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Monitoring Comprehensive Mechanism of Risk Detection and Management in Modern Construction Projects

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Abstract- Taking a comprehensive mechanism to monitor and control risk management in modern construction projects is vital and development of supportive systems and instruments in this field can be significantly helpful for the executers. Risk in project is an abnormal event and can have positive or negative effects on project goals. These risky and abnormal factors can affect achievement of goals of big projects. Accordingly, project risk management including measures to detect, analyze and showing response to uncertainty plays key role in maximization of favorable results and minimization of unfavorable results. In this study, through getting opinions of experts and using Delphi method in 3 steps and analysis of potential risks in the literature, risk items have been classified based on risk custodian and the impact of risk on project goals. In terms of nature, this study is an exploratory study and in terms of structure, this is a case study on construction projects. In this study, the effect of each risk item on project goals (time, quality, cost, safety) has been analyzed and prioritized using direct interview and filing out the questionnaire based on opinions of 34 managers and experts of construction projects. The most indicator risks obtained in this study include employers' lack of liquidity, inadequate contractor finances, compact schedules, sanctions, price fluctuations, mistakes in timing and sequence of activities, contractor management weaknesses. To overcome its negative impacts, reactive measures such as adequate planning and cash flow preparation, materials and resources planning, estimation of value gained, knowledge management system deployment and project backgrounds are presented for implementation.

Keywords- *Monitoring and Control, Project Risk, Human Financial Resources, Delphi Method, Modern Construction Projects.*

I. INTRODUCTION

Nowadays, with acceleration of advancement and development of countries, management of financial and human resources has been highlighted. Creating mother industries, job creation projects, establishment of early returns firms and small and investment industries in modern construction projects are the main methods to achieve sustainable development at the developing countries. As hydrocarbon resources can remain as the most important modern energy resources up to 2050 and Iran is one of the few suppliers of the energy, changing modern oil industry to pioneer industry is required. In this regard, with changing approaches such as crude oil exports and reliance on economic internalization and restricted markets, focus on exports of products with high value added and economic internalization and extension of markets, petrochemistry is important as one of the basic axes of the development. Achievement to annual production of 20billion dollars by petrochemical industry up to 2015 and changing Iran to the first supplier of petrochemical products in the region up to 2025 can show importance of considering challenges in way of realization of these goals.

As the construction and installation step is one of the keyset steps of a modern construction project, considering this step of construction process of a project as focal point of problems of projects is essential and the clear consequence of that can be increased time and cost and failure in other goals of projects (Porkhojasteh, 2005). In countries such as Iran, according to possessing divine resources and talents and potential facilities such as availability of expert workforce, access and communicative ways, good geographical location in the region has high capability to move in way of development and ultimately, enhancement of social welfare level.

According to available literature and performance of contracting companies, it could be observed that majority of these projects have not been completed based on predictions in terms of time, implementation, project costs, quality and measurable variables in the project. Analysis of factors affecting lack of realization of predictions can be one of the activities needed for more recognition of real status of projects in time limit and real time costs and can prevent waste of time and cost to implement the desired project under probable unfavorable conditions. In terms of purpose, this study is a survey and is an exploratory study in step of risk detection and is a case study according to the selected project. This study has tried to collect experiences of some experts and managers relevant to modern construction project such as Elfin 13 Ilam (as case study) and collection and analysis of relevant studies in Iran and aboard to detect risk factors affecting construction phase activities and to classify these factors based on the origin of project risk. Hence, the impact of risk factors has been

analyzed at the first step on each project goal (time, quality, cost and safety) separately and the collected data have been used to obtain the effect of detected factor affecting project. As statistical population consists of all activities of the said project, no special sampling method is needed. To increase accuracy of collecting all activities of the said project, questionnaire and interview with planners, experts and executive managers of projects and other involved in construction project have been used. Moreover, to enhance accuracy of collecting required data, using consistency of opinions and ambiguity in questions, Delphi method (3 steps) has been used to design questionnaires. Finally, data collection was done using questionnaire and individual interviews. The term "risk" has various concepts. Different researchers have provided special definition of risk due to their field and attitude. It could be claimed that all definitions are common in 3 factors. Situations with risk are as follows:

- Factor or measure brings more than one outcome.
- Till the time of touching the outcome, no certain knowledge is available from gaining any outcome
- At least, on probable outcome can lead to unfavorable outcomes.

In other words, uncertainty of outcome of an action and exposition to one of the unknown factors can be one of the most underlying components of types of risks.

- Oxford dictionary has defined the term "risk" as the probability of occurrence of an event or a danger or loss.
- Project risk is an abnormal event, which can have positive or negative effect on project goals (Hatefi, 2005).

The definition shows two dimensions of risk: uncertainty and the intensity of effect on project goals. At the time of evaluation of project significance, both dimensions should be considered. Uncertainty can be considered same as the term "probability" and effect can be a synonym of effect intensity. Project beneficiaries can mostly lead to determination of importance of a risk. Various factors can affect the attitude: 1) project size among activities of beneficiaries 2) public responsiveness to project performance 3) sensitivity of beneficiaries to issues such as environmental effects 4) industrial relations and other factors of attitude of beneficiaries towards risk project can mostly lead to tendency to enhance certainty in outputs of project and may cause preference of goals of a project to another one. The attitude towards project risk is usually affected by organizational culture (Shakeri, 2005). In this study, an applied model of risk management has been presented based on risk management field in PMBOK standard for deployment and implementation in Elfin 13 project in Ilam petrochemical complex. As the study is not aimed at development of risk management sciences or innovation of special method, this study has tried to present the process of deployment and executive requirements of project risk management model.

II. METHODOLOGY

The first step in this study for designation of risk management plan is analysis of beneficiaries and supporting successful executive organization management for risk management.The most underlying limitations in this study include:

- Lack of a knowledge management system for projects and also lack of availability of executive and technical backgrounds of projects
- Variety of project risk factors in project goals in terms of geographical and social environments and other economic and cultural contexts of projects to achieve list of effective project risks
- Limitation of access to respondents according to distance between set of respondents
- Non-practical approach and evidence of concept of risk control, management and detection on behalf of some respondents
- Lack of deployment of integrated project risk management systems in majority of projects
- Lack of promotion of systematic approach among managers of country and existence of partial look at project management fields, especially in field of risk management, statistical population in this study consists of experts and management in field of modern petrochemical projects, which were in direct or indirect relation with studied project or social, economic and cultural environment of organization. The questionnaire was also filled out by a 7-member group of managers and supervisors using Delphi method and was also revised in 3 steps, so that reliability of responses of respondents can be obtained with elimination of similar and ambiguous items. To analyze risk and to monitor relevant activities of each risk, a relevant databank of risks of each risk of each project has been created. The databank includes information related to risk title, its description, the amount and type of its impact on project goals and required measures to overcome risk and its custodians in different steps of risk management process. The example of databank structure and its items is presented in table 1

TABLE I. RISK DATABANK

Form of recording risk control information							
Project name			Project code	Registration date		Update date	
Risk code			Probability of event	Relative effect		Risk custodian	
Risk name	Risk even description						
Risk impact based on goal							
Safety	Time		Cost	Quality			
Risk responsiveness measures							
Row	Measure description	Relative cost	Measure custodian	Implementation date		Measure outcome	
1							
2							
Revising reactive measure relevant to code risk							
Reactive measure name				Required revision			
Suggestions in changing or revising risk management or project management plan:							

In quantitative analysis of risk, simultaneous effect of impact intensity and probability of risk on each project goal is estimated. To this end, Omid Riyazi has analyzed the effect of risk on goals based on opinions of respondents. The effectiveness index has been defined based on equation 1, in which the mean value of multiplication of the effect on goal and probability or risk is based on opinions of 10 respondents and it has been considered as criterion for prioritization and significance of effects of risk relevant to each project goal.

$$R_X^K = \frac{\sum_{Y=1}^{N} A_{XY}\beta_{XY}^K}{N} \quad \text{effect of risk x on goal k} \qquad (1)$$

Where;

M refers to total number of risk (50)

K= project goals (time, cost, quality and …)

Y= valid response to risk x

N= total number of valid responses to risk x

Axy= probability of occurrence of risk x determined by Y assessor

β_{XY}^K = level of risk effect on project goal determined by Y assessor

For example, response of a respondent for risk of lack of liquidity and delay in payment of contractor and relevant calculations has been presented in tables 2, 3 and 4.

The effect of the said risk on time, quality, cost and safety has been determined at 5 levels respectively to average, low and very low. Hence, according to assessment of a respondent, probability of occurrence was detected in high level.

TABLE II. RESULTS OF ASSESSMENT OF LACK OF LIQUIDITY ON PROJECT GOALS

Effect of risk on project goals (number 1 for lowest effect and number 5 for highest effect)				
Risk item	Time	Quality	Cost	Safety
Lack of liquidity and delay in payment of bill to contractor	3	2	2	1
Allocated numerical value of effect intensity	0.2	0.1	0.1	0.5

TABLE III. RESULTS OF ASSESSMENT OF PROBABILITY OF LACK OF LIQUIDITY ON PROJECT GOALS

Effect of risk on project goals (number 1 for lowest effect and number 5 for highest effect)					
Risk item	Very low	Low	Average	High	Very high
Lack of liquidity and delay in payment of bills to contractor				*	
Allocated numerical value of effect intensity	0.7				

TABLE IV. EFFECT OF EFFECT INTENSITY AND PROBABILITY OF OCCURRENCE OF LACK OF LIQUIDITY

Effect of probability of occurrence and impact intensity of risk, lack of liquidity and delay in payment of bill to contractor				
Risk item	0.75.0.2	0.750.01	0.750.1	0.750.05
Allocated numerical value of impact intensity				

III. RESULTS OF QUESTIONNAIRE

A. *Information of respondents*

Details of information relevant to respondents has been presented in table 5 and summary of results obtained from educational degree, history, contract fee and project positions are presented in following tables and diagrams.

B. *Educational level*

Conditions of respondents based on educational level and work experience are presented in table 5. As it is observed, 89% of respondents have a BA degree; 8% have MA degree and 3% of them have post-diploma degree.

TABLE V. BACKGROUNDS BASED ON EDUCATIONAL LEVEL OF RESPONDENTS AND THEIR PORTION

Group	Sub-group	Percent
Educational degree	MA and PhD	7.58%
	BA	89.02%
	Diploma / post-diploma	3.39
	Below diploma	0.00%

IV. CONTRACT FEES

Conditions of respondents based on contract fees and work experience are presented in table 6. Clearly, 43% of respondents have portion of 100bilion toman in the projects and 34% of them have portion of 25-200billion toman.

Conditions of respondents based on job position and work experience are presented in table 7. 42% of backgrounds of respondents are relevant to technical expert; 13% are workshop supervisor and 16% are project manager.

Conditions of respondents based on working field are presented in table 8. 42% of respondents are technical expert; 13% are workshop supervisor and 16% are project manager.

TABLE VI. BACKGROUNDS BASED ON CONTRACTUAL FEES OF PROJECTS OF RESPONDENTS AND THEIR PORTION

Group	Sub-group	Percent
Contract fee	Below 1billion	1.20%
	Below 5billion	4.19%
	Below 25billion	17.56%
	Below 100billion	34.13%
	More than 100billion	42.91%

TABLE VII. BACKGROUNDS BASED ON POSITION OF RESPONDENTS AND THEIR PORTION

Group	Sub-group	Percent
Position	Project manager	15.77%
	Workshop supervisor	12.57%
	Technical expert	41.72%
	Planning expert	27.94%
	Technician	2%

TABLE VIII. BACKGROUND BASED ON WORKING FIELD OF RESPONDENTS

Group	Sub-group	Percent
Job	Employer	37.72%
	Consultant	26.75%
	Contractor	24.75%
	Designer	8.38%
	Supplier	2.40%

Details of information related to opinions of respondents on probability of risk have been presented in the appendix and the results are presented in table 9.

TABLE IX. MEAN VALUE OF PROBABILITY OF 50 RISKS MENTIONED IN THE STUDY

Row	Risk item	Prob	Row	Risk item	Prob
1	Lack of systemic attitude among relevant sections of project	51.8	26	Lack of using project management processes	58.8
2	Inadequate rewarding/maintenance or punishment systems	46.5	27	Lack of low-quality material access	53.5%
3	Unfamiliarity and use of modern executive methods	49.4	28	Unawareness in observance of safety principles and inadequate training of labor	58.8
4	Lack of support of senior director for planning requirements	50.6	29	Violation of approved executive methods	45.3
5	Lack of required support of staff departments for project	42.9	30	Violation of contractual conditions and limit	42.9
6	Imperfect feasibility and economic studies	49.4	31	Weak workshop equipment (machinery and equipment)	57.6
7	Inefficiency of management information system in projects	45.3	32	Insufficient supervision on quality of executive activities	48.8
8	Lack of availability of background of similar projects	35.5	33	Damage of material and project equipment	45.3
9	Exchange rate determination	61.2	34	Delay in delivery of executive plans	58.8
10	Inflation in price of project materials	67.6	35	Attitude of reduced designation time and acceleration in implementation	53.5
11	Fire and unexpected events	32.9	36	Problems with designation and changes in executive plans in implementation phase	48.8
12	Delay in gaining permissions and creating bureaucracy	52.9	37	Using inadequate designation methods and standards	46.5
13	Sanction / war	49.4	38	Lack of engineering use of value in designation phase	53.3
14	Change in regulations	42.4	39	Delay in solving contractual items	58.2
15	Cultural conflicts and sabotage of regional residents	40	40	Imposing compacted schedule on contactor	60.6
16	Theft of installed equipment	45.9	39	Executive changes while working by order of employer	46.5
17	Inadequate industrial culture of workforce	44.1	42	Interferences and low breaking by employer	40
18	Mistake in scheduling and sequence of project activities	69.4	43	Abuses of project resources by managers	45.3
19	Wrong estimation to present price in tender	56.5	44	Lack of liquidity and delay in payment of bill to contractor	63.5
20	Inadequate allocation of force and equipment	60.6	45	Inconsistency of groups involved in the project	55.9
21	Weak efficiency of workforce	58.2	46	Inefficiency of assessment system and selecting contractors	58.2
22	Shift and leaving job by key personnel	56.5	47	Damage while carrying	42.4
23	Weak management and consistency of contractor	56.5	47	Damage while carrying	42.4
24	Weakness management and contractor ability	58.2	49	Delay in carrying equipment	58.8
25	Inadequate personnel organization	61.2	50	Inadequate qualitative supervision to make equipment	55.9

The impact of risk on each goal of project has been analyzed based on calculations presented in previous sections and only for valid responses collected (impact intensity * occurrence probability). The results of ranking for each goal are presented independently in the table following.

According to collected responses, simultaneous effect of risk on time and probability based on eq.1 presented in previous quantitative analysis has been presented in table 10.

TABLE X. QUANTITATIVE VALUES OF EFFECT OF RISK ON TIME

Risk item	Effect of risk on time
Lack of liquidity and delay in payment of bill to contractor	0.38
Mistake in scheduling and sequence of project activities	0.35
Insufficient financial ability of contractor	0.33
Wrong estimation to present fee in tender	0.30
Sanction / war	0.30
Delay in making equipment	0.30
Weak management ability of contractor	0.29
Shift and leaving job by key personnel	0.28
Inadequate allocation of force and equipment	0.27
Delay in carrying equipment	0.26
Imposing compacted schedule on contractor	0.25
Weak workshop equipment (machinery and equipment)	0.24
Lack of consistency between groups involved in project (lack of knowledge or techniques)	0.24
Delay in delivery of executive plans	0.23
Lack of systemic attitude among relevant sections of project	0.22
Delay in solving contractual items	0.19
Unavailability or low material quality	0.18
Imperfect economic and feasibility studies	0.18
Inefficiency of assessment system and selecting contractor	0.18
Damage of material and equipment of project	0.18
Lack of support of senior director for planning requirements	0.17
Executive changes while working by order of employer	0.16
Lack of engineering use of value in designation phase	0.16
Interferences and law breaking by employer	0.16
Violation of approved executive methods	0.15
Designation problems and changes in executive plans in implementation phase	0.15
Inadequate industrial culture of workforce	0.14
Using inadequate designation methods and standards	0.14
Unfamiliarity and lack of using modern executive methods	0.14
Cultural conflicts and sabotage of regional residents	0.14
Theft of installed equipment	0.13
Change in regulations	0.13
Inadequate rewarding / maintenance or punishment systems	0.12
Fire and unexpected events	0.12
Lack of required support of staff departments for the project	0.12
Unavailability of background of similar projects	0.12
Delay in getting permissions (administrative bureaucracy)	0.11
Inefficiency of management information systems in projects	0.11
Lack of knowledge in observance of safety principles of labor	0.10
Insufficient supervision on quality of executive activities	0.10
Inadequate personnel organization	0.09
Exchange rate change	0.08
Inadequate qualitative supervision in making equipment	0.08
Violation of contractual provisions	0.08
Weak efficiency of workforce	0.08
Abuse of project resource by managers	0.08
Managerial attitude to reduce designation phase time and rapid transfer to implementation phase	0.07
Damage while carrying	0.06

V. THE EFFECT OF RISK CUSTODIANS ON EACH PROJECT GOAL

According to the opinions of respondents, the effect and portion of each risk custodian relevant to project has been presented in second level of risk failure structure as it is clear in table 11. The most effects have been detected on behalf of contractor, employer and are also detected as inadequate economic conditions, design and supplier in next steps

TABLE XI. THE EFFECT OF RISK CUSTODIANS ON PROJECT

Risk custodian	Relative effect
Contractor	16.88%
Employer	14.77%
Economic	12.90%
Designer	12.31%
Supplier	11.49%
Political / governmental institutes	9.85%
Infrastructures	9.50%
Cultural / social	6.57%
Force majeure	5.74%

VI. CONCLUSION

As it was mentioned before, main risks on affecting cost behalf of contractor, employer and outside environment can affect project. The most underlying items of increasing project costs are as follows:

- Overhead costs and lost costs caused by any kind of inadequate delay and work sequence
- Cost for rework and reforms caused by insufficient supervision and lack of financial resources in required period
- Non-integrated decision making and separated from relevant sections of project and lack of efficient use of financial and human resources
- Effects of outside and unavailable environment such as increased rate of inflation, exchange, sanction and force majeure

As the orientation of risk management deployment should be determined and all steps of risk management should be controlled by that, the reactive result and effects of risk on project goals should be recorded as much as possible in databank of risk based on tables above and due to selecting each above mentioned measure. Then, according to their effect, continuity of reactive plans and revision of these plans was taken. In some cases, risk management plan or project risk management plan is revised. Detecting necessity or lack of necessity of that is taken with getting opinions of experts and custodians and information is presented in databank.

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