Identify and prioritize the factors influencing project risk by using AHP & VIKOR Fuzzy
(Case Study: South Pars Gas Complex)

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Abstract
Risk Management is one of The Basic and Important Subjects of The Project. So in This Research, First The Risk of South Pars Gas Complex In Iran Will Be Recognized. Then The Wight of Every One of These Standards is ranked in The Method of FAHP and Finally the Ranking of Suggested Options of Research Will Be Considered with the Method of VIKOR.

The main criteria for this study include: Financial factors, Factors related to the employer, Management factors and Factors relating to the contract. For each of these criteria Measures intended to As Selected 32 Sub criteria in sum. The results indicate that Fiscal agent with normal weight 0.349, Have The highest priority. Also The best choice As a means of reducing risk, Method of SHA&SSHA, is selected as the preferred option.

Keywords: Project Risk, Risk Management, AHP Method, VIKOR Method, Method of SHA&SSHA.

1 Introduction

The major changes of business setting such as globalization and high rate of technological changes have led to increase of competition and managerial complications in the organizations. In such complicated settings, the managers should consider and categorize the innate complexities during their significant decision making [14]. An effective risk management based on a valid conceptual principle is a significant part of this decision-making process. In the present study, this principle is discussed through identification of main elements of risk, studying the potential effects of these elements upon the success of organization, and the analysis of the ways to deal with and manage risks [11].

The experiences of major projects of the past in Iran show that one of the primary factors of failure of projects is lack of sufficient attention to presence of uncertainty and risk of projects. Most of the projects do not end within the limits of their assigned time and project. One can point to ignorance of risk management and its undeniable significance in projects as the main reasons of this lack of success [15].

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The risk identification is the first step in the process of risk management in which the potential risks associated with oil and gas projects are identified. When the project risks are identified and analyzed, the strategy of response to risk should be applied so as to deal with risks during the implementation of projects. Of course, the risk management cannot completely remove risks but though identification of proper strategies, it helps the project owners to manage the risks [1].

As a result, regarding the insecure essence of projects and necessity of efficient application of resources, each project faces some uncertainties. The existence of risk and uncertainty in project leads to lower accuracy in proper estimation of objectives and reduction of efficiency of projects. Therefore, the need for identification and management of risk of project risks is completely evident [3].

In this regard, the present study identifies the risk of projects of South Pars Gas Complex and then, fuzzy AHP method is used to prioritize the weight of each criterion. After all, the VIKOR method is applied to prioritize the suggested options of present study [17].

2 Literature Review

Nasirzade in his M.sc dissertation dealt with “study and analysis of rink in construction projects”. In this regard, the researcher used the concepts of project control to introduce some solutions for timely identification of risk and offered a method to get to the roots of risks within the executive stages of a project with the objective of prevention from their recurrence. In addition, a method was developed to analyze the delays during the project and determine the share of each factor in the resulting delay. In the end, a computer program was developed for facilitation of application of these methods [13].

Mojtahedi et.al (2012) identified and evaluated the project risks through multi-criteria decision making techniques. In this study, they suggested a method for identification and evaluation of risks of oil and gas projects through one of the multi-criteria decision making methods and found out that external factors are the most significant reasons for increase of risk projects [9].

Nori and Faraji (2012) in a study titled “the study of delay factors of civil engineering projects and offering a technique for reducing delay time of delay” studied the factors of delaying projects of civil engineering and offered a model to reduce delay duration. The results showed that the three factors of financial problems, land ownership, and design and study were the most significant factors of delay [5].

Vatankhah (2011) did a case study on three construction projects and reported that lack of proper workforce, inefficient information system, and weakness in structure, planning, budgeting and lack of precise design and evaluation of projects are the most important factors of delay. Although he believed that lack of assigning sufficient budget is the primary reason behind increase of duration of executive stage of the projects but he considered this factor to be influenced by mismanagement and structural problems of national executive and technical systems [18].

Chan and Kumaraswamy (2011) compared the risk factors of projects in 11 countries and concluded that the risk factors, especially among developing countries, are identical. For instance, in these countries the improper estimation and design, weak project management and insufficiency of materials are among the significant risk factors. This is while the risk factors in developed countries such as US and England are related to justified delay reasons such as undesirable climate or performance of human resources [10].

Li et.al (2009) studied the issue of “risk management in major engineering projects through basin-hopping algorithm. In this study, they dealt with risk management of shipbuilding industry through basin-hopping algorithm and identified the difference of efficiency risks of project among shipbuilding companies of large and medium scale [20].
3 Theoretical Foundations

3.1. Definition of Risk

To understand the nature of risk, one should initially start from its definition. Although there are many differences in the ways of defining risk but the following definition shows its essence in general.

“Risk is the probability of loss”. This definition includes two aspects of risk. First, the value of loss should be probable. Second, lack of confidence in regard to the loss should exist [4].

3.2. Risk management

In a proper risk management, a prioritization process is used in which the risks of highest loss and highest probability of occurrences followed by risks with lower possibility and loss are studied. In practice, this process might be very difficult and in most of the cases, creating a balance among the risks of high possibility and low loss and the ones with low possibility and high loss might not be handled properly. As a result, the risks within the organization could be studied from these two aspects [25].

3.3. Analytical Hierarchy process

The Analytical Hierarchy process is one of the most famous techniques of multipurpose decision making which was first introduced by Thomas Saati in 1970s. This technique analyzes the complicated problems based on their mutual effects, convert them into a simple form and solve them [26]. This decision-making method is based on paired comparisons. The decision maker starts with offering a hierarchical decision-making tree. This tree shows the compared factors and evaluated alternative decision choices. Then, a series of paired comparisons is done. These comparisons show the weight of each factor in relation to the evaluated alternative decision choices. Finally, the logic of hierarchical analysis process combines the matrices of paired comparison in a way that an optimal decision is obtained [7].

3.4. VIKOR technique

The VIKOR technique was introduced by Opricovic (1984). This method is one of the multi-criteria decision-making methods for selecting the best option. This technique, in addition to offering two reference points as ideal negative and positive points, considers the relative significance of the interval between them. The VIKOR method uses linear normalization in which the normalized value is not dependent upon its measurement unit [24].

3.5. South Pars Oil and Gas Company

The Pars Oil and Gas Company (POGC) was founded in 1998/10/20 as one of the subordinate companies of National Iranian Gas Company to use the development phases of south pars gas field. This company is responsible for using land facilities of all ten phases of South Pars. The development plan of all 10 phases of gas fields of South Pars was done by Pars Oil and Gas Company (POGC) as one of the subordinate companies of Iranian National Oil Company though signing development contracts of different phases of South Pars with Iranian and international contractors as EPSCE and mostly through foreign investment.

4 Methodology

Due to the fact that the main objective of present study is to offer proper solutions for reduction of risks of projects of South Pars gas field, one could say that the present study is applied in its objective. Because the present study used the methods of library study and field-based methods such as questionnaire, one could say that the present study is a descriptive survey in its essence and methodology. Riza and Vazilis (1988) pointed out that the number of experts as interviewees shouldn’t be too many and they suggested 5 to 15 individuals. In sum, 15 experts were included in the sample.

The number of experts is determined through Cochran’s formula as shown in equation (4.1).
\[ n = \frac{N Z_{\alpha/2}^2 p(1-p)}{\varepsilon^2 (N-1) + Z_{\alpha/2}^2 p(p-1)} \]  

(4.1)

In this regard:
n represents the size of sample
N refers to size of population
P shows the rate of success (equal to 0.5 to determine the largest sample size)
\( \varepsilon \) refers to the degree of error based on previous studies (considered as equal with 22%)
\( Z_{\alpha/2} \) represents the area under normal diagram in the level of 95% (i.e. equal with 1.96) [6].

The main questionnaire used is the expert questionnaire. The expert questionnaire is used to prioritize the primary criteria of selecting the method of doing a project through paired comparison techniques of hierarchical and VIKOR analysis. These questionnaires are set based on 9 point scale.

4.1. Validity and Reliability of Data Collection Instrument
The condition for collecting good data is to ascertain of validity and reliability of measurement method of a phenomenon. Reliability refers to the extent that the measurement instrument obtains identical results in identical conditions [8]. The concept of validity answers the question that to what extent the measurement instrument measures the intended characteristic. To measure the validity of the questionnaire, the method of construct validity with KMO (Kaiser-Mayer-Olkin) index. If the level of this index gets close to (4.1), the intended data has sufficient validity and otherwise (i.e. less than 0.6), the intended data lacks desired validity. To verify the reliability of the questionnaire, the Cronbach’s alpha method is used. If it ranges from 0.5 to 0.7, the questionnaire has medium reliability. If the value of Cronbach’s alpha coefficient is equal with or higher than 0.7, the questionnaire had sufficient reliability but if its value is less than 0.5, the questionnaire has proper reliability. These values are shown in tables 1 and 2.

<table>
<thead>
<tr>
<th>Table 1: KMO index</th>
</tr>
</thead>
<tbody>
<tr>
<td>KMO index</td>
</tr>
<tr>
<td>0.712</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s alpha</td>
</tr>
<tr>
<td>Number of items</td>
</tr>
<tr>
<td>0.799</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

5 Research Findings
The main criteria of present study are financial factors, factors associated with employer, managerial factors and factors related to contractor. For each criterion, some items were considered so that 32 sub-criteria were selected. The criteria and sub-criteria of present study are shown in figure 1.
5.1. Prioritization of Influential Factors upon Project Risk

First, 30 questionnaires were distributed among the experts and the collected data from experts and previous studies were used to identify the associated factors. After identifying the factors, each expert does the paired comparison of elements through 9-degree scale shown in table 3 and offers his idea.

Table 3: Scoring the expert questionnaire

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Comparison of i to j</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index I have equal importance than index j</td>
<td>Equally Preferred</td>
<td>1</td>
</tr>
<tr>
<td>Index I a little importance than index j</td>
<td>Moderately Preferred</td>
<td>3</td>
</tr>
<tr>
<td>Index I importance than index j</td>
<td>Strongly Preferred</td>
<td>5</td>
</tr>
<tr>
<td>Index I Very importance than index j</td>
<td>Very strongly Preferred</td>
<td>7</td>
</tr>
<tr>
<td>Index I Exactly importance than index j</td>
<td>Extremely Preferred</td>
<td>9</td>
</tr>
<tr>
<td>Intermediate Value</td>
<td>Intermediate</td>
<td>2-4-6</td>
</tr>
</tbody>
</table>

In the next step, the main criteria are compared in pair based on the objective. The paired comparison is really easy and all elements of each cluster are compared in pairs. Therefore, if there is n element(s) in a cluster, \( \frac{n(n-1)}{2} \) comparisons are done. Because there are four criteria, the number of comparisons are shown in relation (5.2).

\[
\frac{n(n - 1)}{2} = \frac{4(4 - 1)}{2} = 6
\]  

(5.2)

Afterwards, the quantification of experts’ viewpoint is done through fuzzy scale. The geometric mean shown in relation (5.3) (i.e. each one of triangular fuzzy numbers) is used to obtain a general perspective of experts’ viewpoints.
\[ F_{AGR} = (\prod(l), \prod(m), \prod(u)) \] (5.3)

In the next step, the matrix of paired comparison is formed by using fuzzy geometric mean of experts’ opinions and the calculation of fuzzy sum of each row as shown in relation (5.4) is used to form the eigenvector of paired comparison matrix.

\[ \sum_{j=1}^{n} M_{gj}^{j} \] (5.4)

After developing the paired comparison matrix, the fuzzy sum of set of elements in the preference column is calculated and normalization of preferences of each criterion is done. In this regard, the reverse sum is calculated and the fuzzy sum of each row is multiplied by the reverse product of multiplication. Each one of the obtained values are the fuzzy and normalized weight of primary criteria. These items are shown in relation (5.5) and table 4 and 5.

\[ F_{1}^{-1} = (1/u_{1}, 1/m_{1}, 1/l_{1})(\sum_{i=1}^{n} \sum_{j=1}^{n} M_{gj}^{j})^{-1} = (0.05, 0.06, 0.07) \] (5.5)

<table>
<thead>
<tr>
<th>Table 4: Fuzzy Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.54</td>
</tr>
<tr>
<td>5.08</td>
</tr>
<tr>
<td>5.88</td>
</tr>
<tr>
<td>3.04</td>
</tr>
<tr>
<td>21.55</td>
</tr>
<tr>
<td>0.067</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5: Fuzzy weighted and normalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.504</td>
</tr>
<tr>
<td>0.340</td>
</tr>
<tr>
<td>0.393</td>
</tr>
<tr>
<td>0.203</td>
</tr>
</tbody>
</table>

In the last step, the center of gravity method shown in relation (5.5) is used to do the defuzzification of values and calculate the crisp number. Then, the obtained numbers are used to prioritize the factors as shown in table 6.

\[ x_{max}^{1} = \frac{l + m + u}{3} \]
\[ x_{max}^{3} = \frac{l + 2m + u}{4} \]
\[ x_{max}^{2} = \frac{l + 4m + u}{6} \]

Crisp number = \( Z^* = \max \{ x_{max}^{1}, x_{max}^{2}, x_{max}^{3} \} \) (5.6)
Table 6: Calculations for Determine of The main criteria’ Priority

<table>
<thead>
<tr>
<th>Normal</th>
<th>Defuzz</th>
<th>X1max</th>
<th>X2max</th>
<th>X3max</th>
<th>X1max</th>
<th>Financial factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.349</td>
<td>0.364</td>
<td>0.356</td>
<td>0.360</td>
<td>0.364</td>
<td>0.349</td>
<td>Factors related to the employer</td>
</tr>
<tr>
<td>0.241</td>
<td>0.251</td>
<td>0.247</td>
<td>0.249</td>
<td>0.251</td>
<td>0.241</td>
<td>Management factors</td>
</tr>
<tr>
<td>0.266</td>
<td>0.278</td>
<td>0.271</td>
<td>0.275</td>
<td>0.278</td>
<td>0.266</td>
<td>Factors relating to the contract</td>
</tr>
</tbody>
</table>

As shown in figure 3, the financial factors with normal weight of 0.349 has the highest priority. In addition, the prioritization was done for all of the following 32 sub-criteria as shown in figure 3. The factor of insufficiency of assigning credits (i.e. budget) for initial studies with weight of 0.0852 has the highest priority among the sub-criteria.
5.2. Prioritization of risk reduction solutions
After ranking the most significant criteria and items affecting the project risk based on the weight of identified items, the prioritization of existing choices is done through VIKOR method.

The existing options from the experts’ viewpoint were ETBA, FTA, HAZOP, PHA, SHA& SSHA, and FMEA methods.

The ETBA method is a relatively new technique based on some principles of management oversight and risk tree (MORT) in which an event is defined as an unwanted energy current. An event happens when an unwanted energy stream is made which due to lack of sufficient barriers in the way, it might hit different objectives and create damages to individuals or create financial losses [23].

FTA (fault tree analysis) is logical-visual model which is used to describe the way undesirable events, especially in a system, are made by effects of a simple fault [22].

HAZOP method is a way of identifying all probable deviations of expected designing operations and all risks made by these deviations [2].

PHA (process hazard analysis) is a semi-quantitative analysis used to identify the potential risks and rank the identified events based on their risk [21].

In SHA and SSHA Methods, the analysis of system and sub-system hazard is used to evaluate the existing hazards at the system and sub-system levels and determine their effects upon the whole operations [16].

FMEA method (failure modes and effects analysis) is an engineering technique to determine and eliminate the errors, problems and probable mistakes of the system, production process and offering services for the clients [19].

In the first step, the decision matrix is developed. The decision matrix is the matrix of scoring options based on the criteria. The weight of each item was determined by FAHP technique. First, the experts were polled regarding the performance of each item. To fuzzicate the experts’ viewpoint, the seven-degree scale shown in table 7 was used [12].

<table>
<thead>
<tr>
<th>Fuzzy</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0, 0, 1)</td>
<td>Very poor</td>
</tr>
<tr>
<td>(0, 1, 3)</td>
<td>Poor</td>
</tr>
<tr>
<td>(1, 3, 5)</td>
<td>Medium poor</td>
</tr>
<tr>
<td>(3, 5, 7)</td>
<td>Fair</td>
</tr>
<tr>
<td>(5, 7, 9)</td>
<td>Medium good</td>
</tr>
<tr>
<td>(7, 9, 10)</td>
<td>Good</td>
</tr>
<tr>
<td>(9, 10, 10)</td>
<td>Very good</td>
</tr>
</tbody>
</table>

Then, the experts’ viewpoints were used to obtain the fuzzy mean and develop the deterministic decision matrix through defuzzification method of weighted mean. In the second step, the division of corresponding entry in the initial matrix by the sum of corresponding elements of the column as shown in relation (5.7) is done to eliminate the scale of decision-making matrix through linear normalization method.

\[ n_j = \frac{d_{ij}}{\sum d_{ij}} \quad (5.7) \]

In the third step, the determination of ideal positive and negative point is done as described in the following.

- Determining the best \( \bar{f}_j^* \) and the worst \( \bar{f}_j^- \) choice among all choices for a criterion.

- If the criterion is positive, \( \bar{f}_j^* \) is maximum value and \( \bar{f}_j^- \) is the minimum value of the column.
- If all \( f^*_j \) s are connected to each other, an optimal combination with maximum score is obtained (ideal positive point).

- If all \( f^-_j \) s are connected to each other, an optimal combination with minimum score is obtained (ideal negative point).

In this matrix, all criteria are of positive type.

\[
f^*_j = f^{\text{max}} = \begin{bmatrix}
0.182 & 0.185 & 0.204 & 0.180 & 0.170 & 0.200 & 0.185 & 0.161 & 0.169 & 0.192 & 0.168 \\
0.191 & 0.181 & 0.159 & 0.178 & 0.174 & 0.210 & 0.179 & 0.207 & 0.209 & 0.200 & 0.176 & 0.205 \\
0.211 & 0.176 & 0.193 & 0.217 & 0.179 & 0.195 & 0.195 & 0.205 & 0.165 & & & \\
0.109 & 0.084 & 0.086 & 0.108 & 0.099 & 0.114 & 0.107 & 0.124 & 0.121 & 0.057 & 0.099 & 0.106 \\
0.101 & 0.122 & 0.112 & 0.114 & 0.108 & 0.110 & 0.099 & 0.093 & 0.110 & 0.067 & 0.103 & 0.076 \\
0.091 & 0.105 & 0.114 & 0.105 & 0.111 & 0.119 & 0.095 & 0.122 & & & & \\
W & 0.055 & 0.054 & 0.068 & 0.045 & 0.041 & 0.085 & 0.025 & 0.021 & 0.027 & 0.022 & 0.024 \\
0.037 & 0.029 & 0.023 & 0.020 & 0.014 & 0.038 & 0.047 & 0.042 & 0.035 & 0.042 & 0.063 & 0.014 \\
0.011 & 0.017 & 0.013 & 0.016 & 0.020 & 0.016 & 0.015 & 0.015508408 & 0.008527415 & & & 
\end{bmatrix}
\]

Therefore, in the fourth step the calculation of suitability (S) and regret (R) values for each option is done (relation (5.8)). In this regard, the suitability value (S) denotes the relative distance of \( i^{\text{th}} \) option through ideally positive solution (i.e. the best combination) and the regret value (R) represents the maximum discomfort of an option from ideal positive solution.

\[
S_j = \sum_{i=1}^{n} W_i \cdot f^*_i - f_{ij} \\
R_j = \max \left[ w_i \cdot f^*_i - f_{ij} \right]
\]

(5.8)

In the fifth step, the calculation of VIKOR Index (Q) for each option is done through relation (5.9) and the options are ranked based on suitability and regret of each option.

\[
Q_i = v \left[ S_i - S^* \right] + (1 - v) \left[ R_i - R^* \right] \\
S = \max S_i, S^* = \min S_i \\
R = \max R_i, R^* = \min R_i
\]

(5.9)

In the end, the arrangement of options based on values of Q, R and S was done. In this regard, the options were arranged into three groups from high to low values based on the values of Q, R, and S. The best option is to have the smallest Q if the following two conditions are satisfied.

The first condition states that if the A1 and A2 options have the first and second positions among \( m \) options, the relation (5.10) is maintained.

\[
Q(A_2) - Q(A_1) \geq \frac{1}{m - 1}
\]

(5.10)

The second condition states that the A1 option should be the top one among one of the R and S groups, at least. If the first condition is not satisfied, both of the options are the best ones. If the second condition is not satisfied, both A1 and A2 options are the top options.

Therefore, based on VIKOR calculations, the A5 and A2 options are in the first and second rank. Now, the first condition is verified through relation (5.11).
In this regard, the first condition holds. In addition, the second condition regarding the fact that the top option should be the top rank among one of the R and S groups is satisfied. Therefore, the SHA & SSHA option is selected as the best one.

6 Discussion and Conclusion

In the present study, it was endeavored to identify and rank the factors affecting the risk of projects of South Pars Gas Field through AHP method. In addition, different methods of evaluation project risks were ranked through VIKOR Method due to reduced project risk. As discussed in the study, among the four identified factors, the financial factor with the highest weight was selected as the most important criterion. In addition, all of these factors were divided into a number of sub-criteria so that 32 sub-criteria were obtained. The ranking of research sub-criteria was done and the factor of insufficiency of credits in the initial studies was identified as the most important project risk among all other factors with weight of 0.0852. Then, the VIKOR Technique was used to rank the suggested options by experts regarding the solutions of reducing risk. Among the (5.7) selected solutions, the SHA & SSHA Method was used as the best option for evaluating and reducing risk. One can use it for improvement and reduction of risk of gas and oil projects. Therefore, based on the significance of the intended discussion, it is suggested that the researchers use this method to conduct their studies. This method is effective in many studies for identification and prioritization of influential factors. In the present study, all solutions of reducing risk of projects are methods of risk evaluation. Therefore, the researchers might implement these methods in their studies to reduce the risks from the beginning. In this regard, the authors of present study could prioritize the factors affecting the project risk through AHP method. As a result, they can completer the prioritization and use ANP method to study the mutual associations among the variables as reciprocating relationships. To rank the options, when the normalized values are dependent upon the measurement unit of the criterion, one can use TOPSIS method.

References

\[
0.246 - 0.000 \geq \frac{1}{7 - 1} \implies 0.246 \geq 0.167
\] (5.11)


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