

IDENTIFYING CAUSES OF DELAY IN OIL AND GAS CONSTRUCTION PROJECTS USING FUZZY DELPHI METHOD

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1- INTRODUCTION

Successful implementation of construction projects is one of the key factors for economic development of every country. Every year, a major part of the countries' capital is allocated to civil and infrastructure projects most of which are implemented with delay. Construction projects are often criticized for overrunning time and budgets.

Experience and the literature revealed that successful construction projects should be completed before project due dates and within budget. Therefore, causes of time delay are of critical importance to the profitability of most construction projects. Many researchers have identified these problems as factors that affect the delay in construction projects and will affect company's performance and overall economy of the country as well. The delay in construction projects by many factors is usually linked to the performance of time, cost, and quality. Meanwhile, identification and evaluating factors causing delay in construction projects have been carried out in the last decade; however, a deeper understanding is still needed to improve that. A construction project is commonly acknowledged as successful when it is completed on time, within budget, in accordance with specifications and to stakeholders' satisfaction (Aziz, 2013)

In this research causes of delay for oil and gas construction projects in Iran are taken into consideration. In this respect, the factors are defined using fuzzy Delphi method.

The article is structured as follows: In Section 2, literature review is presented. Summarized explanations about fuzzy Delphi method are given in Section 3. Findings are dealt with in Section 4. Finally, Section 5 concludes the paper.

2- LITERATURE REVIEW

Over the years, professionals and researchers from different countries have investigated various aspects of delays in construction projects. Some of these studies are listed below:

The most important causes of delays in construction projects with traditional type contracts from the viewpoint of construction, contractors, and consultants were identified by Odeh and Battaineh (2001).

Frimpong et al. (2003) identified causes of delay and cost

overruns in construction of groundwater projects in Ghana.

A survey on time performance of different types of construction projects in Saudi Arabia was conducted by Assaf & Al-Hejji (2006) to determine the causes of delay and their importance according to each of the project participants consisted of the owner, consultant and the contractor.

A questionnaire survey was conducted by Sambasivan and Soon (2007) to solicit the causes and effects of delay in Malaysian construction industry from clients, consultants, and contractors viewpoint.

Le-Hoai et al. (2008) employed a questionnaire survey to elicit the causes of delay and cost overruns in Vietnam large construction projects.

Sweis et al. (2008) identified and classified causes of construction delays in residential projects in Jordan.

Salama et al. (2008) investigated the main causes of delays within oil and gas projects in UAE. The research method comprised interviews with experts for the purpose of identifying the most important factors leading to time overruns.

Causes of delay in construction projects in the oil and gas industry in the Persian Gulf cooperation council countries were investigated by Ruqaishi and Bashir (2009).

Hamzah et al. (2011) identified cause of construction delay in Malaysia. There were two main types of delay: excusable and non-excusable delays.

Ravand and Salahi (2011) examined the causes of delays in the implementation of oil and gas industrial projects in Iran. These factors were investigated in five groups consisted of weaknesses in basic studies, lack of expert labor, lack of timely funding, contractual ambiguities and other problems.

Factors affecting delays in Indian construction projects were analyzed by Doloi et al. (2012). Using a regression model, the reasons that affect the overall delay of the project significantly were indicated.

Fallahnejad (2013) identified and ranked the causes of delay in gas pipeline projects in Iran. 24 executed gas pipeline projects were studied and extracted delay factors were conferred with experts from several disciplines.

Aziz (2013) determined various factors causing delay in construction projects in Egypt. Ninety-nine factors were short-listed to be made part of the questionnaire survey and were identified and categorized into nine major categories

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consist of consultant, contractor, design, equipment, external, labor, material, owner and project related factors.

Sunjka and Jacob (2013) determined the most important causes of project delays in Niger Delta region. They designed a questionnaire that could be adapted for the collection of multi-variate data from project practitioners in the mentioned region.

Project pathology and leading causes of delay in the projects of zone 3 of Iranian Gas Transmission Company were investigated by Atafar and Eghbali (2014). Some managers and experts were interviewed.

Marzouk and El-Rasas (2014) presented a list of construction delay causes retrieved from literature. The feedback of construction experts was obtained through interviews.

Głuszek & Leśniak (2015) studied construction delays from the client’s perspective. Three basic categories of delay in construction works were caused by the contractor, investor and, external.

Rahimi et al. (2015) investigated the reasons of delay in Iran Gas Field. These reasons have been ranked using TOPSIS method which is a multi-criteria method.

Delay causes of road construction projects in Egypt were explored by Aziz and Abdel-Hakam(2016). A questionnaire and personal interviews formed the basis of this paper listing 293 delay causes.

Causes of construction delays in construction projects were studied by Gundaz and AbuHassn (2016). Data collection was carried out through an online web survey system.

Alzara et al. (2016) identified the major causes of a university (in northern Saudi Arabia) construction project delays. The University’s delay factors were then compared to delay factors experienced on Saudi construction projects, identified by performing a literature research.

Al-Hazim et al.(2017) investigated factors causing completion delay and cost overrun in infrastructure projects in Jordan.

Gebrehiwet and Luo (2017) investigated the typical causes of delay at different stages of construction and its effect in the Ethiopian construction projects. The methodologies used in this research were relative important index and correlation coefficient.

3 - FUZZY DELPHI METHOD

The traditional Delphi method has obvious weaknesses including its subjectivity and time-consuming features. To overcome these shortcomings, a number of scholars proposed certain optimized methods, the most representative of which is the fuzzy Delphi method developed by Murray et al. (1985), which combines fuzzy theory and the Delphi method. In the fuzzy Delphi method, the experts’ judgments are represented by fuzzy numbers. Then, the subjective opinions are transformed into objective data through a fuzzy operation. This study uses the fuzzy Delphi method to obtain the evaluation indicators of causes of delay for oil and gas construction projects in Iran. The procedure of the fuzzy Delphi method used in this study is as follows:

Step 1: Collect the decision of the group experts. The judgment of every expert on every evaluation indicator is obtained using these semantic variables in the questionnaire. In this study, the evaluation linguistic term is set, and the triangular fuzzy numbers are shown in Table 1.

Step 2: Calculate the evaluation values of every indicator according to the triangular fuzzy number. Suppose that the evaluation value of the importance of the kth indicator given by the ith expert is w_{ik} . Then, the fuzzy weight of the kth indicator is defined as:

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Step 2: Calculate the evaluation values of every indicator according to the triangular fuzzy number. Suppose that the evaluation value of the importance of the kth indicator given by the ith expert is $w_{ik} = (a_{ik}, b_{ik}, c_{ik})$, $i = 1, 2, \dots, m$. Then, the fuzzy weight of the kth indicator is defined as:

$$w_k = (\alpha_k, \beta_k, \gamma_k), \quad k = 1, 2, \dots, n \tag{1}$$

where $\alpha_k = \min(a_{ik})$, $\beta_k = \frac{1}{m} \sum_{i=1}^m b_{ik}$, and $\gamma_k = \max(c_{ik})$

Step 3: Defuzzification. To obtain the final weight S_k , the fuzzy weight of every evaluation indicator is defuzzified using a simple center of gravity method by Equation (2).

$$S_k = \frac{\alpha_k + \beta_k + \gamma_k}{3} \tag{2}$$

Step 4: Set a threshold ρ so as to select the more important evaluation indicators from the total group. If $S_k > \rho$, the kth indicator is retained; if $S_k < \rho$, the kth indicator is abandoned. In practice,

if we want more indicators, ρ is set at a smaller value, while conversely, ρ is set at a larger one (Zhang, 2017).

Table 1: Evaluation linguistic term set and its corresponding triangular fuzzy numbers.

Fuzzy linguistic scale	Evaluation linguistic term set	Triangular fuzzy numbers (a,b,c)
$\tilde{9}$	Very important	(7,9,9)
$\tilde{7}$	Important	(5,7,9)
$\tilde{5}$	Moderate	(3,5,7)
$\tilde{3}$	Unimportant	(1,3,5)
$\tilde{1}$	Very unimportant	(1,1,3)

4 - FINDINGS

In order to construct an integrated evaluation index system, this study determines the owner, contractor, consultant, equipment, workforce, materials, design, contract, and contractual relations, laws and regulations, managerial factors,

and environmental factors by referring to related literature and by consulting Iranian experts in the field of oil and gas project management. Then, this study presents the initial evaluation indicators from the eleven aspects mentioned below:

1. Owner

- Financial problems and delay in payment
- Unrealistic contract duration
- Delay in reviewing and approving documents
- Slowness in decision making and administrative bureaucracy
- Poor communication and coordination with other parties
- Delay in site delivery
- Technical weakness
- Delay in material delivery
- Interference of owner
- Types of bidding and rewards
- Ineffective incentives and penalties
- Change of managers
- Failure to resolve the conflicts at the right time
- Lack of experience
- Inappropriate feasibility study of the project

2. Contractor

- Financial problems
- Inadequate experience
- Poor management and site supervision
- Rework to correct undesirable work
- Inappropriate construction methods
- Poor communication and coordination with other parties
- Inappropriate project planning and scheduling
- Problems with subcontractors
- Weak project management
- Lack of technical personnel in the contractor's organization
- Improper pricing by contractors to win the bid

3. Consultant

- Weak communication and coordination with other parties
- Inadequate experience
- Delay in conducting inspection and testing
- Delay in reviewing and approving design, drawings and ...
- Ambiguities and mistakes in specifications and drawings and documents
- Technical and managerial weakness
- Poor contract management
- Quality assurance / control

- Lack of adequate supervision during the conduct of geotechnical studies
- 4. Equipment
 - Frequent failure of equipment
 - Shortage of equipment
 - Low efficiency of equipment
 - Inappropriate selection of equipment
 - Slow mobilization of equipment
 - Lack of high-tech mechanical equipment
- 5. Workforce
 - Low productivity
 - Low motivation
 - Shortage of workforce
 - Personal differences of employees
 - Nationality
- 6- Materials
 - Shortage of materials
 - Delay in delivery of materials
 - Low quality
 - Changes in price
 - Changes in the type and characteristics of materials
 - Damage of stored materials
 - Problems with providing materials at current official prices
 - Difficulties in obtaining construction materials
- 7. Design
 - Mistakes and discrepancies in design documents
 - Unclear and inadequate details in drawings
 - Un-use of advanced engineering design software
 - Changes in design
 - Misunderstanding of owner requirements by design engineer
- 8. Contract and contractual relations
 - Mistakes and disputes in the contract documents
 - Changes in orders
 - Lack of communication between the parties
 - Major disputes and negotiations
 - Inappropriate organizational structure linking to the project
- 9. Laws and regulations:
 - Changes in laws and regulations
 - Weaknesses in the laws and regulations
 - Tax laws, tariffs and customs duties
- 10. Managerial factors
 - Absence of a real system for managers' performance measurement
 - Failure to appoint managers based on their performance evaluation
 - Governmental management systems and therefore no need to provide feedback in case of any deviations in time and cost and quality of projects
- 11. Environmental factors
 - Unexpected geological conditions
 - Weather conditions
 - Incidental events such as flood, earthquake, and storm
 - Sanction
 - Inflation
 - Economic changes such as changes in exchange rate
 - Problem with neighbors
 - Change in government policies

Given the background, this study adopts the fuzzy Delphi method to determine the final representative indicators. Taking into account the advantages of the fuzzy Delphi method, this study collects the experts' judgments through a two-round survey. In order to ensure that the results are more reliable, we select Iranian experts who work as an oil and gas construction project manager with at least 10 years of experience in this field. Every expert was asked to assess the importance per indicator according to the triangular fuzzy numbers shown in Table 1. Then, this study uses Equations (1) and (2) to deal with the data and obtain the values in Columns 3 to 6.

Regarding the threshold Shen et al. (2010) pointed out that its value depends on the fuzzy linguistic scale and the user's preference. Generally, the greater the series of the fuzzy linguistic scale the smaller and vice versa. In addition, if users want more indicators, they can set the threshold small, and vice versa. In this study, we adopt the 9 fuzzy scale; we simultaneously consider the representative of the indicators and the higher management efficiency. Thus, this study sets the,

with the mean for moderate and important. The final causes of delay are listed in the Table 2.

5 - CONCLUSION

This study quantitatively investigates the selection of causes of delay in oil and gas construction projects using fuzzy Delphi approach. In this regard, first of all the factors were determined by referring to related literature and by consulting Iranian experts in the field of oil and gas project management. Eleven factors were introduced as causes of delay in oil and gas construction project. These were consisted of owner, contractor, consultant, equipment, workforce, materials, design, contract and contractual relations, laws and regulations, managerial factors, and environmental factors. Then using fuzzy Delphi method and by collecting the experts' judgments through a two-round survey the important factors were defined. The results are useful for decision makers in the way of reducing or omitting the delay factors and timely implementation of the projects.

Table 2: The factors causes delay in oil and gas construction projects in Iran.

Dimension	Indicators	Scores			
		Min	Mean	Max	Final
Owner	Financial problems and delay in payment	3	6.6	9	6.2
	Unrealistic contract duration	3	6.6	9	6.2
	Delay in material delivery	3	6.6	9	6.2
	Types of bidding and rewards	3	6.6	9	6.2
	Inappropriate feasibility study of the project	3	6.2	9	6.1
Contractor	Inadequate experience	3	6.6	9	6.2
	Poor management and site supervision	5	7.4	9	7.1
	Rework to correct undesirable work	3	6.2	9	6.1
	Inappropriate construction methods	3	5.4	9	5.8
	Inappropriate project planning and scheduling	3	6.2	9	6.1
	Problems with subcontractors	3	5.8	9	5.9
	Weak project management	5	8	9	7
	Improper pricing by contractors to win the bid	3	7.4	9	6.5
Consultant	Inadequate experience	3	6.6	9	6.2
	Delay in conducting inspection and testing	3	6.2	9	6.1
	Ambiguities and mistakes in specifications and drawings and documents	3	5.8	9	5.9
	Technical and managerial weakness	3	6.6	9	6.2
	Poor contract management	3	5.4	9	5.8
Equipment	Low efficiency of equipment	3	6.2	9	6.1
Workforce	Low productivity	5	7.8	9	7.3
	Low motivation	3	7	9	6.3
Materials	Changes in price	3	7	9	6.3
Design	Changes in design	3	6.6	9	6.2
Contract and contractual relations	Inappropriate organizational structure linking to the project	3	75.4	9	5.8

Laws and regulations	Changes in laws and regulations	3	6.6	9	6.2
Managerial factors	Absence of a real system for managers' performance measurement	5	7.8	9	7.3
	Failure to appoint managers based on their performance evaluation	5	7.4	9	7.1
	Governmental management systems and therefore no need to provide feedback in case of any deviations in time and cost and quality of projects	5	8.6	9	7.5
Environmental factors	Sanction	5	7.8	9	7.3
	Inflation	5	8.2	9	7.4
	Economic changes such as changes in exchange rate	5	8.6	9	7.5

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SUMMARY

One of the challenges project managers are dealt with is management of delay in construction projects. Organizations particularly pay special attention to the efficient management of projects and make a lot of efforts to achieve this goal by reducing delay in projects. Analyzing the factors causing

delay is essential with the aim of omitting them and timely implementation of these projects. On account of the importance of oil and gas projects, in this research the factors causing delay in oil and gas construction projects are taken in to the consideration. These factors are identified by using fuzzy Delphi method.

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