Impact of Project Complexity and Environmental Factors on Project Success: A Case of Oil and Gas Sector of Pakistan

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Abstract: Oil and gas industry significantly contribute for economic development of countries enriched with petroleum resources. Mega projects of oil and gas sector usually face many challenges due to environmental issues, high level of risks, huge investments, tight schedules and interdependencies between project activities. Therefore keeping in view, the issues faced by oil and gas sector this study was made to analyze the impact of project complexity and environmental factors on success of oil and gas projects of Pakistan. Based upon hypothetical framework developed for this study, data collection was made from an oil and gas company of Pakistan. After which, data analysis was carried out by using a statistical technique known as structural equation modeling. Project complexity, environmental factors and project success were taken as constructs for model evaluation on AMOS. Analysis of data has concluded that project complexity has negative impact on project success whereas better control over environmental factors enhance the project success rate.

Keywords: Oil and gas projects, Project complexity, Environmental factors, Structural equation modeling.

1. INTRODUCTION

Oil and gas industry is considered as backbone of nation's economy [1]. Therefore the success of oil and gas projects is highly important. These projects usually involve huge capital investments and large number of workforce including engineers, geologists, suppliers, contactors, technical staff and workers [2]. But many times these projects face challenges like market conditions, external and internal environment, labor availability and infrastructure constraints [3]. These challenges lead projects towards poor performance by exceeding expected budget and time for project completion [4]. Interdependencies between project activities and uncertainties make projects more complex [5]. External and internal environmental factors also influence the performance of projects [6]. Therefore the knowledge of significant factors / indicators of project complexity and environmental factors is very essential for project managers to successfully complete ongoing projects. Literature about project complexity, environmental factors and project success is illustrated as fellow.

1.1. Project Complexity

Project complexity can be considered as a measurement of difficulties faced during execution of complex processes. It cannot be quantified accurately because it is a combination of different attributes having dynamic and uncertain properties [7]. But there is a difference between complex project and complicated project i.e. project dealing with uncertainties is considered as complex whereas rest of others are regarded as complicated [8]. According to a study carried out in China, project complexity includes goal complexity, organizational complexity, information complexity, task complexity and technological complexity [9]. In another study, project complexity is grouped into task, culture, operation, cognition and society complexity [10]. Technological, organizational and environmental complexities are also studied by using analytic hierarchy process based on evaluation of seven projects [11]. Various forms of project complexities, demand the clear understanding that either it is technological, organizational, social or environmental complexity to facilitate management [8]. These complexities make project goals and objectives unclear. Project complexity also effects the selection of workforce according to their demand and required expertise due to improper definition of scope and requirements [7]. It also has a significant impact on project completion with in expected time and budget. In simple words, higher the project complexity, higher will be time and cost of project.

1.2. Environmental Factors

Environmental factors also have a significant impact on execution and performance of projects. A study carried out in Nigeria explored the impact of environmental factors on performance of building project using different statistical tests. These environmental factors include political, cultural, economic, physical, legal, financial and sociological factors [12]. These factors are also considered as

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critical success factors for projects due to their significance. Most of environmental factors have a significant influence on projects during planning phase but some factors affect the projects till their completion, such factors include social and natural environment. One of the most significant factor which influence project's performance is political situation [13]. These factors may lead to project termination at implementation stage. Market conditions being an external environmental factor also influence the performance of projects. Market conditions include demand, competition and client power [14]. Environmental scanning is also an important factor for successful implementation of projects. Some environmental factors become challenge for management, organization and project. These factors include external as well as internal environment [15].

1.3. Project Success

According to previous studies, it is impossible to design a specified criteria for project success. Because every project has its own criteria based on project complexity, size and uniqueness [16]. Mostly project success is based on golden triangle which incorporates cost, time and quality [17]. If a project is completed within expected budget and duration while maintaining the desired quality level, then that project is considered as successful. According to a study, along with cost, time and quality, cost saving is also considered as an indicator of project success [18]. Besides this, a study also incorporated clients / users satisfaction as a success criteria for projects [19]. Project success is also measured by project's impact, stakeholder satisfaction, benefits gained by organizations, future potential and project efficiency [20].

It is evident from literature that, project complexities and environmental factors influence project success but it lacks empirical evidence for oil and gas sector. Therefore this study is made to analyze the impact of project complexity and environmental factors on success of oil and gas projects. Structural equation modeling (SEM) technique is used to explore the relationship between these variables.

2. STRCUTRAL EQUATION MODELING

It is a multivariate statistical tool which is used to evaluate complex theoretical models with empirical data. This technique is an extension of regression analysis and ANOVA [21]. The main advantage of SEM is its ability to analyze the relationship between latent constructs being measured by multiple variables / indicators. Its main purpose is to evaluate consistency of hypothetical model with respect to collected data through goodness of fit measures [22]. There are two basic components of SEM i.e. measurement model and structural model. Measurement model evaluates that how well hypothetical model is supported by collected data whereas structural model analyze the proposed relationship between latent constructs [8]. SEM is also preferred over other statistical techniques because it is used to evaluate complex models involving large number of variables. Moreover it has also ability to explore the complete model simultaneously.

3. DEVELOPMENT OF HYPOTHETICAL MODEL

Hypothetical framework was developed using constructs and their interrelationships to meet research objectives

3.1. Latent Variables and Measurement Components

Based upon previous literature review, environmental factors, project complexity and project success were selected as constructs for this research work. Each of these constructs has its own indicators / observed variables. Environmental factors were indicated by political stability, legislations processes, international joint ventures, geological conditions, inflation rate, technological advancements [12-14, 23]. Whereas project complexity was measured by diversity of task, number of organizational structure hierarchies, influence of external stakeholders, complexity of contractual relationship, dependencies between schedules, uncertainty of project management methods and tools [8, 9, 11, 24]. Project success was measured by project completion within expected budget and time, desired quality outcomes and customer satisfaction [17-19]. All the latent variables and their corresponding measures have been given in Table **1**.

3.2. Hypothesis Development

Environmental factors have a significant impact on project performance. It was concluded by a study carried out in Nigeria about building projects [12]. Whereas project success has negative influence on project complexity [9]. Based upon literature and expert's opinion (oil and gas sector) following hypothesis were proposed to meet research objectives.

Hypothesis 1: Increase in project complexity has negative influence on success of oil and gas projects

Table 1: Latent Variables and their Corresponding Measures

Latent Variables	Observed Variables	Notations	References
Environmental Factors (EF)	Political Stability	EF1	[12-14, 23]
	Legislations Processes	EF2	
	International Joint Ventures	EF3	
	Geological Conditions	EF4	
	Inflation Rate	EF5	
	Technological Advancements	EF6	
Project Complexity (PC)	Diversity of Task	PC1	[8, 9, 11, 24]
	Number of Organizational Structure Hierarchies	PC2	
	Influence of External Stakeholders	PC3	
	Complexity of Contractual Relationship	PC4	
	Dependencies Between Schedules	PC5	
	Uncertainty of Project Management Methods and Tools	PC6	
Project Success (PS)	Completion with in Estimated Budget	PS1	[17-19]
	Completion with in Estimated Time	PS2	
	Desired Quality Outcomes	PS3	
	Customer Satisfaction	PS4	

Hypothesis 2: Better control over environmental factors has positive impact on success of oil and gas projects

Hypothesis 3: Better control over environmental factors decreases complexity of oil and gas projects

In Figure **1**, hypothetical model has been given based upon proposed relationship between latent variables / constructs.

4. METHODLOGY

After the development of hypothetical model, questionnaire based survey was carried out for data collection relative to project complexity and environmental factors. As this study was based on multiple constructs measured by observed variables therefore, analysis of collected data was carried out by SEM.

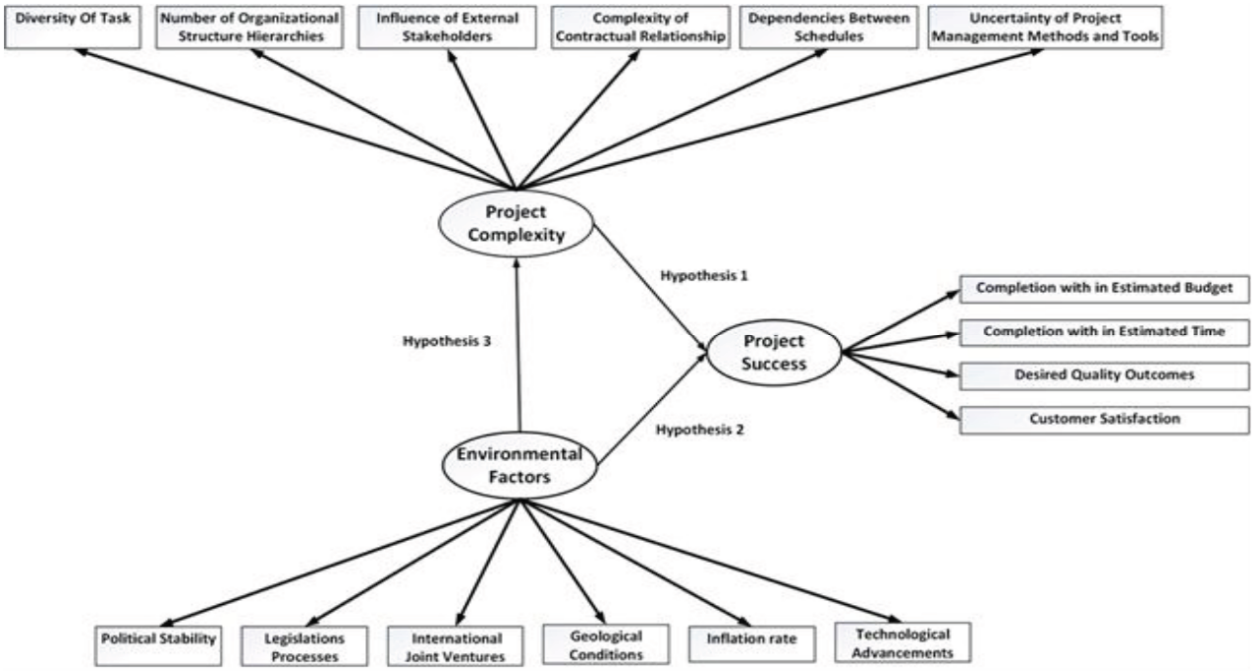

Figure 1: Structural equation modeling based hypothetical model.

Table 2: Respondents Profile

Designation	Experience (Years)	Percentage out of total Sample Size
Project Managers	25-32	4.5 %
Planning Engineers	10-22	19.2 %
Petroleum Engineers	5-20	33.9 %
Exploration Engineers	8-25	30.2 %
HSEQ Engineers / Officers	1-15	11.9 %

4.1. Questionnaire Survey for Data Collection

Questionnaire based survey was carried out for data collection from an oil and gas industry of Pakistan. For survey, questionnaire was developed using five point Likert scale (1= strongly disagree, 2=disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree). A total of 300 questionnaires were distributed among participants. After data screening, 272 valid responses were used for data analysis. Usually sample size of more than 200 is enough for SEM based analysis [25]. Data screening was carried out by removing outliers, incomplete and invalid responses. Participants of this survey included project managers, planning, petroleum, exploration and HSEQ engineers having vast experience of oil and gas projects. Pilot survey was also carried out to ensure the understanding of questions to respondents. A summary of respondents has been given in Table **2**.

4.2. Data Reliability Test

Chronbach's Alpha test is applied to analyze the internal consistency of constructs [26]. Data reliability test is essential before the implementation of SEM. It has range from zero to one. Its value greater than 0.70 is regarded as sufficient indicator of construct's reliability [8]. If its value is greater than 0.90 then internal consistency of construct is considered as excellent. In some studies Chronbach's Alpha of 0.60 is also considered as reliable. In Table **3**, all constructs have been given which all were sufficient reliable with alpha value greater than cut off value of 0.70. This test was performed by using a statistical software known as "SPSS".

4.3. Data Analysis

Analysis of collected data was carried out by SEM technique. This technique is the combination of measurement model and structural model [27]. Measurement model was analyzed by using confirmatory factor analysis (CFA) whereas structural model was tested using SEM analysis which incorporates regression and path analysis. After the validation of measurement model, structural model was analyzed. Analysis was performed on AMOS which is a software package designed for SEM.

Table 3: Chronbach's Alpha Value of Reliability Test

Latent Variables	Observed Variables	Chronbach's Alpha Value
Environmental Factors	EF1 EF2 EF3 EF4 EF5 EF6	0.78
Project Complexity	PC1 PC2 PC3 PC4 PC5 PC6	0.81
Project Success	PS1 PS2 PS3 PS4	0.92

4.3.1. Measurement Model

Measurement model is used to analyze the relationship between constructs and their corresponding measures. CFA is used to evaluate measurement model by analyzing goodness of fit (GOF) measures and convergent validity. Convergent validity is used to measure correlation between indicators measuring a construct. If all factors loading are above 0.5 and also significant then convergent validity exists [23]. In Table **4**, all the factors have been given, which all were significant as well as above 0.5 indicating the existence of convergent validity [28, 29]. Observed variables of environmental factors indicated by EF1, EF2.EF3, EF4, EF5 and EF6 have standardized estimates equal to 0.69, 0.84, 0.87, 0.85,

0.71 and 0.70 respectively. Whereas observed variables of project complexity indicated by PC1, PC2, PC3, PC4, PC5 and PC6 have standardized estimates equal to 0.67, 0.85, 0.78, 0.74, 0.72 and 0.72 respectively. PS1,PS2,PS3 and PS4 being the observed variables of project success have standardized estimates equal to 0.71,0.72.0.68 and 0.65 respectively.

Table 4: Standardized Estimates of Observed Variables

Latent Variables	Observed Variables	Standardized Estimates
Environmental Factors	EF1	0.69
	EF2	0.84
	EF3	0.87
	EF4	0.85
	EF5	0.71
	EF6	0.70
Project Complexity	PC1	0.67
	PC2	0.85
	PC3	0.78
	PC4	0.74
	PC5	0.72
	PC6	0.72
Project Success	PS1	0.71
	PS2	0.72
	PS3	0.68
	PS4	0.65

GOF measures analyze the overall fitness of hypothetical model with respect to data. Different types of GOF measures are used to evaluate model. Relative chi square test is a traditional measure which evaluate goodness of fit. It has range from zero to five [19].Other fit indices include incremental fit index (IFI), comparative fit index (CFI), Tucker Lewis fit index (TLI) and normed fit index (NFI). These fit indices closer to one indicate better fitness of model [18]. IFI is a comparison of fit of model over null model whereas NFI is a measure of chi square of model relative to null model. CFI is a revised form of NFI which also considers sample size. Besides this, TLI is a measure of improvement in fitness of hypothetical model over null model [22]. Adjusted goodness of fit index (AGFI) and root mean sq. error of approx. (RSMEA) are also used to evaluate measurement model. AGFI is a measure of fit between theoretical model and observed covariance matrix. All the fit indices with their defined criteria have been given in Table **5** for initial and final model. Relative chi square has value of 2.902 for initial model and 2.587 for final model, which were within recommended level of 1-5. AGFI has values of 0.806 and 0.828 for initial and final models respectively which satisfied the recommended level of 0.8. RMSEA has values of 0.095 and 0.087 for initial and final models respectively which were within recommended level of 0.05 to 0.1. TLI has values of 0.871 and 0.892 for initial and final models respectively with better fit closer to 1. In the same way CFI, IFI and NFI have values of final model equal to 0.915, 0.916 and 0.870 indicating better model fit towards 1. These fit indices were well with in desired criteria indicating the validity of measurement model followed by convergent validity.

GOF measures of final model were obtained by modifying the model. Modifications in model are usually made by modification indices or by deleting the insignificant paths or factors [13]. For this study, modifications were made using modifications indices suggested by AMOS. The purpose of model modification is to enhance the overall fitness of model.

4.3.2. Structural Model

After the validation of measurement model, next step is to analyze structural model using SEM analysis. To validate structural model, hypothetical relationships were drawn between constructs by replacing covariance. In Table **6** standardized estimates have been given explaining the relationship between constructs. Hypothesis are rejected or accepted based upon p value and critical ratio. If critical ratio is greater

Table 5: GOF Measures of Initial and Final Model

Goodness-of-fit measure	Recommended level of GOF Measure	Initial CFA	Final Model
χ^2/degree of freedom	1 – 5	2.902	2.587
Adjusted goodness-of-fit (AGFI)	>0.8	0.806	0.828
Root mean sq. error of approx. (RMSEA)	0.05 - 0.1	0.095	0.087
Tucker–Lewis index (TLI)	0 (no fit)–1 (perfect fit)	0.871	0.892
Comparative fit index (CFI)	0 (no fit)–1 (perfect fit)	0.891	0.915
Incremental fit index (IFI)	0 (no fit)–1 (perfect fit)	0.892	0.916
Normed fit index (NFI)	0 (no fit)–1 (perfect fit)	0.845	0.870

than 1.96 and p value is less than 0.05 then hypothesis is accepted [30]. Latent variable "EF" has negative effect on "PC" and positive effect on "PS". Whereas "PC" has negative effect on "PS".

Table 6: Standardized Estimates of Hypothetical Relationship between Constructs

Hypothetical Relationship			Standardized Estimate
PC	<---	EF	-0.16
PS	<---	PC	-0.23
PS	<---	EF	0.42

5. RESULTS AND DISCUSSION

The hypothesized relationship between project complexity and project success is negative with standardized estimate of -0.23. It means our first proposed hypothesis was supported i.e. project complexity has negative impact on project success of oil and gas sector. This result was in accordance with the study carried out about construction industry in China [9]. Therefore project managers / team management should handle the project complexities in an effective way to lead towards a successful project. Indicators of project complexity are of keen importance to manage complexities faced by oil and gas projects.

Whereas environmental factors have positive impact on project success with standardized estimate of 0.42. Our second hypothesis was also supported that better control over environmental factors enhance the chances of success of oil and gas projects Result of second hypothesis was according to the study carried out in Nigeria about building projects [12]. Environmental factors like geological conditions, political stability, joint ventures etc. are of keen importance for success of oil and gas projects. All the ongoing projects of oil and gas exploration and production are influenced by political stability and geological conditions. Hence project managers should carefully handle environmental factors for successful execution and completion of oil and gas projects.

Environmental factors have negative relationship with project complexity with standardized estimate of -0.16. It indicated that our third hypothesis was also supported i.e. better control over environmental factors decrease complexity of oil and gas projects. This hypothesis lacks relevant findings in literature because it was suggested by industrial experts of oil and gas sector. It is obvious from this result that careful handling of environmental factors will decrease the complexity of oil and gas projects. Project managers should keep in view political stability, geological conditions and inflation rate of desired location before carrying out exploration and production of oil and gas. All these relationships were significant with p value less than 0.05. Final structural equation model has been shown in Figure **2**.

Most significant indicators of project complexity were "number of organizational structure hierarchies", "influence of external stakeholders "and "complexity of contractual relationship" with standardized estimates of

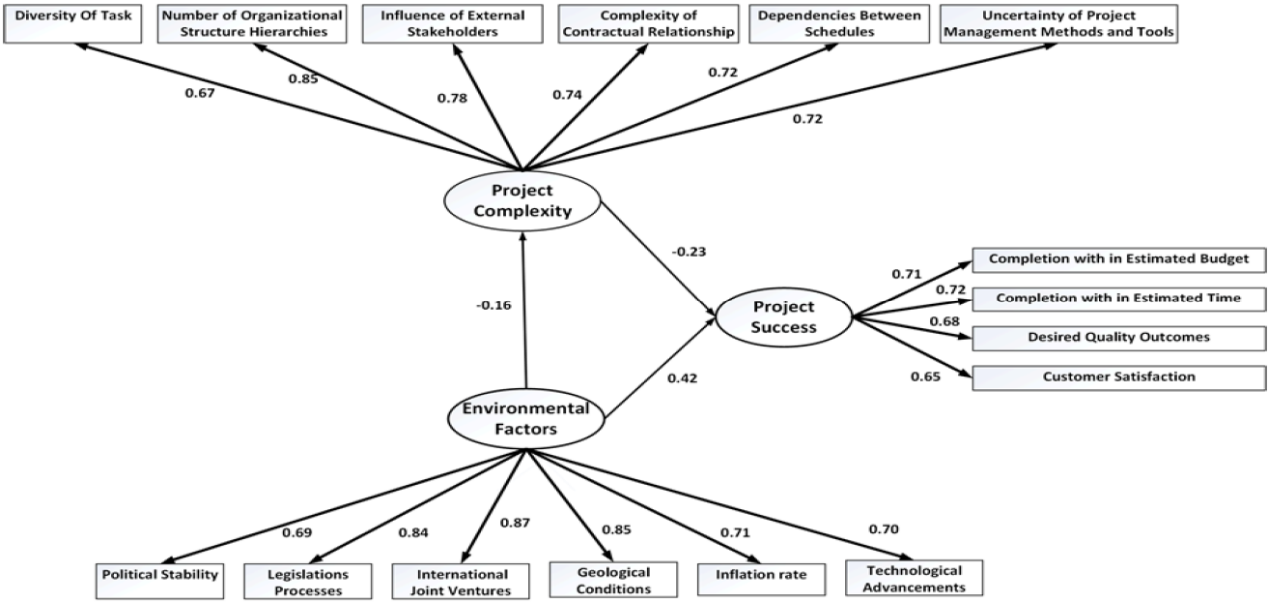

Figure 2: Final structural equation model with standardized estimates.

0.85, 0.78 and 0.74 respectively. Whereas significant indicators for environmental factors were based upon "international joint venture", "geological conditions" and "legislations processes" having standardized estimates of 0.87, 0.85 and 0.84 respectively. Other indicators were also important and significant followed by these factors. Whereas least significant indicator of environmental factors was "political stability" with standardized estimate of 0.69. For project complexity, least significant variable was "diversity of task" having standardized estimate of 0.67

6. CONCLUSIONS

According to the literature, project complexities and environmental factors have their influence on execution, completion and success of different projects being carried out. In this study a hypothetical framework was developed to explore the impact of project complexities and environmental factors on success of oil and gas projects. This framework was developed using SEM technique which incorporated three constructs i.e. project success, project complexity and environmental factors. The findings of this study has confirmed all proposed hypothesis. It was demonstrated that project complexity has negative impact on success of oil and gas projects. This finding has become an empirical evidence of relationship between project complexity and success of oil and gas projects. The positive impact of environmental factors on project success demands an improvement in managing environmental factors for oil and gas projects. It has provided a theoretical background to relationship between these two factors. Additionally, the relationship between project complexity and environmental factors was also explored. Moreover, project complexity and environmental factors can be managed well for oil and gas projects by their significant indicators highlighted by this study. The basic contribution of this paper has been to explore the relationship between project complexity, project success and environmental factors from the perspective of oil and gas sector of Pakistan. This study has made it clear by refining the existing knowledge that what is actually required for the success of oil and gas projects.

7. RECOMMENDATIONS AND FUTURE WORK

Project managers can enhance the project success by considering the factors highlighted by this study. Moreover indicators of project complexity and environmental factors are also of keen importance for project managers to handle these two factors. This research work can be enhanced by considering other factors like financial performance, total quality management and project planning to explore the impact of project complexity and environmental factors on them as well. Moreover this study is based on oil and gas sector of Pakistan, therefore by incorporating data from other countries a more generic model can be made.

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