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# Prioritization of Effective Risk Factors on Oil Industry Construction Projects (By PMBOK Standard Approach)

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**Abstract:** This study is an applied, analytic-descriptive research in terms of nature. It is thus an analysis in which a sample has been applied for data collection and it is descriptive since its variables are assessed and reported as they are in reality. This study seeks to identify effective risks existing in construction industry specifically in the national macro projects such as oil industry projects through utilizing Project Management Body of Knowledge (PMBOK) model and to estimate the relative impact of each risk on the projects. It aims at prioritizing the effective risk factors on the construction projects (a case study of National Iranian Oil Company). Thus NIOC construction projects, consulting engineers companies and contractor companies in construction projects of oil industry have been selected as the statistical universe to identify and prioritize the risks. Due to the focus of oil industry construction projects on South Pars Special Economic Zone, under planning, implementation or completion phases and with regard to the phases' expansion in terms of number and volume of activities and also strategic features and confidentiality of information, three phases out of 28 ones have been case-studied. It is generally concluded in this study that with respect to the country significant strategic, geopolitical, geographical, economic and military position in the world, it is a matter of great magnitude to regard the risks identification and management as one of the important areas in the project management and to consider it as a national and comprehensive plan when designing and ratifying industrial projects of the country.

**Keywords:** PMBOK standard, prioritization, risk factors, risk management

## INTRODUCTION

One of the most important elements in managing the important projects is to consider the risks. No project is immune to unpredictable phenomena. A perpetual difference between projects planning and real implementation within the scope of time, cost and quality is resulted from the impact of positive or negative risks on the project life time which are sometimes undetectable. Generally, risk management is a systematic process in which risk factors are identified and defined and their impacts are planned to be minimized. Risk management may better realize the project objectives through identifying the project opportunities and threats and planning to face with them. It monitors the effective factors on fast or slow progress of the project and provides the project manager with the appropriate solutions. Risk management processes design can be carried out to be applied in the projects based on various tools and standards; however, implementation of an integrated effective system for applying risk management processes is challenging in the firm environment. In the implementation phase, not only the tools applied are important but the culture of applying those tools must also be created (Keivanlu and Atashafrouz, 2009). Generally, risk is composed of three elements namely unplanned event or change (scenario), event occurrence probability and size of its impact; and through attaining these elements, risk is defined. Projects are at any point in time exposed to encountering a crisis due to the current market and business circumstances. The projects environments are greatly variable and many uncertainties exist. The conditions are even more difficult for bigger projects. There is no doubt that accurate management of these risks is the prerequisite of easing the projects critical conditions and the necessity of achieving the related sciences and developing them is completely evident (Paybandan and Mirbagheri, 2008). One of the areas that has been a contemporary issue of the project management sciences and has drawn the attention of many scholars is the project risk management. Project risk management is a new topic in project management even in the industrial countries and within the recent years it has highly been considered by managers, which is due to the assurance that is yielded for the whole project organization through accurate risk management. Risk management is an organized and regulated matter in the developed countries whereby it can be applied better.

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Increasing acceptance of project management implies the application of proper knowledge, processes, skills, tools and techniques which can be effective on the project success. As per PMBOK standard, project management is defined as applying knowledge, skills, tools and techniques relating to the project activities, consistent with meeting project requirements (PMI, 2008). The main challenge in risk management is providing an accurate estimate regarding future probabilities so that it will be possible to change the project plan properly. To quantify these estimates, various methods have been presented by researchers which have great differences in terms of cost and applicability.

## LITERATURE REVIEW

In this section, theoretical basics and research background are presented respectively.

**Theoretical basics:** The present study views the project management based on PMBOK standard approach prepared and published by the United States Project Management Institute (planning, risk identification and qualitative analysis, risk quantification and analysis, response, risk monitoring and control), evaluates time, cost and scope impact of risks through attaining main factors and prioritizes the risks.

As per PMBOK standard, risk is a potential event, occurrence of which will affect at least one of the project objectives such as time, cost, scope or quality, positively or negatively. Risk management aims at increasing positive events probability and impact and decreasing adverse events probability and impact. With regard to the comprehensive above-mentioned definition, it is found that there are two kinds of risks in the projects (Haghnevis and Sajedi, 2007):

- Positive risks known as opportunity. These risks, with regard to their nature, provide the project beneficiaries with an opportunity.
- Negative risks known as threat. These risks, in case of occurrence during the project life cycle, may cause problems in the project progress.

Contrary to crisis management, risk management (besides considering positive risks) identifies potential crisis preceding its occurrence and foresees prevention ways. Furthermore, it takes measures as regards the opportunities to make an optimal use of them through which costs incurred by crisis will be reduced and efficiency will be increased (Avazkhah and Mohebbi, 2010).

The project manager is required to base his measure upon risk management techniques to assure that project will not be encountered the threats. These techniques underscore qualitative information through which projects risks may relatively be controlled. Risks will not actually be identified and foreseen unless a plan is formulated to enumerate the titles of project risks with a particular framework. So all projects possess different degrees of risk and most of project managers have still difficulties in discovering the risk at the time of occurrence or identifying the potential risks adequately (Etminan, 2005).

**Research background:** All references of this study will be analyzed in the following.

Keivanlu and Atashafrouz (2009), "Construction Projects Risk Management" concepts provided in this book are comprehensive and readers are provided with adequate issues regarding construction projects. Haghnevis and Sajedi (2007), "Risk Engineering for Project Managers" this book elaborates various models for risk management and sketches the position of each model. Avazkhah and Mohebbi (2010), "Project Risk Management" in this book, comprehensive vocabularies as regards important matters in the risk management process have been gathered so that adequate information regarding risk management different processes may be easily accessed. Mohammad *et al*. (2009), Strategic Risk: Guidance for Managers. This book considers risk factors from a strategic point of view and clarifies the strategic treatment with organizational risks properly. Etminan (2005), "Analytic Assessment of Normal Risks Identification in the Construction Projects" this study introduces potential risks in the building construction projects. Haj (2005), "The Role of Risk Management in National and Strategic Projects" this study refers to the important areas of national projects and their key points properly. Sheikh and Sobhie (2005), "Assessment and Application of Techniques for Identifying Project Risk" techniques for identifying risks has been gathered and presented in the form of a collection. Makuei *et al*. (2008), "Introduction of Modern Applied Techniques for Identifying Risks in Macro Projects" this study presents modern methods based on collective decisions. Mojtahedi *et al*. (2005), "Evaluation of Critical Risks in Engineering Projects via DEMATEL Method" this study introduces one of the techniques for identifying project risks. Hatefi (2005), "A Review of Principles and Challenges in the Project Risk Management Process" this study clarifies challenges of the risk management in the country. Tehran *et al*. (2008), "Value and Risk Integration Model in Construction Projects" simplicity of the model provided for integrating value engineering and risk management and proper suggestions for implementation are among this study features. Mojtahedi *et al*. (2008), "Identification and Evaluation of Critical Risks in MEPCC Projects via Cognitive-Mapping Method" this study introduces an innovative method for identifying project risks. Mohammadi and Jafari (2008), "Risk Management in

Sea Project Implementation as per PMBOK Standard" this study defines properly various models of contractor agreements and provides the readers with the related points of each item. Nouraei (2006), "Risk Assessment in Offshore Industries" this study elaborates better methods of projects risks identification inside the country. Paybandan and Mirbagheri (2008), "Risk and Indefinite Affairs and Effective Factors on Risk" a comprehensive collection of the matters relating to the risk management based on PMBOK standard has been provided. Khatlan *et al*. (2008), "A Comparative Study on Risk Assessment Systems in Oil and Gas Drilling Operations" this study presents good experiences regarding risks relating to the oil wells.

## RESEARCH METHODOLOGY

The present study is an actual and objective case study whose conclusions may be applied practically. It is an applied, analytic-descriptive research in terms of nature. An applied research seeks to achieve a scientific goal and emphasizes on fulfilling prosperity and welfare of people and modifying products or processes (testing theoretical concepts in real situations). This study is analytic as a sample has been applied for data collection and is descriptive since its variables are assessed and reported as they are in the real world.

**Research method:** This study seeks to identify effective risks existing in the construction industry specifically in the national macro projects such as oil industry, through utilizing PMBOK model and to estimate the relative impact of each risk on the projects.

Thus a comprehensive list of effective risks on the construction projects is presented and risks are prioritized in terms of importance and influence within the project.

**Statistical universe:** This study aims at prioritizing effective risk factors on construction projects (a case study of National Iranian Oil Company). So Oil Company construction projects and managers of active companies' in these projects are regarded as the subset of National Iranian Oil Company. Consultant engineers companies and contractor companies relating to the oil industry construction projects have been selected as the statistical universe to identify and prioritize the risks; because these managers are closely familiar with leading these kinds of projects as well as risks and uncertainties existing in this industry. Construction projects comprise gas refineries, oil platforms and the related facilities.

The statistical universe of this study comprises construction projects of Oil Company and other active companies in this regard. On the other hand, due to the focus of most oil industry construction projects on South Pars Zone, the projects relating to this zone have been considered in this study. And since various phases are under planning, implementation or completion in South Pars Special Economic Zone and with regard to the phases expansion in terms of number and volume of activities and strategic features and confidentiality of the information, three phases out 28 ones have been case studied.

**Data collection:** To collect data and extract information, both library and field studies have been employed. In library studies, books, credible Persian and English papers and some available theses have been applied to understand the essential concepts of this study namely PMBOK model and risk management and to identify and prepare a list of risks relating to the construction projects as well. Various web sites online forums engaged in risk issues including the United States Project Management Institute have also been used. Opinions of the Zone safety experts and previous managers as regards potential risks were gathered via a technique comprising brainstorming known as NGT and added to the list prepared in the previous sections and finally a comprehensive list of potential risks in construction industry was provided (3.6).

In field studies, a questionnaire was designed with cooperation of experts and professional including the projects senior executive managers to attain such factors as risk type, risk classification and its occurrence probability. A question was also raised regarding the respondent individual experience in encountering any of the mentioned risks in the questionnaire. This item was raised in the primary studies to obtain a comprehensive archive comprising individual experiences of the Zone senior managers in this regard.

In the next section, having specified the type of risks mentioned in the lists, probability and impact of each risk occurrence, risks are prioritized and a new prioritized list will be provided.

**Questionnaire justifiability and reliability:** Reliability deals with the fact that to what extent the measuring instruments give identical results under similar circumstances. In the other words, what is "the correlation between a set of scores and another set of scores obtained independently from an equal test on a test group". It means that if a single group is provided with the measuring instrument several times at short intervals, the results are close to each other. To measure reliability, an index known as reliability coefficient is applied. Reliability coefficient varies from 0 to +1. Zero and +1 reliability coefficients denote non-reliability and complete reliability, respectively. A variety of methods are used to estimate the measuring instrument reliability coefficient, including:

- Test-retest method
- Parallel or equivalence method

Table 1: Cronbach's alpha results

| | | (%) | N |
|---|---|---|---|
| Cases | Valid | 15 | 100 |
| | Excluded (a) | 0 | 0 |
| | Total | 15 | 100 |

Table 2: Reliability statistics

| Cronbach's alpha | Cronbach's alpha based on standardized items | N of items |
|---|---|---|
| 0.786 | 0.700 | 10 |

- Split-half method
- Kuder-Richardson method
- Cronbach's Alpha method

One of the common software to determine reliability through one of the above mentioned methods (usually Cronbach's Alpha method) is SPSS software. Having collected primary data through 15 questionnaires, Cronbach's Alpha was calculated as per below (Table 1) and via SPSS software. The formula for calculating this coefficient is as below:

$$\alpha = (\frac{j}{j-1})(1-\frac{\sum s_j^2}{s^2})$$

α, j, $s_j^2$ and $s^2$ denote respectively: Test validity estimate, number of questions, $j^{th}$ sub-discipline variance and the test total variance.

The more the alpha value is closer to one, the more the questionnaire is reliable. If alpha value is more than 0.7, reliability will be good, if it is between 0.5 and 0.7, reliability is moderate and if it is less than 0.5, the questionnaire lacks the required reliability. In this research, Cronbach's Alpha value (0.786) represents the questionnaire reliability (Momeni, 2007) (Table 2).

**Formulating projects risks:** Project work breakdown structure may be created by using multiple tools. Yet it is frequently created through using stick notes (containing experts' opinions) by the project team and in order to divide the project into the smaller controllable parts. These smaller parts are those which are managed by the project manager and estimation, scheduling, human resources allocation, budgeting and risk management will be undertaken for them. Many project teams conceive mistakenly that risk management is a merely high-level assessment of the project risks, while risk management considers identifying risks of each activity besides the whole project risks. The list of common risks in this research provided from different resources is briefly discussed in the following:

- Design risks (14 items)
- External risks (17 items)
- Environmental risks (16 items)
- Organizational risks (13 items)
- Project management risks (19 items)
- Current affairs risks (11 items)
- Construction risks (18 items)
- Engineering services risks (18 items)

After collecting and recording list of project risks in the brainstorming session (NGT), all list were reviewed and classified in the cause-effect diagrams and risks relating to each part were distinguished. Then probability and impact of risks were determined for prioritization. Also the case study carried out in this research regarding South Pas Zone phases and risks identification and prioritization methods will be presented in the following.

Having accessed to the adequate information of all risks, probability and impact of risks were determined. First, risks measures were standardized by PMBOK standard. Table 3 depicts ranking of risk occurrence probabilities.

Probability means risk occurrence probability. Impact means the effect of risk, in case of occurrence, on the project. In qualitative analysis of risk, probability and impact of risk have been theoretically estimated and the word impact embraces all possible effects. Table 4 presents ranking of risk impact on each project goal.

In quantitative analysis process, a probability value is allocated to each risk which indicates the risk occurrence probability. A variety of methods has been introduced in this process; the objective of all methods is the achievement of project goals (time and cost). Monte Carlo simulation is among these methods. The method that has received proper attention in the last version of PMBOK standard is the method of determining the risk final rank. In this method, a coefficient known as "risk reduction coefficient" is introduced which determines the risks final ranks by influencing results revealed in the previous section. Table 5 depicts the ranking of this coefficient. In determining final rank, previous stage results will be fully utilized. So in this method, by combining risk mathematical expectancy and risk reduction coefficient inferred from experts opinions and through below formula, the risk final rank is obtained:

Risk final rank = risk mathematical expectancy × risk reduction coefficient

If a risk occurrence probability is 100% and its impact rank on the project objectives is very high (16) and it is uncontrollable (5) in terms of reduction coefficient, then the final rank will be 80 which equals to the risks final rank value. As it can be seen, this value matches the predicted value in qualitative analysis and demonstrates the relation between these two analyses.

Table 3: Ranking of risk occurrence probability

| Rank | Occurrence probability | Range of risk probability |
|---|---|---|
| 1 | Very low | 1%≤ occurrence probability during the project ≤9% |
| 2 | Low | 10%≤ occurrence probability during the project ≤19% |
| 3 | Moderate | 20%≤ occurrence probability during the project ≤39% |
| 4 | High | 40%≤ occurrence probability during the project ≤59% |
| 5 | Very high | 60%≤ occurrence probability during the project ≤99% |

Table 4: Risk impact on project goals

| Project goals | Very low (1) | Low (2) | Moderate (4) | High (8) | Very high (16) |
|---|---|---|---|---|---|
| Cost | Change in project total cost ≤1% | 1%≤ change in project total cost ≤2% | 2%≤ change in project total cost ≤5% | 5%≤ change in project total cost ≤10% | 10%≤ change in project total cost |
| Quality | Change in project total quality ≤1% | 1%≤ change in project total quality ≤2% | 2%≤ change in project total quality ≤5% | 5%≤ change in project total quality ≤10% | 10%≤ change in project total quality |
| Time | Non-critical activity time shift that does not displace any other activity | Non-critical activity time shift without affecting critical path | Critical path shift without affecting critical path time | Critical path time shift up to the maximum reservation time | Critical path time shift more than reservation time |
| Scope | Change in project total WBS ≤1% | 1%≤ change in project total WBS ≤2% | 2%≤ change in project total WBS ≤5% | 5%≤ change in project total WBS ≤10% | 10%≤ change in project total WBS |

Table 5: Risk response strategies

| Range of risk final rank | Proposed risk response strategy |
|---|---|
| 250≤ risk final rank ≤400 | For these risks, avoidance, transmission and reduction strategies can be applied depending upon the risk nature (risk occurrence probability and risk impact rate). |
| 200≤ risk final rank ≤249 | For these risks, a combination of transmission and avoidance strategies can be used. Risk must be reviewed every two months. |
| 150≤ risk final rank ≤199 | For these risks, a combination of transmission and acceptance strategies can be used. Risk must be reviewed every three months. |
| 100≤ risk final rank ≤149 | For these risks, a combination of reduction and acceptance strategies can be used. |
| 50≤ risk final rank ≤99 | For these risks, a combination of transmission and acceptance strategies can be used. |
| 1≤ risk final rank ≤49 | Accept risk and do not undertake any measures for the time being. If necessary, simple control levers must be used. Risk must be reviewed at least every six months. |

Critical risks will be determined through using the mentioned calculations.

**Critical risks (case study):** With respect to the previous issues, oil industry project is selected for the case study in this section and risks are identified and prioritized in this industry. Since nowadays most of construction major projects are implemented through three dimensional contracts (EPC), previously identified risks are classified with the above ranks in the form of these contracts:

- Engineering:
  - Imperfection or inaccuracy of primary studies
  - Inaccurate cost estimate
  - Lack of information resources
  - Obligation on the initial design
  - Not preparing the initial licenses
- Procurement:
  - Financial and economic field
  - Sanction and political matters
  - Purchase and delivery processes
  - Custom and transportation affairs
  - Existing regulations and infrastructures
  - Inter-firm problems of some contractors
- Implementation:
  - Low experience in project implementation
  - Special equipment
  - Materials used in the project
  - Executive risks

Risk details must be seen in the prepared risk registration form. The emphasis on details is due to the fact that totting up and analyzing the events are generally difficult jobs. Yet sensitive risks status must be reported regularly to the project managers. Continual managerial reviews must be undertaken during the project implementation and each activity must be documented in the risk registration form. For optimum implementation of this cycle, feedbacks must be attained from any person engaged in the project implementation regarding whether risks are managed properly, or how this process can be modified. This information may be used in future projects for modifying risk management and usually constitutes a part of reviews at the end of the project. When a matter happens for one of the known risks, project manager must find it out promptly and undertake proper preventive measures to cope with and control the risk. Then it must be ensured that all the project beneficiaries including managers, customers and team members who are going to implement these solutions, have agreed upon the foreseen solutions. It is necessary to note that the response to the risk shall be designed when the cause and effect of each risk has been considered and analyzed adequately. It is in this stage that we decide what strategy must be adopted to cope with the risk.

Risk response strategy must be selected with respect to the risk nature and the time of responding to the risk. However, with regard to the risk prioritization and ranking in this study and by using the techniques of interview with different experts and data gathered in the first section regarding risk response successful strategies of previous projects, Table 5 suggests the appropriate strategy with respect to risk factors ranks.

The Table 5 is the output of gathering experiences pertaining to the country macro projects and

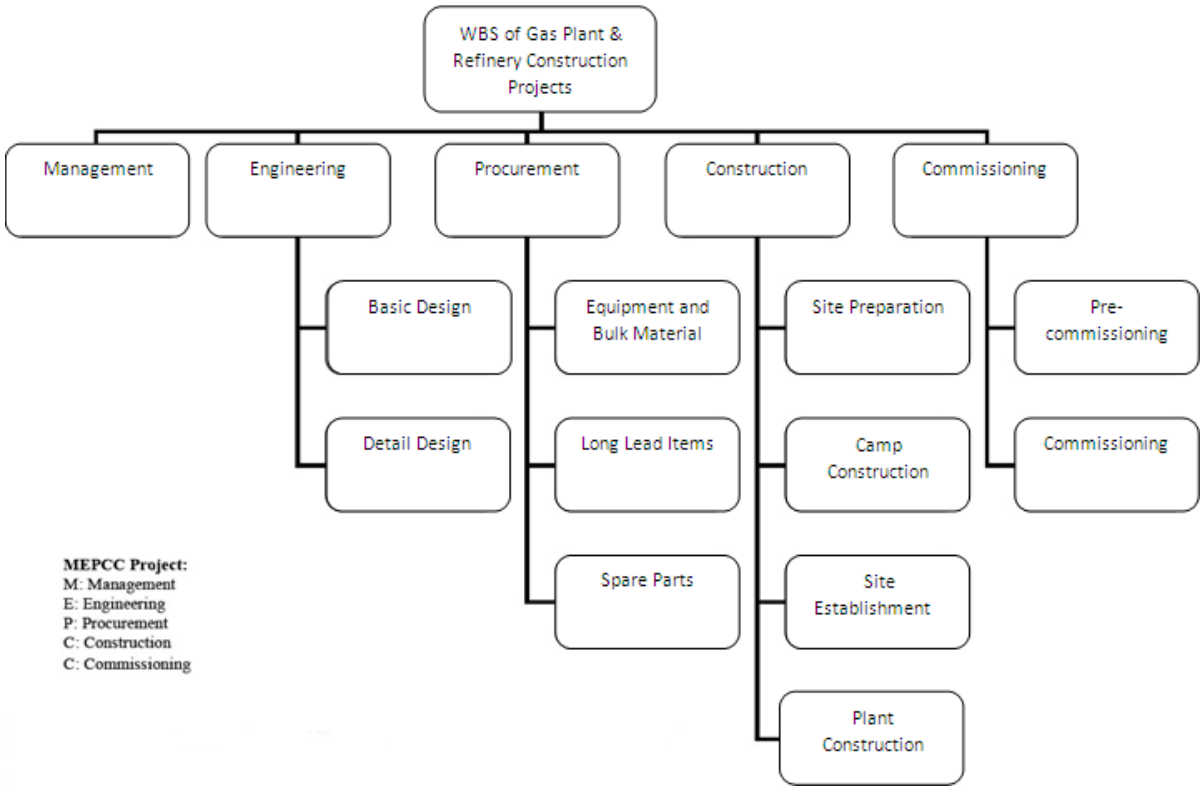


Fig. 1: Contract work breakdown structure (MEPCC)

Table 6: Prioritization of risks identified in south pars zone under implementation phases

| WBS zero level | WBS one level | Identified risks with high priority | | |
|---|---|---|---|---|
| Management | - | • Lack of proper managerial infrastructures in the project<br>• Not considering contractual needs<br>• Client weak executive power | • Not considering regulations and political matters<br>• Lack of proper relations between consortium members<br>• Delays in financial receipts and payments (statements) | • Changes in currency rate, interest and inflation<br>• Lack of accurate control over contractors agreements |
| Engineering | Basic engineering | • Lack of access to foreign consultants due to political affairs | • Changes in consumed gas specifications and products | • Inaccurate design |
| | Detailed engineering | • Information inaccurate transmission from basic design to detailed design | • Change in the project work scope | • Lack of expert human resources in design phase |
| Procurement | Equipment and bulk materials | • Ambiguity of project funds injection policies | • Lack of appropriate supplier list | • Providing suppliers with imperfect specifications |
| | Lead long items<br>Spare parts | • Inaccurate scheduling for supplying lead long items | • Problems with inspection and equipment transportation | • Foreign suppliers unwillingness to cooperate due to political matters |
| Construction | Site preparation<br>Camp construction<br>Site establishment<br>Plant construction | • Problems with earth and soil.<br>• Unfavorable weather conditions.<br>• Events for manpower and equipment.<br>• Not constructing camps on-timely. | | |
| Commissioning | Pre-commissioning<br>Commissioning | • Problems with goods, equipment and materials transportation.<br>• Lack of coordination between contractors and client.<br>• Lack of proper relationships between head office and site.<br>• Shortage of human resources.<br>• Changes in construction work scope. | | |

experiences of individuals involved in these projects; however, under other projects circumstances, other strategies may be adopted for the same risks at the discretion of project managers and beneficiaries.

**Risk factors prioritization (implementation):** South Pars gas fields projects were selected for risk factors prioritization. South Pars gas field is one of the biggest gas resources throughout the world which is located on the border shared by Iran and Qatar in Persian Gulf and it is regarded as one of main energy resources in the country. The field has an area of 9,700 and 3,700 km$^2$, respectively belongs to Iran. Gas reserves in this portion amounts to 14 trillion m$^3$ of gas with 18 billion barrels of gas condensate which comprises about 8% of the world gas and nearly half of the country's gas reserves. Following steps have been taken respectively to carry out risk factors prioritization:

- An outlined list of risks and macro project risks was prepared.

- Contract work breakdown structure (MEPCC) of these projects was prepared and distributed as per Fig. 1 in the form of a diagram for gathering experts' opinions.
- Information required for identifying risks was gathered by using NGT technique and identified risks were assessed and finalized in a session through brainstorming method.
- Using the results obtained, risk factors in construction projects of Oil Company were prioritized.
- Identification and prioritization process was implemented in three phases of under implementation phases in South Pars Zone as a case study and final results were revealed in the form a risk breakdown structure in the related Table 6.

## CONCLUSION

Table 1 to 6 depict respectively, Cronbach's Alpha results, reliability calculation, risk occurrence probability ranking, risk impact on project goals, risk response strategies, prioritization of identified risks in South Pars Zone under implementation phases. Figure 1 illustrates contract study breakdown structure (MEPCC). With respect to the prioritization and calculation of oil projects risks (South Pars) in this study, following items are briefly concluded:

- Applying risks identification and prioritization as one of the important elements of managing projects relating to oil and gas industry
- Necessity of transparency in using three- or five-dimensional contracts
- Great projects like oil industry projects must enjoy lower risks in project management
- Optimal completion of identification process plays a key role in potential risks management
- Through using previous projects experiences and experts' opinions, projects can achieve their pre-determined objectives in a favorable manner
- By applying simple methods in primary studies and sharing risks, time losses and monetary losses may be prevented

With regard to the above conclusions, below suggestions are provided to modify the results status.

## RECOMMENDATIONS

- By documenting events and risks existing in each project, costs of reworks as well as unforeseen costs may be prevented and increase in the speed of project implementation and optimum management of events caused by projects implementation relating to oil and gas industry will be achieved. Also risk range will be reduced in these kinds of projects.
- By announcing certain macro policies regarding cooperation with foreign contractors and suppliers, transparency in using three- or five- dimensional contracts will be resulted and employees will automatically be able to make decisions when facing with matters.
- Creating continual risk monitoring and measurement committees (current and new) plays a key role in managers decision making and appropriate policy making in projects executive management.

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