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Critical Risk Factors Associated with Schedule Delays in Gas Processing Facility Projects: Case Study in Indonesia

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A B S T R A C T

Purpose: This research intends to provide project stakeholders with a thorough understanding of the risk landscape in gas processing projects from project owner's perspective, allowing them to navigate the maze of problems and ensure project success, thereby promoting energy security and economic growth.
Design/methodology/approach: Survey employing focus group discussion (FGD) and questionnaires has been used empirically to identify significant risk factors in the Indonesian gas processing facility project. At first literature research revealed a total of 122 risk variables, of which 97 were validated in FGD by a panel of experts to have effect on the gas processing facility project. Then, questionnaires comprising 97 verified risk variables were delivered to 40 respondents, of whom 33 provided their feedback about the probability and impact of those risks on project schedule performance. The resulting data was evaluated using statistical descriptive analytic techniques, and the study quantifies the relative influence of each risk factor with the use of statistical tools SPSS 28.
Findings: This paper found that Contractor financial problem and risks related to virus pandemic are prominent risk factors. Additional significant variables encompass engineering, procurement, construction, and commissioning (EPCC) related risk factors.
Research limitations/implications: Further analysis still needs to be performed to explore how project critical risk findings affect cost and quality in other upstream oil and gas projects, and also in projects with different spectra such as in oil and gas downstream sectors.
Originality/value: This study comprehensively identifies and analyzes key risks and further investigates the interdependencies and cascading effects of these risks on gas processing facility project, shedding light on their synergistic amplification of schedule burdens.

Keywords: Gas processing facility, Schedule delays, Risk factors, Risk management, Project management

I. Introduction

The fact that gas is one of the most extensively utilized energy sources in Indonesia has led to its rise to prominence. Natural gas has become the backbone of national oil and gas production, with total proven reserves of 36.3 trillion standard cubic feet (tscf) in 2022 as indicated in Table 1, assuming no substantial new gas reserves discoveries, gas production is expected to continue until 2038 (Dirjen Migas, 2022). Gas is employed in many different contexts, ranging from domestic to industrial. Gas

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finds widespread application in several industrial domains such as the petrochemical, manufacturing, transportation, oil and gas, and logistics industries, where it serves as a primary energy source for production. In Table 2, at an expected 2,343.92 Billion British Thermal Unit per Day (BBTUD) in 2022, the industrial and fertilizer sectors in Indonesia are the country's largest gas consumer equal to 43.31% of national gas consumption (Dirjen Migas, 2022). For now, a sizable amount of Indonesia's gas requirements is being imported. The government continues to strive to increase gas production in the country. One of the efforts made is to increase exploration and production of natural gas in Indonesia (Dewan Energi Nasional, 2019). Building a gas processing facility is one of the actions taken by the Indonesian government to counteract the rising demand and increased gas output.

In general, the construction of oil and gas projects is associated with significant risk and complexity because of the industry's distinct characteristics, complicated technology, varied stakeholders, and dynamic working environment (Van Thuyet et al., 2007). The magnitude of the construction project of the gas processing facility is comparatively larger than other building projects because it is being carried out on a turnkey lump-sum contract that encompasses Engineering, Procurement & Construction (EPC) (Kang & Kim, 2016). Due to the project's complexity, vast scope of work, and strict requirements for high-quality materials and equipment, there are numerous risks associated with it that might create disruptions to construction projects for gas processing facilities, which can result in schedule delays and cost overruns (Jang et al., 2015). In construction projects, schedule and cost overruns typically range from 20% to 25%; however, in certain industries, such as oil and gas, power and infrastructure projects, overruns might exceed 50% (Ernst & Young, 2013). According to Ernst & Young's recent investigation report, which focused on oil and gas megaprojects and covered 365 projects for oil and gas companies, 73% of

Table 1. Indonesia natural gas reserves (in tscf)

Reserve Status	2016	2017	2018	2019	2020	2021	1st half 2022
Proven	101.22	100.37	96.06	49.74	43.57	41.62	36.34
Potential	42.84	42.35	39.49	27.55	18.82	18.99	18.49
Total	144.06	142.72	135.55	77.29	62.39	60.61	54.83

Source: Dirjen Migas, 2022

Table 2. Indonesia domestic natural gas utilization 2016-2022 (in BBTUD)

Description	2016	2017	2018	2019	2020	2021	1st half 2022
Gas fuel	3.59	7.06	9.34	7.65	4.62	3.92	4.21
City gas	2.53	3.73	3.65	6.13	6.75	8.42	10.45
Lifting	195.07	179.89	188.79	181.59	173.19	167.78	188.14
Fertilizer	697.75	690.05	726.63	742.68	690.85	681.97	730.17
Electricity	1,010.96	928.13	829.66	838.75	682.72	679.90	628.84
Industry	1,474.81	1,555.70	1,677.52	1,597.42	1,524.07	1,578.28	1,613.75
Domestic LNG	431.43	372.64	405.15	508.25	381.40	479.27	458.68
Domestic LPG	180.70	143.20	154.31	102.90	129.22	88.05	81.68
Export Gas Pipeline	807.30	795.71	761.70	738.34	717.77	752.70	636.82
LNG Export	2,052.52	1,940.66	1,907.78	1,417.00	1,390.47	1,294.12	1,059.73

Source: Dirjen Migas, 2022

large-scale projects went over budget, 64% had schedule delays, and an average of 59% went over the original budget plan (Niven, 2015). The risks associated with the project grow in parallel with its magnitude, and these risks may have an impact on project outcomes. Unfortunately, upstream oil and gas projects are growing larger and more complicated over time, eventually becoming mega-projects (Rostand et al., 2012). Large cost and schedule overruns for the oil and gas companies and increased difficulty maintaining economic viability are two common outcomes of delays, and these factors may obstruct the construction of gas projects (Basak et al., 2019). Inadequate risk deliberation and a lack of awareness and accountability of risks during the project's decision-making phase are the primary causes of these overruns (Flyvbjerg et al., 2003).

Researchers have carried out a number of studies on the risk factors linked to delays and cost overruns in various construction projects. (Basak et al., 2021) explored on the interaction between non-technical and technical risks in upstream gas project schedule overruns in Australia. They discovered that delays are directly and significantly impacted by technical and non-technical risks. According to the research, risks connected to management have the greatest potential to affect project delays, and these are followed by risks related to contracts, project parties, and procurement. This is consistent with the hypothesis that as oil and gas projects grow in scope and complexity and enter more complex environments, the likelihood of risks growing and posing a threat to the project grows. As risks are ranked according to their severity and frequency of occurrence, technical risks are ranked higher than non-technical ones. Nevertheless, the study's scope is limited to Australia, making it impossible to depict how these risks would affect projects in other nations.

Meanwhile (Orangi et al., 2011) discovered numerous factors might cause delays even in regular linear projects like pipeline infrastructure operations. After years of investigation, a number of core causes for pipeline projects were identified. These included poor communication, design errors, changes made to the project, problems with customers or end users, inadequate subsurface investigation, problems with permissions or approvals, weather, delays in procurement, site management issues, problems with subcontractors, rework, and issues with cultural and heritage management. Nonetheless, the research findings, like those of (Basak et al., 2021), are restricted to the conditions and circumstances of Victoria State, Australia.

Research by (A. Kassem et al., 2019) focuses on investigating the demographic parameters that affect risk factor identification, such as job title and experience. They found that the top five risks that affect the success of construction projects in Yemeni oil and gas processing facilities are changes in the construction process, unstable governments, inaccurate project cost estimation, government delays in decision-making, and inaccurate project time schedule estimation. The results also revealed that there were no statistically significant differences between individuals based on their job title or the oil firms they work for. Conversely, based on the expertise of the project team that completed the survey, statistically significant disparities were discovered in the risk factor classification. They asserted that similar gas processing facility projects in other developing nations with comparable political systems and risk considerations could benefit from the application of their case study from Yemen. However, their assertion, it can be claimed, may only apply to Gulf Cooperation Council (GCC) nations that have comparable political, cultural, and environmental systems. It is not possible to say the same about other developing nations in different regions.

(Jergeas, 2009) conducted research on the current global economic situation and its negative effects on major oil and gas capital projects in Alberta. The study found that the five main risk factors that affect project delays are: ineffective labor management, conditions, and relations; poor project front-end planning (loading) and workface planning; lack of construction and support management; lack of engineering management; and ineffective supervision and leadership.

A case study of a mega project in Korea (Han et al., 2009) found that there are five main reasons why projects take longer to complete than expected. These reasons include the owner's incapacity to manage large projects, the project's numerous variations, an unsuitable delivery system, the use of time-management tools for a linear project, and change orders brought on by the project's complexity.

As can be seen from the previous research discussed above, the risk factors identified as having the greatest impact on project delays vary from region to region. We cannot simply conclude that the factors identified in one region will also apply to another region, even if the regions share some similarities. Therefore, the goal of this research is to define and evaluate the risk factors that influence delays in Indonesian gas processing facility project from project owner's perspective. This work serves as a case study for the oil and gas industry in adjacent nations in same region with comparable political, cultural, and environmental systems.

II. Literature Review

A. Risk Management

Risk is defined as the likelihood that an adverse event may transpire and the consequences of every potential result (Vivek & Hanumantha Rao, 2022). Project risk is also defined as an unforeseen circumstance or event that, if it materializes, could have a favorable or unfavorable impact on the goals of the project. An event that might or might not occur, its likelihood, and its consequences are the elements that make up risk (Abd El-Karim et al., 2017). International companies strive to deal with risks and uncertainties such as a country's internal difficulties, governmental turmoil, cultural problems, and financial issues (Oh et al., 2023). Projects inherently involve uncertainty, arising from both internal and external variables. Therefore, risk management is necessary to mitigate the probability of risk events occurring and their adverse consequences (Fan et al., 2008). Risk management should be purposefully integrated and prioritized within project operation, combining risk assessment, mitigation, and contingency planning into decision-making processes. This will enhance project performance by implementing efficient risk mitigation techniques (Abdou et al., 2024). Since they differ between projects, internal risk variables may be evaluated and are comparatively more manageable than external risk factors (Carr & Tah, 2001). In construction projects, risk management is important for achieving project goals without overspending or delays. The success of these endeavors will be largely dependent on the project's design and planning. Project managers can better prioritize resource allocation and make accurate decisions with the aid of the risk management system, both of which are necessary for the project to succeed and meet its goal (A. Kassem et al., 2019). It is important to recognize that risks can lead to a variety of negative outcomes for a project, including delays in schedule, overspending, poor quality, disputes, arbitration, lawsuits, and even the complete abandonment of the project (Boateng et al., 2015). The process of evaluating, executing, and concluding oil and gas projects—particularly those in the upstream sector—is a complicated one that invariably entails more difficult, sophisticated, and demanding risks (Dehghan et al., 2022). The upstream industry faces significant challenges from geopolitical, political, environmental, and internal risks in addition to geological risks and fluctuations in oil prices (Haghighi & Ashrafi, 2022; Urgilés et al., 2019).

Despite the fact that risks to oil and gas projects cannot be completely eliminated, treating each risk as serious will result in wasting time and money (Srivastava & Gupta, 2010). Oil and gas project risk management is an essential process to implement in oil and gas projects. According to (R. E. Westney, 2001), the objectives of oil and gas project risk management are to identify all risks that could affect the project, analyze the likelihood and impact of each risk, develop a plan to address the risks, monitor and review risks on a regular basis. By implementing

risk management, oil and gas projects can be more assured of success and the risk of losses can be minimized. Here are some examples of risks that can occur in oil and gas projects: technical risk, such as equipment failure or work accidents (Basak et al., 2021), commercial risk, such as changes in oil prices or market demand (Khadem et al., 2018). environmental risk, such as pollution or habitat damage(Waqar et al., 2023), political risk, such as regulatory changes or social conflict (C. Cheng et al., 2019).

The implementation of oil and gas project risk management can help to reduce the impact of these risks. Risk management is a four-step procedure that aims to reduce risk impact and control risk variables. Effective risk management entails recognizing risks, analyzing possibilities and dangers, and prioritizing them for proper control to avoid negative outcomes (Hong, 2023). Risk identification, risk analysis, risk response and mitigation, and risk monitoring and control are the four steps in the process (Fang & Marle, 2012). The process of risk identification aims to pinpoint the elements that can have a positive or negative impact on the outcome of an oil and gas project. This stage is crucial because risk management relies on the idea that risk factors can be identified, since it is difficult to protect a system from unknown risk. Early risk identification and the creation of a comprehensive risk list are necessary for effective project risk management in order to make sure that no risk is missed (R. Westney, 2008). The goal of risk analysis is to assess how identified risk variables will affect the project in terms of probability, frequency, likelihood, severity, and degree of impact. An appropriate and correct knowledge base and real facts are necessary for both risk identification and analysis because they provide the necessary amount of input for a successful risk evaluation. Risk response and mitigation pertain to the appropriate way to address risks and make decisions that will minimize consequences and decrease hazards. In order to maintain proper risk management, risk monitoring and control are ongoing procedures that are used to find and assess new risk factors, reevaluate existing risk factors, and enhance existing risk responses (Kraidi et al., 2019).

B. Risk Classification

Estimating the likelihood of risk event using statistical methods or expert opinion using Delphi method and interview is one of the most important elements in the risk assessment process. The Delphi technique is a method for achieving consensus from experts. Experts in the field of project risk participate anonymously, and are facilitated with a questionnaire to gather ideas about the dominant project risks (Chapman, 2001). While interview is a technique for gathering data about project risks. Interview is conducted with project team members and other stakeholders who have experience with project risks (A. Kassem et al., 2019). The risk register is the final output of the risk identification process. For the next process, this risk register will be supplemented with risk analysis and a risk response plan. This risk register will continue to be updated as the project progresses (Whipple & Pitblado, 2010). In this study, the risk register is the final output of the risk identification process. The risk register that is reviewed can come from a literature review or from existing project data. Risk registers should include all assessed risks so that risks requiring managerial attention can be ranked in order of importance (Filippin & Dreher, 2004). Each oil and gas project has unique characteristics and risks, and effective risk management is the key to overcoming these risks and ensuring the smooth running of the project and its profitability.

Risk is arranged in the framework of project management at the top level, with a worldwide perspective (Suslick & Schiozer, 2004). The literature has a variety of methods for categorizing risks according to project stakeholders' ownership (Perry & Hayes, 1985), the source and effects of risk on a project (Carr & Tah, 2001), risks' characteristics and extent (Rostand et al., 2012), project's exposure to risks that are acceptable or unacceptable, internal

or external, dynamic or static, and positive or negative (Baloi & Price, 2003). Projects should, according to (Van Thuyet et al., 2007), be exposed to both internal and external risks, including financial, design, contractual, construction, project parties, and operational risks as well as legal, social, political, and environmental ones. While classifying risks, other studies have given priority to technological obstacles as a category (G. S. Cheng & Abdul-Rahman, 2013). Nonetheless, the justification for using any certain risk classification strategy must align with the study's objectives (Khodeir & Mohamed, 2015). The issues surrounding risk concerns in construction projects have a significant impact. As a result, various studies have been done to study these issues in several countries, such as in Iran (Dehghan et al., 2022), in Oman (Khadem et al., 2018); in Saudi Arabia (Issa et al., 2019); in Yemen (A. Kassem et al., 2019); in Turkiye (Balas, 2023); in Egypt (Nabawy & Khodeir, 2020); in Australia (Basak et al., 2021); in Nederland (Mayer et al., 2020); in China (Guan et al., 2018); in India (Kumar Gupta & Thakkar, 2018); in Ecuador (Urgilés et al., 2019); in Poland (Gierczak, 2014); in Malaysia (Waqar et al., 2023), and in Indonesia (Hatmoko & Khasani, 2020).

The aforementioned investigations generate a list of risk factors, which should be investigated further using a questionnaire through FGD and interview to determine their impact on the success of gas processing facility project.

III. Materials and Method

A. Data Collection

This section outlines the approach for examining risk variables in Indonesian construction projects related to the oil and gas industry, with a focus on data collection, analysis techniques, and tool use. A closed-ended questionnaire was used to gather data in order to address the study questions and validate the hypotheses. The risk variables were categorized into 11 major groups as follows, taking into account the sources of risks, the literature evaluation, and the researchers' 20 years of experience working on building projects in Indonesia's oil and gas industry: Procurement; Stakeholder Interface; Oil Price; Engineering, Construction & Commissioning; Project Management; Financial; Contractual; Politics; Health, Safety, Security; Environment; Land Acquisition & Regulatory.

1. Risk factors validation

At first respondents were asked to validate the 122 pre-identified risk factors from literature review by conducting a FGD with experts consisting of project practitioners from various departments. The aim was to determine which risk factors from the list of risk variables that were asked have an influence on the gas processing facility project. Nine experts, including managers, assistant managers, and senior engineers, participated in a FGD to ensure the questionnaire's completeness and clarity as well as the risks' applicability to the gas processing facility construction project in Indonesia, which served as the case study. The participant responses served as a roadmap for the final questionnaire's reworking and improvement. After the FGD data was obtained, which consisted of input, responses, and comments from the questionnaire regarding the risk factors that influence the gas processing facility project, data analysis was carried out using the Delphi method. Consequently, the list of risk variables influencing the project for a gas processing facility was reduced by 25 out of 122. The majority of the detected risk factors' redundancy and the fact that some risk factors were addressed and mitigated prior to the project's start are the main causes of their exclusion from the case study.

2. Risk probability and impact

The next step is to distribute a questionnaire containing 97 risk factors that were previously validated to determine the probability and impact of

Table 3. Risk rating for probability and impact

Rating	Probability	Impact
1	Rare	Insignificant
2	Unlikely	Minor
3	Moderate	Moderate
4	Likely	Significant
5	Almost Certain	Catastrophic

these risk variables on the schedule performance of the gas processing facility project. The questionnaire was divided into two sections: the first included an introduction, goals, study background, scope of research, data confidentiality and research findings; the second section included inquiries about the respondents' name, age, current work position, years of work experiences, and respondents' educational background. The probability and impact were the focus of the next two sections. Using a five-point Likert scale, respondents were asked to rank the significance of 97 potential risk variables. The risk rating for the risk elements can be seen in Table 3.

B. Data Analysis

Sample size selection is an essential step in the data collection process, and an effective way to ensure the generality of results is to use a sufficient sample representative for the community. A data adequacy test is conducted to ensure that the collected data is objectively sufficient. There are two main factors that influence the data adequacy test: accuracy level (this refers to the acceptable level of error that can be tolerated during data collection) and confidence level (this reflects the degree of certainty that the collected data represents the actual population). The following equation can be used to evaluate the adequacy of observational data (Sutalaksana, 2006):

$$N' = \left[\frac{\frac{k}{s}\sqrt{N.\sum Xi^2 - (\sum Xi)^2}}{\sum Xi} \right]^2 \quad (1)$$

Where N': number of required measurements, N: number of measurements performed, k: confidence level, s: accuracy level, Xi: i-th data. There were forty questionnaires distributed in total, and 33 respondents in all responded to the survey. With 95% of confidence level and 5% of accuracy level, the required number of measurements is 19.73. Since $N' < N$ then the number of observations meets the requirements. The number of measurements in this study is comparable to characteristics described in prior pertinent investigations by (Fallahnejad, 2013; Ruqaishi & Bashir, 2015; Van Thuyet et al., 2007) with 23, 59, and 42 respectively.

The collected data would be analyzed using non-parametric statistical tools: Kruskal-Wallis test, reliability test and descriptive analysis. When examining replies on a Likert five-point scale in circumstances where the assumption of normality is not supported, the Kruskal-Wallis test should be used (Montgomery, 2013). Using the SPSS program, a Kruskal-Wallis test was used in this study to ascertain whether the mean significance of each component was the same regardless of working experience, job position, and educational background.

Validity test is a statistical procedure used to determine the extent to which a research instrument measures what it is intended to measure. While to determine whether variables are dependable, reliability tests are typically employed. For all variables, the Cronbach's alpha result needs to be more than 0.7 in order to be accepted (Nunnally & Bernstein, 1994).

In order to assess the impact of each risk, the study used a risk influencing factor (RIF). According to (Yazdani-Chamzini, 2014) the Risk Index (RI) values of the RIFs are calculated and used to rank them traditionally.

$$RIF = Risk\ Probability\ x\ Risk\ Impact \quad (2)$$

By employing RIs to indicate the probability and severity levels of the variables, it is possible to rank the RIFs using this method.

IV. Discussion

A. Demographic Analysis

Regular emails were used to gather the completed responses. Thirty-three of the forty surveys that were issued were completed and used in the analysis. The respondents' profile is summed up in Table 4. This survey's significance can be explained by the demographic feature. Of those surveyed, 43% had between 16 and 20 years of work experience, 18% had between 21 and 25 years of work experience, and 12% had more than 25 years of experience. The job title category might give you a decent indication of how the answer relates to the survey's topic. Managers and assistant managers make up 27% of the participants, while senior engineers and engineers who work directly with project risk management make up 73%.

The demographic figure in Table 4 illustrates the four key sectors that were the focus of this survey, which included all project divisions. The questionnaire respondents have a wide range of job titles and educational backgrounds, and they have worked in Indonesia's oil and gas industry for a long time. Consequently, the analysis's findings are valuable from a scientific standpoint, and the questionnaire is now legitimate, thorough, and suitable for use as a template for comparable research in neighboring developing nations. The core of the study is its demographic analysis. The study aims to identify and assess the risk variables that impact project delays for Indonesian gas processing plants.

Table 4. Respondent demographic characteristic

Characteristic	Frequency	(%)
Age		
31-40	11	33%
41-50	17	52%
51 and above	5	15%
Education		
Undergraduate	24	73%
Postgraduate	9	27%
Job position		
Engineer	10	30%
Senior Engineer	14	43%
Assistant Manager	5	15%
Manager	4	12%
Working experience		
6-10 years	3	9%
11-15 years	6	18%
16-20 years	14	43%
21-25 years	6	18%
25 years and above	4	12%

B. Statistical Analysis

The Kruskal-Wallis test was used to assess the homogeneity after the primary data from the questionnaire were examined from the perspectives of educational background, work experience, and project team job title. The experimental results of the Kruskal-Wallis test, which was used to test the hypotheses, indicate that there is no significant difference in the perception of the risk factors associated with the gas processing facility project based on educational background. The Kruskal-Wallis test indicates a significant difference at the 0.05 level. More specifically, only 2 out of 97 risk factors show substantial differences in perception. As a result, there is some degree of agreement across respondents with varying educational backgrounds regarding the risk factors that influence project success.

Comparable outcomes were also seen when respondents with varying work experiences and job titles were analyzed for homogeneity of perception using the Kruskal-Wallis test. Just 2 out of 97 and 9 out of 97 risk variables, respectively, showed a significant difference at the 0.05 level.

Validity test was conducted using the SPSS software with the corrected item total correlation analysis method. A variable is considered valid if the calculated r value is greater than the r table value. In this study, the r table value can be seen at the confidence level = 95% or the level of significance

Table 5. Reliability statistic

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.987	0.987	97

(α) = 5% for a 2-tailed test with a sample size (N) of 33 respondents, resulting in a calculated degree of freedom (df) = N-2 = 33-2 = 31. Based on the r table with df = 31 and P = 0.05, the r table value is 0.344. All items exhibit a corrected total item correlation with r values > r table 0.344, according to the validity test findings that were calculated for all variables. This demonstrates the validity of each variable item included in the questionnaire.

Table 5 shows SPSS results of the reliability test showed a computed coefficient Cronbach's Alpha of 0.987 with a total of 97 research variables for risk variables. Therefore, it can be concluded that the reliability level of this research instrument is very reliable.

C. Qualitative Risk Analysis

The mean of the responses is used to rank the risk factors, indicating the participants' direction in determining the risk index (RI) and risk influencing factor (RIF) in the Indonesian gas processing facility project, as shown in Table 7. These factors were then projected on a probability and impact matrix, as shown in Figure 1, to provide the outcome of eight high-level risk variables that have the largest influence on schedule delays of the gas processing facility project in Indonesia, as shown in Table 8.

Following the matrix in Figure 1, there is a scale of risk probability and impact with five levels and categories as shown in Table 6.

The majority of respondents think that these risk factors will likely have a significant influence on gas processing facility project. Part of these outcomes (contractor financial problem, and risks related to EPCC) resemble those findings by (Fallahnejad, 2013; Hatmoko & Khasani, 2020; Kazemi et al., 2020; Rawat et al., 2023; Sweis et al., 2019). Meanwhile

Table 6. Risk level and scale

Risk Level	RIF Scale
Low	$1 < x \leq 3$
Low-Moderate	$3 < x \leq 4$
Moderate	$4 < x \leq 9$
Moderate-High	$9 < x \leq 12$
High	$12 < x \leq 25$

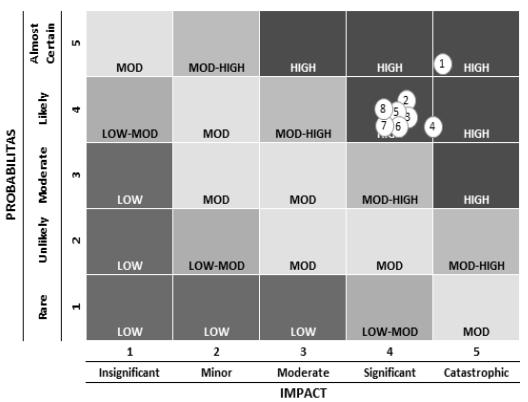

Figure 1. Probability and impact matrix

Table 7. Validity and risk ranking

Risk Factors	r-value	RIF	Rank
X.1.1	0.797	12.99	3
X.1.2	0.663	7.86	43
X.1.3	0.689	7.17	62
X.1.4	0.760	6.17	81
X.1.5	0.775	6.56	75
X.1.6	0.601	5.95	85
X.1.7	0.602	7.58	53
X.1.8	0.690	8.35	36
X.1.9	0.630	9.55	24
X.1.10	0.607	10.31	14
X.1.11	0.661	12.14	8
X.1.12	0.611	9.31	27
X.1.13	0.753	7.11	63
X.1.14	0.642	9.65	23
X.1.15	0.654	12.89	5
X.1.16	0.605	8.79	34
X.2.1	0.662	6.63	74
X.2.2	0.687	9.09	29
X.2.3	0.772	7.42	56

Table 7. Continued

Risk Factors	r-value	RIF	Rank
X.2.4	0.751	9.27	28
X.3.1	0.545	7.02	67
X.3.2	0.707	7.60	51
X.3.3	0.567	5.94	86
X.3.4	0.650	6.79	73
X.3.5	0.636	5.55	93
X.3.6	0.527	5.44	95
X.4.1	0.731	12.57	6
X.4.2	0.722	10.02	17
X.4.3	0.736	12.14	7
X.4.4	0.719	7.27	58
X.4.5	0.695	6.95	69
X.4.6	0.808	9.74	20
X.4.7	0.651	8.20	38
X.4.8	0.639	10.99	11
X.4.9	0.665	10.90	12
X.4.10	0.688	7.19	61
X.4.11	0.731	8.46	35
X.4.12	0.717	6.48	76
X.4.13	0.593	12.97	4
X.4.14	0.683	11.42	9
X.4.15	0.717	9.36	26
X.4.16	0.727	6.10	82
X.4.17	0.623	7.42	57
X.4.18	0.624	9.55	25
X.4.19	0.680	8.90	32
X.4.20	0.642	8.99	30
X.5.1	0.628	8.10	42
X.5.2	0.696	5.48	94
X.5.3	0.664	7.85	44
X.5.4	0.704	7.10	64
X.5.5	0.588	7.85	45
X.5.6	0.629	10.30	15
X.6.1	0.738	7.47	55
X.6.2	0.694	8.25	37
X.6.3	0.681	16.37	1
X.6.4	0.683	9.74	21
X.7.1	0.670	7.07	65
X.7.2	0.777	7.25	60
X.7.3	0.760	7.84	46
X.7.4	0.659	8.81	33

Table 7. Continued

Risk Factors	r-value	RIF	Rank
X.7.5	0.802	11.41	10
X.7.6	0.571	9.92	18
X.7.7	0.591	9.73	22
X.7.8	0.686	9.91	19
X.8.1	0.802	5.85	88
X.8.2	0.579	7.01	68
X.8.3	0.561	7.68	50
X.8.4	0.679	6.31	78
X.9.1	0.675	7.59	52
X.9.2	0.565	7.71	49
X.9.3	0.738	7.55	54
X.9.4	0.715	6.86	71
X.9.5	0.695	6.32	77
X.9.6	0.539	13.67	2
X.9.7	0.771	10.22	16
X.10.1	0.666	6.10	83
X.10.2	0.707	7.83	47
X.10.3	0.697	5.61	91
X.10.4	0.586	5.61	92
X.10.5	0.636	5.67	90
X.10.6	0.414	4.56	97
X.10.7	0.648	6.23	80
X.10.8	0.672	5.37	96
X.10.9	0.640	8.97	31
X.10.10	0.534	10.42	13
X.10.11	0.551	7.83	48
X.10.12	0.414	8.18	39
X.11.1	0.681	6.94	70
X.11.2	0.522	7.03	66
X.11.3	0.759	8.11	40
X.11.4	0.686	6.27	79
X.11.5	0.537	5.87	87
X.11.6	0.699	8.11	41
X.11.7	0.823	5.80	89
X.11.8	0.670	6.01	84
X.11.9	0.615	6.80	72
X.11.10	0.693	7.26	59

there are risk factors which were identified as risks related to virus pandemic (in this case COVID-19) that disrupts project activities, and travel restrictions

Table 8. High level risk factors

Risk Factor	Risk Variable	RIF	Rank	Risk Group
X.6.3	Financial problems of contractors due to mismanagement	16.37	1	Financial
X.9.6	Virus pandemic causing project activities to be disrupted	13.67	2	Health, Safety, Security
X.1.1	Material delays due to poor vendor quality and performance	12.99	3	Procurement
X.4.13	Punch list activities that need to be completed before commissioning	12.97	4	Engineering, Construction, Commissioning
X.1.15	Travel restrictions due to the pandemic	12.89	5	Procurement
X.4.1	Contractor's failure to meet the agreed design	12.57	6	Engineering, Construction, Commissioning
X.4.3	Differences between FEED assumptions and field conditions	12.14	7	Engineering, Construction, Commissioning
X.1.11	Delays in the fabrication stage	12.14	8	Procurement

due to the pandemic. These findings concurrent with researches by (Adepu et al., 2023; Almohassen et al., 2022; Suvittawat, 2024) among others that found out that COVID-19 pandemic caused interruptions and issues in several commercial sectors, including the construction industry. The pandemic had a significant impact on the construction sector by increasing the frequency of project schedule delays, which affected a large number of projects worldwide.

V. Conclusions, Limitation and Future Research

The objective of the present research was to identify and evaluate the main risk factors linked to the construction of gas processing facility project in Indonesia. The research employed a mixed-methods design, comprising a FGD and a comprehensive questionnaire survey, to collect data from a group of professionals in the industry. Qualitative techniques were employed to analyze the data and determine the most significant risk factors linked to schedule delays on this particular project.

Among the eight highest risks identified for the gas processing facility project, six are related to technical factor (engineering, procurement, construction, and commissioning variables), and two risk factors related to non-technical (one risk factor is related to health, safety, and security variables; and one risk factor is related to financial variables). This suggests that non-technical risk factors can also have a significant impact on project delay risk, although technical risk factors have the greatest impact on project time performance. These factors, both directly and indirectly, have a significant impact on the project's progress, something that was initially not given enough attention by project stakeholders. These findings are consistent with the results of research conducted by (Basak et al., 2021) which showed that non-technical risks have a much greater impact on delays than technical risks, causing project delays or delays to become more severe. Other studies (A. Kassem et al., 2019; Kraidi et al., 2019) have also found that non-technical risks have a significant impact on the progress of oil and gas projects. Further emphasize on two risk factors related to COVID-19 pandemic (X.9.6 and X.1.15) as disruption in project activities and travel delay as a consequence of pandemic, in previous research these risk factors have received less attention due to the severity of previous pandemics and their impact on the construction industry not being significant enough to disrupt project performance compared to COVID-19.

The identified critical risk factors for gas processing facility delays have several practical implications for the industry:

a. By understanding the most impactful risk factors,

project managers can allocate resources more effectively during the planning stages. This allows for proactive measures to address potential delays caused by procurement issues, financial constraints, or health & safety concerns. More realistic timelines and budgets can be established, leading to increased project predictability and stakeholder confidence.

b. Project teams can use the identified risk factors to develop more targeted risk management plans. These plans can include specific mitigation strategies for each critical risk, such as improving vendor selection processes, securing early project financing, or implementing robust safety protocols. These proactive measures can reduce the likelihood and severity of project delays.
c. The findings highlight the importance of effective communication and collaboration among all project stakeholders. By bringing together engineering, procurement, finance, and health & safety teams early in the project lifecycle, potential risks can be identified and addressed collaboratively. This improves overall project coordination and reduces the likelihood of delays caused by communication breakdowns.
d. Project owners and contractors can leverage these findings to establish industry benchmarks for risk management in gas processing facilities. Sharing knowledge and best practices regarding critical risk factors and mitigation strategies can lead to improved overall project performance across the industry.

Although, this research has made significant contributions to theory and practice, it necessarily has limitations that warrant further research. At present, this research only considered schedule delay. However, apart from this issue, cost and quality are of critical issues in oil and gas industry. Therefore, research can be extended to incorporate these issues in the project objectives. The lessons learned from this research, can also be examined in other projects having different spectra and dimensions, such as in the downstream oil and gas projects.

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Conflicts of Interest

The authors declare no conflict of interest.

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