International Journal of Operations Research and Artificial Intelligence

www.ijorai.reapress.com

Research Expansion Alliance Int. J. Oper. Res. Artif. Intell . Vol. 1, No. 3 (2025) 121–130.

Paper Type: Original Article

Risk Ranking of Oil and Gas Projects in the Exploitation Phase: An OPA-Based Case Study of the National Iranian Oil Company

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Citation:

Received: 23 February 2024 *Revised: 18 April 2024* *Accepted: 21 August 2024*	Abbasi, M., Kaviani, S., & Sheikhian, L. (Date). Risk ranking of oil and gas projects in the exploitation phase: An OPA-based case study of the national Iranian oil company. *International journal of operations research and artificial intelligence, 1*(3), 121-130.

Abstract

This study examines the systematic risk management process throughout the life cycle of oil and gas projects, emphasizing the need to identify, evaluate, and control risks to safeguard national assets. Given the sector's high exposure to operational, financial, and environmental uncertainties, the research applies the Ordinal Priority Approach (OPA) to assess the relative importance of risk factors in the exploitation phase. The methodology unfolds in four stages: establishing an expert panel, identifying relevant sub-criteria through literature and expert judgment, ranking experts based on their professional expertise, and eliciting individual prioritizations of risk factors. Subsequently, a linear programming model was solved using the official OPA platform to derive optimal weights for both experts and criteria, ensuring consistency and analytical reliability in the ranking process. The findings indicate that cost and time constitute the most influential dimensions shaping project success, followed by human resources, procurement, quality, miscellaneous factors, and scope. The analysis further identifies three paramount risks: insufficient infrastructure in exploration areas, a shortage of skilled professionals due to regional constraints, and oil extraction from shared reservoirs by neighboring states. Overall, the results underscore the importance of proactive, data-driven risk management strategies that integrate expert judgment and analytical rigor to strengthen decision-making, minimize potential disruptions, and promote sustainable performance across the oil and gas industry.

Keywords: Risk management, Oil and gas projects, Exploration phase, Ordinal priority approach, Risk prioritization.

1 | Introduction

The oil and gas industry represents one of the most influential global sectors, driving economic development, employment, and technological progress. Continuous exploration and production projects reflect its rapid growth, yet they also expose the sector to substantial risks resulting from the hazardous and flammable characteristics of hydrocarbons [1]. These risks frequently cause accidents, environmental damage, and

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https://doi.org/10.48314/ijorai.v1i3.72

operational disruptions, particularly during exploration and production phases, making effective risk management a top industrial priority [2].

Given the strategic role of oil and gas in sustaining global economies, enhancing the effectiveness of risk management frameworks has become indispensable [3]. Robust risk management not only improves project performance but also strengthens sustainability in complex, uncertain industrial environments. However, in politically unstable or safety-deficient regions, the lack of sufficient knowledge about failure causes and weak implementation of safety mechanisms remain key barriers to effective risk control [3].

In project management, systematic risk identification and assessment are central to achieving success, as they directly affect cost, time, scope, and quality performance. Among risk management components, qualitative risk analysis plays a crucial role in ranking and prioritizing risks under uncertainty [2]. Studies show that structured and data-driven approaches—such as fuzzy logic, multi-criteria decision analysis, and probabilistic modeling—can significantly enhance the precision of risk evaluation in oil and gas projects [3]. Despite the extensive literature on construction and IT sectors, relatively few studies have focused on risk management in oil and gas exploration projects, where uncertainty and technical complexity are most intense [4].

Exploration and production phases are characterized by intertwined financial, technical, and environmental uncertainties requiring both engineering expertise and systemic managerial insight [4]. Global supply chain disruptions have further amplified project risks, as dependence on international logistics exposes companies to procurement delays, cost volatility, and political restrictions [5]. Addressing these vulnerabilities through structured evaluation and prioritization can improve organizational resilience and ensure operational continuity.

Empirical evidence indicates that inadequate coordination among contractors, limited liquidity, and infrastructure deficiencies often cause schedule delays and cost overruns. Transparent procurement systems and integrated stakeholder management are therefore essential for maintaining operational efficiency [6]. In addition, geopolitical instability, trade sanctions, and regulatory volatility increasingly restrict access to technology and capital, highlighting the need for supply chain diversification and adaptive governance [7].

As oil fields mature, operational risks become more pronounced due to aging equipment, reduced productivity, and environmental concerns. Managing these challenges through technological innovation, human resource development, and adaptive maintenance strategies ensures production stability while upholding safety and environmental standards [8].

In this regard, selecting appropriate operational and manufacturing strategies is vital to managing uncertainty and optimizing performance. The literature provides several examples of the application of operations research and analytical decision-making techniques to formulate and prioritize strategic alternatives [9–15]. Approaches such as Interpretive Structural Modeling (ISM) [9], [10] Fuzzy AHP and importance–performance matrix [11], robust Data Envelopment Analysis (DEA) [12], and Blue Ocean–Porter hybrid frameworks [13], [14] have proven effective for aligning operational goals with strategic objectives under uncertainty. Integrating these methodologies enables organizations to systematically identify priorities, allocate resources efficiently, and strengthen competitiveness within volatile markets.

Accordingly, this study aims to identify and prioritize the key risks associated with exploration projects in the oil and gas sector. The Ordinal Priority Approach (OPA) serves as the primary analytical framework for risk prioritization. The research focuses on exploration projects executed by the National Iranian Oil Company (NIOC), contributing to a deeper understanding of structured risk management and its practical implementation within the oil and gas industry.

2 | Methodology

The OPA is a systematic Multi-Criteria Decision-Making (MCDM) method that simultaneously determines the relative weights of criteria, sub-criteria, and experts by formulating and solving a linear programming model. This approach provides a structured framework for integrating expert judgments into a coherent prioritization process, ensuring consistency and transparency in the weighting procedure. As outlined in [15], the principal stages of the OPA method—when applied to problems involving only criteria and experts—are as follows:

Step 1 (formation of the expert committee and identification of sub-criteria risk factors). In the initial stage, an expert committee is established to guarantee that the evaluative judgments are credible and technically sound. Subsequently, the sub-criteria or risk factors are identified through a comprehensive literature review, supplemented by expert consultations. This step ensures that all relevant dimensions of the problem are adequately captured before the quantitative analysis.

Step 2 (expert ranking). Once the expert team is constituted, the members are ranked based on their academic and professional qualifications, domain expertise, and familiarity with the research subject. Depending on whether the decision context is individual or group-based, different ranking mechanisms may be applied. In the present study, professional experience served as the primary criterion for expert ranking, with individuals with longer, more substantial industrial experience assigned higher ranks.

Step 3 (prioritization of risk factors). At this stage, each expert independently evaluates and ranks the identified sub-criteria (risk factors) based on their perceived significance. These ordinal rankings serve as input data for the mathematical model, enabling subsequent quantification of relative importance via linear optimization.

Step 4 (model formulation and optimization). In the present research, the OPA model incorporates only the main criteria (risk dimensions) and their corresponding sub-criteria (risk factors); therefore, no alternative options are considered. The objective is to determine the optimal weights of both experts and sub-criteria simultaneously. The general mathematical programming formulation of the model can be expressed as follows:

$$\begin{aligned} &\text{Max } Z, \\ &\text{s.t.} \\ &Z \leq i\left(j\left(W_{ij}^{r} - W_{ij}^{r+1}\right)\right) \quad \text{for all i, j and r,} \\ &Z \leq ijmW_{ij}^{m} \quad \text{for all i, j,} \\ &\textstyle\sum_{i=1}^{p}\sum_{j=1}^{n} W_{ij} = 1, \\ &W_{ij} \geq 0 \quad \text{for all i, j.} \end{aligned} \tag{1}$$

Here, W_{ij}^{r} represents the weight assigned to the j criterion by the i expert at rank r. Finally, the overall weights of the criteria are calculated using the following relationship:

where W_{ij}^{r} denotes the weight assigned by expert i to criterion j at rank r. Upon solving the optimization model, the aggregated weights of the criteria are obtained as follows:

$$W_j = \sum_{i=1}^{p} W_{ij} \quad \text{for all j.} \tag{2}$$

The OPA linear programming model was implemented and solved through the official web-based OPA platform developed by [16], ensuring computational precision and methodological robustness. This optimization procedure yields consistent and normalized weights that quantitatively reflect the relative significance of the identified risk factors. Consequently, the derived weighting structure provides a mathematically rigorous foundation for subsequent stages of analysis, including comparative evaluation, sensitivity assessment, and decision optimization within the broader risk management framework.

3 | Results

To establish the expert committee, the snowball sampling method was employed. In this process, initial contact was made by phone with the first expert, who was invited to participate in an interview. After explaining the research topic and objectives, the expert was asked to recommend another professional with relevant knowledge and experience in oil and gas exploration. This iterative process continued until five experts with substantial experience in the oil and gas industry's exploration sector were identified and interviewed. The professional background and academic qualifications of the selected experts are summarized in *Table 1*. The panel includes senior specialists from the NIOC, each with extensive experience in exploration operations, project planning, and management.

Table 1. Characteristics of the expert panel NIOC.

Expert	Position	Academic Degree	Years of Experience	Rank
1	Senior exploration operations engineer (project manager)	M.Sc. in petroleum engineering–drilling	24	1
2	Senior exploration operations engineer	M.Sc. in petroleum engineering–drilling	15	4
3	Senior project planning and control engineer	M.Sc. in petroleum engineering–exploration	18	3
4	Senior information and communication engineer, exploration operations	M.Sc. in Information Technology Engineering	21	2
5	Senior project planning and control engineer	M.Sc. in industrial engineering	15	4

By reviewing references [4–8], the key risks associated with oil and gas projects during the exploitation phase of the NIOC were identified and summarized in *Table 2*. According to the OPA, when decision-making occurs in a group context, the ranking of experts should be based on criteria such as professional experience, educational background, and domain-specific expertise. In this study, since the decision-making problem was group-based, the experts' ranks were assigned primarily according to their years of professional experience and depth of involvement in oil and gas exploration projects. Following an extensive review of the relevant literature and expert panel insights, 23 sub-risk factors were identified. Subsequently, each expert was asked to assign a rank to every sub-factor based on its relative significance and potential impact on project performance. The consolidated ranking results are presented in *Table 2*.

Table 2. Identified risk of oil and gas projects in the exploitation phase.

No.	Main Dimension	Risk Sub-factors	Source
1	Time and Cost	Delay in the delivery of drilling rigs due to late site construction and untimely access road completion	[4-8]
2		Oil extraction from shared fields by a neighboring country	[4], [7], [8]
3		Constraints in the procurement of goods and equipment	[4-7]
4		Soil contamination at the project site caused by explosive materials	[4], [6]
5		Lack of essential infrastructure in the region for the oil and gas project implementation	[4-6]

Table 2. Continued.

No.	Main Dimension	Risk Sub-factors	Source
6		Obstruction by farmers in land acquisition for project implementation	[4],[8]
7		Restrictions on specialized consulting services by foreign firms	[4], [7]
8		Insufficient liquidity among domestic contractors	[4-6]
9		Failure to attract foreign investors to the project	[4], [7]
10		Delay in financial payments to foreign contractors	[4], [7]
11		Lack of modern technology and equipment in exploration processes	[4-6]
12	Human resources	Shortage of skilled labor due to regional deprivation	[4], [6]
13		Shortage of the professional workforce due to regional deprivation	[4], [6]
14		Inadequate training of human resources in project management and technical areas	[4], [6]
15	Quality	Extraction of light, heavy, and extra-heavy oil from different field layers	[4]
16		Lack of studies on enhanced Oil Recovery (EOR) methods	[4]
17		Non-compliance with health, safety, and environmental (HSE) standards	[4], [6]
18	Procurement	Ignoring the national calendar in project scheduling	[4], [5]
19		Neglecting project cost estimation and profitability analysis	[4], [5]
20		Complex bureaucratic procedures are restricting capable firms from tender participation	[4], [6], [7]
21	Scope	Lack of awareness regarding project objectives and related activities	[4]
22	Other factors	Political and economic sanctions	[4], [7]
23		Insurance coverage for goods and equipment	[4-7]

Subsequently, *Model (1)* was established, and using *Eq. (2)*, the corresponding weights were calculated. The results of this analysis are summarized in *Table 4*. According to *Table 4*, the Time and Cost dimension obtained the highest weight coefficient (0.468) and ranked first among all dimensions. It was followed by human resources (0.171), procurement (0.116), quality (0.111), other factors (0.083), and scope (0.050), which ranked second to sixth, respectively.

4 | Discussion and Conclusion

The present study proposed and applied a structured three-stage framework to identify, categorize, and prioritize the risks associated with oil and gas exploration projects. The findings from the OPA clearly indicate that the Time and Cost dimension exerts the greatest influence on project outcomes, underscoring the importance of timely procurement, infrastructure readiness, and financial planning for operational success. The subsequent importance of human resources and procurement dimensions underscores the critical role of skilled expertise, effective workforce management, and transparent supply chain mechanisms in minimizing project uncertainty. Among the 23 identified risk factors, the absence of adequate infrastructure in exploration regions, the shortage of skilled professionals due to regional deprivation, and cross-border oil extraction by neighboring countries emerged as the most critical challenges. These risks not only threaten project efficiency but also pose strategic implications for national resource management and energy security.

Table 3. Ranking of identified risk sub-factors by experts.

No.	Risk Sub-Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
1	Delay in the delivery of drilling rigs due to late site construction and untimely access road completion	3	2	2	2	
2	Oil extraction from shared fields by a neighboring country	10	18	15	16	14
3	Constraints in the procurement of goods and equipment	8	7	14	8	7
4	Soil contamination at the project site caused by explosive materials	2	3	6	15	6
5	Lack of essential infrastructure in the region for the oil and gas project implementation	1	1	3	1	2
6	Obstruction by farmers in land acquisition for project implementation	9	10	16	14	13
7	Restrictions on specialized consulting services by foreign firms	5	4	5	5	3
8	Insufficient liquidity among domestic contractors	14	19	13	17	15
9	Failure to attract foreign investors to the project	15	6	7	6	4
10	Delay in financial payments to foreign contractors	12	11	12	7	5
11	Lack of modern technology and equipment in exploration processes	5	5	4	3	2
12	Shortage of skilled labor due to regional deprivation	16	17	22	23	21
13	Shortage of the professional workforce due to regional deprivation	11	16	10	18	12
14	Inadequate training of human resources in project management and technical areas	17	12	11	11	11

Table 3. Continued.

No.	Risk Sub-Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
15	Extraction of light, heavy, and extra-heavy oil from different field layers	21	20	23	19	20
16	Lack of studies on enhanced EOR methods	18	13	9	12	16
17	Non-compliance with health, safety, and environmental (HSE) standards	7	8	8	10	8
18	Ignoring the national calendar in project scheduling	20	21	20	21	18
19	Neglecting project cost estimation and profitability analysis	13	14	17	13	9
20	Complex bureaucratic procedures restricting capable firms from tender participation	6	9	18	9	10
21	Lack of awareness regarding project objectives and related activities	19	15	19	20	17
22	Political and economic sanctions	4	2	1	4	1
23	Insurance coverage for goods and equipment	22	22	21	22	19

The results highlight the need for a proactive, integrated risk management approach that combines technical, managerial, and policy-level interventions. Strengthening regional infrastructure, investing in human capital development, and improving coordination among domestic and international stakeholders can substantially enhance the resilience of exploration projects. In addition, adaptive financial strategies and continuous monitoring of geopolitical developments are recommended to mitigate high-impact risks. Overall, the proposed framework provides a practical foundation for risk-based decision-making in the oil and gas sector, offering valuable insights for policymakers, project managers, and investors seeking to enhance sustainability and competitiveness in exploration operations.

Table 4. Final weights and rankings of risk factors in oil and gas exploration projects.

No.	Main Dimension	Weight of Dimension	Risk Factors	Weight of Risk Factor	Rank
1	Time and Cost	0.468	Delay in the delivery of drilling rigs due to late site construction and untimely access road completion (R1)	0.044	12
2			Oil extraction from shared fields by a neighboring country (R2)	0.062	3
3			Constraints in the procurement of goods and equipment (R3)	0.015	23
4			Soil contamination at the project site caused by explosive materials (R4)	0.042	13
5			Lack of essential infrastructure in the region for oil and gas project implementation (R5)	0.081	1

Table 4. Continued.

No.	Main Dimension	Weight of Dimension	Risk Factors	Weight of Risk Factor	Rank
6			Obstruction by farmers in land acquisition for project implementation (R6)	0.036	17
7			Restrictions on specialized consulting services by foreign firms (R7)	0.021	21
8			Insufficient liquidity among domestic contractors (R8)	0.058	5
9			Failure to attract foreign investors to the project (R9)	0.034	18
10			Delay in financial payments to foreign contractors (R10)	0.048	9
11			Lack of modern technologies and equipment in exploration processes (R11)	0.027	19
12	Human Resources	0.171	Shortage of skilled labor due to regional deprivation (R12)	0.047	10
13			Shortage of professional workforce due to regional deprivation (R13)	0.063	2
14			Inadequate training provided to personnel in project management and technical areas (R14)	0.062	4
15	Quality	0.111	Extraction of light, heavy, and extra-heavy oil from field layers (R15)	0.040	14
16			Lack of studies on enhanced EOR methods (R16)	0.050	8
17			Non-compliance with health, safety, and environmental (HSE) standards (R17)	0.021	22
18	Procurement	0.116	Ignoring the national calendar in project scheduling (R18)	0.039	15
19			Neglecting project cost estimation and profitability analysis (R19)	0.055	6
20			Complex bureaucratic procedures restricting capable firms from tender participation (R20)	0.022	20
21	Scope	0.050	Lack of awareness regarding project objectives and related activities (R21)	0.050	7
22	Other factors	0.083	Political and economic sanctions (R22)	0.046	11
23			Insurance coverage for goods and equipment (R23)	0.037	16

Funding

No funding was received for conducting this study.

Data Availability

All data are included in the text.

Conflicts of Interest

The authors declare no competing interests.

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