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Modeling the effects of Construction Risks on the Performance of Oil and Gas Projects in Developing Countries: Project Managers' Perspective

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ABSTRACT: Oil and gas (O&G) construction projects are considerably prone to risk due to their complex nature, environment, and the involvement of numerous stakeholders. Additionally, the increase in global energy consumption makes it imperative for decision-makers to assess O&G risks and understand how they impact project performance (PP). This research seeks to (1)identify and assess the level of riskiness of the key risks facing O&G construction projects by considering the case of Iraq; and (2)capture the effects of O&G risks on construction PP from project managers' perspective. To achieve this, a mixed-method approach was adopted. First, we identified O&G project risks through a focus group session with six Iraqi project managers. Second, we rated the level of riskiness of the identified risks and their impact on PP by administrating a survey to 75 experts. Third, we quantitatively analyzed the identified risks under fuzzy-analytical hierarchy process environment. Fourth, we quantitatively analyzed the effects of the identified risks on PP under structural equation modelling environment. The findings show that the most significant O&G risks are poor communication, skilled workers shortage, unstable security, political instability, and contractor bankruptcy. Furthermore, the results of the SEM analysis show that management risks have the strongest effects on PP, followed by legal risks, financial risks, technical risks, and logistics risks. The findings of this investigation might be of interest to O&G decision-makers, as they offer insight into how these risks may affect PP. This should facilitate the development of mitigation strategies in the early stages of the project.

KEY WORDS: Oil and gas, project performance, risk management, developing countries

1 INTRODUCTION

Oil and gas (O&G) construction projects are complex and risky due to their dynamic environment, unique nature, complex technology, remote geographical locations, and involvement of numerous stakeholders and must adhere to a tight schedule and budget. There are numerous risks associated with O&G construction projects, including social, political, financial, and technical risks, as well as those associated with natural disasters. Understanding the risks associated with the energy sector is not only vital for the construction sector, but also for the upstream and downstream oil and gas sub-sectors [1].

Iraq, as a case study of oil-producing developing countries, is the fifth-largest oil producer in the world and the second-largest oil producer in OPEC. It contributes to approximately 65% of the country's gross domestic product (GDP), as well as, over 90% of its public income. Its importance makes it essential for the financial stability of the country, the vitality of the economy, and the ongoing construction and reconstruction efforts. The Iraqi government is therefore under considerable pressure to ensure that construction projects are completed on schedule, within the estimated budgets, and with the least amount of uncertainties and risks. Unfortunately, the construction sector in Iraq is not as advanced in assessing and managing risks as it is in developed countries [2]. This is due to management challenges such as lack of expertise in using modern technology for construction project management, and lack of awareness of risk management potential benefits, insufficient risk management resources, and insufficient familiarity with risk management processes. Along with the project management challenges, the country's ill security profile, fluctuating political conditions, and economic instability had resulted in a decline in petroleum prices on the global market. These challenges, in turn, have a continuing effect on the performance of the construction sector, particularly for critical infrastructure projects like O&G projects leading to cost deviation, failure to meet the expected work quality, and schedule delays. A handful of studies have investigated the impact of O&G risks on the construction sector. For example, Thuyet et al. [3] proposed strategies to address the key O&G construction risks in Vietnam in terms of their impact on project objectives. Al-Sabah et al. [4] evaluated the impact of O&G construction risks on project cost, schedule, and company performance in the Arabian Gulf region from the perspective of multinational architecture, engineering, and construction firms. Furthermore, Kassem et al. [5] assessed the level of impact of the critical risks facing Yemen's O&G construction projects in terms of their impact on project success. To the best of our knowledge, no study has examined the impact of O&G risks on construction projects' performance from the perspective of project managers. This research thus attempts to address the following research question: "What are the key risks facing the Iraqi O&G construction sector, and how do these risks affect project performance (PP)?" To address this research question, we begin by identifying the key O&G construction risks in Iraq. Then we outline our proposed analytical methods to quantify the level of riskiness of the identified risks and their effects on PP under Fuzzy-Analytical Hierarchy Process (FAHP) and Structural Equation Modelling (SEM) environments. Finally, we discuss the outputs of the assessment models, their implications, suggestions for future research, and research limitations.

2 METHODOLOGY

In this study, we used a multi-phase methodology to achieve the research objectives. Details on each one of the implemented phases are presented in the following subsections.

2.1 Phase One: Data Collection

2.1.1 Focus Group Session

In this study, we held one focus group session with six experienced project managers working on O&G construction projects in Iraq to (1) identify the key O&G construction projects risks; (2) identify the key indicators of project performance; and (3) develop the hypothesized relationships between O&G construction risks and project performance. We chose this method of data collection since there have been few studies that examine O&G construction risks both internationally and locally (in Iraq). Moreover, this method offers the advantage of exploring and understanding phenomena and situations more deeply and has been extensively utilized in previous studies to identify risks and challenges associated with engineering and construction management [6].

2.1.2 Structured Questionnaire Survey

In this study, we developed a structured survey to (1) assess the level of riskiness (i.e. weights) of O&G risks; and (2) examine the effects of O&G risks on the performance of O&G construction projects. There were four sections in the questionnaire survey. The first section precedes the main body of the survey, and it sets forth the objectives of this study. In the second section, respondents provided demographic information, which comprised information about their working sector, their experience, and their educational background. The third section compared the values (i.e., relative weights) of each risk category and it risks with other risk categories and their risks in a set of pair-wise comparison matrices. Lastly, the four section examined the respondents' perceptions about the effects of O&G risks on project performance. To this end, 75 survey forms were distributed to project managers working on O&G construction projects in Iraq.

2.2 Phase Two: The Development of Risk Analysis Model

2.2.1 Background

Analytical Hierarchy Process (AHP) is one of the most widely used methods for multi-criteria decision-making developed by Saaty [7] to address complex decision problems. In this method, factors are categorized into groups and levels, and then weighted and prioritized accurately and consistently. This method is used to derive ratio scales from paired comparisons, both discrete and continuous. These comparisons can be made using actual measurements or a scale that reflects the relative strength of feelings or preference. Its key benefit resides in its ability to verify and decrease the inconsistencies in expert judgments; it provides a comprehensive view of the complex relationships arising from an event, and it examines the spread of influence from more critical to less critical factors [8]. Although AHP is widely used for multi-criteria decision making problems, particularly when qualitative assessment is needed, it involves subjectivity in pairwise comparisons and thus vagueness type uncertainty resulting from a lack of information or conflict of opinions dominates in this process. To address the deficiency of AHP, Fuzzy Sets Theory (FST) is integrated with AHP to capture this type of uncertainty. This integration was developed proposed by Buckley [9].

FST was developed by Zadeh [10] in the 1960s and has since become a major tool for analyzing and solving problems involving uncertain parameters. The value of FST lies in its ability to formalize and deal with human knowledge and uncertainties in decision-making. FST is used to handle complex and poorly defined problems as a result of a lack of precise and complete information that characterizes the real-world situation [8]. Further, Alhumaidi [11]stated that the use of FST does not only deal with incomplete and imprecise data, but also takes into account the vagueness and subjectivity inherent in linguistic terms. In contrast to numerical variables, linguistic variables have values that are expressed as sentences or words rather than as numbers.

2.2.2 Risk Analysis

In this section, we describe the methodological steps used to analyze the level of riskiness of the identified O&G construction risks under the FAHP environment (adapted from Li et al. [12]). **First**, we structured the elements of the problem into a three-level hierarchy. The first level is the target (i.e., the analysis of O&G risks). The second level is the criteria (the categories of O&G risks). Finally, the third level is the sub-criteria (i.e., O&G risks). **Second**, we administrated a structured survey to 75 Iraqi construction experts to conduct pairwise comparison of risks using fuzzy numbers (refer to section 2.1.2).

Third, we constructed a set of judgment matrices after synthesizing the experts' judgments. **Fourth**, we used the Eigen value method to determine the eigenvector or weighting vector for each pair-wise matrix. **Fifth**, we computed the consistency ratio for each of the developed matrices and the overall inconsistency for the hierarchy using Eq. (1) and Eq. (2). A CR of 10% or less indicates a consistent and valid matrix, and if it exceeds this threshold, the matrix is inconsistent and should not be further analyzed.

$$CR = \frac{CI}{RI} \tag{1}$$

$$CI = \frac{\lambda max - n}{n-1} \tag{2}$$

Where CR is the consistency ratio; RI is the consistency index of a pair-wise comparison matrix (obtained from Table 1); λmax is the maximum eigenvalue; n is the number of criteria.

Table 1. Consistency Index

n*	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Sixth, the weighting of the fuzzy matrixes was calculated using Eq. (3) and fuzzy arithmetic operations [11, 13].

$$\tilde{w}_{x_i} = \sum_{i=1}^{m} M_x^i \otimes \left[\sum_{i=1}^{m}\sum_{j=1}^{m} M_x^{i,j}\right]^{-1},\ i,j = 1,2,3,\dots,m \quad (3)$$

Where $\tilde{w}_{x_i}$ is the fuzzy weighting of the ith risk factor; m is the number of risk factors; M_x^i is the *i*th row of M_x; $M_x^{i,j}$ is the *i*th row and *j*th column of M_x.

Seventh, we calculated the composite fuzzy weighing vector of each risk factor using Eq.(4)

$$\tilde{W}_{RS_t} = \tilde{w}_{S_t} \otimes \tilde{W}'_{RS_t},\ t = 1,2,3,\dots m \quad (4)$$

Where $\tilde{W}_{RS_t}$ is the composite fuzzy weighting vector of the hierarchy criteria level; $\tilde{w}_{S_t}$ is the the fuzzy weighting of the criteria level;$\tilde{W}'_{RS_t}$ is the local fuzzy weighing vector of the sub-criteria level.

Eighth, since a fuzzy number consists of an interval of real numbers, comparing the fuzzy weighting of each risk factor may not produce reliable results. Consequently, we defuzzified the fuzzy weightings using α and β indices. The α index reflects the experts' knowledge and experience (i.e., understanding and familiarity with the risks involved), whereas the δ index reflects their risk taking attitude. A scale of six grades was used to represent the level of familiarity that experts had with the identified O&G risks. These grades were as follows: not familiar, low familiarity, medium familiarity, high familiarity, and very high familiarity, with the corresponding ratios of 0, 20%, 40%, 60%, 80%, and 10%, respectively.

Assuming $Y = (x_1, x_2, x_3)$, the fuzzy interval for triangular membership function (x_1, x_3) will reduced to $[x_1^\alpha, x_3^\alpha]$ (refer to Eq. 5 and 6).

$$x_1^\alpha = x_1 + \alpha(x_2 - x_1) \quad (5)$$

$$x_3^\alpha = x_3 - \alpha(x_3 - x_2) \quad (6)$$

If the α value is equal to 1, this indicates that the experts are most experienced and confident in their evaluation, and the fuzzy interval will then be reduced to the crisp value x^2. In contrast, if the α value is equal to zero, then this indicates that the experts have the least experience and confidence in their judgment. The crisp weighting of the risk factors was computed by using Eq. (7)

$$x = \delta\, x_3^\alpha + (1 - \delta\,)x_1^\alpha \quad (7)$$

To this end, the average α was 0.83, suggesting that respondents had a high level of experience evaluating risks. Further, the δ was 0.5, reflecting the neutral risk attitude of the study experts.

2.2 *Phase Two: The Development of Impact Assessment Model Under SEM Environment*

In this research, we used Structural Equation Modelling (SEM) to analyze the relationships between the identified O&G construction risks and project performance. In contrast to other techniques like least square regression, logistic regression, and log-linear modeling, SEM has many advantages, such as estimating and evaluating the entire conceptual model instead of just testing individual hypotheses. During the focus group session, project managers identified the indicators of project performance, which were then used to develop the hypothesized model. Following the development of the hypothesized relationships among the constructs (i.e., O&G risks and project performance indicators), we administered a structured questionnaire survey to 75 Iraqi project managers as described previously in section 2.1.2. The survey output was analyzed using PLS-SEM by Smart PLS software package V. 3.

3 RESULTS

3.1 *Profile of the Focus Group Participants*

As mentioned in Section 2.1.1 of the research methodology, we conducted one focus group session with six Iraqi project managers. The session lasted 3 hours and took place in April 2022. The questions were grouped into three themes. The first theme focused on the respondents' role in construction, their working experience, and their educational background. The second theme focused on the identification and classification of the key O&G construction risks. Finally, the third theme investigated the respondents' perceptions about the impact of the O&G 19 risks on project performance. The profile of the focus group participants is presented in Table 2.

Table 2. Profile of Focus Group Participants

Number of Group Participants	Years of Experience	Education Level		
		BSc	MSc	PhD
Expert 1	17	1	-	-
Expert 2	22	1	-	-
Expert 3	19	-	1	-
Expert 4	26	-	-	1
Expert 5	16	1	-	-
Expert 6	20	-	-	1

3.2 *Profile of the Survey Respondents*

In total, 75 survey forms were administered online to O&G construction project managers in Iraq. Out of the 75 administered surveys, 63 were returned. However, only 56 responses were completed and considered for further analysis. Table 3 outlines the distribution of respondents among the public and private construction sectors, their range of experience, and their educational qualifications.

Table 3. Profile of survey respondents

	Category	Distribution (%)
Working Sector	Public Sector	19
	Private Sector	81
Range of Experience	1-5 Years	2
	6-15 Years	34
	16-25 Years	46
	>25 Years	18
Educational qualifications	BSc degree	71
	MSc Degree	21
	PhD degree	8

3.3 O&G construction risks and their level of riskiness

In this research, we identified and validated a set of O&G risks through a focus group session with key construction project managers in Iraq. To this end, the 47 identified risks were categorized under two categories, namely external risks and internal risks. The internal risks were categorized into five sub-categories, namely financial risks, legal risks, political risks, social risks, and environmental risks. The external risks, on the other hand, were categorized into six sub-categories, namely technical risks, logistics risks, zoning risks, human risks, design risks, and management risks. The identified O&G risks categories, sub-categories, and their risks are in columns 1 to 3 of Table 4.

In total, 22 reciprocal matrices were created to assist the respondents in performing pair-wise comparisons of the hierarchy's criteria and sub-criteria levels. Consistency ratios were computed to confirm the consistency of the experts' assessments throughout all reciprocal matrices. In the following subsections, we summarize the most significant O&G risks according to their weights (*W*) and rankings (*R*) as determined by the FAHP analysis (refer to columns 4 and 5 of table 4).

In the financial risks subcategory (*CR*=0.0726 <0.1), the most significant risk was contractor bankruptcy (*W*=0.68; *R*=5). In the legal risks sub-category (*CR*=0.0563<0.1), the most significant risk was bribery and corruption (*W*=0.64; *R*=7). In the political risks sub-category (*CR*=0.069<0.1), the most significant risk was unstable security (*W*=0.79; *R*=3). In the social risks sub-category (*CR*=0.035<0.1), the most significant risk was disturbance to local residence (*W*=0.39; *R*=32). In the environmental risks sub-category (*CR*=0.062<0.1), the most significant risk was pollution (*W*=0.58; *R*=11). In the technical risks sub-category (*CR*=0.020<0.1), the most significant risk was the use of defective materials (*W*=0.53; *R*=16). In the logistics risks sub-category (*CR*=0.072<0.1), the most significant risk was skilled workers shortage (*W*=0.82 ;*R*=2). In the zoning risks sub-category (*CR*=0.059<0.1), the most significant risk was remote site location (*W*= 0.62; *R*=8). Moreover, in the human risks sub-category (*CR*=0.0437<0.1), the most significant risk was construction site deaths and serious injuries due to poor safety measures (*W*= 0.43 ;*R*=27). Furthermore, in the design risks sub-category (*CR*=0.0812<0.1), the most significant risk was design delays (*W*= 0.65; *R*=5). Finally, in the management risks sub-category (*CR*=0.062<0.1), the most significant risk was poor communication (*W*= 0.83; *R*=1).

Table 4. Identified O&G construction risks and their level of riskiness

Category	Sub-category	Risk	*W*	*R*
	Financial risks	Insufficient contingences	0.42	28
		Inflation	0.29	43
		Contractor bankruptcy	0.68	5
		Resource monopolizing	0.49	20
		Economic instability	0.37	36
		Currency rate fluctuation	0.59	10
		Materials and Equipment price escalation	0.52	17

Table 4. Continued

Category	Sub-category	Risk	*W*	*R*
Internal Risks	Legal risks	Lack of clarity regarding contractual obligations	0.64	7
		Delays in resolving disputes	0.56	13
		Change in laws	0.35	38
		Bribery and corruption	0.61	9
	Political risks	Political instability	0.73	4
		Unstable security	0.79	3
		Appropriation and/or confiscation	0.36	37
	Social risks	Land acquisition problems	0.28	44
		Tribal conflicts	0.35	38
		Disturbance to local residence	0.39	32
	Environmental risks	Adverse weather conditions	0.42	28
		Natural disasters	0.27	45
		Pollution	0.58	11
		Construction debris	0.41	30
	Technical risks	Changes in the specification of materials	0.48	22
		The use of defective materials	0.53	16
		Poor constructability	0.39	32
		Equipment breakdown	0.44	26
		Inadequate QS/QC	0.3	42
	Logistics risks	Skilled workers shortage	0.82	2
		Materials and equipment shortage	0.38	35
		Lack of transportation facilities	0.47	24
	Zoning risks	Unforeseen site conditions	0.23	47
		Remote site location	0.62	8
		Artificial obstructs	0.45	25
External risks	Human risks	Deaths by natural causes	0.26	46
		Construction site deaths and serious injuries due to poor safety measures	0.43	27
		Strikes	0.31	41
		Illnesses	0.40	31
	Design risks	Poor design	0.39	32
		Rushed design	0.48	22
		Design delays	0.68	5
		Design changes	0.33	40
		Design complexity	0.52	17
	Management risks	Subcontractors deficiency	0.51	19
		Poor communication	0.83	1
		Poor equipment management	0.55	15
		Inefficient planning	0.57	12
		Inadequate scheduling	0.56	13
		Poor budgeting	0.49	20

3.4 Project performance indicators and hypotheses development

3.4.1 Performance Indicators

In this research, we identified 11 key performance indicators from the perspective of project managers during the focus group session. These indicators are as follows: team management, project coordination, conflict management style, communications and reporting, quality control system, quality assurance, risk and opportunity management, contract management, schedule management, stakeholders management, and health and safety management.

3.4.2 Hypotheses development

On the basis of the focus group session outputs, we developed 11 hypotheses that examine the impact of O&G construction risks on PP and its indicators. Listed below are the developed hypotheses:

H1. *Financial risks have a positive impact on PP.*
H2. *Legal risks have a positive impact on PP.*
H3. *Political risks have a positive impact on PP.*
H4. *Social risks have a positive impact on PP.*
H5. *Environmental risks have a positive impact on PP.*
H6. *Technical risks have a positive impact on PP.*
H7. *Logistics risks have a positive impact on PP.*
H8. *Zoning risks have a positive impact on PP.*
H9. *Human risks have a positive impact on PP.*
H10. *Design risks have a positive impact on PP.*
H11. *Management risks have a positive impact on PP.*

3.5 Assessment of the Measurement Model

The Measurement Model specifies the rules of correspondence between measured and latent variables and is assessed using internal consistency reliability, convergent validity, and discriminant validity.

3.5.1 Internal Consistency Reliability

Internal consistency reliability (ICR) refers to the degree to which test measurements remain consistent when performed under similar conditions repeatedly. ICR measured by Cronbach's alpha (i.e., a measure of tests' internal consistency) and composite reliability (i.e., a measure of internal consistency in scale items). the Cronbach's Alpha values ranged between 0.804 and 0.920. The composite reliability, on the other hand, ranged between 0.870 and 0.913. Both measures exceeded the threshold of 0.707, indicating accepted construct reliability [14].

3.5.2 Convergent Validity

Convergent validity refers to the degree to which a new scale is related to other measures and variables of the same construct, based on the outer loading of indicators and average variance extracted. To this end, the range of the outer loadings for the constructs' indicators was from 0.814 to 0.959, exceeding the minimum threshold of 0.60 for item reliability [15] . Furthermore, the CV values were deemed adequate ranging from 0.538 to 0.801, exceeding the recommended threshold of 0.5 [16].

3.5.3 Discriminant Validity

Discriminant validity refers to the degree of differentiation and independence between a set of factors. In this research, Heterotrait-monotrait Ratio of Correlations (HTMT) was used to measure discriminant validity. To this end, the range of the HTMT values was from 0.373 to 0.627, which was below the threshold of 0.90 [17]. Accordingly, the test results were deemed satisfactory.

3.6 Assessment of the Structural Model

The Structural Model (SM) examines the relationships among constructs and is assessed using the coefficient of determination, Cross-validated redundancy, and path coefficients

3.6.1 Coefficient of determination (R^2)

In this research, R^2 values were obtained using the bootstrap algorithm in SMART PLS 3.0 with the recommended iterations of 300. R^2 values for the effects of O&G risks on PP was 0.713, exceeding the minimum acceptable level of 0.1 as recommended by Falk and Miller [18]. Hence, indicating a satisfactory predicting capability.

3.6.2 Cross-validated redundancy (Q^2)

In this research, the Q^2 values were obtained using the blindfolding algorithm in SMART PLS 3.0 with the recommended iterations of 300 and an omission distance of seven. The Q^2 values for the effects of O&G risks on PP was 0.421 exceeding the minimum acceptable level of 0.00 as recommended by Hair et al. [19]. Hence, indicating a satisfactory predicting relevance level.

3.6.3 Path coefficients(β)

In the context of SEM, a path coefficient is a standardized version of a linear regression weight, which can be used to evaluate the hypothesized correlation between two variables. In order to accept the hypothesis, the T-valu (T) e must be greater than 1.96, while the P-value (P) must be less than 5%. In this research, H1 examines whether financial risks have a positive impact on PP. Results indicated that financial risks had a significant impact on PP (β =0.606, T =8.786, P<1%). Consequently, H1 was supported. H2 examines whether legal have a positive impact on PP. Results indicated that legal risks had a significant impact on PP (β =0.639, T =6.735, P<1%). Therefore, H2 was supported. H3 examines whether political risks have a positive impact on PP. Results indicated that political risks had a significant impact on PP (β =0.316, T =4.109, P<1%). Thus, H3 was supported. H4 examines whether social risks have a positive impact on PP. Results indicated that Social risks had a significant impact on PP (β =0.466, T =6.964, P<1%). Accordingly, H4 was supported. H5 examines whether environmental risks have a positive impact on PP. Results indicated that environmental risks had a significant impact on PP (β =0.452, T =6.119, P<1%). Hence, H5 was supported. H6 examines whether technical risks have a positive impact on PP. Results indicated that technical risks had a significant impact on PP (β =0.531, T =6.183, P<1%). Therefore, H6 was supported. H7 examines whether logistics risks have a positive impact on PP. Results indicated that logistics risks had a significant impact on PP (β =0.526, T =5.726, P<1%). Accordingly, H7 was supported. H8 examines whether zoning risks have a positive impact on PP. Results indicated that zoning risks had a significant impact on PP (β =0.470, T =5.732, P<1%). Consequently, H8 was supported. H9 examines whether human risks have a positive impact on PP. Results indicated that human risks had a significant impact on PP (β =0.512, T =5.875, P<1%). As a result, H9 was supported. H10 examines whether design risks have a positive impact on PP. Results indicated that design risks had a significant impact on PP (β =0.476, T =6.873, P<1%). Hence, H10 was supported. H11 examines whether management risks have a positive impact on PP. Results indicated that management risks had a significant impact on PP (β =0.728, T =7.745, P<1%). In light of this, H11 was supported.

4 CONCLUSIONS

O&G construction projects are complex and risky due to their dynamic environment, unique nature, complex technology, remote geographical locations, and the involvement of numerous stakeholders. In order to achieve the set goals of such projects with high performance, it is crucial to thoroughly examine the major risks associated with these projects. The aim of this paper is to quantify the effects of construction risks on the performance of O&G projects by considering the case of O&G construction projects in Iraq. In this research, we (1) identified the key risks facing O&G construction projects, as well as the key performance indicators from the perspective of Iraq project managers; (2) developed a set of hypotheses to capture the impact of O&G construction risks on project performance; (3) quantified the riskiness level of O&G risks; and (4) examined how construction project managers in Iraq perceive the impact of O&G risks on project performance. First, a focus group session was conducted with six construction project managers in Iraq to identify O&G risks and key project performance indicators, and to hypothesize the relationships between the O&G risks and PP. Second, a structured survey (i.e., AHP and SEM-based) was administered to 75 experts to assess the level of riskiness of O&G risks and their impact on project performance. Third, a FAHP model was developed to quantify the level of riskiness of O&G risks. Last, a SEM model was developed to quantify the direct effects of O&G risks on PP.

Based on the results of the FAHP analysis, the top 10 significant risks facing O&G construction projects were (high to low riskiness level): poor communication, skilled workers shortage, unstable security, political instability, contractor bankruptcy, design delays, bribery and corruption, remote site location, lack of clarity regarding contractual obligations, and currency rate fluctuation.

Based on the results of the SEM analysis, all analyzed risk categories had a significant impact on the performance of O&G construction projects in Iraq. In fact, management risks had the strongest effects on PP ($\beta=0.728$), followed by legal risks ($\beta=0.639$), financial risks ($\beta=0.606$), technical risks ($\beta=0.531$), logistics risks ($\beta=0.526$), human risks ($\beta=0.512$), design risks ($\beta=0.476$), zoning risks ($\beta=0.470$), social risks ($\beta=0.466$), environmental risks ($\beta=0.452$), and political risks ($\beta=0.316$), respectively. Ultimately, this study contributes to the body of knowledge by providing a useful aid to practitioners and researchers seeking a reference on common potential risks affecting the performance of O&G construction projects. For future work, the findings of this paper can be used by research scholars to (1) develop guidelines and strategies to respond to O&G risks; and (2) model the effects of O&G construction risks on developing versus developed countries.

4.1 Limitations

Despite its importance, this study has a number of limitations. First, this research relies on expert judgment, derived from focus group sessions and questionnaire surveys. Other inputs, such as historical data from previously achieved projects, should be considered to complement the results. Second, 47 risks were identified in this research and grouped into two categories and 11 subcategories. Other O&G risks should be identified and classified under the study's existing classification or under new construction categories and sub-categories. Last, the results of this study were based on the perspective of construction project managers in Iraq. The perspectives of other construction stakeholders (e.g., contractors, consultants, etc.) regarding the effects of O&G risks on project performance may differ.

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