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Research Article

Providing a Model for Identification and Evaluation of Risks in Construction Projects

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Abstract: The present study is a kind of practical, analytical and descriptive in nature. Being analytical is due to collection of information by sampling and descriptive because the variables are measured as they are in real life. In this study by gathering evidences on existing effective risks in oil industry we aim to identify risk limits and present a more precise definition of risks of low, medium and high risks borders. Because of centralization of construction projects of petroleum industry in special economic zone of South Pars, planning, implementation and completion phases based on phases broadness regarding number and size of activities and separate strategic characteristics, 3 out of 28 phases were undertaken sample case study. It is concluded in general that using quantitative and numerical methods in determination of high and low risks approve more precise results. Additionally, carrying numerical tests out requires documentation within study based on identification of potential risks, risk record (earlier and similar) as well as estimation of incidence of risk probability. Though frequency of risk may be less damaging, as reproducibility rule suggests it can be highly risky.

Keywords: Determination of risk limit, normal curve, risk evaluation, risk management

INTRODUCTION

Uncertainty, risks and job accidents at industrial study places have shaped internal environment in producing and industrial organization into a very risky environment. Considering the nature of job risks and necessity of consuming resources after the accident indicates the inevitable importance if risk management. Identification of risks and their prioritizing could be the most challenging and critical part in process if risk management. It is for this reason that inability in exact identification and prioritizing of risks cause other risk management steps to be imperfect and no reasonable response is given to environmental hazards (Jabal, 2005). Identification and prioritizing of risks at executive and technical study is a basis for taking appropriate policies for risk management and choosing more economic method consequently. Also, identification of risky and critical places contribute to create barriers against potential risks and establishment of safety systems at time of risk in order to minimize damages as much as possible (Mohammadi, 2004).

The history of risk management confirms that by beginning of modern management era in 1950, the risk management initiated its progress that within next decades continued in form of project management. Generally speaking, risk management is understood as a systematic process during which risk factors are identified and defined and the minimization of their effect get programmed.

A risk has been consisted of three elements:

- Unplanned event or change
- Probability of event to occur
- The impact of event that altogether define risk

Risk planning, identification, quantitative and qualitative analysis of risk, respond ding it and controlling risk are key steps can be studied in most of risk management methodologies (Keivanlou and Atashfaraz, 2006).

The major challenge in risk management is associated to correct estimation of future possibilities in order to make proposer changes in project program. To quantify them, many different methods have been introduced by investigators which differ significantly from cost and applicability point of view. What is less taken into consideration is determination of risk measurement limit by scientific and computational principles and methods. To specify risk limit, experts express their opinions orally. These opinions are subjective and rooted in occurred events. As an example, disastrous regions or activities are divided into high, low and no risk according to number of incidents happened (Painadan *et al*., 2008). Although, this approach could not be a true basis for detection of exact amount of risk at study or disastrous areas, access to documents for determination of these limits for computational methods seem crucial.

The present study seeks to use quantitative and computational methods present a model for rating of

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probability if occurrence of risk. Deficit in computational and accurate methods in this field of industry (safety and risk management) as well as ignorance of any form associated to human lives should not be abandoned.

Thus, access to a method for scrutinize finding of probability in risk occurrence helps health, safety and job experts in their executive study to better identify hazardous areas and rank them consequently.

LITERATURE REVIEW

In this part the theoretical framework and background will be dealt with.

Theoretical framework: To have a comprehensive view on field of risk and risk management, the author has studied and introduced seven reference books. The study of every book in fact, is a sign how much is important to develop the present study in domain of risk management.

In book of "risk management of construction projects" after investigating on general models and concepts in project management, the place and role of risk in contracts and administrative methods of projects are considered. The book tries to depict an overview of existing activities in construction projects, takes the reader's mind into the world of employers, counselors and subcontractors of construction projects. But one of its inconveniences is inability in providing an approach for identification and analysis if risks (Keivanlou and Atashfaraz, 2009).

A guide to the project management body of knowledge: The book "A Guide to the Project Management Body of Knowledge", fourth edition is the standard document of project management body of knowledge by Project Management Institute (PMI) Standard Committee. This book a through definition of project management and related concepts are included and the life cycles of projects management beside its processes are explained in details. As a benefit, it contains a full description of project management processes based on standards of project management body of knowledge (PMI, 2008). The book of "project risk management" besides giving full concepts about risk and its management has described different models of risk management and related tools. By using diagrams and flow-charts, the writers have struggled to optimize each pattern of every model and prepare a clear diagram for all. Lacking some practical examples that show ability of models implementation as much as possible is regarded as the weak point (Haghnevis and Sajedi, 2007).

The handbook of project risk management reviews the process of risk management in Transportation department of California and covers major concepts and processes that govern planning and administering of risk management during the project. The authors do their attempt by preparing an integrated approach to risk management present a newer and more useful view of it and make it easier to understand. As a strong point, the book has widely referred to case studies. The users are not limited to transportation area only and the comprehensive guide is rooted in project management body of knowledge standards. Using this book could be beneficial for preparing a check list as well as identification of potential risks (Office of Statewide Project Management Improvement, 2007). The book of project risk management as the first step has included whole problems associated to risk management models and for the second step it has introduced 6 project risk management processes based on project risk management standards.

All debated in the book are from project risk management standards of PMI institute. To say a weak point, the book is totally theoretical though, most of problems can be more meaningful when a couple of practical examples is predicted (Avazkhah and Mohebi, 2010). The next studied book is "strategic risk "which guides managers at time an organization may deals with different sorts of risks. It then precisely focuses on risks that may threat the organizational goals. The weak point therefore is in its old examples (1992) and lack of an integrated model for identification of strategic risks and inability to differentiate them consequently (Keivanlou and Atashfaraz, 2009).

Carl (2001) in his book has described methods of risks identification, required techniques and instruments and implementation rules regarding project management body of knowledge standards. The advantage then is the authors endeavor in precise coverage of introduced techniques in project management body of knowledge standard as well as their description and reporting of needed instruments for implementation of each method. What has been mentioned in previous references more rely on principles and systematic methods of risk management. In some of executive projects (oil industry) for instance, ranting of risk calculated through below formula:

Risk mitigation coefficient × expected risk - final ranking of risk

The point may be vague is how expected risk and risk mitigation coefficient could be computed. As we know, expected risk is a random (continuous) variable defined as the below:

$$E[X] = \int x f x(x) dx$$

where, is probability density function of random variable X. for discrete random variables the fx (x) above statement is rewritten as below:

$$E[X] = \sum_{i=1}^{n} x_i p x(x_i)$$

Table 1: Rating of risk probability

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

Therefore, determination of variables (incidences records) and their nature (discrete or continuous) is different in calculation of expected value. On the other hand, calculation of risk mitigation coefficient needs a computational method be as much reliable and validate as possible and documented enough. In references more experts' opinions are reliable. However, the present study criticizes computation of risk probability and its rating. Table 1 show a sample of risk probability rating (oil industry) extracted from Mohammadi (2004).

The criticism to this table refers to determination of risk probability rank based on number of incidence. That is the basis for determination of risk probability is frequency of documented incidences. The main problem here exists in time interval of an incidence that is absent in the table. In other words, frequency of incidents during what period determines estimated likelihood in the table. On the other hand, the ranking took place very simply just based on likelihood.

Research background: In this part we according to all used articles and books as references for the present study analyze everyone regarding the related subject and area of investigation. The current study introduced analytical examination of identification of risks are usual in construction projects as well as potential risks in construction projects (Etminanmoghadm, 2005). In study of "role of risk management in national and strategic projects "the major areas of national projects are covered and their key points are highlighted (Haj Hussein, 2005).

In "examination and application of identification techniques of project risk "the techniques of risk identification are collected and presented in a collection (Sheikh and Sobhie, 2005). In "introduction of new and practical techniques for identification of big projects risks", the author has gathered modern group-decision making methods (Makouee *et al*., 2008).

Assessment of critical risks of engineering projects through DEMETAL method is one of identification techniques of project risks which has been as an advantage dealt with in the study (Mojtahedi *et al*., 2005).

Hatefi (2005) in his study "a review on principles and challenges of project risk management "has specified the existing challenges in risk management in Iran. Tehrani *et al*. (2008) in a study named "integration model of value and risk in construction projects "pretty easily has provided a model for integration of value engineering and risk management. It also contains suitable recommendations for ways of implementation. in the study of "identification and assessment of critical risks of MEPCC projects by applying Cognitive-Mapping approach "an innovative approach for identification of project risks are established (Mojtahedi *et al*., 2008).

Mohammadi and Jaferi (2008) in their study titled as "risk management in execution of offshore projects according to PMBOK standards" has interestingly defined different models of contracts that the reader have an access to related points. The study of risk assessment in offshore industries, the efficient methods of risk project identification inside Iran is explained in details (Nouraee, 2006). "Risk, unspecified affairs and effective factor on risk" is a comprehensive set of related issues to risk management regarding project management body of knowledge standard (Payandan and Mirbagheri, 2008a, b).

In his study "comparison of risk assessment system of oil and gas drilling operations". Khatlan *et al*. (2008) have taught us good experiences in domain of oil wells.

METHODOLOGY

The present study is a real and objective case study whose results can be scientifically used. In this study we aim to bring together a comprehensive list of effective risks (potential hazards) on construction projects and then provide a model for determination of risks probability (percent) from significance and impact on risk management viewpoint.

Statistical population: The purpose in current study was to priotorise factors of effective risk in industry (case study of national Iranian oil company). The statistical population consisted of construction projects of Oil Company besides active corresponding companies. However, because of centralization of most of oil industry construction projects in South Pars region, the current study concentrated on the region construction projects. Due to broadness of administrative phases from viewpoint of number and size of activities, strategic characteristics and confidentiality of information, 3 out of 28 phases were case studied.

Data collection: As an essentially survey research, an expert made questionnaire was developed to extract information and gather data. The questionnaire includes an item asking respondents about their experience in facing with mentioned risks. This is to attain a widespread archive of senior managers' personal experiences in the region. In the second part after realizing type of risks, their probability and effect according to the methodology were calculated and presented in final part of the study.

Reliability and validity: The reliability of questionnaire was confirmed by senior managers an

Table 2: Reliability statistics

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

d construction projects experts after they carried a pilot study and moderated it. The items were significantly clear for respondents.

The primary data was collected from 15 questionnaires. The Cronbach's alpha (Table 1) through SPSS computed. The calculation formula is as follows:

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

where,

α = Estimation of test reliability
j = Number of items
sj^2 = Variance for j subset
S^2 = Whole test variance

The obtained results of Chronbach's alpha are shown in Table 2.

In this research, the value of Cronbach's alpha equals 0.786 which affirms questionnaire reliability (Momeni, 2007).

Extraction and development of project risks: The environmental risks extracted from questionnaires are categorized into 4 main groups:

- Risks arising from installation process of equipments
- Risks resulting from incorrect use of equipments
- Risks arising from failure to observe safety in the workplace
- Risks resulting from lack of experience and training in studying with equipments by users

The mentioned risks were sent to the associated experts to undertake measurement on costs and probability of incidence based on previous documents. Table 3 shows these obtained data. Cost of every risk incidence is separately written down in the Table 3. To avoid prolong report of events frequency only 30 cases are described.

RESULTS

To have a shorter computation only risks resulted from lack of safety at study were assessed. The t-test method calculated the risks. In a way that risky hazards were determined in the range of six sigma, moderate risks in range of three sigma and less risky hazards in range of one sigma. t-test statistics are written below (Pearson and Hartley, 1972).

The t-test results for three risk categories of very risky (99), moderately risky (95) and less risky (68%) are presented in Table 4, 5 and 6, respectively.

Table 3: Comparison of workplace risks and costs in a one-year period (Rial)

Number	Installation	Incorrect use	Safety	Lack of training
1	77139427	56360965	13419759	40018517
2	74068522	73026711	14910773	54015094
3	103484666	74922971	10688887	62750201
4	105772246	26139657	15053213	57173500
5	105614209	84615492	9360791	65553757
6	116373281	57758874	13394374	53414268
7	104482295	57838307	8523904	20249328
8	108064010	68163808	13960949	56262363
9	106707376	19979240	16691640	19515235
10	96882623	17947386	10677591	13161122
11	105307679	81686290	8389863	61229328
12	102397374	53701589	17241273	49928182
13	112129351	23046226	15701210	6405851
14	86338730	67484975	17208652	24835240
15	111378295	71176615	17353519	15381634
16	91575848	25442677	11469697	54395388
17	117012101	33280278	8417745	19344517
18	93760659	69702818	16269758	21428698
19	99639172	51661172	10213684	40859889
20	80181155	48966626	10284447	36461845
21	104601340	88499029	10834235	65518352
22	76443195	39932977	10082159	60563768
23	110701676	44750898	16133976	18410697
24	93589433	84975474	12700272	13576273
25	117636339	59077132	10863670	6302419
26	100695988	43302484	12393269	71879599
27	82735895	21633625	16660941	17070943
28	76001514	51914621	14034159	21760895
29	102507392	66331889	9632617	54226221
30	95545447	69658293	17674696	22281415

Table 4: Results of t-test (99%)

	Test value = 0					
					99% confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean difference	Lower	Upper
VAR00001	23.143	29	0.000	13008057	11458793	14557322

Table 5: Results of t-test (95%)

	Test value = 0					
					95% confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean difference	Lower	Upper
VAR00001	23.143	29	0.000	13008057	11858508	14157607

Table 6: Results of t-test (68%)

	Test value = 0					
					68% confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean difference	Lower	Upper
VAR00001	23.143	29	0.000	13008057	12439360	13576755

Table 7: Comparison of chance of risk incidence ranking

Risk	Risk ranking	Lower limit	Upper limit
Installation of equipments	Less risky-low risk	92113311	93773644
	Moderate risky-average risk	93773645	96235151
	Pretty risky-high risk	96235152	Over
Incorrect use of equipments	Less risky-low risk	43799712	46543040
	Average risk-moderate risky	46543041	50529544
	High risk-pretty risky	50529545	Over
Lack of safety at work	Low risk-less risky	11458793	11858508
	Average risk-moderate risky	11858509	12439360
	High risk-pretty risky	12439361	Over
Lack of lack of experience and training in working with equipments by users	Low risk-less risky	26928490	29647154
	Average risk-moderate risky	29647155	33597816
	High risk-pretty risky	33597817	Over

Similarly computation results of other risks as well as their comparative results are observable in Table 7.

As the table results show, it is possible to place every group of events in four defined risks in one of risk range (high, average and low). For instance, if costs of human injuries in risk raised from absence of safety in workplace (based on frequency of events) equals 12872391 Rials in the mentioned year, the human traumas caused by this risk locates in range of highly risky.

CONCLUSION

Ranking of probability of risk incidence, Table 1, test of reliability (questionnaire reliability), Table 2, comparison of workplace risks and costs in a one year period, Table 3, results of T-test for three range of pretty risky 99, moderately risky 95 and less risky 68%, respectively in Table 4, 5 and 6 and comparison of ranking of risk incidents, Table 7 could be observable respectively.

To sum up:

- Using quantitative and numerical method in determination of high and low limit of risk caused more precise results.
- Administaring numerical tests requires documentation in study place based on identification of potential risks, previous and similar records of risk as well as calculation of likelihood of risk.
- In this study the currency basis has been used as data. Since frequency of events may have fewer damages though as repeatability rule says considered as highly risky hazards.

Therefore, considering the above results, the following recommendations in line with improvement of results are presented.

RECOMMENDATIONS

- Through documentation of accidents and potential risks in every project it is possible to put off costs arising from duplication and unpredicted costs along with increasing rate of projects execution and optimal management if accidents derived from related projects to oil industry.
- Establishment of continuous monitoring and measurement committees (current and new) plays a

critical role in mangers' decision-making and appropriate policy making in projects management.

- Record and report information about the costs and consequences of study accidents to employees in case of observing safety is warning and leads to their exactness at time of study.

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