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Cause and Effect Analysis of Risks of Refinery Developmental Turnkey Projects through System Dynamics Approach Case Study: Development Project of Third Distillation Unit and LPG (Liquefied Petroleum Gas) in Isfahan Oil Refinery

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Abstract
Project managers are grappling with a variety of risks today as a result of increasing complexity and dynamics of projects in different stages of project life cycle. Thus, it seems quite necessary to employ an efficient risk management process that can overcome the shortcomings of traditional methods in order to handle such complexities and reach the optimal project management. This matter is even more important in large scale and complicated projects such as EPC (Engineering, Procurement, and Construction) or turnkey projects where the contractor accepts total responsibilities. One of these new and powerful methods is system dynamics approach that can aid project managers through identification, analysis and evaluation phases. One of the major strategic projects of Isfahan Refinery Development Plan is the third distillation unit and LPG project which is executed through EPC method. The study population consists of 18 experts and project managers examined using census method. To this purpose; a list of potential risks was prepared through literature review in the form of questionnaire to identify risks of mentioned project. Next, by using causal loop diagram (CLD), the cause-effect relationship between risks specified was explained. Applying experts' opinions, the primary loop was validated structurally. Several feedback loops were identified and analyzed deeply to determine the influential risks which affect all other risks directly or indirectly. Results show that some risks are more vital and critical for this project which are: project management weaknesses, poor time and cost estimation, poor designs and plans, weaknesses in the procurement, incompetence at site manager and establishing communications between site personals and subcontractors poor performance. In the end, practical policies to improve those situations were presented. To analyze questionnaire data, SPSS was used and to perform system dynamics approach, Vensim software was applied.

Keywords
Risk Management, Cause and Effect Analysis, Feedback Loop, EPC or Turnkey Projects, Isfahan Refinery Development and Revamping Project

1. Introduction

One of the most important ways for project-based organizations to survive is to have successful projects. The increasing complexity of projects and their failure, however, pulls organizational goals in the opposite direction and contrary to the managers' desires. The risks and uncertainty reduce projects effectiveness which ultimately leads to their failure. However, risk is an inherent element of a project thus cannot be completely eliminated. So, risks are likely to happen in at least one of aspects of the project such as scope, time, costs or quality. In order to decrease the impact of risks on achieving projects goals, they can be effectively managed. The risk management process is able to identify, analyze risks and offer some strategies to reduce their effects [1]. Under such circumstances, leading and efficient executives are required to manage risks optimally using new approaches and methods to deal with their adverse effects. One of these new techniques is system dynamics approach which functions very powerfully in analysis of complex systems and their dynamics. By using this approach in project risk management, risks can be identified and analyzed deeply.

The need for regarding this matter would be even more vivid in particular in large and complex projects such as EPC which are implemented in oil and gas industries and are faced with numerous hazards. In EPC projects, contractor is made responsible for all activities from management, implementation to quality control. Therefore, extension of responsibilities and complexity of managing multiple domains increase the likelihood of exposure to various risks [2].

The third distillation unit and LPG is one of the major strategic projects of Isfahan Refinery Development Plan which is executed through the EPC. Extension of project and its strategic importance highlights the need for evaluation of dynamics of project risks precisely and managing them optimally. However, the static and traditional risk management methods will not be effective for this particular purpose because of the project's complexity and dynamics. That's why system dynamics approach with its strategic and futuristic perspective aiming to shed light on causal and logical relationships between risks in order to identify the key ones would be an appropriate method which can find the roots of the existing problems and provide managers with the proper solutions.

The main purpose of this research is to identifying main risks of present project through investigating cause-effect relationships between all specified risks. To this end, first the literature and previous studies will be reviewed in this article to identify potential and more likely risks. After questionnaire was developed, the briefing session was held to collect the data required to be analyzed. After data analysis stage, risks of the project were identified. In the next step, risks identified were analyzed causally using system dynamics approach and drawing causal loop diagrams thus the most important risks affecting the project were recognized.

2. Theoretical Framework

2.1 Project Risk

There is no single definition of the word "risk" available in the scientific literature. According to the Oxford dictionary, risk is defined as "the possibility that something unpleasant or unwelcome will happen in the future" and is rooted in Italian words "risco", "riscare" and " richiare" from the 17th century [3]. According to the Project Management Body of Knowledge (PMBOK), risks in projects are unknown and contingent events or circumstances which affect project's objectives as negative or positive consequences in case they happen. Each of these events or situations has clear causes and results in detectable consequences, such outcomes directly affect project's timing, costs and quality expected [4]. What's of great importance is that it is not possible to determine the positive and negative effects and outcomes of risks on project's goals prior to identifying them. After risks are known and analyzed, they could be planned and guided, while unknown risks cannot even be managed relying on past experiences [5].

2.2 EPC Project

EPC consists of three main themes including design and engineering (E), procurement (P) and implementation and construction (C). In EPC projects, contractor is made responsible for all the activities including design and engineering, procurement of all materials, tools and equipment, construction, to commissioning as well as on-site construction of the project or delegating some work packages or some project phases to subcontractors. On the other hand, the employer is obliged to supply the location required for the project implementation, provide information and current regulations on site such as environmental standards or land use laws and investigate contractor's documents received in due course. These contracts are also called turnkey projects as after installation and construction operation is completed and tests and technical inspections are done, the employer simply presses a key to exploit the project [6]. Advantages and disadvantages of this type of contract in the opinion of both contractor and employer could also be examined. For example, advantages of this contract from employers' perspective include: more security in operating costs, less need for manpower, better integration and disadvantages are raising costs and less control over the details. In the eyes of contractor, the advantages are more flexibility in implementation and more integration, also the major flaw is the increased risk [7].

2.3 System Dynamics Approach and Methodology

Jay Wright Forrester developed system dynamics in the mid-twentieth century to understand systems' time-dependent behavior. System dynamics helps us comprehend structures and dynamics of complex systems [8].

The aim of dynamic system modeling is to achieve a specific sight on system relations so that policies that are likely to be used to improve the system can be considered. Every dynamic system that can be changed over time has a hierarchical structure with the following pillars in causal analysis:

- Closed boundary or causal loop diagrams: a tool to visualize the cause and effect relations between a set of variables involved within the system. The main elements of causal loop diagrams are variables (factors) and arrows (relations).
- Feedback loops (including positive and negative feedback loops): positive feedback loop is a circle that enhances or amplifies changes when a factor is changed in one direction. Negative feedback loop, on the other hand, is a circle where anytime a change is made in one factor in a certain direction that it opposes and tries to lessen it.
- Positive feedback structure: in such structure, changes in the system are strengthened by feedbacks. Thus, variables strengthen their own growth or decline. An even number of negative links in the causal loop diagram (including zero) signifies that the loop has a positive polarity [9].
- Negative feedback structure: in such structures, feedbacks oppose changes made in the system and thus they are characterized with behavior seeking target and guided by purpose. Negative feedback loop is always linked to a purpose and functions as a control loop in the system. A feedback loop is called negative where there is an odd number of negative links between variables in the loop [9].

3. Research Literature

3.1 Review of Previous Research on Projects Risk Management

Research studies suggest that numerous investigations have been done so far on projects risk management especially industrial projects using various approaches and methods. These studies and their approaches as well as weaknesses are summarized in Table 1.

Table1. A summary of research done on risk management of large industrial projects and the approaches employed

Researchers	Industry	Research purpose	Research approach	Risk management phases				Research weaknesses
				Identification	Evaluation	Response	Control	
[10]	Construction projects	Evaluate risks	Fuzzy AHP and Fuzzy TOPSIS	□	□			Using traditional static methods, lack of strategic standpoint, neglecting cause and effect relationships between risks
[11]	construction projects in china	Understand the key risks and develop strategies to manage them	Statistical analysis	□	□			Using static methods, lack of strategic standpoint, neglecting cause and effect relationships between risks
[12]	Construction projects in developing countries	Identify and evaluate of risks	Alien Eyes Risk Model	□	□			Lack of attention to strategic and prospective perspective, neglecting cause and effect relationships between risks
[13]	Construction of a radial intake well for a thermal power plant	Identifying and analyzing of risks	Brain-storming secession	□	□			Disregarding strategic standpoint, neglecting cause and effect relationships between risks
[14]	EPC project in IRAN	Risk identification and prioritization	Group decision-making in fuzzy environment	□	□			Using static methods, lack of regarding strategic standpoint, neglecting cause and effect relationships between risks
[15]	EPC projects	Risk identification and prioritization	Mathematical optimization procedure	□	□			Lack of regarding strategic standpoint, neglecting cause and effect relationships between risks
[16]	LPG storage tanks construction	Identify and evaluate of risks	MCDM	□	□			Using static methods, lack of regarding strategic standpoint, neglecting cause and effect relationships between risks

3.2 Identifying Potential Risks of EPC Projects by Reviewing Previous Researches

Risks have been categorized in different research through numerous approaches so they could be analyzed properly. Depending on the requirements of each project, some of the risks were recognized as more important while some others as less important. Therefore, risk groups are chosen mainly on the basis of projects scope, requirements and the analysis approach. In this study, risks are grouped into three main phases of engineering, procurement and implementation and other risks are considered as a subset of these phases. On the other hand, risks can be examined from the viewpoint of any parties involved in the project. Risks can be analyzed on the basis of comments and opinions of employer, contractor or project consultant. In the present study, risks will be evaluated from the perspective of project contractor who bears the greatest burden of the risk in EPC projects.

As represented in the next three tables, the potential risks of large industrial projects are derived from different studies and categorized into three main groups including engineering (Table 2), procurement (Table 3) and construction (Table 4). Any of them could be potentially regarded as an important and determinant risk in the project studied here which will be detected and clarified after survey of expert's opinions.

Table2. Project Potential risks in engineering section and supporting researches

No.	Risks of engineering section	Supporting research
1	Failure to estimate the expenses of engineering section correctly	[18], [17], [11]
2	Wrong estimation of engineering time	[18], [17], [10]
3	Lack of specialized managers and personnel	[19], [11]
4	Design errors (weaknesses or over design)	[18], [12], [11]
5	Mismatched and inappropriate technical drawings	[17], [10], [11]
6	Reduced design phase time and rapid transition to the implementation stage	[10], [11]
7	Using improper standards and methods in design	[24], [18]
8	Lack of obtaining or delay in getting the initial permits required for the project	[10], [12], [11]
9	Errors in initial studies	[10]
10	Inadequate feasibility studies	[10]
11	Project management incompetence	[12], [11]
12	Poor project planning and control over the engineering section	[20], [17], [19], [10], [11]
13	Changes caused by political developments	[19], [17]
14	Reducing wages and rewards and employees dropped motivation	[21]
15	Changes in organization's internal policies	[22]
16	Changes in the project's scale of work	[23]
17	Lack of resources required and their accurate estimation	[23], [10]
18	Failure to pay salaries timely	[19]
19	Changes of employer's demands and standards	[10], [11]

Table3. Project Potential risks in procurement section and supporting researches

No.	Risks of procurement section	Supporting research

1	Failure to estimate the expenses of procurement section	[11]
2	Wrong estimation of procurement time	[11]
3	Low quality of equipment and materials	[19], [17], [24]
4	Fluctuations in the price of some materials and equipment	[17], [24], [11]
5	Lack of timely supply of some materials and equipment	[20], [17], [23], [11]
6	Inappropriate selection of equipment and materials manufacturers	[19], [17], [23]
7	Legal restriction on entering materials and equipment	[18]
8	Poor project planning and control in procurement section	[17]
9	Administrative bureaucracy and lack of coordination in procurement section	[18]
10	Changes resulted from political and commercial developments	[17], [24]
11	Delay caused by technical inspection	[17]
12	Unstable management in equipment manufacturers	[17]
13	Scarcity and lack of access to some materials and equipment	[17]
14	False information exchange with suppliers	[24], [25]
15	Lack of proper international communication	[25]
16	Poor quality control of equipment and materials construction	[24]
17	Damage during equipment transport	[24]
18	Contractors financial difficulties in procurement and purchasing section	[18]
19	The extension and complexity of process	[18]
20	Lack of integrated information and documentation system	[18]
21	Difficulties in clearance	[1]
22	Changes made in laws such as insurance, taxes, etc.	[18], [25]

Table4. Project Potential Risks in construction section and the supporting research

Row	Risks of implementation section	Supporting research
1	Failure to estimate the expenses of implementation section	[19] ,[20],[24] ‹[11]

	correctly	
2	Wrong estimation of implementation time	[15] ،[24]
3	Delays in checking and paying the financial statements off	[17] ،[10] ،[12]
4	Delays caused by the long process of obtaining permits required	[20], [24]
5	Incompetence of subcontractors	[19] ،[17] ،[20] ،[10] ،[24]
6	Lack of skilled and technical workers	[19] ,[17] ،[20],[12] ، [11]
7	Lack of sufficient safety and disregarding HSE principles	[19] ،[17] ،[24] ،[11]
8	Workshop facilities shortage	[20],[24] ،[11]
9	administrative and physical errors in the project	[19] ،[17]
10	Poor planning and control of the project in implementation section	[19] ،[17] ،[20] ،[24] ، [11]
11	Administrative bureaucracy and lack of cooperation over the implementation phase	[20] ،[10]
12	Unexpected disasters such as floods, earthquakes, etc.	[17] ،[12]
13	The impact of climatic factors	[17] ،[20]
14	Changes in key personnel in the implementation section	[17] ،[24]
15	Changes resulted from governmental and political developments	[19] ،[17] ،[20] ،[12]
16	Errors in testing concrete, soil, etc.	[17] ،[11]
17	Rework and increasing the time and cost of project implementation	[21] ،[20]
18	Delays in the start-up phase	[21]
19	Lack of financial capability among subcontractors	[22] ،[19]
20	Mismatch between implemented sectors and design drawings	[22] ،[26]
21	Unfamiliarity with social and cultural context of the site	[15] ،[12]
22	Equipment and machinery failure and unreliability	[26]، [24] ،[11]
23	Measurement and control equipment failure	[20]
24	Staff riot ad strike	[23]
25	Poor communication and teamwork	[23] ،[10]
26	Contagious diseases	[23],[12]
27	Poor inspection process, quality control and quality assurance	[23],[24]
28	Failure to pay timely salaries	[19]
29	Lack of training and updating the enforcement personnel	[19]
30	Facing obstacles during project implementation	[20]
31	Lack of timely access to necessary maps and information over the implementation phase	[20]
32	Employing unskilled engineers in monitoring	[24]
33	Poor of the project site manager	[20] ،[11]
34	Contractor's financial problems	[20] ،[24] ،[11]
35	Delays caused by employer's senseless intervention	[10]
36	Subcontractors' working clashing	[18]

4. Methodology

Data collection method used in this study consists of two parts:

A) Library studies: to review the literature on this topic, Latin and Persian books, articles and other resources gathered through databases, internet and libraries were used.
B) Surveys: in order to collect the information needed and measure the variables, if necessary, a combination of two methods including in-person meetings and questionnaire were used.
The questionnaire was designed to present potential risks gathered by literature review to the experts and obtain their opinions about certain risks related to the project studied here. To this end, a briefing session was held with participation of experts to discuss the project risks and questionnaire's items. Census sampling method was applied among managers of project's different departments. Finally, 18 executives attended the session and responded to the questionnaire and provided their comments and ideas on how to identify risks relevant.
In this part, risks defined involving in the project were analyzed causally and then Vensim software was run to draw the causal loop diagrams of the links between risks. As a matter of fact, the effects of risks on each other were examined and causal relations between them were visualized as the primary loop causal diagram. The diagram was then put at experts' disposal over an in-person meeting to validate it and their corrective comments and suggestions were applied on it and this causal loop diagram was approved and finalized. The causal loop diagram was analyzed and several important feedback loops as dynamic hypothesis were extracted from it.

5. Analysis of Results

5.1 Project risks Identification

Taking into account the results of tests performed on data obtained from the questionnaires, the importance of a number of risks suggested by experts was confirmed. This means that these are great importance in this study and "risks irrelevant to the project" and "less important risks" were not approved. The finalized risks are presented in Table 5.

Table5. Identified Risks

Section	No.	Identified risks	Section	No.	Identified risks
Engineering	1	Failure to correctly estimate the expenses of engineering	Construction	1	Mistakes in estimation of implementation process expenses
	2	Failure to correctly estimate the time of engineering		2	Failure to correctly estimate the time of implementation process
	3	Lack of skilled and specialized managers and staff		3	Incompetent subcontractors
	4	Design errors (over design)		4	Poor communications and teamwork
	5	Mismatched and improper technical drawings		5	Dealing with obstacles during the project implementation
	6	Design phase reduced time and rapid transition to the implementation phase		6	Poor of the project site manager
	7	Lack of obtaining and delays in getting the initial permits for the project		7	Contractor's financial problems
	8	Errors in initial studies		8	Lack of training and updating implementation personnel
	9	Inadequate feasibility studies		9	Administrative and physical errors in the project
	10	Incompetent project management			
Procurement	1	Mistakes in estimation of procurement expenses			
	2	Failure to correctly estimate the time of procurement			
	3	Fluctuations in the price of some materials and equipment			

5.2 Drawing and Analysis of Causal Relations

In order to draw the cause and effect diagram in this study, therefore, risks specified were put at experts' disposal to evaluate their behavior and depict the type of relationships between risks and feedback loops arising from them. This way, the primary causal model is created. In order to validate this primary causal loop, it is given to the experts and confirmed by them (Figure 1).

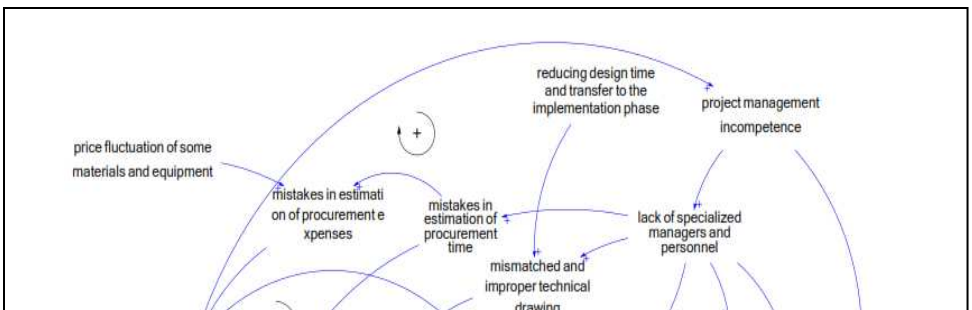

Figure1. Causal loop diagram

After examining the signs of the problem, system dynamics models move backward through the causal chains to detect Rooty causes that may exist anywhere [8]. Reviewing the overall structure of causal loop, feedback loops existing inside are investigated:

5.2.1 Feedback Loop 1: Poor Estimations of Engineering Section

Unspecialized project managers select and appoint unskilled executives and personnel. The unspecialized managers and personnel won't be able to perform the preliminary estimates and reviews properly and adequately for example on the original feasibility studies when beginning the project. This inadequate feasibility studies will be followed by some difficulties in project's initial investigations and calculations. Incorrect assessment and evaluation in turn results in obstacles over the process of obtaining the initial permits required from the authorities to start the implementation of the project which sometimes leads to delay or even failure to get the licenses. Delays in turn lead to errors in estimating the time and subsequently the costs of engineering section. Such time and cost estimation mistakes will impose inevitable financial problems on contractor. The rest of the loop implies that financial difficulties created will be followed by incompetence of project management team (Figure 2).

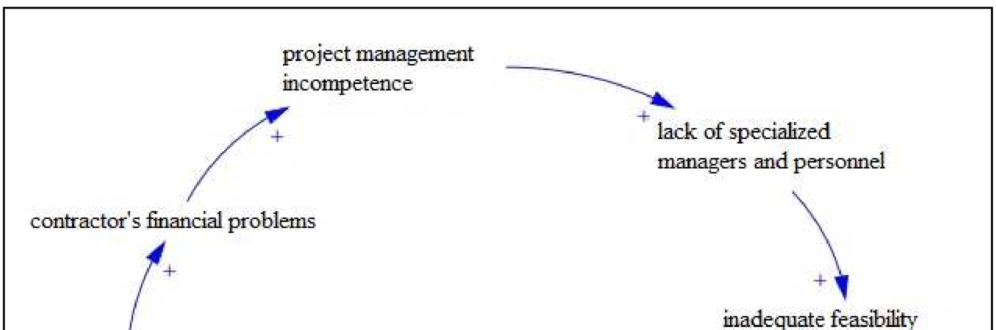

Figure2. Feedback loop 1

5.2.2 Feedback Loop 2: Poor Design

As described in previous loop, unspecialized project management would choose and appoint some unprofessional executives and personnel in design phase. Such unskilled employees will provide drawings with high design factor when designing the project. Using these drawings full of defects in construction and implementation process will result in using materials exceeding what was predicted in design phase in optimal conditions. Besides, creating drawings with low design factor will raise the probability of incidents caused by damaged structures and equipment during construction or in the worst case over operation. In both cases, poor and flawed design will impose unforeseen additional costs on the contractor and financial problems eventually unveil incompetence of project management team (Figure 3).

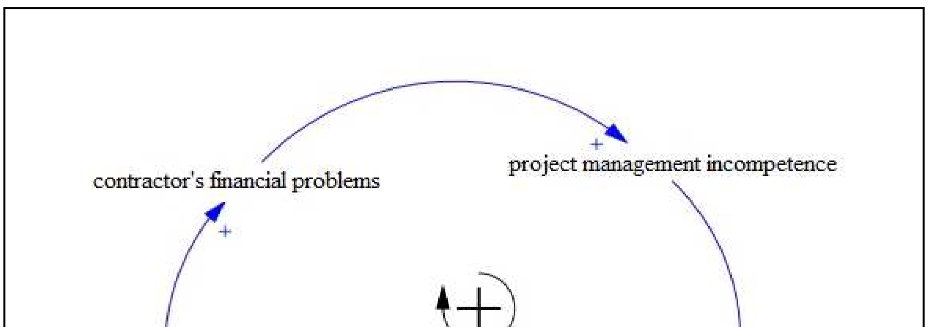

Figure3. Feedback loop 2

5.2.3 Feedback Loop 3: Errors in Drawings and Executive Stages

Referring to the description on previous loops, it is obvious that unspecialized project managers recruit unprofessional executives and employees during design phase. Employing unskilled personnel and insufficient studies and research on refinery's existing facilities drawings lead to creating new drawings that could stop the entire operation, digress personnel and equipment, cause delays and thus failure to meet the schedule planned and so forth after transition to the implementation phase and dealing with obstacles (especially underground ones) that have not been seen over the design stage. In the meanwhile, sometimes we had witness some external forces exerting pressure by company (client) to prepare the drawings and transfer them to the implementation section as fast as possible which in turn leads to increased errors when designing as a result of insufficient studies and information. Errors, stoppages and rework caused by aforementioned factors will impose unforeseen costs on contractor and increase their financial problems. The latter factor, employer's pressures to accelerate the preparation and transmission of drawings to the execution phase is out of contractor's hands however errors caused by inadequate studies on existing drawings before designing are under control of the company (Figure 4).

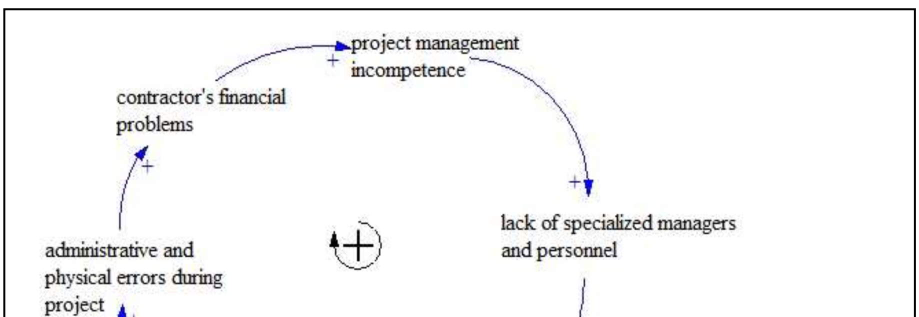

Figure4. Feedback loop 3

5.2.4 Feedback Loop 4: Weaknesses over Supply and Construction of Materials and Equipment Needed in the Procurement Section

As explained in previous loops, inexperienced managers always hire and appoint unprofessional executives and personnel. Given that the whole process is very complicated and that unskilled managers and employees lack sufficient knowledge on procurement of goods and equipment required for the project, they won't be able to estimate the time needed for supplying the items listed correctly thus the equipment won't be provided on time to be used in the implementation section. Failure to provide the equipment needed timely will stop the construction thus increases the project time and overhead costs which will exert financial pressure on contractor eventually (Figure 5).

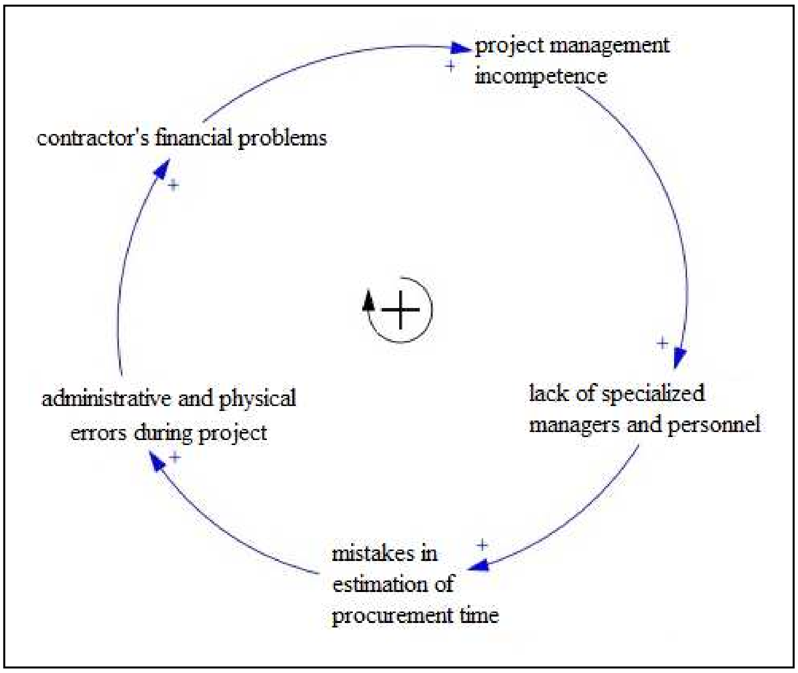

Figure5. Feedback loop 4

5.2.5 Feedback Loop 5: Weaknesses in Procurement Section Estimations

Considering the complexity of the process and lack of sufficient information about procurement of goods and equipment required, unskilled managers and personnel won't be able to evaluate the time and costs of this section correctly which in turn will impose financial problems on contractor. On the other hand, price fluctuations (usually rising price) of some materials such as iron; cement etc. during implementation will also have a significant impact on project cost price. Such serious inefficiencies of contractor will eventually attract senior decision makers' attention to the project management incompetence (Figure 6).

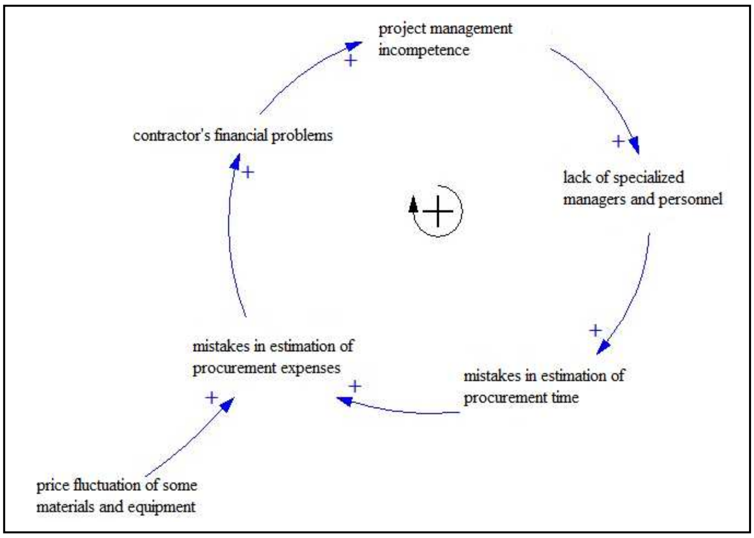

Figure6. Feedback loop 5

5.2.6 Feedback Loop 6: Implementation Poor Estimations

Furthermore, manager incompetence results in recruitment of inefficient executives for organizational subset positions especially in headquarter various departments. This could happen as a result of lack of knowledge and poor management skills of the senior executive team in choosing efficient employees, regarding relations instead of qualifications and pressure exerted by senior managers to hire certain managers and employers. Lack of qualified and professional personnel in the engineering phase including planners and experienced experts in assessment process leads to numerous errors which affect accurate estimation of time and prices at the beginning of the project when tender is held. Such key mistakes when estimating time and prices will create serious disruptions in delivering the completed project on time and meeting expenses and impose many financial consequences on contractor at the beginning of the project. These basic weaknesses lead to inefficient project management which again will attract senior decision makers’ attention to the manager's incompetence (Figure 7).

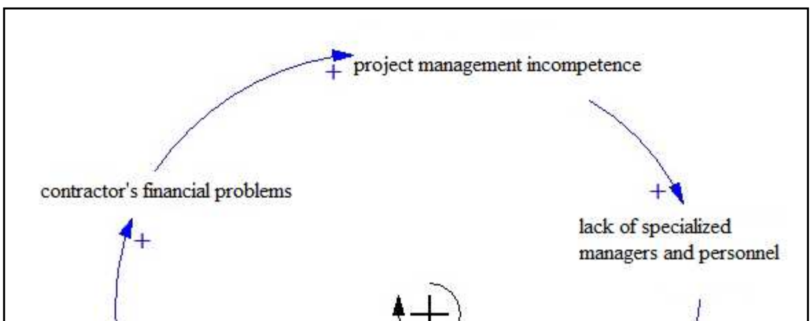

Figure7. Feedback loop 6

5.2.7 Feedback Loop 7: Workshop Training and Communication

Factors such as project management team inefficiency, lack of knowledge on management principles, considering connections instead of qualifications or having to hire individuals because of the pressure imposed by company's higher officials will result in choosing an inefficient and incompetent site manager who is in charge of all activities done in the site and plays a key role in the project. On the other hand, such poor unprofessional site managers normally disregard training principles, updating personnel information and implementation of regulations on healthy and effective relationships in the work setting which create an unhealthy competitive environment in the organization where workshop staff forget all about efficient team communication and cooperation to achieve administrative goals and start to compete with each other unfairly seeking to keep or promote their own position and this is in stark contrast with the spirit of teamwork. This lack of coordination and cooperation between departments and people involved during implementation of the project will be followed by disruption, errors and delays. It is clear that such problems happening over the physical implementation of the project will impose additional costs on the contractor. Increased unintended and unforeseen costs in turn will cause disturbances in the project management process. Such poor performance will capture senior managers' attention to the incompetency of executive team which could be a wake-up call manifesting weaknesses and defects of the whole project (Figure 8).

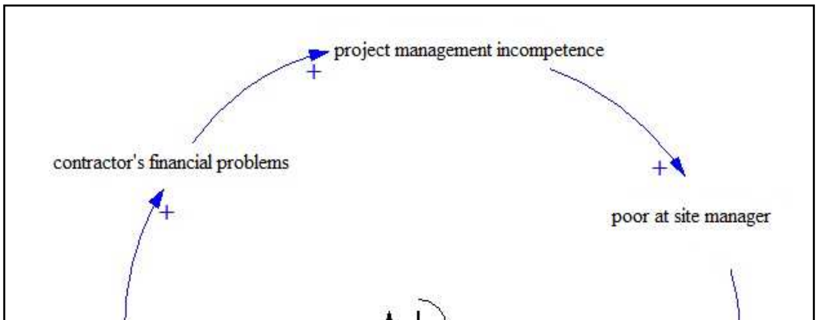

Figure8. Feedback loop 7

5.2.8 Feedback Loop 8: Incompetence of Workshop Contractors

According to abovementioned, inefficient project management leads to selection and recruitment of unqualified site manager for various reasons. site manager's lack of technical ability to perceive capacities of subcontractors given the high sensitivity of the project and the need to assess contractors when holding domestic tenders, regarding relations instead of rules and competencies and non-standard influence by senior managers over directors to choose certain individuals, even if incompetent, will result in employment of improper subcontractors. Unqualified contractors are followed by lack of progress project implementation activities accordance with plans predetermined before. In addition to the prolongation of the project, lack of physical progress on schedule rises overhead and opportunity costs for the main contractor. Increased unintended and unpredicted costs of the project could disturb management process. This in turn attracts senior managers' attention to incompetence of project management team (Figure 9).

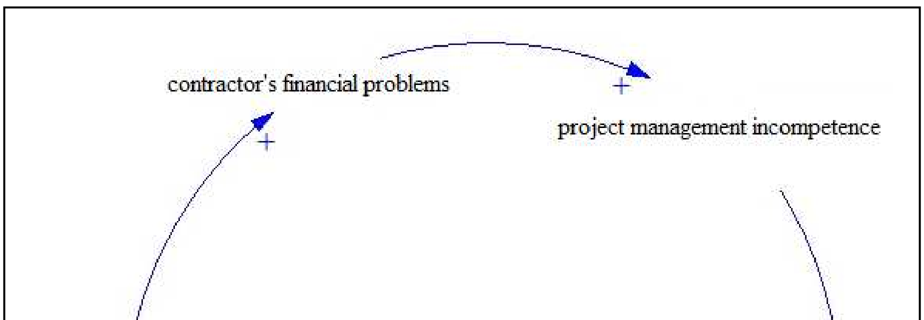

Figure9. Feedback loop 8

6. Summary and Conclusion

The need to use an efficient and updated risk management process by organizations to help them achieve their project goals is inevitable. The main purpose of this research is to identify main risks of present project through investigating cause-effect relationships between all specified risks. In first step of this process, the most effective risks are tracked. It will be impossible to carry out other steps of risk management without efficient identification of potential risks. In the next step, these risks are analyzed causally which in fact helps us recognize their main consequences. Isfahan Refinery's third distillation unit and liquefied gas project is one of the major strategic projects of the company's development plan which is executed through EPC and is studied in this research. Reviewing the previous research on risks of industrial projects, the potentials risks were gathered and represented in a list (77 risks) consisting of three parts of engineering (19 risks), procurement (22) and construction (36). After statistical analysis was performed, a number of risks affecting the project studied here (a total of 22 risks) were selected and categorized into three groups, engineering (10), procurement (3) and construction (9).

Practical suggestions on the most important risks identified in feedback loops are as follows:

- Project management team weaknesses: Employing qualified project managers with good reputations and high knowledge of oil industry who are chosen by looking at their successful projects and meeting their spiritual and material needs aiming to return the capital (costs spent on project management) through increasing project productivity arisen from high performance management, focusing on meritocracy and taking into account the rules instead of relations when selecting project management team, choosing those with sufficient competence in the field of technical and managerial knowledge especially in human resource management.

- Weaknesses in estimating time and costs: Taking the estimation matter seriously and professionally as the first step of project success by creating a specialized task force and establishing the estimate unit considering the large number of tenders in oil and gas industry

- Poor designs and maps: Signing contracts with design contractors through the consortium in order to use their experience and expertise and sharing the profits obtained from design optimization and losses from poor designs with contractors which transfers the risk of such flawed designs to them as well, holding in-service training sessions to enhance designers' knowledge, enabling designers to use the experiences from similar projects by arranging internal and external visits

- Weaknesses of supply and procurement section: Signing fixed-price contracts with foreign suppliers in order to reduce the risk of fluctuations in goods and exchange prices when political conditions are instable

- Poor site manager and communications: Appointing site manager with new management insights to inculcate teamwork spirit, taking into account the rules and qualifications rather than relations and focusing on meritocracy principle, holding training courses required.

- Deficiencies of subcontractors: Establishing proper procedures to choose subcontractors, avoiding delegating the entire activities of the same discipline to one contractor in order to create a competitive environment at work and giving appropriate rewards to the subcontractors to motivate them to expedite the project process

The main contribution of this research comes as follows:

-Applying a dynamic approach in risk management of the present project instead of outdated static methods

-Investigating causal relationship between risks of the mentioned project to show the leverage points of these project problems

-Identifying influential risks by a qualitative approach which could empower managers to have a holistic view to all risks together.

This Research faced with some limitations such as limited number of experts for survey and qualitative method which despite its benefits has some shortcomings for obtaining exact results. Another limitation is that results could not be generalized to other similar projects. For future studies some practical paths could be followed:

-Using this approach for another industrial and non-industrial projects

-Applying a quantitative method for analyzing the results to narrow the conclusions

-Simulating project key risks to apply a complete systems dynamic methodology

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