ANALYZING VULNERABILITIES IN THE OIL AND GAS SUPPLY CHAIN OF OMAN VIA FMEA

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1. **ABSTRACT:** The complex nature of operations in the oil and gas sector makes it highly exposed to risks that might impact its overall performance. Maintaining the industry's competitive edge and ensuring the efficiency of supply chain operations requires proper risk identification and management. This paper focuses on the study of the risks associated with the oil and gas supply chain in Oman. This study uses the Failure Mode and Effects Analysis (FMEA) approach to evaluate the risks associated with several stages of the supply chain in Oman's oil and gas sector, such as exploration, drilling, production, transportation, storage, refinement, and distribution. As a structured methodology for mitigating risks and improving supply chain reliability, FMEA systematically identifies and prioritizes potential failure modes. To do this, interviews were conducted with four experts from two distinct Omani-based oil and gas companies, utilizing their knowledge and experience with supply chain operations and associated risks. According to the results obtained, drilling and transportation emerge as the riskiest activity in the Omani oil and gas supply chain, while exploration is rated the least risky. This study advances the knowledge of supply chain risk management in the oil and gas sector by demonstrating the effectiveness of the FMEA technique for detecting and mitigating supply chain hazards. The study's findings are important for supply chain managers and industry experts in Oman's oil and gas industry, as they can help improve risk mitigation approaches and overall supply chain efficiency.

2. INTRODUCTION

Oman's oil and gas industry has significantly transformed the economy, accounting for 40% of GDP and 75% of government revenue [1]. The industry's complexity increases its supply chain operations, making it susceptible to risks. Effective cooperation between organizations is crucial for a seamless operation. Risk assessments help identify and prioritize potential risks, enabling proactive strategies. However, improvement in supply chain risk management is still needed. Oil and gas operations require efficient risk management, but Oman's risk analysis approaches have been understudied. Previous studies focused on pipelines or construction projects, necessitating a comprehensive failure mode and impact study. This research aims to assess risks in the oil and gas sector's supply chain, including upstream drilling, midstream transportation, storage, and downstream activities. It focuses on upstream procedures, midstream transportation, storage, and refining procedures. Risks include leaks, spills, and managing storage-related hazards, while downstream activities mitigate refining risks. As oil and gas are crucial for Oman's economy and little attention has been given to the risks focusing this industry in Oman, this study focuses on the Omani oil and gas sector. The goal is to identify supply chain hazards and develop measures to minimize these risks, ultimately improving operational resilience using a Failure Mode and Effects Analysis (FMEA) approach. Moreover, the engaged involvement of the researcher and industry managers highlights the diligence and practical importance of the study.

3. LITERATURE

The COVID-19 pandemic significantly impacted the oil and gas industry, affecting global operations and transportation supplies. The industry is divided into three segments: upstream, midstream, and downstream, with the upstream sector involving drilling, extraction, and reservoir searches. According to Pillai et al. [2], this sector plays a significant role in initiating the industry's value chain.

The midstream industry is vital in integrating upstream and downstream activities. Lima et al. [3] investigated this industry's activities. These activities include the processing, storage, and transportation of several commodities, including crude oil, natural gas, and liquids. Finally, the downstream sector includes marketing, crude oil refining, and distribution of refined goods. According to Pillai et al. [2], the downstream industry is essential to the value chain by providing clients with completed goods.

Chima [4] emphasizes the importance of exploration in the upstream oil and gas supply chain showing that the precise locations of oil and gas sources ensures cost-effective utilization. Craig and Quagliaroli [5] highlight the role of drilling. They emphasize that oil firms commonly choose joint venture agreements to manage their drilling and production operations. Devold [6] highlights that offshore support and designated operators play crucial roles.

Kalita [7] highlights that pipelines and marine tankers are cost-effective and safe methods for oil transportation, particularly long distances. They transform crude oil into market fuels and specialty goods in refineries, marketed through B2B and B2C channels. Oil products are transported through primary and secondary distribution channels.

The importance of integrating data transfers and supply chain activities to attain an advantage within the oil and gas industry is emphasized by Bastas and Liyanage [8]. Critical components such as sourcing, procurement, inventory management, production planning, and performance measurement are given significant emphasis. A similar approach is presented by Giannakis and Papadopoulos [9] who emphasizes the relevance of efficient supply chain management in achieving a competitive advantage. Ahmad et al. [10] added to the evidence of the relevance of supply chain management in the oil and gas sector, highlighting its vital role in meeting market demand while maintaining profitability and promoting growth in the sector.

There are numerous hazards present in oil and gas supply chain activities. Ennouri [11] highlights the need for identifying and controlling risks within companies and offered a strategy that incorporates supply chain risk management. The study shows that risk assessment is important by integrating risk management strategies into each aspect of the supply chain. Also, some processes were discussed to identify some of the procedures responsible for risk control in oil and gas supply chains.

There have been many FMEA risk analyses studies in literature to identify potential hazards in supply chain operations. Scannell et al. [12] highlighted some potential hazards such as late deliveries, poor quality, and production delays. The results of this study demonstrate the need of FMEA in controlling risks, and also provide information on how supply chain performance and resilience may be increased. Using an extensive FMEA risk analysis, Petrovskiy et al. [13] used advanced hazard assessment methods based on fuzzy logic to develop risk mitigation methods. The study identified some possible hazards resulting from breakdowns in machinery, employee mistakes and unanticipated circumstances that may impact gas and oil installations. Ho et al. [14] further identified additional risk variables that negatively impact the operations, such as supplier risks, market uncertainty, transportation delays, catastrophic weather events, unstable political systems, and unpredictable economic conditions. The study attempted to correlate the risk indicators and how this could affect supply networks' rate of recovery. Yusof and Abdullah [15] conducted FMEA research on butterfly valves, a common component in the oil and gas sector. The study identified the main factors that had led to failure and used FMEA to decrease the valve failures. Keyghobadi et al. [16] employed FMEA to investigate the risks associated with the adoption of sustainable supply chain in oil and gas sector discovering numerous hazards. The study shows the interconnection of environmental and economic elements influencing the robustness of supply chains.

Afzali Behbahani et al. [17] used FMEA to study the environmental risks in drilling oil wells, introducing a variety of environmental problems such as pollution of groundwater, loss of soil, and pollution of air. Hekmatpanah et al. [18] conducted an FMEA study on the process of producing four-liters oil cans at Sepahan Oil Company in Iran focusing on issues pertaining to equipment failures, quality concerns, and health and safety risks. Bahrami et al. [19] expanded the usage of FMEA by proposing a methodology for managing projects and performance. Bahrami identified several failure modes such as schedule delays, money overruns, and design creep, emphasizing that the best way to improve project costs and procedures is to use FMEA at every stage of the project.

Nuchpho et al. [20] surveyed papers from 2002 to 2012 emphasizing different factors that contribute to failure such as a lack of resources and insufficient training. The study shows the extensive usage of the risk priority number (RPN) approach for evaluating risks in companies. Zuniawan [21] carried out an extensive survey of literature, focusing on the application of FMEA in various sectors.

Sutrisno et al. [22] provided a comprehensive framework that combines FMEA with SWOT analysis, easing the assessment of competing risk-based improvement initiatives. AlNoaimi and Mazzuchi [23] underlines the need for risk management structures in oil and gas projects. Security measures, training programs, and risk management strategies were given top attention by the oil and gas firms in Bahrain. Hatefi and Balilehvand [24] improved the FMEA to enhance risk analysis in oil and gas, focusing on hazard identification, comprehensive risk analysis, and wellbore risk calculation.

FMEA has been demonstrated to play a critical role in the oil and gas industry by numerous academic studies. Petrovskiy et al. [13] underlined how crucial FMEA is to evaluate the hazards related to oil and gas processing facilities. The study improved the accuracy and efficacy by employing advanced risk assessments grounded in fuzzy logic. Keyghobadi [16] utilized FMEA to assess the risks associated with using eco-friendly supply chains in oil and gas. Samimi [25] used FMEA to improve risk management methods in the oil and gas refineries sector to enhance operational resilience and safety procedures. AlNoaimi [23] investigated the usage of FMEA to manage inherent risks in oil and gas projects. Hekmatpanah [18] used FMEA to identify and assess potential causes of failure and their effects in oil and gas. Problems including leaks and inadequate filing were identified, and measures to reduce the risks were introduced. Afzali Behbahani [17] assessed the environmental hazards of oil well drilling combining TOPSIS and FMEA revealing issues such as air and water pollution and oil leakage.

Although it is generally acknowledged that FMEA plays a significant role in mitigating risks associated with supply chain operations, there is a gap in the existing literature concerning the actual application of this approach in Oman's oil and gas sector.

4. METHODOLOGY

The study utilizes FMEA to provide a thorough analysis of risks in supply chain operations and to propose efficient strategies for managing these risks. This research focuses on the active involvement of significant participants in the supply chain field (supply chain managers, health and safety managers and operations manager) to provide feedback regarding supply chain operations, leveraging their broad practical knowledge. The theoretical framework of the study is shown in Figure 1.

The oil and gas sector uses both quantity and quality-based techniques to study supply chain risks. However, qualitative methodologies like semi-structured interviews are preferred for identifying risks. These interviews allow flexibility in questions and maintain consistency in data collection. The study uses semi-structured interviews to identify factors and activities affecting risk in Oman's oil and gas sector, including key stakeholders like supply chain managers and operations managers.

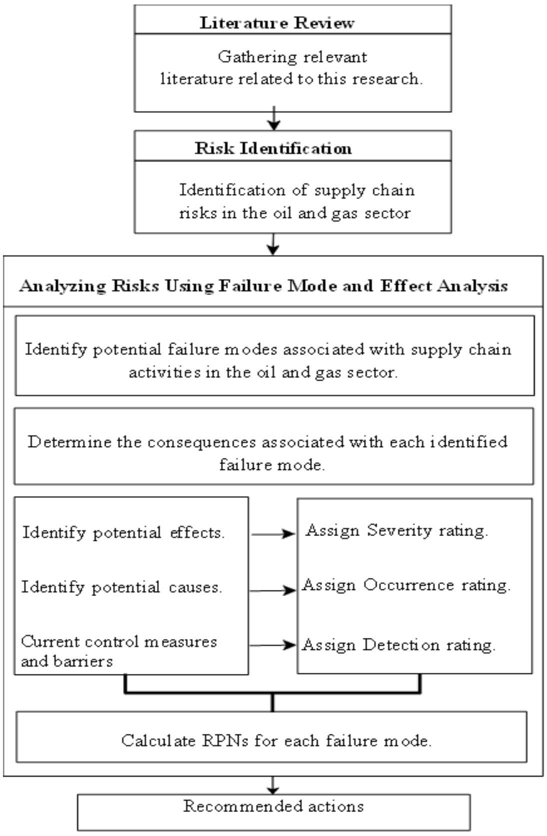

Figure 1. Theoretical framework of the study

Before the interviews, an extensive literature review was performed to gain a deep understanding of risk management in the oil and gas supply chain including methods and best practices. An initial FMEA form was prepared for the sake of our research.

Besides the background and personal questions, participants were asked about the most significant risks faced in supply chain operations, the key supply chain processes associated with the most significant risks in the oil and gas industry and their opinion on the FMEA form developed. Participants are asked to suggest any additional factors to be included. Moreover, they are asked to provide their opinions on successful solutions for resolving these problems.

After the initial discussion, the participants continued to fill out the FMEA form. The participants were then provided with a list of potential failure modes for each activity in the supply chain operations, instructing them to rate each mode's severity on a scale of 1 to 5, signifying the seriousness of its impact. Afterwards, the participants assessed the likelihood of each mode occurring by assigning a rating on a scale from 1 to 5, indicating the probability of an event occurring. Following that, the participants assessed the effectiveness of the existing controls or barriers by assigning a rating of 1 to 5 for detection. Using the responses, the risk priority number (RPN) was calculated, which is the multiplication of severity (S), occurrence (O), and detection (D). A failure mode with a high RPN number should be given the highest priority in the analysis and corrective action.

Additionally, participants were asked to provide suggestions for improving risk control and mitigation techniques. The subsequent part on risk management and control provides effective strategies for mitigating supply chain risks, including an analysis of the current risk management procedures in their firms.

The purpose of these interviews is to gain in-depth knowledge and understanding of managers' experiences and perspectives on risk management in the oil and gas sector. The extensive data gathered will be used to develop robust risk management techniques that will enhance Oman's supply chain operations, enabling them to effectively manage disruptions and mitigate the consequences of potential failures.

Table 1: Interview Questions (developed by the authors)

Interview Questions	
1.	Introduction
-	Can you please introduce yourself and describe your role and responsibilities within the company?
-	From your experience, what are the most significant risks that your company faces in its supply chain operations within the industry?
-	Could you kindly review the FMEA Form I have prepared based on my research regarding the most significant factors influencing the supply chain operation in the oil and gas industry? Moreover, I would greatly appreciate your input on identifying any other factors you believe should be included.
2.	FMEA Assessment
-	List the potential effects of each failure mode identified in your company's supply chain operations?
-	On a scale from 1 to 5, how severe are the potential effects of each failure mode?
-	Could you List the root causes of each identified failure mode?
-	On a scale from 1 to 5, how likely is each failure mode to occur?
-	Could you list the current actions or controls your company has in place to mitigate the risks associated with each failure mode?
-	On a scale from 1 to 5, how effective are the current detection methods in identifying each failure mode?
-	List the recommendations or actions you would propose for better risk control and mitigation for safe operation moving onward?
3.	Risk Management and control
-	From your experience, can you list the most important and effective strategies that can be implemented to mitigate supply chain risks in the oil and gas industry?
-	What risk management method is the company currently employing?
-	How does the company prioritize risk mitigation efforts to address the most critical risks first?
-	Can you provide examples of successful risk mitigation strategies implemented by your company or others in the industry?
4.	Conclusion
-	Can you outline recent incidents and challenges the company has faced in relation to supply chain operations, and describe how you have managed them?
-	From your experience, what are the key challenges that companies face when implementing risk management practices in the oil and gas industry?
-	How effective do you believe the FMEA approach has been in mitigating risks within your organization's processes?

Table 1 outlines the division of the interview questions into four sections. The first part of the interview consists of background questions. Next, questions are introduced to gather information about the interviewee and to evaluate the FMEA form, developed from studying literature to find the key factors influencing supply chain operations in the oil and gas industry. The second section provides guidance on answering questions designed to assist in completing the FMEA form and a table that detailed the severity, occurrence, and detection scales. The purpose of this table is to facilitate the evaluation of the identified hazards. The third section is concerned with the company's risk management procedures and control mechanisms. The interview concluded with questions about the company's recent supply chain challenges and their resolution. Also, the interviewees are asked about the effectiveness of the FMEA technique in risk mitigation within their organization's procedures.

For the FMEA Form in Table 2, we divide it into 15 columns. The first 2 columns cover the name of the operation and specialized activity within it. The next 8 columns are for pre-risk mitigation. Following the implementation of pre-risk mitigation measures, the next 5 columns are for post-risk mitigation to analyse possible failures and their respective effects. The FMEA form serves as a tool to evaluate potential system failures and the subsequent impacts that may occur within the system. This worksheet has been designed to conduct an in-depth assessment of potential failure modes in every process.

The components in the FMEA are defined as follows. Operation determines the precise stage of oil and gas supply chain operation. Activity provides specific activity that is directly associated with each operation. Potential Failure Mode identifies various ways in which the process step might failure. Potential Failure Effect refers to the impact of a system failure on both the system itself and the end user. Severity (S) determines the level of seriousness associated with the potential failure impact. Possible Failure Cause lists the root causes or conditions that contribute to the indicated failure mode. Occurrence (O) assesses the probability of the prospective failure scenario happening. Current control procedures and barriers explains current preventive measures to avoid or identify failure. Detection (D) assesses the level of ease in which a failure can be identified by current controls or measures in place. Risk Priority Number (RPN) is determined by multiplying the scales of severity, occurrence, and detection. This calculation is used to prioritize failure modes which represent a high risk.

Post- risk mitigation includes the following. Recommended Actions provides a list of methods to reduce the likelihood of the indicated failure mode happening. New Severity (S), New Occurrence (O), New Detection (D), and New Risk Priority Number (RPN) are the new values after mitigating measures.

Table 2: FMEA Form

Operation	Activity	Potential Failure Mode	Potential Failure Effect	Severity (S)	Potential cause of failure	Occurrence (O)	Current Control Measures and Barriers	Detection (D)	RPN	Recommended Actions	New Severity	New Occurrence	New Detection	NEW RPN
		Pre-Risk Mitigation of Failure Mode and Effect Analysis (FMEA)								Post-Risk Mitigation of Failure Mode and Effect Analysis (FMEA)				

Severity (S) evaluates the seriousness of the effects that might arise if the possible risk occurs. Severity is represented by a scale of 1 to 5. Severity ranking criteria are discussed in Table 3.

The likelihood of occurrence (O) is a quantitative assessment of the probability that a system or process is going to encounter failure. When conducting a thorough assessment, it is crucial to consider historical data, the reliability of the equipment, maintenance procedures, and the current environmental circumstances. In the absence of existing protective measures, the initial assessment of occurrence would probably be higher. Occurrence is represented by a 1 to 5 scale, where a rating of 1 indicates a nearly impossible occurrence and a rating of 5 signifies a high probability of occurrence. The criteria used for assessing the occurrences are displayed in Table 4.

Detection (D) evaluated the probability of detecting possible failures before they cause disruption or injury on a scale ranging from 1 to 5 where 1 indicates a high possibility of detection, while 5 shows an instance in which the likelihood of identifying the failure before it causes harm is extremely questionable. Table 5 shows the detection rating criteria used.

The equation for risk priority number (RPN) is as follows:

$$RPN= S * O * D$$

Subsequently, recommended actions are suggested to effectively manage and reduce the hazards that have been identified. Subsequently, the identified risks are effectively mitigated and managed through the implementation of the suggested measures. After the implementation of these procedures has been completed, it is critical to reevaluate the severity, occurrence, and detection factors. The analysis aims to mitigate potential risks by evaluating changes in the severity, occurrence, and detectability of hazards resulting from the implementation of risk management strategies and suggested actions. By employing this process, the oil and gas industry can continuously enhance the safety, dependability, and efficiency of its risk management. The eight stages that are required for implementing the FMEA approach into action are shown in Figure 2.

Table 3: Classification of severity ranking

Severity rank	Failure effect	Description
5	Critical	Worst case scenario the problem has an extensive effect on operations and needs urgent attention.
4	High	These failures can be considered serious and have serious impacts.
3	Moderate	The problem has a notable impact on operation and requires attention.
2	Low	The problem has minimal effect on operation but can be managed.
1	No effect	Near miss failure has no noticeable impact in the operation.

Table 4: Classification of Occurrence Ranking

Occurrence rank	Probability of occurrence	Description
5	Very high: failure is almost unavoidable.	Occurs every three to four days.
4	High: failure occur often	Occurs every month.
3	Moderate: occasional failure	Occurs every six months to one year.
2	Low: relatively few failures	Occurs every 1-3 years.
1	Remote: failure is unlikely.	Once occurs is greater than five years.

Table 5: Classification of Detectability Ranking

Detection rank	Probability of Detection	Description
5	No detection	Controls are unable to detect a failure there are no defined controls that may detect a failure mode.
4	Low	The controls have a low probability to detect the existence of a failure mode.
3	Moderate	The controls have a moderate probability to detect the existence of a failure mode.
2	High	The controls have a strong chance to detect the existence of a failure mode.
1	Very high	The controls are extremely certain to detect a failure mode. High degree of detectability

5. Analysis and Observations

According to the interviewee, there are 7 main processes in Oman's gas and oil sectors divided into a total of 17 failure modes across all processes as shown in Figure 3.

Figure 1: Potential failure modes for each operation (Suggested by the authors)

The results indicate both pre- and post-risk mitigation in supply chain operations. The ranking was determined by taking the average scores for the different replies. The findings revealed that loss of well control, uncontrolled release of H_2S, rig collision during transport, and dropping objects due to crane failure during loading and unloading all obtained the highest rating of 5. These risks can cause fatalities, injuries, severe financial losses, equipment damage, and interruptions in drilling operations.

In contrast, insufficient geological evaluation obtains the lowest severity rating of 2. Furthermore, a failure's severity typically signifies the underlying risk of harm it could cause. Even though many factors could influence the likelihood of failure, the worst-case scenario remains generally consistent. As a result, the severity ranking remains unchanged. Figure 4 illustrates several severity rankings.

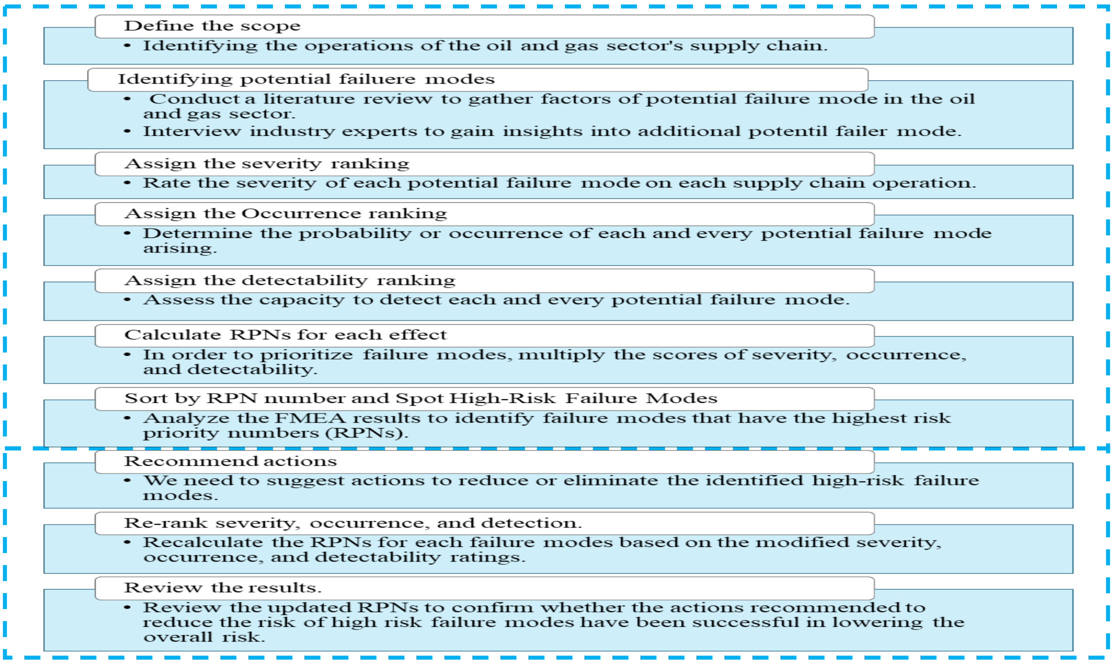

Figure 2: Steps of FMEA Approach

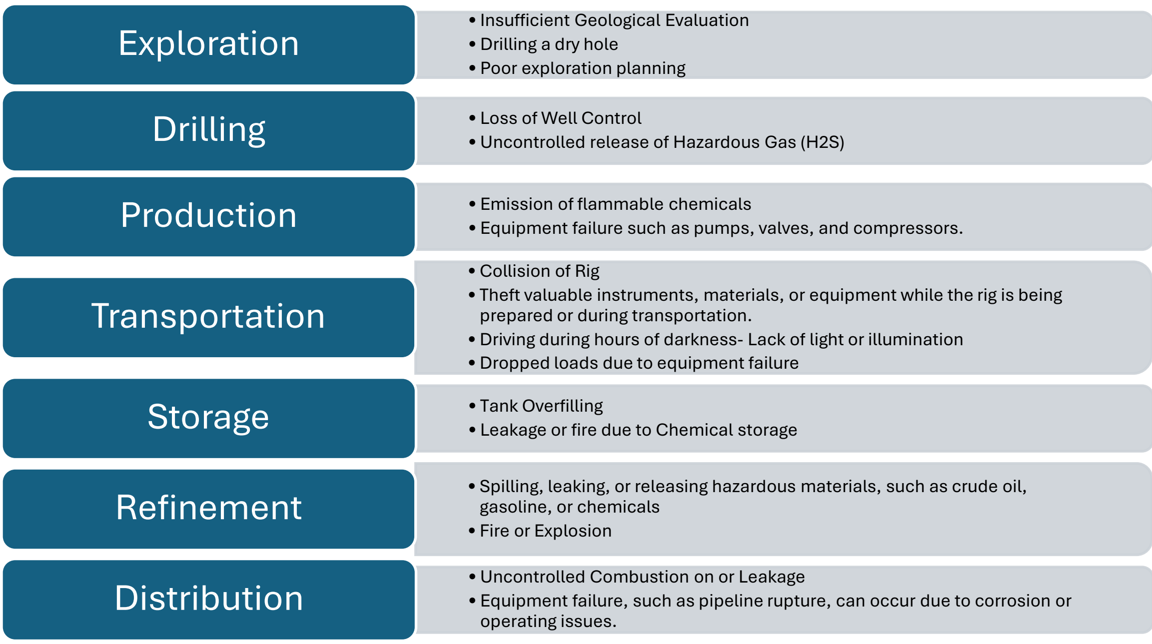

Figure 3: Potential failure modes for each operation

Regarding the occurrence rate, the results indicate that poor exploration planning in selecting a location has the lowest occurrence rate, which is 1 in both pre- and post-risk mitigation. On the other hand, insufficient geological evaluation, drilling a dry hole, theft of valuable equipment during transportation, the leakage or release of hazardous materials ae well as equipment failure, such as pipeline rupture initially have a high occurrence rate of 3. However, after implementing risk mitigation and corrective controls, these rates decreased to 2. Furthermore, a lack of expertise, inaccurate geoscientist interpretations, and reliance on outdated data lead to insufficient geological evaluation. In contrast, the triggers for drilling a dry hole are inaccurate geological data and unexpected geological formations. Moreover, inadequate safety measures and a lack of security contribute to the theft of valuable instruments, materials, or equipment during rig preparation or transportation. Finally, the causes of spilling, leaking, or releasing hazardous materials, such as crude oil, gasoline, or chemicals, are human error, a lack of sufficient control, and inadequate storage or handling. Figure 5 shows some ranking of occurrences.

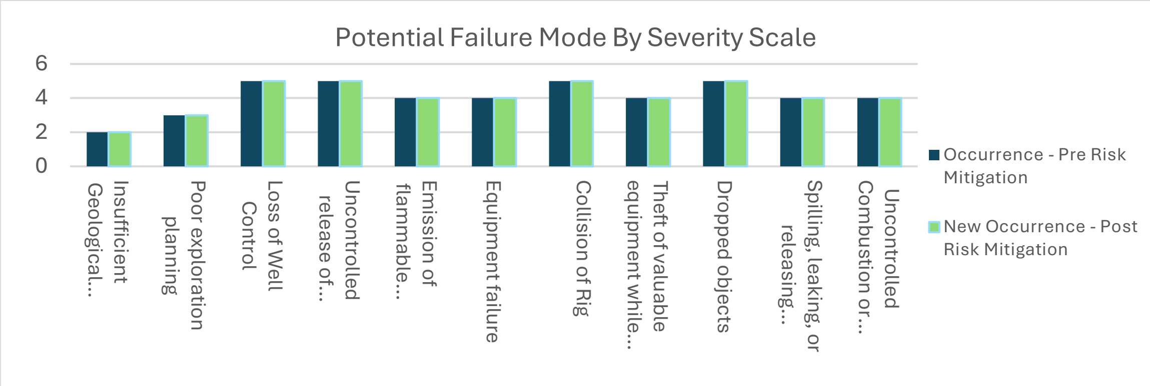

Figure 3: Severity Scale

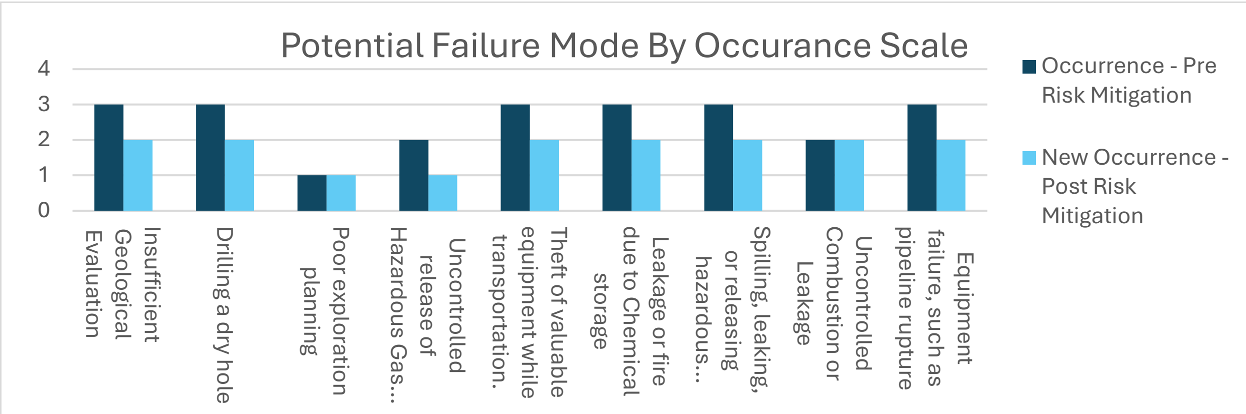

Figure 4: Occurrence Scale

The uncontrolled release of extremely hazardous gases, such as hydrogen sulfide (H2S), has the highest detection rate of 4, indicating that the controls have a low probability of detecting the presence of a failure mode. Due to the colorless nature of the gas, on-site employees can smell the gas at low concentrations in the air, which can result in injuries and fatalities. After corrective actions, such as operator training on H_2S hazards and emergency response procedures and the inspection and maintenance of H_2S detection equipment, the detection rate has improved to 3. Additionally, equipment failures, such as those involving pumps, valves, and compressors, as well as dropped loads due to equipment failure during crane loading and unloading, and tank overfilling, initially showed a high rate of detection, which is 3, indicating a low detection capability. To control these failures, firms need to set up regular inspection and maintenance programs, train workers, establish emergency response teams, and address the fundamental causes of previous incidents or near misses. These corrective efforts have reduced the detection ranking to a scale of 2.

On the other hand, some of the failure modes have a strong chance of detecting the existence of a failure mode. For instance, insufficient geological evaluation and fire or explosion initially have a detection rank of 2 before risk mitigation, which improved to 1 after implementing corrective actions. These corrective actions include analyzing previous dry hole incidents, offering training and development programs for geoscientists to improve their knowledge of regional geology and interpretive abilities, and having an on-scene commander to supervise the activities. Some of these detection rankings are illustrated in Figure 6.

After that, RPN is calculated for each failure mode by multiplying the severity score, the occurrence rate, and the detection rate. For each of the 17 potential risks that were identified, the mean of the RPN pre-risk mitigation was calculated to assess the data and prioritize the risks that were the most severe; the pre-risk mitigation RPN averaged 24.4. The mean value serves as a standard against which risk is categorized. As a result, risks with priority levels below 24.4 are considered usual, indicating that they are less significant and easier to manage in accordance with standard operating procedures. On the contrary, risks assigned priority numbers exceeding 24.4 are considered to be exceptional situations, indicating a concern that necessitates urgent or specific action to reduce potential problems.

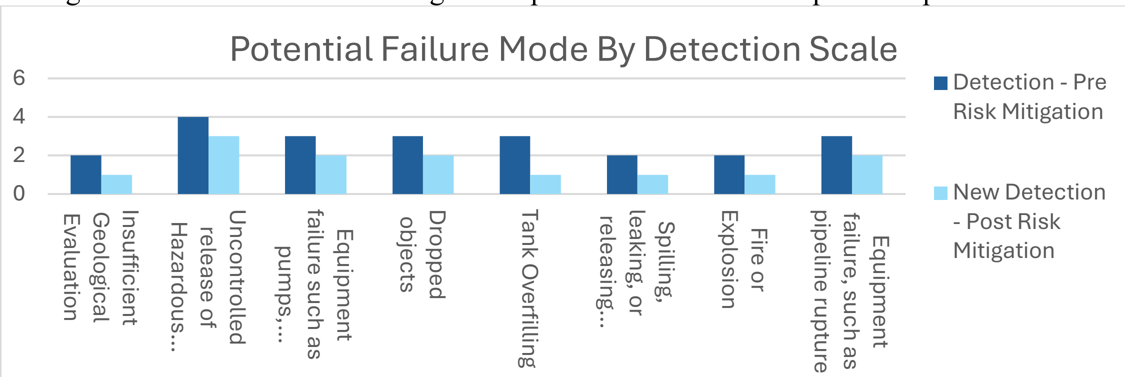

Figure 5: Detection Scale

As indicated in Table 7, drilling and transportation are the riskiest supply chain processes, particularly due to dropped loads caused by equipment failure during crane loading and unloading, which have the highest RPN of 45. Additionally, the uncontrolled release of hazardous gas (H2S) has an RPN of 40. Numerous failure modes in this process exceed the average RPN. For example, oil and fuel storage resulting in tank overfilling, equipment failure, such as pipeline rupture due to corrosion or operating concerns, and failure of pumps, valves, and compressors have an RPN of 36.

In contrast, inadequate exploration planning during the exploration phase results in the lowest RPN of 6. After corrective actions and procedures were applied in the post-risk mitigation phase, the RPNs for nearly all failure modes decreased. For example, the RPN for dropped loads caused by equipment failure fell from 45 to 20, suggesting that this failure mode is now less critical, occurs less frequently, and is more easily identifiable, making it easier to manage under standard operational procedures. Table 7 displays the RPNs for each failure mode before and after risk mitigation.

To reduce risks in the oil and gas supply chain, staff training, diversifying suppliers, implementing advanced technologies like IoT and machine learning, and implementing sustainable logistics methods are recommended. Training in equipment handling, safety, and industry requirements can reduce errors and increase productivity. Using cutting-edge gas detection technology can also help respond to threats.

6. CONCLUSIONS

This study investigates the supply chain risks faced by Oman's oil and gas firms. The Omani government has prioritized logistics and supply chain development in order to strengthen the economy. The initiative of this study is the limited literature for the studies of risk in the oil and gas sector in Oman.

The FMEA method was used in this study to assess supply chain procedures within the oil and gas sector. The investigation showed that the highest RPN of 45 was caused by equipment failure during crane loading and unloading, which resulted in dropped loads. We recommended a corrective action plan to lower the risk priority score and the probability of such failures. We anticipate significant growth in the oil and gas industry over the next few years as Oman progresses with its development plans.

The main limitation of the study is the difficulty in Finding the top experts for the interviews because busy schedule, and the interview timings were difficult to plan.

A future study can also investigate benchmarking and best-practice comparisons with global industry peers and identify areas for development. Integrating sustainability considerations into risk management frameworks, developing proactive risk assessment tools, and encouraging cross-functional collaboration between different stakeholders who would be involved in the study could result in critical improvements to the sector's overall resilience and sustainability.

Table 6: RPNs results in pre-and post-risk mitigation

Potential Failure Mode	RPN	NEW RPN
	Pre-Risk Mitigation	Post-Risk Mitigation
Dropped loads due to equipment failure	45	20
Uncontrolled release of Hazardous Gas (H2S)	40	15
Equipment failure such as pumps, valves, and compressors.	36	16
Tank Overfilling	36	8
Equipment failure, such as pipeline rupture, can occur due to corrosion or operating issues.	36	16
Drilling a dry hole	24	8
Theft valuable instruments, materials, or equipment while the rig is being prepared or during transportation.	24	16
Leakage or fire due to Chemical storage	24	8
Spilling, leaking, or releasing hazardous materials, such as crude oil, gasoline, or chemicals	24	8
Loss of Well Control	20	5
Collision of Rig	20	10
Fire or Explosion	20	10
Emission of flammable chemicals	16	8
Driving during hours of darkness- Lack of light or illumination	16	8
Uncontrolled Combustion or Leakage	16	8
Insufficient Geological Evaluation	12	4
Poor exploration planning	6	3

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