gas Industries, TOPSIS Method, Phase Logic, Risk Reply Strategies.

[1] Master, Industrial Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran. *Email: nafiseh_falahi1368@yahoo.com*

[2] Assistant professor, Department of Industrial Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran. *Email: farshidabdi@azad.ac.ir*

[3] Associate professor, Department of Industrial Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran. *Email: raissi@azad.ac.ir*

# 1. INTRODUCTION

Oil industry is the most important industries in the world and in our country that these projects in industry based on their strategic and sensitive nature and also their complex technology performance attend with multiple risks. Nowadays, despite extending methods and risk management tools, it is perceptible the lack of systematic and integrated approach. Also, non-recognition of real crisis risks and also low focus on decision analysis and risks influences on project results because some disharmonies in operative usage from procedures in oil projects such as pipe lines projects (shahriari et al, 2010). Pipe lines projects are one of the most important projects in oil and gas industry that are faced in different phases (manufacturing, beneficing and reparations) with various risks which their results should be evaluated and studied (Mubin and Mubin, 2008). Considering the fact that management risk in the oil and gas pipe lines projects have been focused from many years ago by many researches, but in the responding to risk step it is seen that the decision in this context is significantly based on managers and experts ideas.

Since decision-making about response to risk is a multi-scale decision issue, so in this article by choosing suitable scales and receiving opinion of experts, the best strategy was chosen for responding to all the crisis risks. So the purpose of the current study was evaluating and prioritizing the risk management strategies to contrast with expenses risks of oil transmit pipe lines, to choose the best response.

In the second part of this paper, the theoretical fundamentals and the applied methodology are presented. Then, the studied project is explained and followed by introducing research process method and presenting research analysis. Finally, the results of subjects are presented.

# 2. RESEARCH OF VISIONARY BASIS

## 2.1. Risk Management

Risk in the project is events or probable incidence situations that if operate, they have positive or negative effect on project purposes (Project Management Association, 2005). Project risk management is “all process correlated with identification, analysis, and response to any misgiving that contains maximizing favorable results of idealistic events and minimizing unfavorable results”. Risk always is an unavoidable operative in projects, and around us. Thus, the risk management in cognition step and project design and in some words before risk event can strongly make high yield. If project risks management is unseen and does not manage correctly, the control of the work will be lost (PMBOK, 2008).

Based on work schedule that was presented by standard project management and a lot of knowledgeable persons, this project contains six following steps:

1. Planed risk management: containing decision about selecting approach, plans and risk management steps
2. Risk identification: containing specified and highlighting project risks and
3. Documentation of its features
4. Qualitative risk analysis: doing a qualitative risk analysis and conditions in order to prioritize theirs effect on project purposes
5. Quantitative risk analysis: measuring probability and consequences risks and estimate their effect on project purposes
6. Planning response to risk: production and distribution of options and proceedings to increase opportunities and decrease threats on project purposes

7. Control and monitoring risk: Tracking identified risks, residual risk monitoring, identification new risks, implementation of response to risk and evaluating their effects in project period are happened in this step (Project Management Association, 2005).

## 2.2. A Review of the Research Literature

The risk management in the oil and gas pipeline projects has been discussed by many researchers. There are so many researches for evaluating and ranking the risk of pipeline projects. Table 1 summarizes many investigations and some models presented in this field.

Table1. Conducted research in the field of risk assessment, oil and gas pipelines
(Source: Findings of research)

| Row | Method | Target | Author and Year | Source |
|---|---|---|---|---|
| 1 | Adjectival phrases - Tree Event | Assess the risks and consequences in the pipeline | Josh, 1998 | 44 |
| 2 | Analytical Hierarchy Process (AHP) | Risk-based model for inspection and maintenance of pipelines | Dey, 2001 | 29 |
| 3 | Mathematical simulation | Fire risk analysis in industrial power systems for gas pipeline | Seleznev & Alshinm,2006 | 67 |
| 4 | Leopold Matrix - Czech List Anatomy - RS and GIS tools | Impact assessment and environmental impacts of construction and operation of gas pipelines | Salehi Moaied & Karimi, 2007 | 10 |
| 5 | Probability distribution curves - the Risk Priority | Provide a simple model for the analysis and risk management projects for gas pipeline | Mubin & Mubin, 2008 | 58 |
| 6 | Multidimensional Utility Theory (MAUT) | Provide a decision model to evaluate and ranking risks of natural gas pipelines | Brito & Almiada, 2009 | 21 |
| 7 | The relative numerical weight - Multi-criteria decision analysis | Geotechnical and Environmental Risk Assessment and Management of Oil Pipelines | Fillho et al, 2010 | 34 |
| 8 | Indexing - Geographic Information System (GIS) | Risk assessment of safety, health and environmental gas pipelines | Malmasi et al, 2010 | 52 |
| 9 | Failure Mode Analysis (FMEA) | Pipeline Risk Assessment | Nwosu & Enyiche, 2011 | 61 |
| 10 | Fuzzy bow | Risk analysis of oil and gas pipelines | Shariari et al, 2012 | 68 |
| 11 | Indexing - AHP | Environmental risk assessment of gas pipelines | Jozi et al, 2012 | 45 |
| 12 | Relative risk score (RSS) - Fuzzy Logic | Developing a new fuzzy inference system for risk assessment of pipelines | Jamshidi et al, 2013 | 43 |
| 13 | Analytical Hierarchy Process - the method of least squares | landslide susceptibility assessment when choosing the appropriate route for oil and gas pipelines | Ma et al, 2013 | 51 |

In general, the phase respond of the risk has been rarely discussed in this research, which the following shows examples of these studies.

Ben & Raz (2001) used an integer programming mathematical model for reduction of the risk. The main aim of this model was to select the strategies for the risk mitigation, so that the overall costs of project risk can be minimize. Thus, this model only takes into the effects induced the costs of risk. In other words, the time-dependent effects are not considered. Kujawski (2002) developed the best strategy approach for minimizing the total project costs, by using some methods like the Decision Tree, Monte Carlo simulation, and cumulative risk profiles. Also, Kujawski divided the total project risks into two technical and managerial risks, in accord with some previous studies, which in its project only has concentrated to the technical risks (ref). Fan & co-workers (2008) designed a mathematical cost model, regarding the characteristics and other related parameters of project. The purpose of the model was to identify an optimal strategy to decline and to minimize the project risks. Wang & Hsu (2009) by using the cumulative prevision theory (CPT) planned an operational module including two sub modules, risk analysis and responding to risk modules. For analyzing this module, four risk parts, corresponding to their risks, were defined. Then, in the response step, the best strategy was chosen for each risk, according to the area corresponded to the risk. Finally, to assess the response module, an integer programming model was used. Based on an oil field development project, Darrei & Hamzei (2010) have published an article to determine a risk response strategy by the analytic network process (ANP), In order to prioritize and select the best strategy for the most important risk. A summary of these studies is shown in Table 2.

Table2. Research conducted in the field of responding to project risk
(Source: Findings of research)

| Row | Author and Year | Target | Method |
|---|---|---|---|
| 1 | Ben & Raz,2001 | Presented a mathematical model to select a set of measures to reduce risk | Integer programming |
| 2 | Kujawski, 2002 | Select the best response to the risk | Decision tree, Monte Carlo simulation and the cumulative risk profiles |
| 3 | Fan et al, 2008 | Identify an optimal strategy to reduce project risk | Mathematical model of cost |
| 4 | Wang & Hsu, 2009 | A module consists of two sub-modules designed for operational risk analysis and risk response | Cumulative Forecasting theory (CPT) |
| 5 | Darrei & Hamzei, 2010 | Determine risk response strategies to manage risk | Analytic network process (ANP) |

## 2.3. Fuzzy Multi-Criteria Decision-Making Methods

Decision making is the process of finding the best procedure among other options. It is clear that in most decision problems, the decision maker is confused, due to the multitude of criteria. In the other words, the decision maker expects to reach more than one target (Zeleny, 1992).

In the classical multi-criteria decision, it is well known the weighting of criteria, but also definitive data are not adequate to express, due to the confusion and uncertainty in the decision-maker statements. Since human judgment cannot be estimated accurately by numerical values, then, it is not possible to apply the classic decision-making methods (Mirzai chaboki, 2009).

Recently, numerous attempts have been done for overcoming to these ambiguities and uncertainties, and finally it led to apply the theory of fuzzy sets (Chen and Hwang, 1992).

Fuzzy set was introduced by Professor Lotfi Zadeh in 1965. This theory is appropriate for variable and incomparable conditions. In general, people statements are unclear, and verbal expressions such as being equal, relatively strong, very strong, infinitely strong and so on, have the same importance. The fuzzy set theory can mathematically express the qualitative statements (Smih et al, 2009). The fuzzy numbers implies the desirability of options, which it is known as fuzzy utility. This means that ranking of the options is based on comparison in their fuzzy utilities (Yeh and Deng, 2004).

## 2.4. The Fuzzy Topsis Method

The TOPSIS has been known as one of the classical multi-criteria decision-making methods, which was originally developed by Hwang and Yoon in 1981. This method is based on the shortest and longest geometric distance of the chosen alternative from the positive ideal and negative ideal solutions, respectively (Hwang and Yoon, 1981). The TOPSIS process is carried out as follows:

Step I- Calculation of the weight indices matrix-vector

Step II- Normalization of the calculated matrix and formation of a new matrix (R), as given in Eq. 1.

(١)

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}$$

The B and C symbols specify the cost and benefit criteria collections, which they can be non-scaled from equations 2 and 3. Accordingly, all the triangular fuzzy numbers are ranged in 0 to 1.

(٢)

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \qquad j \in B;$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \qquad j \in C;$$

(٣)

$$c_j^* = max c_{ij} \quad if \quad j \in B;$$

$$a_j^- = min a_{ij} \quad if \quad j \in C;$$

Step III- Definition of the weighted matrix by the equation 4.

(۴)

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}, \qquad i = 1,2,\dots,m\,, j = 1,2,\dots,n$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j$$

Step IV- determination of the positive and negative ideal solutions, according to Eq. 5.

(۵)

$$A^* = (\tilde{V}_1^*, \tilde{V}_2^*, \dots, \tilde{V}_n^*),$$

$A^- = (\tilde{V}_1^-, \tilde{V}_2^-, \dots, \tilde{V}_n^-)$,
Where $\tilde{V}^* = (1,1,1)$ and $\tilde{V}^- = (0,0,0)$ ate for j =1,2, ..., n.

Step V- calculation of each alternative distance from the positive and negative ideal solutions.

(۶)

$$d_i^* = \sum_{j=1}^{n} d(\tilde{V}_{ij}, \tilde{V}_j^*), \qquad i = 1,2, \dots, m,$$
$$d_i^- = \sum_{j=1}^{n} d(\tilde{V}_{ij}, \tilde{V}_j^-), \qquad i = 1,2, \dots, m,$$

Where the distance between two fuzzy numbers, $\tilde{V}_{ij}, \tilde{V}_j^-$ and $\tilde{V}_{ij}, \tilde{V}_j^*$ can be obtained from Eq. 7.

(۷)

$$d(\tilde{V}_{ij}, \tilde{V}_j^*) = \sqrt{\frac{1}{3}\left[\left(\tilde{V}_{ij}^* - 1\right)^2 + \left(\tilde{V}_{ij}^* - 1\right)^2 + \dots + \left(\tilde{V}_{ij}^* - 1\right)^2\right]}$$
$$d(\tilde{V}_{ij}, \tilde{V}_j^-) = \sqrt{\frac{1}{3}\left[\left(\tilde{V}_{ij}^- - 0\right)^2 + \left(\tilde{V}_{ij}^- - 0\right)^2 + \dots + (\tilde{V}_{ij}^- - 0)^2\right]}$$

Step VI- calculation and ranking the relative closeness to the ideal conditions by Eq. 8.

(۸)

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \qquad i = 1,2, \dots, m$$

## 3. DESCRIPTION OF THE CASE STUDY

The repairing and coating the 18 in. underground pipeline transport oil from Elam to Ahwaz is one of the most important projects in the field of pipeline repairing in Iran. The covering and maintenance operations (including excavation, canaling, embankment, removal of the old covers, great blast, development and implementation of polyurethane coatings, welding, cutting, concreting, running CCW, etc.) were carried out in the length of about 20 km. The time and location of project were ilam, Dasht Abbas- Ahwaz and 9 month, respectively. According to the fact that the project was completed by a further cost rather than the approved cost, so we examined the risks that directly or indirectly could increase the total costs. Also, we prioritized the critical risks and give the procedures to overcome them, and finally select the best procedure ones.

### 3.1. Project Methodology

The aim, nature and data collection method of this research are functional, exploratory, and survey method, respectively. In order to determine the best strategy, some parameters were selected for prioritizing the strategies. For this purpose, the four parameters, i.e., cost, time, quality, and resistance managers were chosen, by applying the brainstorm way and interviews with experts and managers. In final, by using the fuzzy TOPSIS method, the strategies corresponded to the critical risks, were prioritized, and the best ones was selected. It should be noted that in this research library, the inventory, individual, and group interviews were the applied tools for the data collection.

## 3.2. Data Analysis

### A) Identification of Project Risks

By applying the three stage Delphi method, it was prepared a list of risks that may occur during project performance. Next, regarding the risk impact assessment in the earlier projects, and comparing them together, the six risks were specified as critical risks. In the Table 3, the encoded risk breakdown structure has been presented.

Table3. The encoded risk breakdown structure (Source: Findings of research)

| Risk items | Type of risk | Risk Groups | Project Risk |
|---|---|---|---|
| Earthquake (+5 Richter) $R_{1-1}$<br>Heat (+50 °c) $R_{1-2}$<br>Strong winds and dust storms $R_{1-3}$<br>Flood and flooded $R_{1-4}$<br>Landslides $R_{1-5}$ | Natural $C_1$ | Project External Risk | underground pipeline repairs Elam - Ahvaz |
| Fire and explosion $R_{2-1}$<br>Existence minefields due to the war zone $R_{2-2}$ | Safety $C_2$ | | |
| Cultural conflicts and sabotage residents $R_{3-1}$<br>Litigation of organizations from each other $R_{3-2}$ | Cultural / social $C_3$ | | |
| Sanctions $R_{4-1}$<br>Administrative bureaucracy $R_{4-2}$ | Political $C_4$ | | |
| Change Currency $R_{5-1}$<br>Changes in inflation $R_{5-2}$ | Economic $C_5$ | | |
| Technical error executive workforce $R_{6-1}$<br>Equipment failure $R_{6-2}$ | Technical $C_6$ | | |
| Delays in resolving legal cases opponents $R_{7-1}$<br>Delays in payment based on contracts $R_{7-2}$<br>Lack of access to records land $R_{7-3}$ | Legal and contractual $C_7$ | Project Internal Risk | |
| Errors in the timing and sequencing of project activities $R_{8-1}$<br>Errors in the tender bid $R_{8-2}$<br>Delay in supply of goods and equipment needed for project $R_{8-3}$<br>Failure to supply high-quality and standard of goods and equipment $R_{8-4}$ | Contractor $C_8$ | | |
| Administrative changes in the work ordered by the employer $R_{9-1}$<br>Despite the weak system of assessment and selection of contractors $R_{9-2}$ | Employer $C_9$ | | |
| Injury or damage during transportation $R_{10-1}$<br>Delays in transportation $R_{10-2}$<br>Insufficient number of suppliers $R_{10-3}$ | Supplier $C_{10}$ | | |

Table 4 displays a list of the critical risks.

Table4. Critical risks affecting the project cost (source: Findings of research)

| Risk items | Class |
|---|---|
| Sanctions | Political |
| Earthquake (+5 Richter) | Natural |
| Delays in resolving legal cases opponents | Legal and contractual |
| Change Currency | Economic |
| Fire and explosion | Safety |
| Flood and Flooded | Natural |

**B) Determination of Response Strategies for Critical Project Risks**

In the repairing project of the 18 in. underground pipeline transport oil from Elam to Ahwaz, the sanctions, earthquake (+5 Richter), delays in legal issues, change currency, explosions and firing, and flooding were recognized as the most critical and effective risks on project costs. Accordingly, the underlying strategies were prepared to deal with each risk (Table 5).

Table5. Strategies to counter critical risks (Source: Findings of research)

| Row | Critical Risk | Solution |
|---|---|---|
| 1 | Sanctions | Established R & D unit<br>Protect domestic producers<br>Procurement of goods and equipment through intermediaries<br>Using the same sample of internal |
| 2 | Earthquake (+5 Richter) | Use LBV (Lions Gate)<br>Predict storage fuel tank for necessary cases |
| 3 | Delays in resolving legal cases opponents | Reconciliation and compensation<br>Legal proceedings by regulatory authorities<br>Forecasting department of dispute resolution at the beginning of contract |
| 4 | Change Currency | Currency financing of foreign goods<br>Supply of alternative goods similar from types of internal |
| 5 | Fire and explosion | Use LBV<br>Use of safety and fire machinery<br>Develop a written safety instructions at the beginning of the project |
| 6 | Flood and flooded | Use LBV<br>Reinforced concrete lining around the pipeline<br>Postpone parts of the project until the dry months of the year<br>Forecast of drain pump on specific months<br>Planning based on the weather forecast |

**C) Prioritizing Management Strategies to Critical Risks Using Fuzzy TOPSIS Method**

In reality, due to incomplete or inaccessible information, the data are usually not certainty, and they are mostly in the form of fuzzy data. Therefore, in the current study, in order to control the critical risks of oil pipelines projects, it has been tried that by using the fuzzy TOSIS method, the best strategies be prioritized and selected. Hence, the linguistic variables and Weighting of criteria are given in Table 6, and Table 7, respectively.

Table6. Linguistic variables for paired comparisons of criteria (Ganguly & Guin, 2013)

| Verbal expressions | The triangular fuzzy numbers | Reverse of triangular fuzzy numbers |
|---|---|---|
| Equal importance | (1,1,1) | (1,1,1) |
| The importance of very weak | $(\frac{1}{2},1,\frac{3}{2})$ | $(\frac{2}{3},1,2)$ |
| Weak importance | $(1,\frac{3}{2},2)$ | $(\frac{1}{2},\frac{2}{3},1)$ |
| Much importance | $(\frac{3}{2},2,\frac{5}{2})$ | $(\frac{2}{5},\frac{1}{2},\frac{2}{3})$ |
| Too much importance | $(2,\frac{5}{2},3)$ | $(\frac{1}{3},\frac{2}{5},\frac{1}{2})$ |
| Perfect or absolute importance | $(\frac{5}{2},3,\frac{7}{2})$ | $(\frac{2}{7},\frac{1}{3},\frac{2}{5})$ |

Table7. Linguistic variables for valuation of each option (Wang & Chang, 2007)

| Linguistic variable | The triangular fuzzy number |
|---|---|
| Very low | (0,1,3) |
| Low | (1,3,5) |
| Average | (3,5,7) |
| High | (5,7,9) |
| Very high | (7,9,10) |

First, the Chang analysis method was applied to determine the importance level of criteria. The stages of estimation of the importance level of criteria are included:
Step I: For each row of the paired comparison matrix (Table 8), the S as a triangular fuzzy number was evaluated by Eq. 9:

(٩)

$$S_k = \sum_{j=1}^{n} M_{kj} \times [\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}]^{-1}$$

$S_1$ = (3.81, 4.52, 5. 35) × (0.04816, 0.05903, 0.07107) = (0.1538, 0.2668, 0.3802)
$S_2$ = (4.02, 4.97, 6.25) × (0.04816, 0.05903, 0.07107) = (0.1936, 0.2933, 0.4441)
$S_3$ = (3.95, 4.73, 5. 89) × (0.04816, 0.05903, 0.07107) = (0.1902, 0.2792, 0.4186)
$S_4$ = (2.29, 2.72, 3. 27) × (0.04816, 0.05903, 0.07107) = (0.1102, 0.1605, 0.2323)

Table8. The consensus matrix of expert opinion in the case of paired comparisons of criteria (Source: Findings of research)

| | Cost | Time | Quality | Resistance Leaders |
|---|---|---|---|---|
| **Cost** | (1,1,1) | (0.80,0.90,1.00) | (0.79,1.02,1.27) | (1.22,1.60,2.08) |
| **Time** | (1.00,1.10,1.23) | (1,1,1) | (0.84,1.22,1.27) | (1.18,1.65,2.34) |
| **Quality** | (0.78,0.96,1.25) | (0.59,0.81,1.18) | (1,1,1) | (1.58,1.96,2.46) |
| **Resistance Leaders** | (0.47,0.62,0.81) | (0.42,0.60,0.83) | (0.40,0.50,0.63) | (1,1,1) |

Step II: After calculation S, it must be obtained the large degree of them, Calculated as follows:

(10)

$$V(M_2 > M_1) = hgt(M_1 \cap M_2)$$

$$\begin{cases} 1 & m_2 \geq m_1 \\ 0 & l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{سایر موارد} \end{cases}$$

Table9. Large degree (s) relative to each other (Source: Findings of research)

| **Cost** | **Time** | **Quality** | **Resistance Leaders** |
|---|---|---|---|
| $V(D_1 \geq D_2) = 1$<br>$V(D_1 \geq D_3) = 1$<br>$V(D_1 \geq D_4) = 0.426$ | $V(D_2 \geq D_1) = 0.875$<br>$V(D_2 \geq D_3) = 0.941$<br>$V(D_2 \geq D_4) = 0.225$ | $V(D_3 \geq D_1) = 0.938$<br>$V(D_3 \geq D_3) = 1$<br>$V(D_3 \geq D_4) = 1$ | $V(D_3 \geq D_1) = 1$<br>$V(D_3 \geq D_3) = 1$<br>$V(D_3 \geq D_4) = 1$ |

According to second step for calculation weighted criteria matrix:

(۱۱)

$$W'_{(x_i)} = \text{Min}\,\{V(S_i \geq S_k)\} \quad k = 1,2,\dots,n \quad k \neq i$$

Min V ($S_1$> $S_2$, $S_3$, $S_4$) = Min (1, 1, 0.426) = 0.426
Min V ($S_2$> $S_1$, $S_3$, $S_4$) = Min (0.875, 0.941, 0.225) = 0.225
Min V ($S_3$> $S_1$, $S_2$, $S_4$) = Min (0.938, 1, 1) = 0.938
Min V ($S_4$ > $S_1$, $S_2$, $S_3$) = Min (1, 1, 1) = 1

So the non-normalized weight vector calculated as follows:

(۱۲)

$$W'_{(x_i)} = [W'_{(c_1)}, W'_{(c_2)}, \dots, W'_{(c_n)}]^T$$

Step IV: At the end, the non-scale weight vector of the third step and weight vector of criteria calculate as follows:

(۱۳)

$$W_{(x_i)} = [W_{(c_1)}, W_{(c_2)}, \dots, W_{(c_n)}]^T$$

W = (0.164, 0.086, 0.362, 0.386)

In accord with the weighting of criteria, the resistance of managers has the greatest impact.

In the Table 10, which is the initial step of the decision-making process, the importance of each solutions corresponded to the six critical risks with respect to the four criteria (cost, time, quality, and resistance of managers) is measured, and the Quantitative variables are replaced with the corresponding value, according to Table 7.

Table10. Integration matrix of expert opinion (Source: Findings of research)

| | **Cost** | **Time** | **Quality** | **Resistance Leaders** |
|---|---|---|---|---|
| Established R & D unit | (4.50,6.50,8.25) | (4.50,6.50,8.00) | (6.00,8.00,9.50) | (5.50,7.50,9.00) |
| Protect domestic producers | (4.50,6.50,8.25) | (3.25,5.00, 6.75) | (3.00,5.00,7.00) | (3.50,5.50,7.50) |

| | | | | |
|---|---|---|---|---|
| Procurement of goods and equipment through intermediaries | (3.75,5.50,7.25) | (2.75,4.50,6.50) | (4.00,6.00,8.00) | (1.75,3.50,5.50) |
| Using the same sample of internal | (3.50,5.50,7.25) | (2.25,4.00,5.75) | (1.00,3.00,5.00) | (2.50,4.00,6.00) |
| Use LBV (Lions Gate) | (4.25,6.00,7.75) | (4.00,6.00,7.75) | (4.50,6.50,8.00) | (2.25,4.00,6.00) |
| Predict storage fuel tank for necessary cases | (4.00,6.00,7.75) | (1.75,3.50,5.50) | (0.75,2.50,4.50) | (3.25,5.00,6.75) |
| Reconciliation and compensation | (4.50,6.50,8.00) | (0.75,2.50,4.50) | (3.50,5.50,7.50) | (3.75,5.50,7.25) |
| Legal proceedings by regulatory authorities | (4.00,6.00,7.75) | (6.00,8.00,9.50) | (2.00,4.00,6.00) | (1.25,3.00,5.00) |
| Forecasting department of dispute resolution at the beginning of contract | (1.75,3.50,5.50) | (1.50,3.00,5.00) | (3.00,5.00,7.00) | (2.25,4.00,6.00) |
| Currency financing of foreign goods | (3.00,5.00,7.00) | (0.25,1.50,3.50) | (6.00,8.00,9.50) | (3.25,5.00,7.00) |
| Supply of alternative goods similar from types of internal | (3.00,5.00,6.75) | (2.25,4.00,6.00) | (0.75,2.50,4.50) | (2.75,4.50,6.50) |
| Use LBV | (4.25,6.00,7.75) | (3.75,5.50,7.25) | (5.50,7.50,9.00) | (3.25,5.00,7.00) |
| Use of safety and fire machinery | (2.00,4.00,6.00) | (0.25,1.50,3.50) | (4.00,6.00,8.00) | (0.25,1.00,3.50) |
| Develop a written safety instructions at the beginning of the project | (0.75,2.50,4.50) | (0.25,1.50,3.50) | (5.00,7.00,8.75) | (1.25,2.50,4.50) |
| Use LBV | (4.25,6.00,7.75) | (3.00,4.50,6.25) | (3.25,5.00,6.75) | (3.75,5.50,7.50) |
| Reinforced concrete lining around the pipeline | (3.25,5.00,7.00) | (3.00,5.00,7.00) | (5.00,7.00,8.75) | (1.75,3.50,5.50) |
| Postpone parts of the project until the dry months of the year | (3.50,5.50,7.50) | (5.00,7.00,9.00) | (5.00,7.00,8.75) | (4.00,6.00,7.75) |
| Forecast of drain pump on specific months | (2.50,4.50,6.50) | (1.75,3.50,5.50) | (2.50,4.50,6.50) | (1.25,3.00,5.00) |
| Planning based on the weather forecast | (1.00,2.50,4.50) | (1.00,2.50,4.50) | (6.00,8.00,9.50) | (1.75,3.50,5.50) |

The non-scaled fuzzy matrix is given in Table 11.

Table11. The fuzzy weighted normalized matrix (Source: Findings of research)

| | **Cost** | **Time** | **Quality** | **Resistance Leaders** |
|---|---|---|---|---|
| Established R & D unit | (0.068,0.086,0.126) | (0.024,0.029,0.043) | (0.228,0.304,0.362) | (0.073,0.088,0.119) |
| Protect domestic producers | (0.068,0.086,0.126) | (0.028,0.038,0.059) | (0.112,0.188,0.264) | (0.088,0.119,0.193) |
| Procurement of goods and equipment through intermediaries | (0.078,0.103,0.152) | (0.029,0.043,0.069) | (0.152,0.228,0.304) | (0.119,0.193,0.386) |
| Using the same sample of internal | (0.078,0.103,0.164) | (0.033,0.048,0.086) | (0.036,0.112,0.188) | (0.111,0.165,0.270) |
| Use LBV (Lions Gate) | (0.083,0.108,0.154) | (0.018,0.024,0.036) | (0.202,0.293,0.362) | (0.142,0.216,0.386) |
| Predict storage fuel tank for necessary cases | (0.083,0.108,0.164) | (0.026,0.043,0.086) | (0.032,0.112,0.202) | (0.127,0.173,0.266) |
| Reconciliation and compensation | (0.034,0.042,0.062) | (0.010,0.020,0.080) | (0.166,0.264,0.362) | (0.065,0.084,0.127) |
| Legal proceedings by regulatory authorities | (0.036,0.047,0.070) | (0.006,0.007,0.010) | (0.094,0.191,0.289) | (0.096,0.158,0.386) |
| Forecasting department of dispute resolution at the beginning of contract | (0.050,0.082,0.164) | (0.012,0.021,0.043) | (0.144,0.238,0.336) | (0.077,0.119,0.212) |
| Currency financing of foreign goods | (0.068,0.098,0.164) | (0.006,0.013,0.086) | (0.228,0.304,0.362) | (0.150,0.212,0.324) |
| Supply of alternative goods similar from types of internal | (0.072,0.098,0.164) | (0.003,0.005,0.009 | (0.025,0.094,0.170) | (0.162,0.235,0.386) |
| Use LBV | (0.014,0.019,0.027) | (0.002,0.003,0.005) | (0.220,0.300,0.362) | (0.011,0.019,0.027) |
| Use of safety and fire machinery | (0.019,0.029,0.060) | (0.006,0.013,0.086) | (0.159,0.238,0.318) | (0.027,0.061,0.386) |
| Develop a written safety instructions at the beginning of the project | (0.026,0.049,0.164) | (0.006,0.013,0.086) | (0.199,0.278,0.351) | (0.019,0.038,0.077) |
| Use LBV | (0.019,0.026,0.037) | (0.013,0.018,0.028) | (0.123,0.188,0.257) | (0.061,0.084,0.127) |
| Reinforced concrete lining around the pipeline | (0.022,0.032,0.049) | (0.012,0.017,0.028) | (0.188,0.264,0.333) | (0.084,0.135,0.274) |
| Parts of the project until the dry months of the year | (0.021,0.029,0.045) | (0.009,0.012,0.017) | (0.188,0.264,0.333) | (0.061,0.077,0.119) |
| Postpone parts of the project until the dry months of the year | (0.024,0.036,0.065) | (0.015,0.024,0.049) | (0.094,0.170,0.246) | (0.096,0.158,0.386) |
| Planning based on the weather forecast | (0.036,0.065,0.164) | (0.018,0.034,0.086) | (0.228,0.304,0.362) | (0.084,0.135,0.274) |

In the third step of the decision-making process, the non-scaled weight matrix was obtained by equations 2, 3, and 4, in accord with Table 11. In the next step, the positive and negative ideal point set can be calculated by applying equations 5 and 6. The positive and negative ideal points represent the distances from positive and negative ideal solutions, respectively. Then, whatever the indices respectively have more and less distance from negative and positive ideal solutions, they have higher priority. The closeness coefficients, calculating from Eq. 8, show the importance of indices. This means that, whatever the closeness coefficients be higher, the variables are better ranking.
Table 12 gives the positive and negative ideal points, the closeness coefficients, and the final ranking strategies corresponded to each critical risk.

Table12. Set of ideal points of positive, negative and final weights of alternatives (Source: Findings of research)

| | **Solution** | $d_i^+$ | $d_i^-$ | $CC_i$ | **Rank** |
|---|---|---|---|---|---|
| Sanctions | Established R & D unit | 3.485 | 0.526 | 0.131 | ۲ |
| | Protect domestic producers | 3.547 | 0.476 | 0.118 | ۴ |
| | Procurement of goods and equipment through intermediaries | 3.392 | 0.658 | 0.162 | 1 |
| | Using the same internal sample | 3.540 | 0.500 | 0.123 | ۳ |
| Earthquake (+5 Richter) | Use LBV (Lions Gate) | 3.335 | 0.705 | 0.174 | ۱ |
| | Predict storage fuel tank for necessary cases | 3.531 | 0.511 | 0.126 | ۲ |
| Delays in resolving legal cases opponents | Reconciliation and compensation | 3.566 | 0.465 | 0.115 | ۳ |
| | Legal proceedings by regulatory authorities | 3.550 | 0.514 | 0.126 | ۲ |
| | Forecasting department of dispute resolution at the beginning of contract | 3.507 | 0.535 | 0.132 | ۱ |
| Change Currency | Currency financing of foreign goods | 3.335 | 0.709 | 0.175 | ۱ |
| | Supply the alternative goods similar to the internal types | 3.534 | 0.513 | 0.126 | ۲ |
| Fire and explosion | Use LBV | 3.665 | 0.402 | 0.098 | ۳ |
| | Use of safety and fire machinery | 3.665 | 0.341 | 0.085 | ۲ |
| | Develop a written safety instructions at the beginning of the project | 3.570 | 0.482 | 0.118 | ۱ |
| Flood and flooded | Use LBV | 3.675 | 0.337 | 0.083 | ۵ |
| | Reinforced concrete lining around the pipeline | 3.526 | 0.504 | 0.125 | ۳ |
| | Postpone parts of the project until the dry months of the year | 3.610 | 0.402 | 0.100 | ۴ |
| | Forecast of drain pump on specific months | 3.504 | 0.504 | 0.125 | ۲ |
| | Planning based on the weather forecast | 3.411 | 0.643 | 0.158 | ۱ |

Based on table (12) it is seen that by considering time, cost, quality and managers resistance as four yardsticks to prohibit risk, stuff preparation and equipment by go-betweens for earthquake risk (+5), use LBV (control valves), for subsequence risk to solvers the opponents' rights, quarrel solvers prospect at the first step of agreement, for expenses rate changes risk, abroad stuffs of security estimate expenses, for fire and explore risk, safety written edition recipes at the first step of the project and for flood risk, planning based on forecast is selected as the best reply strategies.

## 4. CONCLUSIONS

Utilizes opinion of experts result ideas in Delphi method in three stages, a list of elementary expenses risks is identified that is written in table (13). In this table among all risks, six crisis risks are identified that has the maximum happening effect in increasing project expenses which are different from the others in this table.

Table13. Lists of the main and critical risks (Source: Findings of research)

| The main risks and crises affecting the project cost | |
|---|---|
| Equipment failure | Earthquake (+5 Richter) |
| Delays in resolving legal cases opponents | Heat (+50 c) |
| Delays in payment based on contracts | Strong winds and dust storms |
| Lack of access to records land | Flood and flooded |
| Errors in the timing and sequencing of project activities | Landslides |
| Errors in the tender bid | Fire and explosion |
| Delay in supply of goods and equipment needed for project | Existence minefields due to the war zone |
| Failure to supply high-quality and standard of goods and equipment | Cultural conflicts and sabotage residents |
| Administrative changes in the work ordered by the employer | Litigation of organizations from each other |
| Despite the weak system of assessment and selection of contractors | Sanctions |
| Injury or damage during transportation | Administrative bureaucracy |
| Delays in transportation | Change Currency |
| Insufficient number of suppliers | Changes in inflation |
| | Technical error executive workforce |

Also in table (14) there are some presented works for each crisis risks and best of them with preference grant based on closed coefficient.

Table14. Measures to deal with the critical risks and their priority index
(Source: Findings of research)

| Priority rating | Solution | risk |
|---|---|---|
| ۰/۱۶۲ | Procurement of goods and equipment through intermediaries | Sanctions |
| ۰/۱۳۱ | Established R & D unit | |
| ۰/۱۲۳ | Using the same sample of internal | |
| ۰/۱۱۸ | Protect domestic producers | |
| ۰/۱۷۴ | Use LBV (Lions Gate) | Earthquake (5 + Richter) |
| ۰/۱۲۶ | Predict storage fuel tank for necessary cases | |
| ۰/۱۳۲ | Reconciliation and compensation | Delays in resolving legal cases opponents |
| ۰/۱۲۶ | Legal proceedings by regulatory authorities | |
| ۰/۱۱۵ | Forecasting department of dispute resolution at the beginning of contract | |
| ۰/۱۷۵ | Currency financing of foreign goods | Change Currency |
| ۰/۱۲۶ | Supply of alternative goods similar to internal types | |
| ۰/۱۱۸ | Develop a written safety instructions at the beginning of the project | Fire and explosion |
| ۰/۰۹۸ | Use LBV | |
| ۰/۰۸۵ | Use of safety and fire machinery | |
| ۰/۱۵۸ | Planning based on the weather forecast | Flood and flooded |
| ۰/۱۲۵ | Reinforced concrete lining around the pipeline | |
| ۰/۱۲۵ | Forecast of drain pump on specific months | |
| ۰/۱۰۰ | Postpone parts of the project until the dry months of the year | |
| ۰/۰۸۳ | Use LBV | |

By reviewing papers in the field of oil and gas pipe lines risk projects it is viewed that generally in reply to decision step based on managers, experts and researches has been scheduled in reply field and choosing the best answer to the risk are not done in these projects. So in this project the fuzzy TOPSIS method was used for priorities methods against crisis risks and choosing the best answer.

Recommended method has these advantages:

1- Participating of experts and decision-makers in decision process, causes increasing acceptance of results to work.
2- Recommended method based on fundamentals of scientific decision which give this possibility to managers to choose suitable options from presented options focused on limitations and presented resources.
Use a phase logic in decision caused math modeling to cover uncertainty of votes from the mind of experts.

## ACKNOWLEDGMENTS

None.

## ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

**AUTHOR CONTRIBUTIONS**

Planning and writing of the manuscript was done by the authors.

**CONFLICT OF INTEREST**

Author/s confirmed no conflict of interest.

## REFERENCES:

Hwang, C. L., & Yoon, K (1981), "Multi attribute decision making methods and applications: a state-of-the-art survey", Berlin, Springer.

Chen, S. J., & Hwang, C.L (1992), "Fuzzy multiple attribute decision making methods and applications", Berlin; New York: Springer-Verlage.

Zeleny, M., (1992), "Multiple Criteria Decision Making", McGraw-Hill, New York.

Ben, D., & Raz, T (2001), "An integrated approach for risk response development in project planning", The Journal of the Operational Research Society, 52(1), pp. 14-25.

Kujawski, E (2002), "Selecting of technical risk responses for efficient contingencies", Journal of Systems Engineering, 5(3), pp. 194-212.

Yeh, C.H, & Deng, H (2004), "A practical approach to fuzzy utilities comparison in fuzzy multi-criteria Analysis", International Journal of Approximate Reasoning, 35 (2), pp. 179-194.

Project Management Association (2005), "Book of project management body of knowledge", version 2000- translators: Seied Hosein Osouli, Ali Bayat, Hosein Naseri, Ali Afkhami- Publishing Petrochemical company industries, Research and development of project management, first print(In Persian).

Wang, T. C., & Chang, T. H (2007), "Application of TOPSIS in evaluating initial aircraft under a fuzzy environment", Expert Systems with Applications, 33(11), 870-880.

Fan, M., Lin, N., and Sheu, C (2008), "Choosing a project risk-handling strategy: An analytical model", International Journal of Production Economic, 112(2), pp. 700-713.

Mubin, S., & Mubin, G (2008), "Risk analysis for construction and operation for gas pipeline projects in Pakistan", Pakistan Journal of Engineering and Applied Science, Vol. 2, pp. 22-37.

Project Management Institute MI. (2008), "A guide to the project management body of knowledge (PMBOK Guide) (4ed.)", USA: Project Management Institute Inc.

Smih, O., Selin, S., & Elif, I (2009), "Long term supplier selection using a combined fuzzy MCDM approach: A case Study for a telecommunication company", Journal of Expert Systems with Applications, Vol. 36(2), pp. 3887-3895.

Wang, H., & Hsu, F (2009), "An integrated operation module for individual risk management", European Journal of Operational Research, 198(2), pp. 610-617.

Derri, B., & Hamzei.A (2010), "Strategy appointment of risk reply in manager by ANP technic (case study: oil square development of Azadegan north", Industrial management, second course, number 4, 75-92(In Persian).

Mirzai Chaboki, Mohsen (2009), " Strategy edition for Chooka company and strategies ranking with phase Topsis technic", Nourbakhsh, Seied Kamran, MSc thesis of Islamic Azad University, Central Tehran Unit, management college(In Persian).

Shahriari, A., Sadigh, R., & Tesfamariam S (201٠), "Risk analysis for oil & gas pipelines: a sustainability assessment approach using fuzzy based bow-tie analysis", Journal of Loss Prevention in the Process Industries, Vol. 25, pp. 505-523.

Ganguly, K., and Guin, K. K., (2013), "A fuzzy AHP approach for inbound supply risk assessment", Benchmarking: An International Journal, 20.