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Identifying and Measuring Project Complexity Indicators in Subsurface Studies of Oil and Gas Industry in Iran

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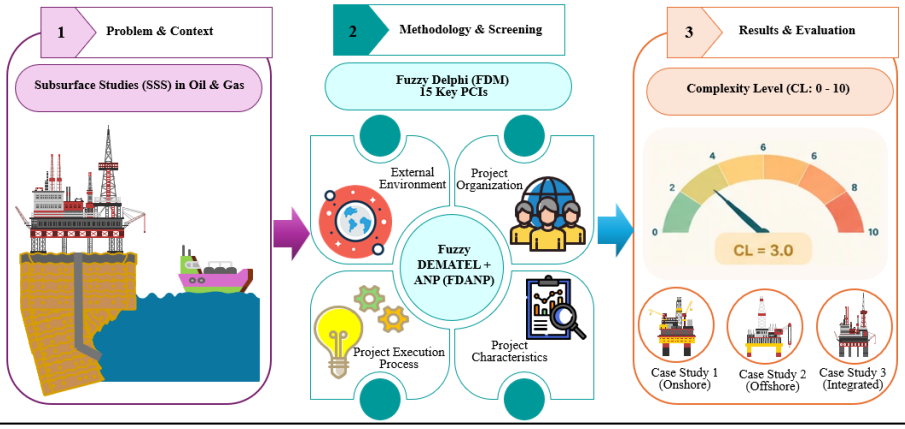
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A B S T R A C T

One of the important factors in oil and gas projects failure is project complexity and inefficiency of project management to deal with. Subsurface Studies (SSS) projects are performed to obtain development plans for oil and gas fields. The purpose of this thesis is to identify and measure complexity in SSS project in Iran. 40 Project Complexity Indicators (PCIs) were specifically compiled for SSS projects and grouped into four dimensions of "external environment", "project organization", "project process of execution" and "project characteristics". Using Fuzzy Delphi Method (FDM), 15 PCIs were screened out as the most important factors. The Fuzzy DEMATEL based ANP (FDANP) method was employed to develop the cause and effect diagram and determine the weights of dimensions and factors. Respectively, "project execution process" and "changes in project goals and scope" are the most important dimension and indicator of complexity in SSS projects. Complexity Level (CL) was employed to measure the project complexity in the range of 0 to 10. Finally, the application of the proposed method was demonstrated in a case study of three SSS projects performed in Iran.



1. Introduction

The oil and gas industry plays a crucial role in driving economic growth, industrial development, and energy security in resource-rich nations [1]. However, oil and gas projects—especially major upstream initiatives—are characterized by substantial capital intensity, aggressive schedules, intricate technical interdependencies, and multi-stakeholder environments [2,3]. Consequently, these projects operate under severe uncertainty, frequently suffering from significant cost overruns, schedule slippages, and failure to meet key performance benchmarks [4]. Industry analyses and project management bodies consistently identify unmanaged project complexity as a primary root cause of project failure [5,6].

Project complexity extends well beyond project size, encompassing the differentiation of operational elements, the intensity of interdependencies, and systemic uncertainties in goals and execution methods [7,8]. Because traditional management approaches often assume predictable, linear project dynamics and fail to distinguish between simple and complex undertakings, evaluating complexity prior to selecting management strategies and allocating resources is essential [9,10].

Despite growing academic interest, a universally accepted definition and standardized framework for measuring project complexity remain elusive [11]. Existing literature has proposed multidimensional perspectives, such as the Technical, Organizational, and Environmental (TOE) framework [12] and various Multi-Criteria Decision-Making (MCDM) approaches [13,14]. Nevertheless, two critical research gaps persist: first, many existing models treat complexity factors as mutually independent, overlooking the intricate causal relationships and feedback loops among indicators [13, 15]; second, generic complexity assessment models fail to address the specific operational

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dynamics of highly technical, high-risk project environments.

This gap is particularly evident in Subsurface Studies (SSS) within the upstream petroleum industry. In Iran, the National Iranian Oil Company (NIOC) and operating exploration and production (E&P) firms rely heavily on subsurface investigations to formulate Field Development Plans (FDP) and Master Development Plans (MDP). SSS projects integrate multiple disciplines—geophysics, geology, petrophysics, reservoir engineering, and production engineering—to evaluate reservoir characterization, determine well placement, and optimize long-term production. These projects operate under extreme geological uncertainty, limited subsurface data, high inter-discipline interfaces, and volatile strategic constraints. Applying generic assessment tools to such specialized environments fails to capture the true profile of project complexity.

To address these shortcomings, this study develops an integrated, context-specific framework to identify, structure, and quantify project complexity indicators in subsurface studies within the Iranian oil and gas sector. The methodology couples the Fuzzy Delphi Method (FDM) for indicator screening with Fuzzy DEMATEL to capture causal interrelationships [16], utilizes Fuzzy DEMATEL-based ANP (FDANP) to determine indicator weights [17], and applies Simple Additive Weighting (SAW) to generate a consolidated Project Complexity Index. The findings provide petroleum project managers and governance bodies with an objective, decision-support tool for resource allocation, risk mitigation, and management strategy alignment.

2. Materials and Methods

2.1. Research methodology

This research is a mixture of deductive and inductive approaches, employing both qualitative and quantitative methods. The research process consists of five stages.

Step 1: A comprehensive literature review on project complexity, existing approaches and methds of measuring complexity, especially in and oil and gas projects, and compiling a general list of PCIs, derived from the literature available on authoritative journal articles, books, published proceedings, and reports;

Step 2: Using Fuzzy Delphi Method (FDM) to develop the final list of PCIs, identified by SME s as the main contributed factors in SSS projects;

Step 3: Using fuzzy DEMATEL method to analyze the interdependence and relationships of PCIs;

Step 4: Using Fuzzy DEMATEL based ANP (FDANP) to calculate the weight factors of the PCIs in total level of project complexity;

Step 5: Measuring the overall project complexity using Simple Additive Weighting (SAW), and demonstrating the application of model through a case study.

Humans are inquisitive by nature, asking many questions around any area of interest. Knowledge is acquired when answering these questions to address research problems. Research methodology forms the foundation of conducting any research, since it dictates how the research problem will be addressed by various philosophical research paradigms.

explains the research methodology. It begins with a description of the research approach, next, a detailed description of the research methods and techniques, which are employed in this study.

Turner and Cochrane [18] developed a tool by the purpose of assessing the potential of project complexity, called “goal and methods matrix”, constructed in two aspects; clarity of goals definition and clarity of goal achievement methodology which makes four groups of projects, and role of the project manager in each group is clarified, see Figure 1 Moreover, this study concentrates on the influence of the goals and methods as the characteristics of complexity.

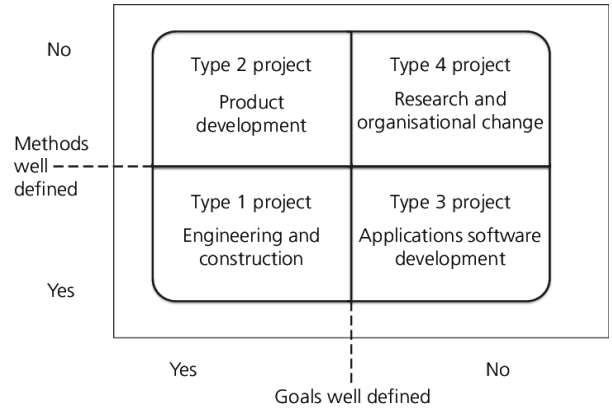


Figure 1. Goal and method matrix

Source: Ref [19]

Baccarini [20] introduced two aspect of organizational and technological complexity as the main components of project complexity, from two perspectives of differentiation and interdependencies. In organizational aspect, differentiation and interdependencies consist of the number of organizational units, the relations and tasks, and in technological aspect, differentiation relates to the various numbers of inputs or outputs, tasks and the number of disciplines. The interdependencies relates to the activities and relations between tasks.

A combination of Turner [17] and Cochrane [18] and Baccarini [20] ideas was proposed by Williams [21]. He considered Baccarini’s two components as structural complexity, and considers uncertainty as a second main component. Finally, he divided uncertainty into uncertainty in goals and uncertainty in methods as Turner and Cochrane’s [18] matrix.

Stacey [22] developed a project complexity matrix based on two aspects; the level of agreement and the degree of its certainty, see Figure.

Based on the levels of these two factors, he subdivided projects in four groups, simple, complicated, complex and anarchy. Project managers can select the most appropriate management approaches after determining to the position of a particular project in the matrix.

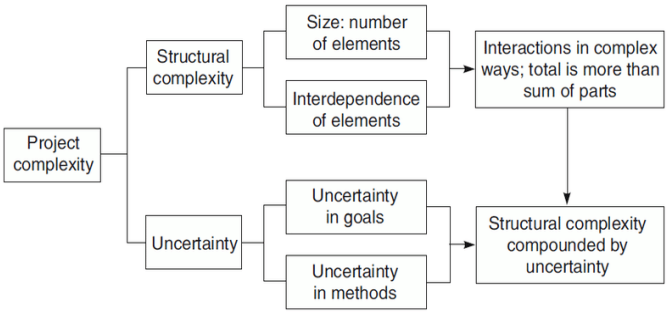


Figure 2. Project complexity model by Williams [8]

Source: Ref [8]

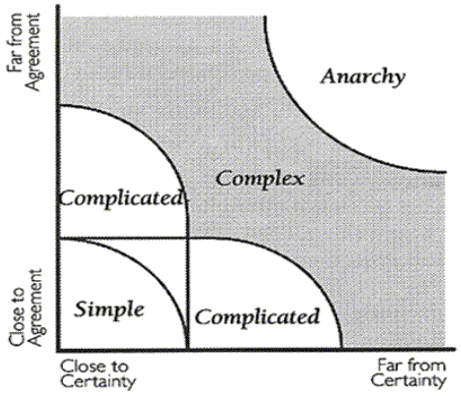


Figure 3. Agreement and certainty matrix

Source: Ref [19]

GAPPS introduced a comprehensive PM complexity measurement tool, entitled “CIFTER”. This tool consists of seven factors, which in order to assess project complexity; they should be rated from one to four, and based on the total CIFTER score, each project is classified in one of following of categories.

- Global level one (scores less than 12)
- Global level two (scores 12 to 18)
- Global level three (score 19 or more)

Moreover, given that each project needs different level of manager competency based on the level of complexity, The GAPSS developed a framework consist of two levels of project manager competency.

- Junior project manager fits global one
- Senior project manager fits global two

3. Result and Discussion

3.1. Identifying PCIs, adaptation and categorization

To refine PCIs based on SSS projects, they are reviewed by a group of SMEs. Results are shown in [1].

Table 1. PCIs before and after validation

Before Validation	Status	After Validation
Changing economy	REV	Changing and unstable national economy
Market competition	DEL	
	REV	National and international laws and regulations
Local laws and regulations	REV	Obligation to have a foreign technical assistant
	REV	Obligation to have an in-country technical assistant
	REV	Non-compliance of the client with the general and private terms of the contract
External political forces	REV	National and international political forces
Cultural differences among external stakeholders	CON	Cultural differences among external stakeholders
Lack of /shortage of capital investment	CON	Lack of /shortage of capital investment
Variety of investors and financial resources	DEL	
Variety of institutional configuration	REV	Bureaucracy in the client organization
	REV	Bureaucracy in the consultant organization
Lack of support from organizations	REV	Lack of client cooperation and interaction with consultant
	REV	Lack of consultant cooperation and interaction with client
Lack of team cooperation and communication	REV	Lack of team cooperation and communication among consultant team
Weak management style of project manager	CON	Weak management style of project manager
Lack of trust within/between teams	CON	Lack of trust within/between teams
Lack of required experience and capabilities	REV	Inaccessibility of required skilled human resources
	REV	lack of consultant enough experience/capabilities
Diversity of participants	CON	Diversity of participants
incorrect allocation of HRs in project	CON	Incorrect allocation of HRs in project
Shared human resources for multiple projects	CON	Shared human resources for multiple projects
Dynamic and evolving team structure	CON	Dynamic and evolving team structure
Conflict of interest and perspectives among stakeholders	DEL	
Variety of required resources	CON	Variety of required resources
Inaccessibility of physical resources	CON	Inaccessibility of physical resources
Inaccessibility of required information	CON	Inaccessibility of required information
Low reliability of information platforms	DEL	
Unpredictability of tasks	CON	Unpredictability of tasks
Severity of processing and transferring information	CON	Severity of processing and transferring information
Diversity of sites and locations	DEL	
Duration of project	MRG	Irrational duration estimation by client
Compression of project schedule		
Changes in technology/method/tools	CON	Changes in technology/method/tools
Uncertainty in technology/method	CON	Uncertainty in technology/method
Process technology/method novelty	CON	Process technology/method novelty
Variety of goals and objectives	REV	Sub-surface project type
Lack of mutual understanding stakeholders about project aim and objectives	CON	Lack of mutual understanding stakeholders about project aim and objectives
Strategic pressure of project	CON	Strategic pressure of project
Changes in project goals and Scope	CON	Changes in project goals and Scope
Novelty of tasks and high level of required innovation	CON	Novelty of tasks and high level of required innovation
	REV	Multiplicity of wells
	REV	Long production history
Technological varieties	REV	Extra water production
	REV	Multiplicity of reservoirs in a field
	REV	Extra fluid production

Source: Research Findings

In the next step, PCIs are categorized in four following dimensions, see Table 2:

Table 2. Project complexity indicators of research and related categorization

Category	Code	Project Complexity Indicator
	External	
	C1	Changing and unstable national economy
	C2	National and international laws and regulations
	C3	Obligation to have a foreign technical assistant
External Environment	C4	Obligation to have an in-country technical assistant
	C5	Non-compliance of the client with the general and private terms of the contract
	C6	National and international political forces
	C7	Cultural differences among external stakeholders
	Internal	
	C8	Lack of /shortage of capital investment
	C9	Bureaucracy in the client organization
	C10	Bureaucracy in the consultant organization
	C11	Lack of client cooperation and interaction with consultant
	C12	Lack of consultant cooperation and interaction with client
	C13	Lack of team cooperation and communication among consultant team
	C14	Weak management style of project manager
(WHO) Project organization	C15	Lack of trust within/between teams
	C16	Inaccessibility of required skilled human resources
	C17	lack of consultant enough experience/capabilities
	C18	Diversity of participants
	C19	Incorrect allocation of HRs in project
	C20	Shared human resources for multiple projects
	C21	Dynamic and evolving team structure
	C22	Variety of required resources
	C23	Inaccessibility of physical resources
	C24	Inaccessibility of required information
	C25	Unpredictability of tasks
	C26	Severity of processing and transferring information
(HOW) Project execution process	C27	Irrational duration estimation by client
	C28	Changes in technology/method/tools
	C29	Uncertainty in technology/method
	C30	Process technology/method novelty
	C31	Sub-surface project type
	C32	Lack of mutual understanding stakeholders about project aim and objectives
	C33	Strategic pressure of project
	C34	Changes in project goals and scope
(WHAT) Project characteristics	C35	Novelty of tasks and high level of required innovation
	C36	Multiplicity of wells
	C37	Long production history
	C38	Extra water production
	C39	Multiplicity of reservoirs in a field
	C40	Extra fluid production

Source: Research Findings

3.2. Screening major PCIs

In order to reasonably decrease the number of initial PCIs, FDM is employed. Achieved results in each step are described as follows.

3.3. Result of running FDM

Selecting participants: The participant for this research is chosen among project managers, who are currently managing SSS projects, in the position of consultant and client of upstream oil and gas industry in Iran. Related statistical information of participants is presented in Table 3:

Table 3. Research participant's statistical information

Panel	Consultant	Client
Position	Project manager (11) Project assistant (0)	Project manager (6) Project assistant (3)
Level of education	Bachelor (0) Master (11) Doctorate (0)	Bachelor (0) Master (6) Doctorate (3)
Years of working experience	Less than 5 years (0) 5-10 years (0) 11-15 years (2) More than 15 years (9)	Less than 5 years (0) 5-10 years (1) 11-15 years (2) More than 15 years (6)

Source: Research Findings

4. Conclusions

The findings of this study demonstrate that project complexity is a multidimensional concept influenced by a wide range of interrelated factors. Despite the numerous definitions proposed in the literature, there is still no universally accepted definition of project complexity. Accordingly, a comprehensive review of previous studies was conducted to identify and measure the attributes contributing to project complexity and to develop a preliminary set of Project Complexity Indicators (PCIs).

Based on the specific characteristics of SSS projects in the upstream sector of the Iranian oil and gas industry, the preliminary PCIs were classified into four main dimensions. The screening and refinement of these indicators were performed using the Fuzzy Delphi Method (FDM), with the participation of experienced subject-matter experts. The results led to the identification of the most relevant and significant complexity indicators for SSS projects. Since these indicators were developed based on the knowledge and practical experience of experts involved in SSS projects in Iran, their applicability is primarily associated with this specific project context.

Furthermore, the interrelationships among the identified PCIs and their corresponding dimensions were examined using the Fuzzy DEMATEL-based Analytic Network Process (FDANP). This approach enabled the relative importance and weights of the indicators and dimensions to be determined while accounting for their interdependencies. The findings indicate that project complexity cannot be adequately assessed by considering individual factors independently; rather, the interactions among different complexity dimensions and indicators should be taken into account.

Finally, an overall Complexity Level (CL) measure was developed to quantify the complexity of SSS projects on a scale ranging from zero to ten. The applicability of the proposed measure was evaluated using three completed SSS projects. The calculated complexity levels were compared with the assessments provided by the respective project managers, demonstrating the potential of the proposed model as a practical tool for evaluating project complexity.

Overall, the proposed framework provides a structured and context-specific approach for identifying, weighting, and measuring project complexity in SSS projects within the Iranian oil and gas industry. By providing a quantitative measure of complexity, the model can support project managers and decision-makers in better understanding complexity drivers, improving planning and decision-making, and developing appropriate strategies for managing complex projects.

Author Contribution

The author was solely responsible for the conception, preparation, and writing of this manuscript.

Conflict of Interest

The author, while observing publication ethics in the referencing, declares the absence of any conflict of interest.

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AI Used Statment

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