PORT SAID ENGINEERING RESEARCH JOURNAL
Faculty of Engineering - Port Said University
Volume (28) No. 4 pp: 15 :24

IMPACT OF PROJECT DELIVERY METHODS ON LIFECYCLE RISK MANAGEMENT OF OFFSHORE PROJECTS

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Received 7-7-2024,
Revised 20-7-2024
Accepted 24-7-2024

ABSTRACT

Offshore projects are complex and require proactive risk management to achieve the desired outcomes. Offshore projects are exposed to many risks due to the large investments, strict regulations, and complex natural challenges. This study highlights the importance of risk management in offshore project execution, focusing on the risks associated with different project delivery methods(PDMs) such as Design Bid Build (DBB), Design-Build (DB), Construction Management at Risk (CMAR), Public-Private Partnership (PPP), Build-Operate-Transfer (BOT), Engineering, procurement and Construction(EPC) and Integrated Project Delivery (IPD) at various stages of an offshore project's lifecycle. This research aims to assess and recognize the risks related to offshore projects to improve understanding and optimize performance outcomes. Risk identification was carried out through an extensive literature review followed by a risk assessment involving expert interviews to evaluate the probability and impact of each risk. It is found that management risks account for an average of 52% of all identified risks, While technical risks account for an average of 24% of the identified risks. Historical data on real-world projects delivered using EPC are utilized to validate these risks' impact on the risk management process by assessing pre-mitigation and post-mitigation risk plans. It is noted that implementing a risk response strategy led to a 27% reduction in the estimated budget and a 14% decrease in the estimated duration.

Keywords: Offshore, Projects Delivery Methods, Risk Management, Project's Life cycle

1. INTRODUCTION

Offshore projects are vital in the oil and gas industry due to their considerable role in accessing available resources, using technological advancements, and contributing to economic growth and energy security. These projects are complex and face many risks, making implementing effective lifecycle risk management essential. Effective risk management helps mitigate technical and environmental challenges, ensures financial capability by avoiding cost overruns and delays, and maintains safety and environmental standards to prevent accidents. By managing these risks effectively, companies can maintain project continuity, comply with regulations, protect investments, and ensure the successful execution and sustainability of offshore projects[1].

The construction of offshore facilities for the development of oil and gas deposits is preceded by careful Conceptual Studies, Front-End Engineering Design Studies (FEED studies), and a Detailed Engineering phase, including accurate construction planning. Still, incidents during the Construction Phase could lead to the need to implement physical strengthening of construction details or changes to the construction process[2].

Oil and gas projects employ the Engineering, Procurement, and Construction (EPC) contract, wherein the same contractor handles the entire process from front-end engineering design (FEED) to the construction stage. Unlike conventional Design-Bid-Build (DBB) contracts, this particular contract enables the concurrent execution of design and construction tasks, enabling the expedited execution of EPC projects compared to other contract forms[3].

According to modern management concepts, construction project management is an effective management that plans and controls the project's activities. It also schedules its activities properly and takes the necessary measures to speed up performing activities to fulfill the obligation of accomplishing the project in time. The role of management in construction projects is not only limited to a specific phase of project performance phases but also begins as the project starts and does not end until the project ends [4].

There is a complexity and difficulty in both technology and management of oil and gas industries; due to this, oil and gas projects are considered the most challenging of all industries, as per Akinremi et al. [5]. However, Briel et al. suggested that project managers adhere to a consistent reference framework and rely on their experience. This framework should be established via continuous monitoring and evaluation of all formal project stages, from initiation to completion[6]. In conclusion, building management strategies that address time, money, and quality are essential to achieving efficient management in the oil and gas sector. This will ultimately enhance the need for knowledge to mitigate potential project failures in the future.

Risk management, as one of the most important project management knowledge areas [7], is responsible for increasing the probability of project success. Risk identification and assessment are two vital processes of project risk management. The probability and impact of risks affect project objectives such as cost, time, scope, and quality. Uncertainty in estimating project time and cost is considered a major challenge in project management science. Risk management is one of the most important effective solutions to this problem.

Risk management involves applying management rules, procedures, and processes to identify, analyze, and control risks. Thus, risks must be recognized and evaluated before starting a project, and risk response techniques must be implemented to reduce risk. Qualitative risk analysis is crucial to risk management because it ranks all project risks and identifies major risks that affect project time, cost, and quality. Presenting response strategies to all identified risks is time-consuming and inefficient. Therefore, a method that can do qualitative risk analysis faster and handle uncertainty in decision-making can be helpful. Some researchers assessed construction and software project risks[8].

2. LITERATURE REVIEW

2.1 Brief Background

Hatefi and Tamošaitienė[8]stated that the methodical application of management rules, procedures, and processes for risk detection, analysis, and control activities is known as risk management. Therefore, to minimize or reduce the probability or impact of risks, project hazards must be recognized and assessed, and suitable risk response techniques must be implemented prior to project execution. Since presenting response strategies to every identified risk in a project is time-consuming and inefficient, qualitative risk analysis is crucial when implementing risk management processes. This allows all project risks to be ranked and major risks that significantly affect project time, cost, and quality to be identified. Consequently, an approach that can handle the unpredictable decision-making environment and execute qualitative risk analysis more quickly may be successful. A few academics assessed the hazards associated with software and construction projects.

2.2 Risk management in offshore Projects

Hatmoko and Khasani[9]reviewed and analyzed project records by conducting interviews. He identified

28 risk variables were gathered. He then divided the risk factors into three groups based on stage, namely engineering [E], procurement [P], construction, and installation [C]. In the engineering stage [E], eight risk factors (22%) were detected, twenty-four risk factors (67%) were found in the procurement stage [P], and four risk factors (11%) were found in the construction and installation stage [C].

Lenkova [10] categorized risks into internal (production, support activities, reproductive sector, circulation, and management) and external (politics, society, environment, science, and technology); he provided a comprehensive risk classification system for support activities .

Dehdasht, Mohamad Zin et al. [11] classified risks affecting oil and gas construction projects (OGC) into six main risk groups: financial, policy and political, weather and environment, design and construction, contractual, and technical, offering a detailed risk assessment framework .

A review of literature on reasons for project failure was conducted by Dey, De et al. [12]; They identified risk categories (organizational, transformation, technology, management, and project management processes) as well as risk events throughout stages (planning, implementation, and evaluation) .

Risk management processes in the South African petroleum industry were studied by Young[13]; he categorized primary risks into nine types: operational, business, credit, legal, market, country, environmental, financial, and safety/health .

Main risks in oil and gas projects was identified and evaluated by Khalilzadeh, Shakeri et al. [14] based on the PMBOK guide under sanctions and uncertain conditions, categorizing risks into time and cost, human resources, quality, procurement, scope, communications, and other main risks.

Alnoaimi and Mazzuchi [15] studied the risk related factors in the oil and gas industries. Based on data collected through reviewing the literature of similar studies and through qualitative and quantitative study, they identified the major risk related issues in the company and measures applied by the company to control and manage risk.

2.3 Project Delivery Methods

The selection of the appropriate PDM is one of the most important managerial decisions since it has a direct impact on the success of any project, it affects the project objectives such as cost, quality, schedule, and safety. Indeed, PDMs have developed over the years, and there have been alternatives introduced in the construction industry to meet various demands [16].

Since it directly affects the success of any project and influences the project objectives, including cost, quality, schedule, and safety, the choice of the suitable PDM is among the most crucial managerial decisions. Indeed, PDMs have evolved throughout time, and the building sector has added choices to satisfy different needs [16].

Mitkus [17] stated that approximately 90% of construction claims and disputes arise due to inadequate communication among the project stakeholders. Several authors have emphasized the significance of collaboration and partnership among all stakeholders in a project, which is typically facilitated by the selection of the Project Data Management (PDM) system.

Choosing an appropriate Project Delivery Method (PDM) is a crucial step in selecting a procurement and contracting approach that aligns well with the project's requirements. The decision should be made in the project initiation phase and certainly before the final design phase begins. Although the purpose and needs must be clear in the scoping stage.

Mahdi, Abdelkhaleq et al. [18]identified risks related to project delivery methods during project' s life cycle before commencement of the projects. To enhance the capability of managing risk in construction projects. Further categorization of risks is done which will help in better allotment of risk responsibilities.

Even though there is wide research on risk management in offshore projects, there are many significant gaps in interpreting the impact of various project delivery methods (PDMs) on the risk management of offshore projects. Current studies often focus on isolated aspects of risk management without comparing PDMs' impacts on risk management across all phases of offshore projects. Many studies highlighted many contract types, such as Engineering, Procurement, and Construction (EPC) or Design-Bid-Build (DBB), but there's a lack of a complete analysis of more modern and integrated methods, such as Integrated Project Delivery (IPD) or Construction Manager at Risk (CMAR). The relations between PDMs and related factors unique to offshore projects, such as environmental impact, economic conditions, and new technologies, are unstudied. By referring to these gaps, this study combines comparative studies and real-world data and focuses on risks related to PDMs to provide a more nuanced understanding of their impact on lifecycle risk management in offshore projects.

Managing risks across an offshore project's lifecycle presents several challenges. These include technical risks related to reservoir behavior and subsurface conditions, safety, and environmental risks due to severe conditions, cost overruns, supply chain dependencies, regulatory

compliance, project complexity, asset integrity, geotechnical risks, and long-term sustainability.
All these challenges require an effective risk assessment, contingency planning, and stakeholder collaboration.

The purpose of this study is to identify the main risks associated with various project delivery methods and with offshore project's life cycle by conducting an extensive literature review. Conduct qualitative and quantitative assessments for risks identified by experts interviewing and evaluate the impact of risks identified on the risk management process.

3. RESEARCH METHODOLOGY

This research aims to explore and enhance risk management practices for offshore project delivery by conducting risk assessment for different project delivery approaches. This research seeks to improve the predictability, efficiency of offshore project delivery, ultimately contributing to the sustainability and success of the offshore industry.
A research process flow-chart is shown in Figure 1 to give the reader a brief on steps conducted to implement the research project Sources of data collected are explained and a conceptual framework will be established to help in modeling the relationship between risks associated with various project delivery approaches and offshore project risk assessments.

3.1 Risk identification

Risk identification is an essential part of the methodological work since it creates the basis for the effective management of risks and achieving the desired project outcomes.
Associated risks for various project delivery approaches and offshore projects are identified through reviewing the literature .The study started by investigating sources including studies ,papers and scholarly articles related to project delivery methods and risks that can affect offshore projects .

A risk profile was constructed to highlight the main causes of cost overruns, schedule delays, and technical challenges. The gathered data helps project managers to implement effective risk mitigation strategies specific to offshore projects by assessing risk probabilities and their impact.
To develop a comprehensive risk assessment, a Risk Breakdown Structure (RBS) was constructed, which categorizes identified risks into four categories: External and site conditions, Economic and financial risks, Technical risks, and Management risks. By categorizing risks, RBS presents a structured framework for recognizing, analyzing, and mitigating threats, making project management more effective and proactive. A sample of risks identified for Engineering, procurement, and construction facing offshore projects is shown in Table 1.

3.2 Risk assessment

By interviewing specialized experts with extensive experience, we gathered beneficial views and understandings of probable risks. These interviews are considered a deep source of data for assessing risk severity and prioritizing risks based on their probability and impact. The results from these expert assessments can be used to perform proactive risk management. To assess the risks identified, a comprehensive questionnaire was developed that contains both qualitative and quantitative questions aiming to get experts' points of view on various risk factors. The questionnaire is designed to obtain detailed information about the probability of various risks facing offshore project delivery and their exposure to project objectives.
To calculate the risk scoring, Primavera risk analysis software was used to perform risk register and risk matrix.
The probability and impacts of risks were inputted into Primavera Risk Analysis to calculate pre-mitigation risk scoring for risks associated with the offshore projects' life cycle. This process involves systematically identifying potential risks, assessing their likelihood of occurrence, and evaluating their potential consequences on the project.

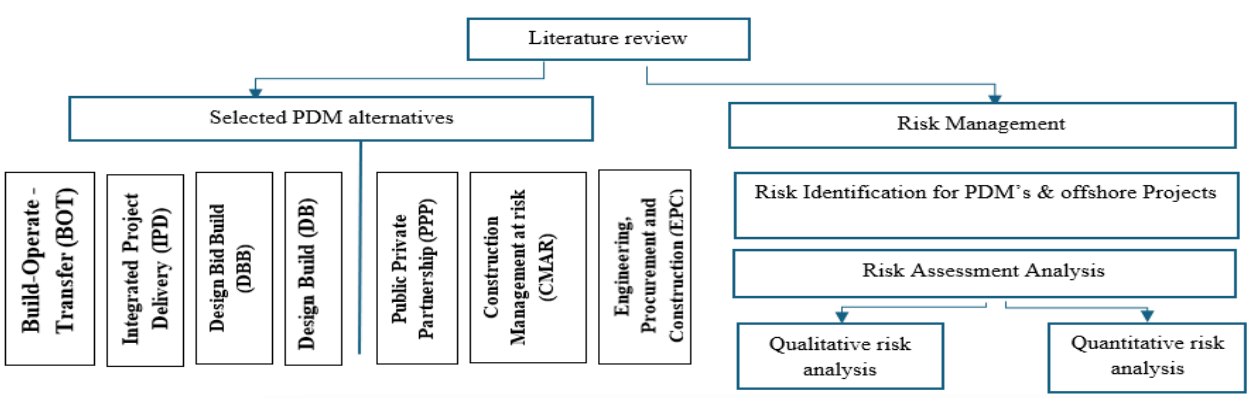


Figure 1: Research Methodology

Table 1. Risk Identification for Engineering, Procurement & Construction Delivery Method (EPC)

Risk Title
Category I. Economical & Financial Risks
I.1. Operational risks
I.1. 1 Cost over-run (bad initial cost estimation)
I.2 Liquidity risks
I.2.1 Project Financing Availability
I.3 Economic risks
I.3.1 Currency fluctuation (foreign exchange rate)
Category II. External &site condition risks
II.1 Government &Law
II.1.1 Delay of government permits
II.1.2 Changes in general legislation affecting the project
II.2 Other main risks
II.2.1 Weather effect on the project
II. 3 Geological risks
II.3.1 Geological structure and complexity of the region
II.3.2 Water Depth at project area
Category III. Management Risks
III.1 Communication
III.1.1 Lack of communication between different parties(client , consultant , contractor)
III.1.2 Bad coordination between sub-contractors
III.2 Tendering & Contractual
III.2.1 Improper verification of contract documents
III.2.2 Work conditions deferring from contract
III.2.3 Ambiguous conditions of contract
III.2.4 Lack of integrity in the tendering process
III.2.5 Unclear and imprecise delegation of responsibilities and roles and project charter
III.3 Organization
III.3.1 Inadequate project organization Structure
III.4 Planning
III.4.1 Weakness in planning and scheduling and initial project resources
III.4.2 Bad staff for site management
III.4.3 Project duration (schedule is too short for the required activities
III.4.4 Bad selection of sub-contractors
III.5 Supply Chain Risks
III.5.1 Increase in Material Price
III.5.2 Bad or insufficient organization for material management
III.5.3 Vendor-labor problems
III.5.4 Increase in labor price
III.6 Construction Risks
III.6.1 Construction mistakes
Category IV. Technical Risks
IV.1 Design
IV.1.1 Design changes during construction
IV.1.2 Late changes to well design and procedures
IV.1.3 Changes in Project Specifications
IV.2 Operational Risks
IV.2.1 Lack of experience
IV.3 Quality Risks
IV.3 .1 High-quality control standard
IV.3 .2 Bad quality control

4. RESULTS AND DISCUSSION

By reviewing the literature, it is noted that Design-Bid-Build (DBB) has the highest number of risk factors identified in the offshore project life cycle because of its segmented approach, which often results in communication gaps and coordination challenges. PPP projects involve collaboration between the public and private sectors and are exposed to complicated regulatory and long-term operational risks. On the other hand, DB projects, despite their integrated approach, may have difficulties in ensuring consistency between the design and construction stages. The Build-Operate-Transfer (BOT) and Engineering, Procurement, and Construction (EPC) procedures involve a significant number of risks, mainly because of their extensive project scopes and significant financial commitments. The Construction Manager at Risk (CMAR) approach entails reduced risks due to the early engagement of the construction manager, facilitating improved planning and risk management. IPD, or Integrated Project Delivery, is a method that minimizes risks by fostering collaboration and integration. This strategy improves communication, aligns stakeholder goals, and ensures thorough risk management throughout the whole offshore project life cycle. Figure 2 and Figure 3 summarize the percentage of risk categories and the number of identified risks in each method, respectively.

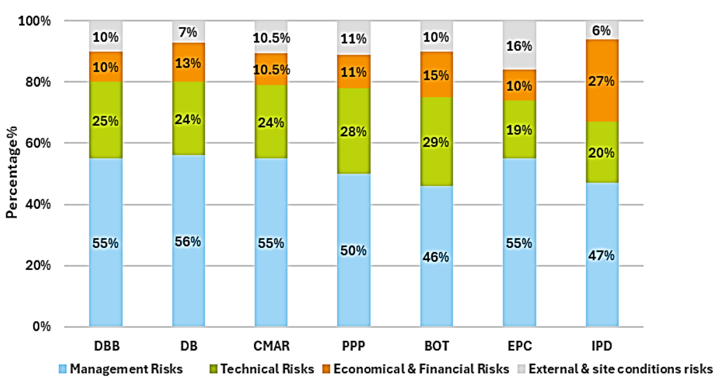


Figure 2: Risk Categorization for Various PDM

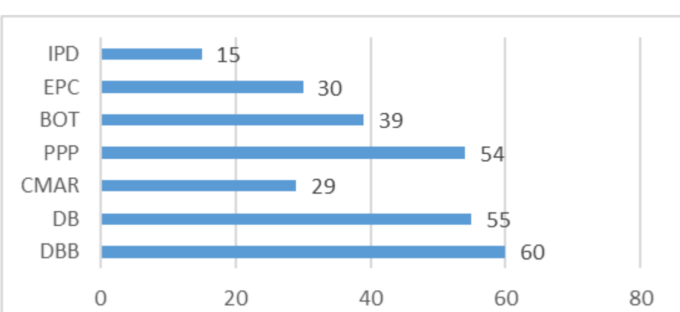
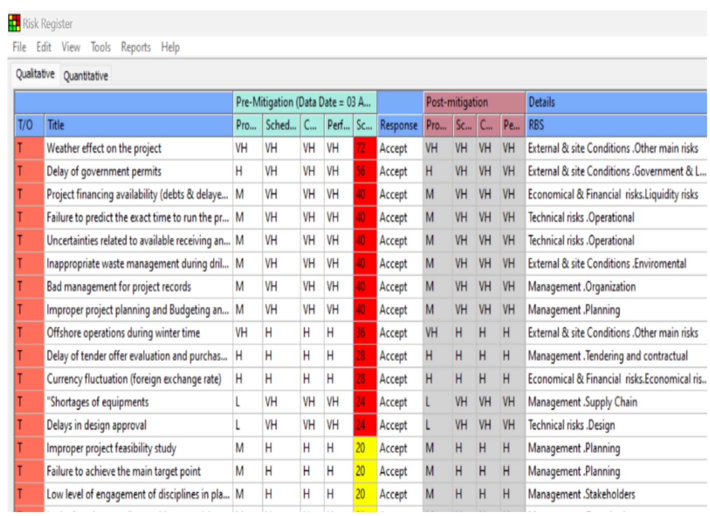


Figure 3: Numbers of risks identified for PDMs

Primavera Risk Analysis was used in risk scoring analysis by assigning probability and impact of each risk for offshore project delivery , in order to provide a clear and concise overview of the most critical risks that could potentially impact the project's success.

Top risks include weather effects on the project that can affect project timelines, Governmental permits that take time for issuance, funding, or cash flow problems leading to project disturbances. Additional high-priority risks include operational and management that may require costly rework and delays. Each of these risks has been accurately highlighted within the risk register, underscoring their significance and urgency. This prioritization enables the project team to focus their risk management efforts on mitigating these top threats, ensuring a more robust and resilient project execution plan.

Figure 4 displays a screenshot of a risk register gathered from Primavera Risk Analysis. The risk register records various risks, each assigned a risk score based on the likelihood and impact as assessed by experts. The highest scoring risks, as identified by expert opinions, are showed in the top.



Risk Register

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Qualitative Quantitative

		Pre-Mitigation (Data Date = 03 A...						Post-mitigation				Details
T/O	Title	Pro...	Sched...	C...	Perf...	Sc...	Response	Pro...	Sc...	C...	Pe...	RBS
T	Weather effect on the project	VH	VH	VH	VH	72	Accept	VH	VH	VH	VH	External & site Conditions .Other main risks
T	Delay of government permits	H	VH	VH	VH	56	Accept	H	VH	VH	VH	External & site Conditions .Government & L...
T	Project financing availability (debts & delaye...	M	VH	VH	VH	40	Accept	M	VH	VH	VH	Economical & Financial risks.Liquidity risks
T	Failure to predict the exact time to run the pr...	M	VH	VH	VH	40	Accept	M	VH	VH	VH	Technical risks .Operational
T	Uncertainties related to available receiving an...	M	VH	VH	VH	40	Accept	M	VH	VH	VH	Technical risks .Operational
T	Inappropriate waste management during dril...	M	VH	VH	VH	40	Accept	M	VH	VH	VH	External & site Conditions .Enviromental
T	Bad management for project records	M	VH	VH	VH	40	Accept	M	VH	VH	VH	Management .Organization
T	Improper project planning and Budgeting an...	M	VH	VH	VH	40	Accept	M	VH	VH	VH	Management .Planning
T	Offshore operations during winter time	VH	H	H	H	36	Accept	VH	H	H	H	External & site Conditions .Other main risks
T	Delay of tender offer evaluation and purchas...	H	H	H	H	28	Accept	H	H	H	H	Management .Tendering and contractual
T	Currency fluctuation (foreign exchange rate)	H	H	H	H	28	Accept	H	H	H	H	Economical & Financial risks.Economical ris...
T	"Shortages of equipments	L	VH	VH	VH	24	Accept	L	VH	VH	VH	Management .Supply Chain
T	Delays in design approval	L	VH	VH	VH	24	Accept	L	VH	VH	VH	Technical risks .Design
T	Improper project feasibility study	M	H	H	H	20	Accept	M	H	H	H	Management .Planning
T	Failure to achieve the main target point	M	H	H	H	20	Accept	M	H	H	H	Management .Planning
T	Low level of engagement of disciplines in pla...	M	H	H	H	20	Accept	M	H	H	H	Management .Stakeholders

Figure 4: Screenshot of a risk register gathered from Primavera Risk Analysis

5. VALIDATION

To achieve a deeper understanding of the results, risks identified for various PDMs are correlated with an actual project in the real world. This validation process involved mapping the theoretical risks to actual project scenarios to assess their impact on project duration and cost. By integrating real-world data from **Egypt General Petroleum Corporation**, we could observe how these risks influence the project's timeline and budget in a practical setting.

Case study Description

The scope of the project is to expand the field concession resources by bringing an additional gas field into production. This development project focuses on the exploitation of reserves that were found during a recent exploration effort in the waters of Egypt with a budgeted cost of **353,900,000 USD.**

<u>Project Constraints</u>

- Implementation of a task force using EPC as a project delivery method
- Implementation of an aggressive procurement plan
- Adopting sourcing some Long Lead packages from Local specialized Companies to secure the shortest possible purchasing & delivery
- Detail Engineering, Construction, and T&I will be prepared during the FEED. Essential activity for fast- track projects.
- FEED Robustness: The purchasing process for main items was started based on supply specifications issued from FEED. Some of these specifications were re- issued with major changes, which led to delayed PO issuance and Variation Orders.

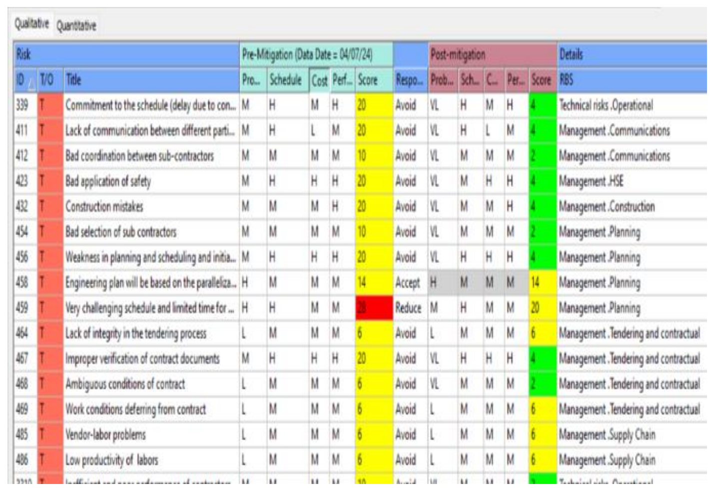
Work Packages included the following:

- **Offers preparations**
- **Offers evaluations**
- **Surveys**
- **Platform**
  - Structural Materials Procurement
  - Top Side Facilities LLI Procurement
  - Jacket Construction
  - Deck Fabrication & TSF Installation, Loadout
  - Jacket Transportation & Offshore Installation
  - Deck Installation & TSf Hook-up/commissioning
- **Sealine & SSIV**
  - Sealines Procurement
  - SSIV Procurement
  - Offshore Installation
- **Onshore Pipeline**
  - Line Pipes procurement
  - Onshore Pipeline Installation

- Drilling Campaign

While setting the project's time schedule and assigning the relationships between activities for this development project, it was considered that it was a fast-track project. This approach needed to optimize the timeline by overlapping phases and accelerating work wherever feasible. Work durations and costs, gathered from the given project data, were analyzed to ensure an efficient schedule. By planning and sequencing tasks, the project aims to meet tight deadlines without impacting quality standards or causing excessive costs.

Since the project is being executed utilizing an Engineering, Procurement, and Construction (EPC) approach, the risks associated with this project delivery, as represented in Table 1, were methodically allocated to the project schedule using Primavera Risk Analysis. Every risk that was identified directly linked to the EPC delivery method was assigned to the related tasks that would be affected by that risk. This integration guarantees that the schedule precisely represents the possible delays and difficulties caused by different risks during the project phases. Figure 5 displays a screenshot of a risk register gathered from Primavera Risk Analysis for case study analysis.



Qualitative | Quantitative

Risk			Pre-Mitigation (Data Date = 04/07/24)						Post-mitigation					Details
ID	T/O	Title	Pro...	Schedule	Cost	Perf...	Score	Respo...	Prob...	Sch...	C...	Per...	Score	RBS
339	T	Commitment to the schedule (delay due to con...	M	H	M	H	20	Avoid	VL	H	M	H	4	Technical risks .Operational
411	T	Lack of communication between different parti...	M	H	L	M	20	Avoid	VL	H	L	M	4	Management .Communications
412	T	Bad coordination between sub-contractors	M	M	M	M	10	Avoid	VL	M	M	M	2	Management .Communications
423	T	Bad application of safety	M	H	H	H	20	Avoid	VL	M	H	H	4	Management .HSE
432	T	Construction mistakes	M	M	M	H	20	Avoid	VL	M	M	H	4	Management .Construction
454	T	Bad selection of sub contractors	M	M	M	M	10	Avoid	VL	M	M	M	2	Management .Planning
456	T	Weakness in planning and scheduling and initia...	M	H	H	H	20	Avoid	VL	H	H	H	4	Management .Planning
458	T	Engineering plan will be based on the paralleliza...	H	M	M	M	14	Accept	H	M	M	M	14	Management .Planning
459	T	Very challenging schedule and limited time for ...	H	H	M	M	28	Reduce	M	H	M	M	20	Management .Planning
464	T	Lack of integrity in the tendering process	L	M	M	M	6	Avoid	L	M	M	M	6	Management .Tendering and contractual
467	T	Improper verification of contract documents	M	H	H	H	20	Avoid	VL	H	H	H	4	Management .Tendering and contractual
468	T	Ambiguous conditions of contract	L	M	M	M	6	Avoid	VL	M	M	M	2	Management .Tendering and contractual
469	T	Work conditions deferring from contract	L	M	M	M	6	Avoid	L	M	M	M	6	Management .Tendering and contractual
485	T	Vendor-labor problems	L	M	M	M	6	Avoid	L	M	M	M	6	Management .Supply Chain
486	T	Low productivity of labors	L	M	M	M	6	Avoid	L	M	M	M	6	Management .Supply Chain

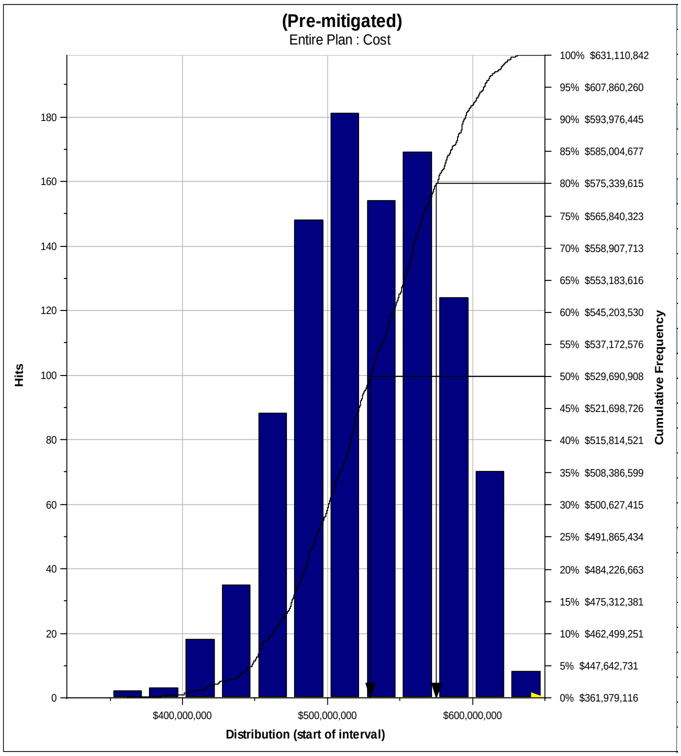
Figure 5: Screenshot for risk register gathered for Case study

<u>Pre-mitigation</u>

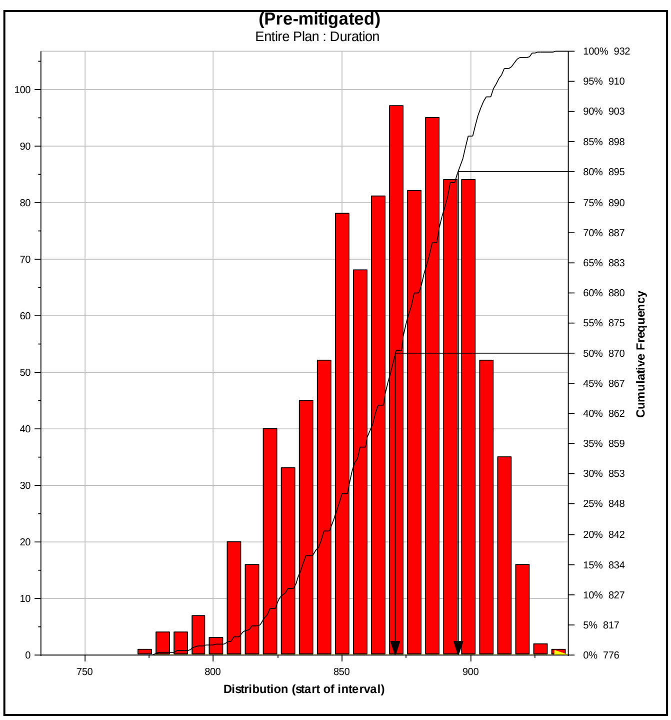
In the pre-mitigation analysis phase, experts' opinions regarding the probability and impact of each risk are considered, resulting in a comprehensive quantitative assessment of potential cost and duration impacts using Monte Carlo simulation. This advanced statistical method allows for the calculation of probabilistic project duration and total project cost by running numerous simulations that account for the variability and uncertainty of each identified risk. Figures 6-a and 6-b show the distribution extracted from the Monte Carlo Simulation for cost and time (Pre-mitigation).

<u>Post -Mitigation</u>

By implementing post-mitigation analysis, risk response strategies were identified based on findings from the literature on how to manage these risks and the specific constraints of the project that limit mitigation plans. This phase involves developing and applying strategies to reduce or eliminate the impact of identified risks to analyze the impacts on project cost and duration. Figures 7-a and 7-b show the distribution extracted from the Monte Carlo Simulation for cost and time (Post-mitigation).

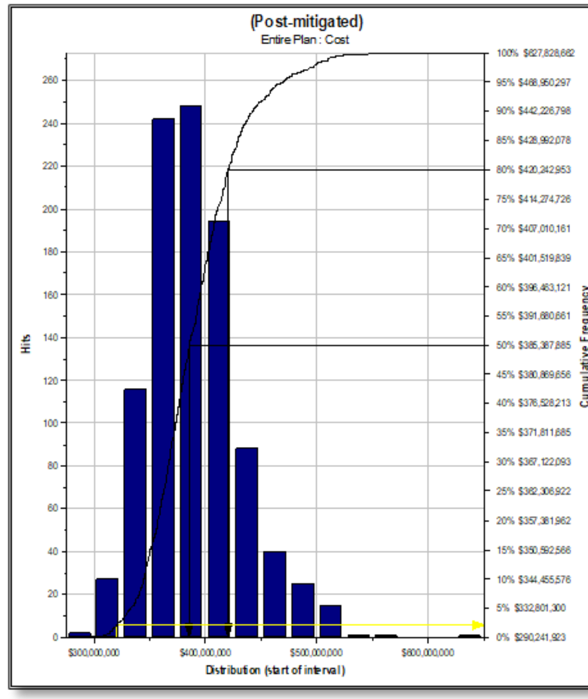


(6-a)

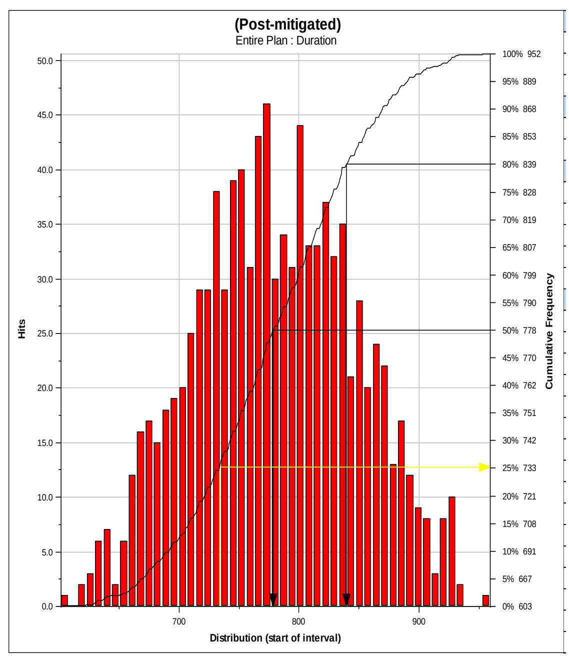


(6-b)

Figure 6: Distribution extracted from Monte Carlo Simulation (Pre --mitigation), a) Cost, b) Duration



(7-a)



(7-b)

Figure 7: Distribution extracted from Monte Carlo Simulation (Post -mitigation), a) Cost, b) Duration

Table 2 shows a comparison between Pre-mitigation and Post mitigation (Cost and Duration) plans with **50% Deterministic probability**.

Table 2. Comparison between Pre-mitigation and Post mitigation (Cost and Duration)

	Cost (USD)	Duration (Months)
Pre -mitigation	**$529, 890, 608**	**29**
Post Mitigation	**$385,387,885**	**25**

By applying sensitivity analysis for duration and cost risks and examining the post-mitigation tornado diagram, it was found that technical risks have the greatest impact on cost sensitivity. These risks, encompassing design and operational issues, can significantly raise the total project cost.

After the construction phase in offshore field development, the drilling and completion phase begins for the contractor. This phase is critical in bringing an offshore field into production, transforming it from a construction project into an asset producing hydrocarbons. This phase includes critical risks that can impact overall project time and cost. Addressing these risks is crucial for effective cost management in the project.

6. CONCLUSION

By investigating the identified risks associated with project delivery methods for offshore projects, It was found that a significant portion of risks associated with offshore projects across different project delivery methods are mostly attached to management risks. These management risks represent about 52% of all the risks that have been found during the whole project life cycle. Technical risks represent about 24% of all identified risks.

For most PDMs, financial risks are about the same percentage as those identified for those PDMs, except for IPD. This is because IPD, new technologies, and lack of experience can all lead to financial and economic risks and cost overruns. Government rules, the weather, and geological formations mostly control conditions outside the site that affect the completion of offshore projects. Regulations and laws from the government greatly affect project timelines and costs because they require getting licenses, following environmental rules, and meeting safety standards.

Bad weather conditions, such as storms and turbulent waves, pose significant risks to construction and operations works, leading to delays and increased costs.

HSE risks associated with offshore projects vary depending on the project delivery approach; however, they are critical in all approaches due to the risky nature of these projects. Improper waste management and its impact on the environments have a significant effect on offshore projects. Inadequate waste management systems can contaminate aquatic ecosystems.

By assigning identified risks to the case study to test their validity and impact on project duration and cost and by comparing pre- and post-mitigation plans, the identified risks—operational and management, financial, and external site conditions—significantly affect project duration and cost.

Implementing risk mitigation strategies, considering the probability and impact of each risk by the project delivery method (EPC), reduced the estimated budget by 27% and the estimated duration by 14%.

The contribution of this research to the field of offshore project management consists in conducting a comprehensive identification and assessment of risks associated with different (PDMs) across the offshore project lifecycle. The identified risks are categorized into management, technical, financial, and external/site conditions. The integration between expert interviews and Primavera Risk Analysis software confirms that the risk assessment is crucial in practical realities. The study extends its contribution by applying the identified risks to a real-world case study of a gas field expansion project in Egypt, using EPC approach. This practical implementation validates the study findings and demonstrates the real effects of risk management implementation on project duration and cost.

7. RECOMMENDATIONS AND LIMITATIONS

Based on the findings, it is recommended to examine the impact of various project delivery approaches on real-world data to compare their impact on project objectives by considering the probability and impact of risks associated with each approach.

This study's conclusions are established based on actual data from the Egyptian project; this could limit the generalization of the results to other regions. The economical and governmental conditions of Egypt may affect the projects outcomes and may not be representative of offshore projects in different countries. Future research should consider various case studies from various regions to enhance the applicability of conclusions.

Future research should focus on exploring the integration of Artificial intelligence (AI) and Machine Learning (ML) in enhancing predictive analytics for risk assessment, project scheduling, and cost estimation in offshore projects in order to achieve efficient project execution, reduced risks, and improved overall project outcomes in the offshore industry .

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