JEAS
Journal of Economics and Administrative Sciences
E-ISSN: 2148-1792 P- ISSN: 1302-2024
Volume 5, Supplement Issue 1
www.jeasweb.org

Identifying and prioritizing the causes of delays in oil and gas projects based on a fuzzy multi-criteria decision-making approach

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ABSTRACT

The purpose of this study is to identify and prioritize the causes of delays in oil and gas projects based on the fuzzy multi-criteria decision approach. From the perspective of objective and methodology, this study is an applied and hybrid research (qualitative and quantitative). The statistical population of the qualitative section includes ten refinery experts and university professors in the field of project management who were purposefully selected. The statistical population of the quantitative section includes 30 senior managers, middle managers, and project managers of the NGL 3200 refinery. In this particular research field, the opinions of managers and the management of refinery projects are of particular importance, and workers do not have sufficient information. Therefore, a census technique was used to sample the population. Subsequently, in the qualitative section, the questionnaire distribution method was used to identify the causes of project delays. In the quantitative section, a questionnaire was designed using a pairwise comparison matrix to prioritize and weight the factors based on the fuzzy AHP hierarchical analysis process. Face validity was used to assess the validity of the questionnaire. The results showed that the most important factors and sub-factors in causing delays in refinery projects are: delays in the evaluation and approval of POs, delays in the evaluation and approval of sub-contractors, inadequate estimation of the goods and services supply time.

Keywords: Oil and Gas Projects, Fuzzy Multi-Criteria Decision Making, NGL 3200 Refinery.

Introduction

The resources used by organizations in projects such as human resources, finance, materials, and energy are very valuable. Optimal use of these resources and prevention of their loss ensures the survival of organizations in the global competitive market (Golenco et al., 2003). To make the best use of these resources and prevent their waste, organizations must improve their performance based on project management science (Humaan, 2010). Successful projects are completed within the budget and time and deliver the desired performance. However, according to previous studies, most projects are delayed and not completed on predicted time and cost (Moradi, 2006). Delay is one of the most important challenges in project management; So many of the complaints raised in the project are related to delays, damages, and the responsibilities of each party to the project. Given many implementation steps and entities involved in the project, identifying the root of work delays is very complex (Artidi and Robinson, 1998).

Khorasani and Khodamipour (2015), in their study, investigated the financial reasons for delays in projects in the Kerman Gas Company. They found that delays in approving and notifying agreements, failure to allocate funds promptly, failure to pay advances on time to the contractor, late payment of financial statements, tenders and selection of contractors, and the effects of inflation on costs were the main reasons for project delays. Sarkhanzadeh et al. (2015) in their study investigated the causes of delays in energy projects. Based on the Friedman test, they showed that the factors affecting priority-based delays are: banking system problems, low liquidity, and financial problems in project implementation, challenges in supplying materials and equipment, inaccurate estimation of activities, inadequate human resource management, the long process of obtaining licenses and approvals, weakness in management knowledge, frequent changes in the project, defects in management information systems and lack of focus on audit and control systems. Rahimi and Keramati (2014) investigated the causes of delays in phase 15 and 16 South Pars gas field projects using the TOPSIS method. Based on the opinions of 46 project managers, senior managers, and project experts, 22 initial indicators were designed, and their weights were determined through the Shannon entropy technique. In the next step, the options were ranked using the TOPSIS method. Farhadi and Nejand (2009) prioritized the causes of delays in engineering and procurement in refinery development projects based on the MADM approach. One of the most important factors in delays in refinery projects is the engineering and procurement process, which due to the high weight allocated to it, causes serious problems in the later stages of the project.

According to the projects related to delay, it is evident that the cause of delays in a particular geographical region is investigated using library and field studies, and these factors are subsequently ranked using statistical methods. Also, in most studies, adequate preventive measures have not been introduced. We identify the causes of delays in oil and gas projects at the NGL 3200 refinery using managers' and experts' opinions and subsequently prioritize them using the fuzzy multi-criteria decision-making technique. According to the literature review, such research has not been performed at the NGL 3200 refinery. So this research is innovative enough. Due to many projects in this refinery, identify the factors affecting the delay.

Theoretical foundations of research

Project management and delays

Project management means applying knowledge, skills, tools, and methods to implement and realize project requirements (Shaleb, 2008). Project management includes planning, delegating, monitoring, controlling project components, and motivating people involved to achieve project objectives according to time, cost, quality, scope, benefits, and risk (Adeli Rad, 2012). Project management includes the activities of planning, organizing, supervising, and directing the implementation process with the aim of optimal use of resources and delivery of results at the estimated cost and time. We must distinguish between critical and non-critical delays in the delay investigation process. All delays are either justified or unjustified. Justified delays are divided into two categories: compensable and irrecoverable (Beheshti et al., 2013). Project delays can be categorized from different perspectives. One of the most important classifications is based on the perspective of responsibility. That is, delays can be compensable/irrecoverable. The employer is responsible for compensable delays, while the employer's role in irrecoverable delays is very limited (Fink, 1999). The contractor has no role or responsibility in forgivable delays, while the contractor is responsible for

unforgivable delays. Some papers divide contractors' forgivable delays into two groups: compensable forgivable and irrecoverable forgivable (Cao and Yang, 2009). In irrecoverable forgivable delays, the contractor only needs extra time to complete the project, but in compensable forgivable delays, the contractor is responsible for the time and damages resulting from the delay. Finally, unforgivable delays are when the contractor is responsible for all consequences (Aradit and Patnalit Chameron, 2006).

Project delay

The problem of project delays is a global problem. In Saudi Arabia, for example, only 30% of construction projects are completed without delay and on schedule (Assaf et al., 2006). In Nigeria, 70% of construction projects are delayed (Odeyinka & Yusif 1997). Researches in Jordan, Hong Kong, and Lebanon also show that most projects are delayed. Delays in development projects in Iran are one of the major challenges. The duration of a construction project directly affects investment and return on investment. Therefore, increasing the project execution time and delay leads to a large waste of capital, including construction credits, human resources, machinery, and equipment. Even delays can challenge the economic justification of the whole project.

Yates (1993) proposed a new system for delay analysis in the DAS building. The main classifications of delays in DAS are engineering, equipment, external delays, labor, management, materials, employer, contractors, and weather conditions. Mansfield et al. (1994) examined the reasons for delays and rising costs in Nigeria and identified lack of credit, environmental changes, material shortages, and poor timing as the most important factors. The most important reasons for the delay of construction projects in Lebanon are contractual relations (from the contractor's point of view) and project management (from the consultant's point of view). Also, from the employer's point of view, financial problems are the most important reason for the delay (Mezher TM, Tawil, 1998). Frimpong et al. (2003) investigated the reasons for delays and capital losses in Ghana submarine projects. Delays in the payment of financial statements by the employer, poor management of contractors, procurement of materials, weakness in technical performances, and increased material costs were introduced as the most important reasons for the delay.

Ghotbi (2001), in his research, examined the most important reasons for delays in the country's airport network projects and introduced deficiencies in studies, weakness of technical services, weakness of contractors, haste in selecting a contractor, and lack of forecast of financial resources as the most important reasons for delays. . Fahmi Azad (2002) investigated the causes of delays in dam construction projects in Khorasan province and introduced following criteria as the most important reasons for the delay: lack of familiarity with project control, lack of timely notification, lack of accurate allocation of approved funds, the mismatch between adjustment rate and inflation, lack of funding and inaccuracy in estimating the volume of operations and time.

Delays are caused by factors that provide a suitable solution for the faster implementation of projects. The structure of construction projects is one of the influential components. Economic conditions, geographical location, access to materials, specialized and local human resources, executive system management, and local culture of the region effectively accelerate or delay the project. Therefore, the factors affecting the delay are different in each region (Fathi and Najafian, 2009).

Delays in oil and gas projects

In studies of the causes of delays in the engineering section of EPC petrochemical projects, the effective factors are classified into two classes: internal and external factors. Internal factors related to human resource estimation are defects in the information system of engineering departments, human resource management, personnel errors, and factors related to corporate management. External factors are related to the exchange of purchasing engineering information with manufacturers of goods and equipment, partnerships between companies involved in the project, problems of sub-contractors in engineering and design, problems of employers such as changing needs, changes in the scope of work, and employer performance in paying financial statements. Surveys conducted in the site of the Project Management Training Association in 2009 on three employers and five contractors in the field of EPC projects show that the main causes of delays in these projects are mainly related to materials and equipment or delays in the delivery of materials to project location, purchase order delays and design changes. Research on Saudi

government projects shows that employers and design companies believe that contractors cause project delays, while contractors believe project delays are due to design companies and employers (Sarkhanzadeh et al., 2015).

Numerous studies have examined the cause of delays from two different perspectives, but their results mainly focus on a specific organization, and the effect of interaction between organizations has not received much attention. Environmental changes (beyond the control of companies, agencies, and governments) have also been ignored. The delay may start in one entity but be apparent in another. For example, suppliers' delays in providing information and technical specifications of equipment can cause delays in project design and engineering and may affect project executives and other related entities, including contractors. All entities involved in the project are faced with delay factors with different effects. All entities try to introduce another organization as the cause of the delay to avoid financial losses. A full understanding of the interrelationships between project entities is limited, and each entity considers only its interests.

Research Methodology

From the perspective of objective and methodology, this study is an applied and hybrid research (qualitative and quantitative). The statistical population of the qualitative section includes ten refinery experts and university professors in the field of project management who were purposefully selected. The statistical population of the quantitative section includes 30 senior managers, middle managers, and project managers of the NGL 3200 refinery. In this particular research field, the opinions of managers and the management of refinery projects are of particular importance, and workers do not have sufficient information. Therefore, a census technique was used to sample the population. Subsequently, in the qualitative section, the questionnaire distribution method was used to identify the causes of project delays. In the quantitative section, a questionnaire was designed using a pairwise comparison matrix to prioritize and weight the factors based on the fuzzy AHP hierarchical analysis process. Face validity was used to assess the validity of the questionnaire. Five questionnaires were distributed among professors and experts in project management. Finally, after applying their final opinions, the final questionnaire was developed, and subsequently, the face validity of the questionnaire was confirmed.

Results

In the first step, prioritization parameters are identified and defined. In the next step, the obtained data are analyzed using a fuzzy hierarchical model, and finally, the data are extracted. The causes of delay are evaluated systematically using the above analysis. The results of a case study are applied to the NGL 3200 refinery. The parameters for prioritizing the causes of project delays have been collected from various researches and library resources or extracted based on interviews with experts and experienced people and are shown in Table (1).

Table 1: Causes of delays in refinery projects

ID	Criteria	Sub-Criteria
C11	Financing	Delay in payment and lack of funding from the employer
C12		Delay in payment of financial statements
C13		Delays in assessing and paying pre-determined amounts
C14		Delay in payment of contractor fees
C15		Banking sanctions
C16		Trade sanctions
C17		The long process of obtaining foreign currency credits
C18		Not considering the appropriate financial capacity
C19		Long process of status check and attachment change of instructions and over-time
C110		Lack of proper financial feasibility
C111		Lack of timely allocation of funds
C21	Engineering Section	Delay due to change in plant capacity
C22		Delays due to document preparation
C23		Delay due to gas supply of reduction unit and sulfinol unit
C24		Defects in information on processes related to the delivery of materials to the factory
C25		Delay in determining process changes

C26		Frequent changes in the engineering documents of the executive department
C27		Frequent changes in the engineering documents of the equipment manufacturing department
C31	Goods Supplement	Inaccurate estimation of the supply time of goods and services
C32		Delays in evaluation and approval of sub-manufacturers
C33		Delays in the evaluation and approval of POs
C34		Laboratory delays in evaluating and approving manufacturers' materials
C35		Delay of the employer to attend the supply meetings
C36		Inaccurate evaluation of suppliers of goods and services
C37		Fluctuations in the prices of raw materials and equipment
C41	Delays caused by the employer	Employer interventions
C42		Delay in decision making
C43		Limitation of project time by the employer to complete the project
C44		Administrative bureaucracy in the employer organization
C45		Apply changes to the scope of tasks
C46		Lack of timely delivery of land for the installation of pipelines
C51	Delays caused by the consultant	Delay in approval of executive plans
C52		Design defects
C53		Waiting for confirmation of test and research results
C54		Quality control and work supervision
C55		Delay in approval of executive plans
C56		Design defects
C61	Delays caused by the contractor	Limited financial capacity and liquidity of contractors
C62		Inadequacy and low experience of contractors
C63		Weakness during project execution
C64		Weakness in workshop management
C71	Construction and execution section	Not employing experienced human resources
C72		Lack of specialized human resources
C73		Inaccurate initial estimate of activity time
C74		Improper distribution of human resources
C75		Lack of access to machines
C76		Defects in the efficiency of existing machines
C77		Lack of familiarity of project managers with project management techniques

Table (1) contains the most important causes of delays in EPCF refinery projects and their indicators derived from previous studies and experiences. Their study shows that the sub-criteria of one criterion is independent of other factors.

Evaluation criteria (7 criteria and 48 sub-criteria) related to project activities were identified through interviews with experts. Experts' experiences and opinions were used to determine the weight and importance of each of the criteria and sub-criteria. Tables (2) and (3) show the aggregation matrix of importance and weight of activity evaluation criteria and sub-criteria.

Table 2: Aggregation matrix of the criteria importance

Criteria	Importance	Normalized value
Financing	5.87	0.20
Engineering Section	5.47	0.19
Goods Supplement	6.20	0.20
Delays caused by the employer	5.13	0.19
Delays caused by the consultant	6.27	0.21
Delays caused by the contractor	6.20	0.18
Construction and execution section	5.13	0.22

The fuzzy spectrum is used in the model based on the information presented in the table below.

Table 3: Verbal phrases of research

Code	Verbal phrases	Fuzzy number
1	Equal priority or importance	(1,1,1)
2	Low priority or importance	(2,3,4)
3	Strong priority or importance	(4,5,6)
4	Relatively strong priority or importance	(6,7,8)
5	Completely strong priority or importance	(8,9,10)

After obtaining the initial opinions of experts, the pairwise comparisons matrix of criteria and sub-criteria are compiled by hierarchical analysis.

Table 4. Aggregation matrix of the sub-criteria importance

Sub-Criteria	Normalized value	Importance
Delay in payment and lack of funding from the employer	5.20	0.206
Delay in payment of financial statements	4.87	0.197
Delays in assessing and paying pre-determined amounts	5.27	0.201
Delay in payment of contractor fees	4.67	0.189
Banking sanctions	4.93	0.206
Trade sanctions	5.47	0.211
The long process of obtaining foreign currency credits	5.20	0.201
Not considering the appropriate financial capacity	5.27	0.203
Long process of status check and attachment change of instructions and over-time	5.13	0.198
Lack of proper financial feasibility	5.13	0.188
Lack of timely allocation of funds	5.20	0.206
Delay due to change in plant capacity	4.87	0.197
Delays due to document preparation	5.27	0.201
Delay due to gas supply of reduction unit and sulfinol unit	4.67	0.189
Defects in information on processes related to the delivery of materials to the factory	4.93	0.206
Delay in determining process changes	5.47	0.211
Frequent changes in the engineering documents of the executive department	5.20	0.201
Frequent changes in the engineering documents of the equipment manufacturing department	5.27	0.203
Inaccurate estimation of the supply time of goods and services	5.13	0.198
Delays in evaluation and approval of sub-manufacturers	5.13	0.188
Delays in the evaluation and approval of POs	5.20	0.206
Laboratory delays in evaluating and approving manufacturers' materials	4.87	0.197
Delay of the employer to attend the supply meetings	5.27	0.201
Inaccurate evaluation of suppliers of goods and services	4.67	0.189
Fluctuations in the prices of raw materials and equipment	4.93	0.206
Employer interventions	5.47	0.211
Delay in decision making	5.20	0.201
Limitation of project time by the employer to complete the project	5.27	0.203
Administrative bureaucracy in the employer organization	5.13	0.198
Apply changes to the scope of tasks	5.13	0.188
Lack of timely delivery of land for the installation of pipelines	5.20	0.206
Delay in approval of executive plans	4.87	0.197
Design defects	5.27	0.201
Waiting for confirmation of test and research results	4.67	0.189
Quality control and work supervision	4.93	0.206
Delay in approval of executive plans	5.47	0.211
Design defects	5.20	0.201
Limited financial capacity and liquidity of contractors	5.27	0.203
Inadequacy and low experience of contractors	5.13	0.198
Weakness during project execution	5.13	0.188
Weakness in workshop management	5.20	0.201
Not employing experienced human resources	5.27	0.203
Lack of specialized human resources	5.13	0.198
Inaccurate initial estimate of activity time	5.13	0.188
Improper distribution of human resources	5.20	0.206
Lack of access to machines	4.87	0.197
Defects in the efficiency of existing machines	5.27	0.201
Lack of familiarity of project managers with project management techniques	4.67	0.189

Table 5: Activities of a refinery project

ID	Activities of a refinery project
A1	Civil and building operations (foundations and industrial and non-industrial buildings)
A2	Metal structure installation operation
A3	Mechanical equipment installation operations
A4	Surface piping operations AG and underground piping operations UG
A5	Electrical operation
A6	Instrument operation
A7	Paint and insulation operations
A8	Precom launch operation
A9	Startup launch operation

In the last stage of hierarchical analysis, the AHP technique presents the final weights and ranks the criteria and sub-criteria. Table (6) prioritizes the main criteria.

Table 6: Final weight of the main criteria

ID	Criteria	Definite weight	Prioritization based on definite weight
C1	Financing	0.389	1
C2	Engineering Section	0.252	2
C3	Goods Supplement	0.134	4
C4	Delays caused by the employer	0.157	3
C5	Delays caused by the consultant	0.068	6
C6	Delays caused by the contractor	0.067	7
C7	Construction and execution section	0.078	5

The final weights of the sub-criteria are reflected in Table (7).

Table 7: Final weight of sub-criteria

Sub-criteria	Definite weight	Prioritization based on definite weight
Delay in payment and lack of funding from the employer	0.021	20
Delay in payment of financial statements	0.025	19
Delays in assessing and paying pre-determined amounts	0.014	22
Delay in payment of contractor fees	0.016	21
Banking sanctions	0.027	18
Trade sanctions	0.029	17
The long process of obtaining foreign currency credits	0.033	14
Not considering the appropriate financial capacity	0.035	13
Long process of status check and attachment change of instructions and over-time	0.037	12
Lack of proper financial feasibility	0.039	11
Lack of timely allocation of funds	0.031	15
Delay due to change in plant capacity	0.03	16
Delays due to document preparation	0.043	10
Delay due to gas supply of reduction unit and sulfinol unit	0.047	8
Defects in information on processes related to the delivery of materials to the factory	0.049	7
Delay in determining process changes	0.0444	9
Frequent changes in the engineering documents of the executive department	0.052	5
Frequent changes in the engineering documents of the equipment manufacturing department	0.0544	4
Inaccurate estimation of the supply time of goods and services	0.0556	3
Delays in evaluation and approval of sub-manufacturers	0.058	2
Delays in the evaluation and approval of POs	0.05906	1
Laboratory delays in evaluating and approving manufacturers' materials	0.0512	6
Delay of the employer to attend the supply meetings	0.003	48
Inaccurate evaluation of suppliers of goods and services	0.004	38
Fluctuations in the prices of raw materials and equipment	0.0034	46
Employer interventions	0.0036	43
Delay in decision making	0.0038	39
Limitation of project time by the employer to complete the project	0.00344	45
Administrative bureaucracy in the employer organization	0.00376	40
Apply changes to the scope of tasks	0.00354	44
Lack of timely delivery of land for the installation of pipelines	0.00321	47
Delay in approval of executive plans	0.00376	41
Design defects	0.00376	42
Waiting for confirmation of test and research results	0.00754	33
Quality control and work supervision	0.0071	36
Delay in approval of executive plans	0.00787	30
Design defects	0.007	37
Limited financial capacity and liquidity of contractors	0.00776	31
Inadequacy and low experience of contractors	0.007967	29
Weakness during project execution	0.0074	34
Weakness in workshop management	0.00766	32
Not employing experienced human resources	0.00734	35
Lack of specialized human resources	0.0082	28
Inaccurate initial estimate of activity time	0.0084	26
Improper distribution of human resources	0.0087	24
Lack of access to machines	0.0089	23
Defects in the efficiency of existing machines	0.00832	27
Lack of familiarity of project managers with project management techniques	0.00854	25

Conclusion

The purpose of this study was to identify and prioritize the causes of delays in oil and gas projects based on the fuzzy multi-criteria decision approach. Due to time constraints and financial resources, the realization of projects requires an accurate estimation of working time and its balance with the parameters used in the project. The implementation path of a project is affected by scheduling, and a defect in project scheduling leads to delays. The most important factors causing delays in refinery projects include failure to allocate funds promptly, delays in the evaluation and approval of sub-contractors, and inaccurate estimates of the time of supply of goods and services. The timely launch of this project will reduce the fuel consumption of 5 oil fields to zero. Due to the environmental problems of Khuzestan province, the delay in this project has adverse consequences on the environment of the region. This research can be done in other fields such as petrochemical, civil engineering, etc. Also, this research can be done separately for each field.

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