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Identification and stakeholder responsibility mapping of contractual risk factors in oil and gas sector infrastructure projects using Delphi technique

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K E Y W O R D S

Contractual Risks

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A B S T R A C T

The continuing demand for energy has led to the need for developing and improving the oil and gas infrastructure through the execution of various infrastructure capital projects in many parts of the world, including Pakistan. Oil and gas companies have vast experience implementing these infrastructure projects, yet many such projects face delays and cost overruns. This failure to meet project targets may be attributable to the lack of identifying and addressing the risks at the pre-execution stage in the contract documents. This study aims to identify the risks to address in the contract documentation developed for the infrastructure projects and allocate each factor to a particular stakeholder (Client, design consultant, legal consultant, and bidders) in Pakistan. Risks were identified through literature review and were validated using the Delphi technique applied through surveys. Twenty-four survey respondents were selected based on their qualifications and experience in Pakistan's Oil and Gas sector. In the first round of the Delphi survey, the level of agreement authenticates the risks applicable to Pakistan's Oil and Gas sector. The level of agreement was reaffirmed in round two of the Delphi survey. It also included a check for stability of responses between rounds using the McNemar test. Results confirmed that sixty-one risk factors are the contractual risk for evaluation when developing contracts for Oil and Gas infrastructure projects in Pakistan.

1. Introduction

There is a continuing increase in energy demand for various reasons, including growth in population and industrialization. Improving standards of living also influence this demand. The energy supply to meet this demand is being affected by depleting reserves of existing oil and gas sources. It is putting pressure on Oil and gas companies to explore and develop new supply sources in the upstream segment of oil and gas along with associated mid-stream projects such as installations, refineries, pumping, and compressor stations. The supply chain projects are needed in the downstream area, including; storage depots, retail outlets, and pipelines. Hence to maintain their supply chains and profitability, Oil and Gas companies continue to invest in infrastructure projects across the entire spectrum of upstream, midstream, and downstream. These Capital infrastructure projects of the Oil and Gas companies play a crucial role in providing consumer

energy. Oil and Gas companies have vast experience executing upstream, midstream, and downstream infrastructure projects. From this experience and external support from consultants, Oil and Gas companies have developed and implemented various project assurance processes to ensure that the projects meet cost, schedule, and quality targets.

Despite their experience and processes, many Oil and Gas projects fail to meet these targets in terms of schedule, cost, or quality. It often impacts the safety and reputation of the company. The cause of such failure to meet targets is attributable to multiple risk factors. One possible reason may be the lack of knowledge management due to which projects initiate with contracts that do not comprehensively address project risks. Tenders that lead to contacts do not address the full range of crucial contractual risk factors critical for project success. Another reason is the misconception about ownership of the contract document. One or more of the stakeholders sometimes assume that other specific stakeholders will address certain factors, while another stakeholder may have assumed that it is not their responsibility. Many of these risk factors are identifiable in the pre-contract stage of the project and are addressable through contractual remedial strategies. Some risks are attributable to the capability of the organizations to develop these contracts directly or through external support in the form of legal and design consultants. There is a need to assess the risk factors that cause Oil and gas companies to miss their targets and highlight the primary stakeholders responsible for addressing risk factors in the contract documents.

This paper's scope covers risks in upstream, midstream, and downstream infrastructure projects in Pakistan's Oil and Gas sector. A literature review initiated this research to identify risks in the oil and gas sector. The addressable risks in the pre-contract award stage were compiled and filtered. Delphi process authenticated risk factors for applicability through assessment by selected Oil and Gas sector experts' focus group using a structured questionnaire based on the identified factors for projects in the oil and gas sector. The Delphi process also highlighted which stakeholders are responsible for ensuring the incorporation of the risk factors in the contract.

2. Literature Review

A definition of risk by Al-Salman (2004) elaborates that it is all those circumstances which could lead to the failure of a contract in one of its functions, thus endangering the transaction's success [1]. A detailed literature review focused on two aspects. The first was to understand and identify contractual risk factors or prior research identified risk factors in a global context. The second focus was to understand the reliability and use of the Delphi technique as a mechanism to authenticate such risk factor identification and allocation of risks to particular stakeholders. Following sub-sections, discuss both aspects.

2.1 Contractual risk Factors

Earlier research was used to identify risk factors that impact project performance, including in the formulation of contracts [2], along with significant risk areas and their sub-factors [3]. Multiple other researchers have quoted various additional factors [4-8].

The detailed search of scholarly papers showed commonality and divergences in the two distinct areas, i.e., Oil and Gas specific projects (Review 01) and general nonspecific projects (Review 02). Risks identified in these reviews were consolidated, and duplication was removed. Review 01 relied on the works of Arain (2011), Elhenshiri (2019), Kassem et al. (2019), Kassem et al. (2020), Van Thuyet et al. (2007), [9, 10, 11, 12, 13, 14]. Ninety-Seven risks were identified which can be divided into three categories as follows:

A. Pre-Contract risks involve organizational and financial issues that the client has to address alongside contractual risks. Twenty-three risks were part of this category.

B. Contractual risks are addressable risks in the executed contract. Sixty-one risks are part of this category. These Contractual risks were further subdivided into eight categories as follows, along with the number of risks shown in each category shown in parenthesis.

    1. Management of change (7)
    2. Timelines (4)
    3. Coordination and communication (4)
    4. Documentation (15)
    5. People (4)
    6. Health Safety and Environment (HSE) and Security (7)
    7. Material (5)
    8. Design (15)

C. Allied risks are those risks that the client should be aware of and tackle outside of the contract. This category included thirteen risks.

Review 02 identified eighty-two risks which can also be divided into three categories as follows:

A. Pre-Contract risks involve the organization and other issues that the client must address alongside contractual risks. This category included ten risks.

B. Contractual risks are addressable risks in the executed contract. In this category, there were forty-five risks. These risks are subdivided into subcategories, with the number of risks within each category shown in parenthesis.

    1. Management of change (2)
    2. Timelines (4)
    3. Coordination and communication (4)
    4. Documentation (11)
    5. People (6)
    6. HSE and Security (2)
    7. Material (6)
    8. Design (10)

C. Allied risks that the client should be aware of and tackle outside of the contract. In this category, there were twenty-seven risks.

The critical difference between Review 01 and Review 02 is that non-Oil and Gas projects listed additional on-site risks attributable to project management by the Contractor. From the above, it is seen that there is a more significant number of risks in the Contractual risk category in Review 01 as compared to Review 02. Most of the risks in Review 02 included those listed in Review 01.

2.2 The Delphi Technique

The Delphi technique is an efficient and reliable alternative to other approaches such as interviews [15] Its primary usage includes identification and prioritization. It is based on techniques that aim to generate an agreed view on a topic [16] The Delphi method offers reliability by going through several rounds, being anonymous, and applying the principles of democracy. This method generates valuable insight that can be said to be more total than the sum of its parts. Questionnaires ensure this structured communication. The Delphi technique is an iterative multistage process of consensus-building, of which various forms exist today [17] The process is anonymous; hence participants can change their initial views without having to defend those initial views in a public forum. Also, due to anonymity, there is no pressure on individual participants to conform to the majority views [18]. The Delphi technique obtains the opinion of experts while eliminating any bias and influence of one expert over another. It is based on the Hegelian principle of reaching consensus [19]

In their research, Ogbeifun et al. (2016), have deemed the Delphi technique appropriate for addressing complex issues seen in the Engineering and Building industry without having apprehensions of coercion or complicity [20]. The Delphi technique needs to have a clearly defined research problem, the rationale for the research, the literature review, a transparent methodology defining the data collection, the number of rounds, and selection of experts [17].

A literature review was also carried out to determine how many rounds of Delphi would be adequate to conclude the Delphi process. Ameyaw et al., in their review of eighty-eight papers, indicate that the number of rounds ranged from two to six [15]. They further elaborate that the desired consensus in forty of these papers was two to three rounds. They have also noted that responses from experts typically reduce after the second round. In their research, Day and Bobeva (2005) have pointed out that while the number of rounds varies between two and ten, they are limited to two or three rounds [16]. Traditionally Delphi has at least three rounds [15]. Notably, Zahoor et al. (2017) have concluded their Delphi exercise in two rounds [21]. In their research, Xia and Chan (2012) provided the results consolidated from round one of the Delphi surveys to the respondents in round two of the same Delphi survey [22].

A literature review also evaluated the level of agreement and stability of response. The research by Heiko (2012) has stressed achieving stability which they have explained as response consistency between successive rounds [23]. He further elaborates that there is controversy in understanding the term consistency and implies that the researchers must establish the definition themselves. Holey et al. (2007) have suggested that agreement and consensus are synonymous and can be determined in three ways, i.e., the aggregate of judgments, central tendency, or stability of answers between rounds [24]. The use of aggregate happens in all rounds, while the latter two happen between rounds. They further explain that Delphi's results can be summarized in agreement percentage, kappa values, statement evolution, importance rankings, and theme production. Measures of central tendency and level of dispersion have been suggested by Hsu and Sandford (2007) as well [25]. Agumba and Musonda (2013) have suggested multiple criteria for determining consensus [26]. One of the criteria is that not less than a sixty percent rating on a question should be achieved. When comparing their [26] research with Jain et al. (2020), it was observed that a level of agreement of more than

sixty percent is acceptable, while a more stringent percentage would be eighty percent [27]. This research uses the approach of accepting the level of agreement to be more than seventy percent.

Yang (2008) has discussed the concept of stopping criteria, which assesses at what point the successive rounds of Delphi may stop [28]. It concludes that an acceptable level of consensus exists. The research proposes using three parametric statistical methods and two alternative methods. The three parametric statistical methods are.

a) The coefficient of variation. A suggestion is that an additional round is not needed if the calculated coefficient of variation s less than or equal to 0.5. This method again stresses that the stopping criteria are arbitrary.

b) The Degree of Association. Here the Pearson correlation coefficient is used.

c) F- Test. It looks at the variances in the item scores between two successive rounds.

The two alternative methods looked at are.

a) McNemar Change test. A null hypothesis was generated on the expectation that deviation on either side of the agreement or disagreement side will be the same. The example used to explain this test cites twenty-four experts whose views were sought regarding agreement or disagreement to a question.

b) The Binomial test.

Ciechalski et al. (2002) also used the McNemar test in a questionnaire that needed a yes/no response in two rounds and evaluated the results against the chi-square statistic [29]. The Chi-square statistic was calculated using the formula shown in Eq. 1.

$$\text{McNemar Change Statistics} = \frac{(a-d)^2}{(a+d)} \quad (1)$$

Where;

a = Number of changes from a positive response to a negative response

b = Number of changes from a negative response to a positive response

The null hypothesis to be tested is a = d

The McNemar chi-square test has also been used by Freitas et al. (2018), to quantify the extent to which there has been a shift in responses and statistical significance, taking P as less than 0.05 [30].

Mitchell (1991) has indicated that the number of rounds should be as few as possible [31].

3. Study Objectives, Scope, and Methodology

The study's objective was to identify Contractual Risk Factors in Oil and Gas Sector Infrastructure Projects in Pakistan and identify which stakeholders should be responsible for ensuring that the risks are addressed in the contract documents. The scope of the research covers those risks addressed in the pre-contract stage of infrastructure projects in the Upstream, Midstream, and Downstream areas of Pakistan's Oil and Gas sector. It includes installations, pumping and compressor stations, pipelines, retail assets, extraction plants, Floating Storage, and Regasification Units for liquified natural gas (LNG). The study methodology included; identification of risk factors, classification of risk factors, authentication of risk factors, and identification of stakeholders responsible for ensuring inclusion in contract using the Delphi Technique. It was used to establish the contractual risk factors applicable in the Pakistan oil and gas sector. A total of sixty-one contractual risks were part of the above-explained process.

Risk factors were identified through a literature review that covered projects in the oil and gas sector and general non-area-specific projects. The identified risks were then consolidated, and duplicate risks were removed. The review of oil and gas projects identified Ninety-Seven risks, while the review of nonspecific projects identified eighty-two risks. These risks included pre-contract risks, contract risks, and allied risks. Contractual risks are those that can be addressed in the executed contract. The next step was to authenticate the risk factors identified through the literature review, which can be addressed through contractual remedies, and establish who the stakeholder responsible for including relevant contractual provisions to address these authenticated risk factors is. The Delphi analysis was used as an efficient and reliable technique to perform authentication of the risk factors through a sector expert focus group. Authentication included the applicability of these risk factors in the Oil and Gas sector of Pakistan, as well as verification that these can be addressed during the contract and developed stages for construction of infrastructure projects. Finally, Delphi analysis identified risk factors that can be addressed through contractual provisions, their categorization, and the relevancy of each risk factor for a particular stakeholder (i.e., Client, Design consultant, legal consultant/advisor, Bidder).

3.1 Characteristics of Identified Contractual Risks

The term contractual risks, as used in this research, are those risks that should be considered while developing the tender documents. After the tendering process, these risks can be addressed through contractual remedial strategies. A total of sixty-one contractual risks were identified from the above-explained process. These were grouped into the following eight groups based on their similarity in nature.

1. Management of Change
2. Timelines
3. Coordination and Communication
4. Documentation
5. People
6. HSE and Security
7. Material
8. Design

The final list of contractual risk factors in oil and gas infrastructure projects as identified under each of the categories mentioned above is in Table 1.

Table 1

Contractual risk factors in oil and gas sector infrastructure projects

Risk ID	Contractual Risk Factor	Citation	Risk ID	Contractual Risk Factor	Citation
	1.0 Management of Change				
1.1	Changes	[9, 13, 14]	4.17	Unclear co-insurance provision/compliance to owner requirements	[9]
1.2	Cost increase	[14]	4.18	Contractor lack of experience / Unclear Work methodology/Value Engineering	[9,11]
1.3	Tax rate fluctuation	[14]		5.0 Human Resources	
1.4	Forex rate fluctuation	[14]	5.1	Local representation requirement.	[11,12]
1.5	Inflation	[14]	5.2	Cultural and language conflicts	[12-13]
1.6	Interest rate fluctuation	[14]	5.3	Resettlement requirements	[14]
1.7	Changes in law	[11-14]	5.4	Disputes with neighbors	[14]
	2.0 Timelines			6.0 HSE and Security	
2.1	Delay in client approvals	[13]	6.1	HSE risks	[12]
2.2	Unrealistic schedule	[11, 13]	6.2	Waste disposal risks	[11-13]
2.3	Invoice payment lag	[11,13]	6.3	Environmental risks	[10, 13, 14]
2.4	Delays in government approvals, permits etc.	[11]	6.4	Pollution risks	[13]
	3.0 Coordination and Communication		6.5	Threats from armed groups	[11-13]
3.1	Unclear communication process	[11]	6.6	Safety of Transportation routes	[11-12]
3.2	Unclear supervisory role of consultant	[14]		7.0 Material	
3.3	Unclear Coordination process		7.1	Poor Quality of materials	[11]
3.4	Unclear consultant deliverables	[9]	7.2	Delay in delivery of materials	[11,14]
	4.0 Documentation		7.3	Fluctuation in material costs	[14]
4.1	Inadequate form of Contract	[14]	7.4	Client supplied material conflicts	[11]
4,2	Inaccurate reflection of prices	[14]		8.0 Design	
4.3	Ambiguity in terms, specs etc.	[9, 14]	8.1	Design changes	[11,14]
4.4	Inaccurate definition of working or site conditions	[14]	8.2	Errors and omissions in design	[9]
4.5	Conflicts within the contract	[9]	8.3	Unclear scope of work	[9]
4.6	Unclear roles/responsibilities	[13]	8.4	Changes in applicable technology	[9]
4.7	Unclear project objectives	[9]	8.5	Design complexity	[9]
4.8	Custom clearance processes and responsibility unclear	[13]	8.6	Inadequate working drawings	[9]
4.9	Un availability of associated infrastructure projects	[11,12]	8.7	Ambiguity in design	[9]
4.10	Ambiguity in permit/approval process	[11]	8.8	Design conflict with government regulations	[9]

4.11	Undefined CSR requirements	[12]	8.9	Design not conforming to owner's requirements	[9]
4.12	Undefined QA/QC procedures	[11]	8.10	Change in specifications	[9]
4.13	Force Majeure provision lacking or unclear	[12]	8.11	Inappropriate project feasibility study	[13]
4.14	Incomprehensive Force Majeure provision	[12]	8.12	Inappropriate technology/ software for design	[9]
4.15	Missing indemnity clauses/compliance to owner requirements	[9]	8.13	Inadequate design	[11,14]
4.16	Lack of Alternative Dispute Resolution Mechanism / Inefficiency of legal process	[14]	8.14	Inappropriate tech. selection	[9,10]

4. Risk Factor Authentication through Delphi Analysis

The objective of this study is to authenticate the risk factors identified through the literature review, which can be addressed through clauses in construction contracts. Authentication includes the applicability of these risk factors in Pakistan's Oil and Gas sector, as well as verification that these can be addressed during the contract development stages of infrastructure projects. The process adopted for authentication of the contractual risks is shown in Fig. 1.

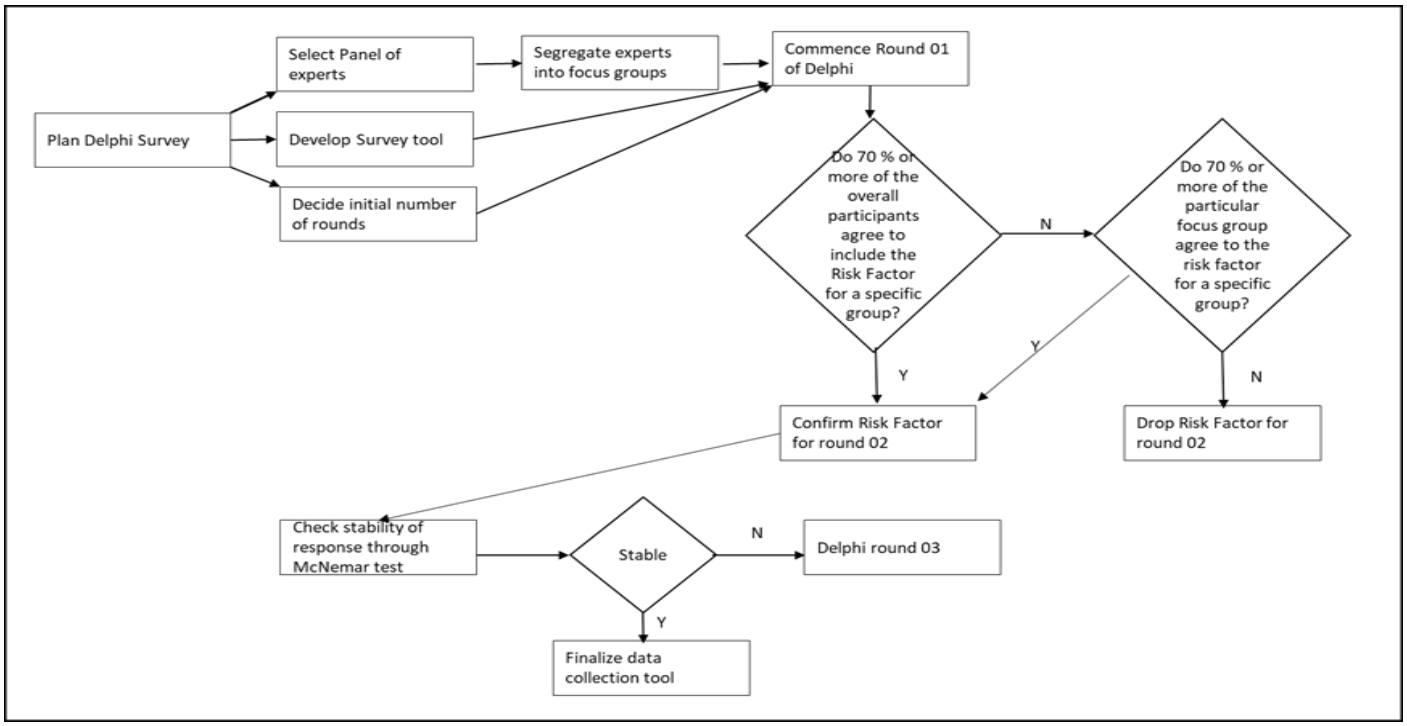

Fig. 1. Process for authentication of the contractual risks

Authentication of the contractual risks was required to ensure the applicability of these clauses in the Oil and Gas Sector. For authentication, selected experts from the Oil and Gas sector in Pakistan reviewed and provided feedback on the list of contractual risk factors consolidated from the literature review, along with mapping each risk to the most relevant stakeholder. The technique used to solicit this feedback was the Delphi technique. Mitchell has stated that "the largest number of Delphi studies are used in the physical sciences and engineering" [31].

4.1 Planning of Delphi

The planning of a Delphi survey, as explained by Stevenson [18], includes: defining the aim and scope of the survey, conducting a literature review, preparing a draft survey, seeking feedback in multiple rounds from a panel of experts, finalizing the survey tool, defining the expertise required of the respondents to the survey and specifying survey distribution and collection methods.

Delphi Techniques' application aligns with what Stevenson [18] explained. The survey aimed to

authenticate contractual risk factors applicable to Pakistan's Oil and Gas Sector, along with mapping each risk to the most relevant stakeholder. This follows a literature review that identified sixty-one contractual risk factors. These contractual risk factors formed the basis of the survey tool. A decided stopping criterion determined how many rounds were required. This stopping criterion had its basis on the level of agreement and stability of responses. The criteria for selecting experts were their qualifications and experience in Pakistan's oil and gas sector. Chan et al. (2001), have elaborated on the difficulties faced in conducting the Delphi surveys and have highlighted the need to keep the questionnaire simple [32].

4.2 Focus group

The key elements that need to be finalized for the Delphi process as defined by Day and Bobeva (2005), are the selection criteria of Delphi experts, the number of Delphi experts required, and the number of rounds .[16] One of the critical criteria for selecting Delphi experts is that they should have the knowledge and /or experience in the area under investigation. They can be judged by their positions in the oil and gas sector, professional qualifications, relevant work experience, and publications [15]. Each factor, as mentioned earlier, i.e., position, qualification, experience, or publications, can be assessed independently or in any combination thereof. Meeting all criteria was not necessary. Another key criterion for selecting experts is individuals' willingness and motivation to engage in the process [16]. The authenticity and accuracy of responses are usual criteria for the success of the Delphi process [33]. Therefore, focus group experts were selected based on their expertise (i.e., qualification, number of years in the sector.) in the oil and gas sector. The focus group was divided into four sub-groups of six each based on their roles, i.e., Client, Consultant, Legal, and Bidder.

The respondents engaged through face-to-face meetings, telephone calls, and emails. Out of the twenty-four respondents, eight were top-level executives holding the position of Chief executive officer or Chairman. Six respondents were at the level of country manager, Director, Chief operation officer, or General manager. The remaining ten respondents held various positions lower than the two above-identified categories. Fig. 2 provides details of the professional level of respondents.

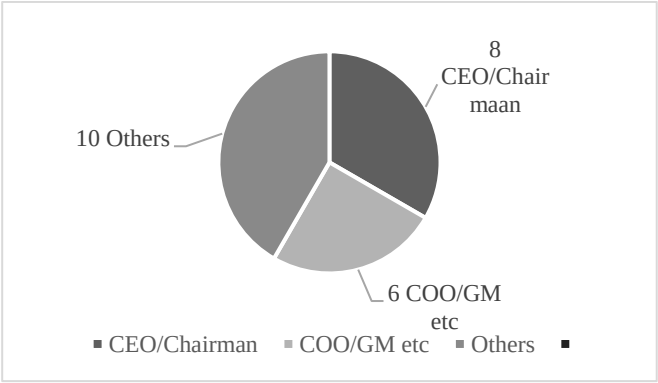

Fig. 2. Professional level of expert group respondents

These twenty-four respondents had overall experience ranging from forty-five to five years, with an average of twenty-seven years. Their relevant experience ranged from three to forty-five years with an average of nineteen years.

4.3 Number of experts

Ameyaw et al. cited eighty-eight papers in their research [15]. Out of these eighty-eight papers, sixty-seven specified the number of experts that made up the panel size. They further elaborated that the panel size ranges from three to ninety-three. However, forty-one of these papers, which make up the majority of papers, show that the panel size has ranged from eight to twenty. In this research, 30 experts were contacted to be part of the expert groups. Out of thirty, 24 experts agreed to be part of the Delphi analysis.

4.4 Focus groups

Ameyaw et al. stated that setting boundaries in the expert panel improve the process's validity. These boundaries divide the experts into groups [15]. After that, the intergroup analysis helps test the similarity of agreements reached between different groups.

The Delphi process in this research envisaged the development of focus groups of experts in the Oil and Gas Sector, classified as client/owner, consultants, legal, and bidders.

A total of twenty-four experts were grouped into four focus groups. The first focus group was made up of six clients, the second focus group was made up of six consultants, the third focus group was made up of six legal experts, and the fourth focus group was made up of six bidders.

The six experts in the owner-client category had overall experience ranging from thirty-one to forty-one years, with an average of thirty-five years. Their relevant experience ranged from ten to thirty-five with an

average of twenty-six and a half years. They included two former managing directors and a major oil and gas company's chief executive officer (CEO).

The six experts in the Design Consultants category had an overall experience ranging from eleven to forty-five years, with an average of thirty-three and a half years. Their relevant experience ranged from four to forty-five, averaging twenty-one years.

The six experts in the Legal Consultants category had overall experience ranging from five to twenty-eight years, with an average of eighteen and a half years. Their relevant experience ranged from three to twenty, with an average of eleven and a half years.

The six experts in the Bidders category had overall experience ranging from eleven to forty-five years, with an average of twenty-two and a half years. Their relevant experience ranged from four to forty, with an average of twenty-two years. The experience details of the experts' focus group are illustrated in Fig. 3.

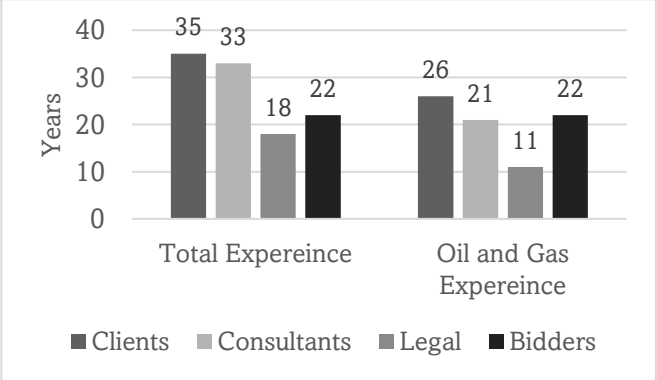

Fig. 3. Experience of focus group

4.5. Engagement in round one.

Once the panel of respondents was established and the contractual risk factors finalized for purposes of testing by Delphi experts, the first round of Delphi engagement was commenced' The responses were collected through structured interviews (in-person and online). They were analyzed by applying the following criteria:

a) If over seventy percent of the respondents agreed that a particular contractual risk factor was significant to a particular stakeholder, then that factor was mapped to that particular stakeholder and included in the questionnaire for round two of the Delphi process.

b) If the level of agreement from criteria (a) above was found to be less than seventy percent, then specific sub-group responses (i.e., from the client, design consultant, legal consultant, and bidders) were reviewed. If more than seventy percent of a specific sub-group agreed that the risk factor is crucial for them, then it has been mapped to them and included in the questionnaire for round two of the Delphi process in the overall assessment.

c) If neither the criteria given in a or b above was met, and there were specific views of the respondents that the said factor is not applicable, then the factor was dropped from the questionnaire for round two of the Delphi process.

A literature review supports this criterion. Research using the Delphi technique has used a criterion that if more than eighty percent concurrence was obtained from the respondents, it was considered an expert panel recommendation [27]. Watkins and Pacheco (2000), found that eighty-eight percent used percent of agreement in assessing observation agreement of the twenty-seven articles they studied [34]. They further define the percent of agreement as the number of agreements between observers divided by the total observations and then multiplied by one hundred. Morris et al.(2008), indicate that Agreement levels should reach 70% or more for them to be acceptable" [35]. The agreement percentage is calculated by dividing the positive responses by the total responses, and the equation is shown in Eq. 2.

$$Agreement\% = \frac{Total\ Positive\ Responses}{Total\ Responses}\ x\ 100 \qquad (2)$$

The data collection tool asked the respondents to identify which focus group would be best suited for making sure inclusion of a provision or remedy in the contract for addressing a specific risk. It indirectly indicated which focus group was most suitable to frame the response to the risk factor and which group was presumed to be accountable for the inclusion of these remedies to risk factors in the contract.

4.6 Engagement in round two.

The process used for round one was repeated for round two. Of the original twenty-four respondents, two did not respond to round two, while twenty-two of the original respondents did respond to round two. This was a 91.67 percent response of the original respondents.

The responses received were tested against three criteria which were.

1. Level of agreement.

2. Stability of response of the individual respondents using the McNemar test.
3. Stability of response to each of the contractual risk factors using the McNemar test.

The McNemar test assesses the stability of response between the rounds and relies on the expectation that deviation on either side of the agreement or disagreement side will be the same and is discussed further under the section dealing with stopping criteria.

4.7 Stability of responses

The McNemar test was applied to the responses of each induvial to the same risk factors in rounds one and two to check the stability of the response of each particular individual between the two rounds. A second test was carried out by summing the responses of the individuals to check the stability of response between rounds of the individuals as a group.

5. Analysis of Results

Once the data collection from the Delphi process was completed, an analysis was carried out to check the level of agreement and stability of responses. There was one factor for which no stakeholder was identified as being responsible for inclusion in the contract: government-related delays.

5.1 Delphi Round 01 Results

The responses received in round 01 showed an agreement of greater than seventy percent on the applicability of all the risk factors either under a or b above, and none met the exclusion criteria in c above. Hence all risk factors were included in the data collection tool for Delphi round 02.

5.1.1 Clients

After Round One of Delphi, it was observed that the responsibility of fifty risk factors could be mapped to the clients. Out of these fifty, there were four risk factors that the client subgroup agreed should be mapped to the clients. However, the overall focus group did not meet the seventy percent criteria of focus group agreement. These four factors were 4.4 inaccurate definitions of working or site conditions, 4.8 Custom clearance processes and responsibility unclear, 8.7 Ambiguity in design, and 8.9 Design not conforming to owner's requirements.

5.1.2 Consultants

In Round one of Delphi, it was observed that the responsibility of thirty-one risk factors could be mapped to the consultants. There were no risk factors that the entire focus group agreed should be mapped to the consultants who did not meet the consultant's focus sub-group criteria of seventy percent.

5.1.3 Legal

In Round one of Delphi, it was observed that the responsibility of ten risk factors could be mapped to the legal professionals. Out of these ten, there was one risk factor that the legal sub-focus group agreed should be mapped to the legal professionals. However, the entire focus group did not meet the seventy percent criteria of focus group agreement. This single risk was 4.1 inadequate form of contract.

5.1.4 Bidders

In Round one of Delphi, it was observed that the responsibility of twenty-four risk factors could be mapped to the Bidders. Out of these twenty-four, there were thirteen risk factors that the Bidders focus subgroup agreed should be mapped to the bidders. However, the entire focus group did not meet the seventy percent criteria of focus group agreement.

5.2 Delphi Round 02 Results

5.2.1 Clients

After Round two of Delphi, it was observed that the responsibility of fifty-seven risk factors could be mapped to the clients. One of the previously mapped factors was reversed and removed from client responsibility which was 1.2. Was there a process in the contract to deal with the increase in cost? The eight additional risks mapped were

The difference of opinion on the above mentioned in the results for round 01 on four risk factors was also seen in the second round of Delphi. The eight risk factors mapped to clients in round two which were not mapped in round one are 4.5 Conflicts within the contract, 4.13 Force Majeure provision lacking or unclear, 4.14 Incomprehensive Force Majeure provision, 4.16 Lack of Alternative Dispute Resolution Mechanism / Inefficiency of legal process, 4.18 Contractor lack of experience / Unclear Work methodology/Value Engineering, 8.12 Inappropriate technology/ software for design, 8.13 Inadequate design and 8.14 Inappropriate tech. Selection. For these eight risks, the client focus subgroup did assess them to be mapped to

clients; however, the entire focus group was of the view that it should not be mapped to the clients.

5.2.2 Consultants

There was no change in the stakeholder mapping for consultants when comparing round 01 and round 02. It was observed that the responsibility of the same thirty-one risk factors could be mapped to the consultants.

5.2.3 Legal

After round two of Delphi, the number of risks mapped to legal professionals increased from ten to eleven. Of these eleven, there were three risks on which the focus group did not reach a seventy percent agreement level, whereas the general population did reach the required seventy percent level of agreement.

5.2.4 Bidders

In Round one of Delphi, it was observed that the responsibility of twenty-four risk factors could be mapped to the Bidders. Out of these twenty-four, there were thirteen risk factors that the general population agreed should be mapped to the bidders. However, the bidders' focus group did not meet the seventy percent criteria of focus group agreement. After Round two of Delphi, it was observed that the responsibility of the twenty-four risk factors mapped in round one remained unchanged. However, there were only two risk factors to which the bidders' focus group did reach a seventy percent agreement. There was a seventy percent agreement of the general population that this risk should be mapped to the bidders.

5.3 Comparison of Delphi Round 01 and Round 02 Results

A comparison of the two rounds indicates that there is no change to the applicability of the risk factors to oil and gas infrastructure projects in Pakistan. There is, however, a difference in perception between the two rounds as to which is the competent category of professional best suited to address the said risks. After round two of Delphi, another tabulation was done of the results to analyze the mapping of the risks to each of the key stakeholders, i.e., Client, Consultant, Legal, and bidders. The tabulation shows the risk ID number, the Delphi round numbers, and the response of the total focus group in the column indicated by F, while S indicates the response of the sub-focus group. This tabulation is shown in Table 2. It was observed that the same level of agreement was obtained for factors themselves between the two Delphi rounds. At the same time, changes did occur as to which particular focus group would be best suited to address these risk factors. That is to say that the respondents agreed to the validity of the risk factor but changed their views on who should take ownership of it in terms of ensuring it is adequately addressed in the contract documents. Based on this test, all factors were retained in the data collection tool for the research. These risk factors were also mapped to the relevant stakeholders, as shown in Table 3.

Table 2

Results of Delphi Rounds

Risk ID	Delphi Rounds															
	1		2		1		2		1		2		1		2	
	Group															
	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S
	Client				Consultant				Legal				Bidder			
1.0 Management of Change																
1.1	100	88	100	86	50	33	50	36	50	29	40	27	33	33	33	36
1.2	83	79	60	68	83	54	83	45	17	38	40	45	33	46	67	50
1.3	100	75	100	73	50	25	50	27	67	71	60	68	33	42	33	41
1.4	83	79	100	82	33	13	33	14	50	63	60	59	67	54	67	55
1.5	100	75	100	73	67	25	67	27	50	50	60	50	50	46	50	45
1.6	100	79	100	77	33	13	33	14	67	50	80	50	33	38	33	36
1.7	100	75	100	73	50	17	50	18	100	92	100	91	33	25	33	23
2.0 timelines																
2.1	67	75	60	77	83	38	83	41	33	17	20	14	50	54	33	50
2.2	83	71	80	68	83	63	83	64	-	-	-	-	83	63	83	59
2.3	83	75	80	73	50	25	50	23	17	25	20	27	67	75	67	73
2.4	67	67	60	64	50	46	50	45	33	63	40	68	50	67	50	64
3.0 Coordination and Communication																

3.1	100	88	100	86	83	50	83	86	33	25	40	50	83	67	83	27
3.2	100	75	100	73	100	75	100	73	33	21	40	23	50	50	50	50
3.3	83	79	80	77	83	75	83	73	33	17	40	18	67	46	67	45
3.4	83	71	80	73	100	75	100	68	17	8	20	9	67	50	33	41
4.0 Documentation																
4.1	100	79	100	77	83	50	83	50	83	63	60	55	67	46	67	41
4.2	100	75	100	77	83	63	83	64	17	29	-	27	67	54	67	55
4.3	50	54	60	55	67	33	67	32	100	88	100	86	67	50	67	55
4.4	83	63	80	59	50	38	50	36	33	13	40	9	83	67	83	73
4.5	67	46	80	50	83	38	83	41	83	88	100	91	50	42	50	45
4.6	100	96	100	95	83	54	83	55	50	38	40	36	83	58	83	64
4.7	100	88	100	86	50	58	50	59	-	4	20	9	17	29	17	23
4.8	100	67	100	64	33	21	33	18	50	42	60	45	67	58	67	55
4.9	83	75	100	77	50	46	50	41	-	4	-	5	83	54	83	59
4.10	100	75	100	73	67	38	67	36	50	33	60	36	67	63	67	59
4.11	100	88	100	86	50	25	50	23	-	38	-	41	67	54	67	55
4.12	83	71	100	73	83	67	83	64		-	-	-	100	63	100	64
4.13	67	58	80	59	67	21	67	18	100	71	100	68	67	50	67	50
4.14	67	54	80	55	67	33	67	32	67	71	60	68	50	46	50	45
4.15	50	50	60	50	67	21	67	23	100	88	100	86	33	33	33	32
4.16	67	63	80	64	67	33	67	36	100	100	100	100	50	38	50	36
4.17	100	88	100	86	50	21	50	18	50	67	60	68	17	25	33	27
4.18	67	58	80	59	83	63	83	59	-	4	-	5	83	71	59	68
5.0 People																
5.1	100	79	100	77	67	33	67	32	17	21	20	23	83	88	83	86
5.2	83	79	80	77	33	25	33	23	17	25	20	27	83	71	83	68
5.3	100	79	100	77	33	25	33	23	17	54	20	55	83	71	83	68
5.4	83	79	80	77	33	13	33	9	67	71	60	68	67	71	67	68
6.0 HSE and Security																
6.1	83	75	100	77	50	46	50	45	50	25	60	27	100	79	100	86
6.2	83	79	100	82	67	54	67	50	50	38	60	36	83	71	83	68
6.3	83	75	100	77	67	58	67	55	50	54	60	50	83	63	83	64
6.4	83	71	100	73	67	54	67	50	17	33	20	32	100	75	100	73
6.5	100	88	100	86	33	21	33	18	67	63	60	64	83	71	83	68
6.6	67	75	80	77	33	25	33	23	17	33	20	32	83	71	83	68
7.0 Material																
7.1	83	79	100	82	83	63	83	59	17	13	20	14	67	67	67	64
7.2	83	75	100	77	83	58	83	59	17	8	20	9	83	63	83	64
7.3	67	75	100	82	83	54	83	59	17	21	20	14	83	67	83	68
7.4	67	83	60	82	83	46	83	50	17	21	20	23	83	63	83	59
8.0 Design																
8.1	83	79	100	82	100	92	100	91	17	21	20	23	67	54	67	50
8.2	67	75	80	77	83	83	83	82	17	17	20	18	67	42	67	41
8.3	67	75	100	82	100	83	100	82	17	17	20	14	50	58	50	55
8.4	67	71	80	73	100	88	100	73	17	8	20	9	83	50	83	50
8.5	83	71	100	73	100	96	100	95	-	8	-	9	50	38	50	36
8.6	83	71	100	73	100	83	100	82	-	8	-	9	67	54	67	50
8.7	83	67	100	68	100	92	100	91	-	13	-	14	50	46	50	45
8.8	83	71	100	73	100	79	100	77	50	50	60	50	67	42	67	41
8.9	83	67	100	68	100	92	100	91	-	13	-	14	67	50	67	45
8.10	83	79	100	82	100	83	100	82	17	13	20	14	83	63	83	64

8.11	100	75	100	73	100	63	100	64	-	8	-	9	83	46	83	50
8.12	67	54	80	55	100	92	100	91	-	8	-	9	-	21	-	18
8.13	67	58	80	59	100	92	100	91	-	8	-	9	33	21	33	18
8.14	67	67	80	68	100	88	83	82	-	13	-	14	50	29	50	27

Table 3

Contractual Risk Factors to Stakeholder Responsibility Mapping

Risk ID	Responsible	Risk ID	Responsible	Risk ID	Responsible
01 Management of Change		4.5	Client, Consultant, legal	6.4	Client, Contractor
1.1	Client	4.6	Client, Consultant, bidder	6.5	Client, Contractor
1.2	Client, Consultant	4.7	Client	6.6	Client, Contractor
1.3	Client, legal	4.8	Client	7.0 Material	
1.4	Client	4.9	Client, Bidder	7.1	Client, consultant
1.5	Client	4.10	Client	7.2	Client, consultant, bidder
1.6	Client, legal	4.11	Client	7.3	Client, consultant, bidder
1.7	Client, legal	4.12	Client, Consultant, bidder	7.4	Client, consultant, bidder
2.0 Timelines		4.13	Client, legal	8.0 Design	
2.1	Client, Consultant	4.14	Client, legal	8.1	Client, consultant,
2.2	Client, Consultant, Contractor	4.15	Legal	8.2	Client, consultant,
2.3	Client, Contractor	4.16	Client, legal	8.3	Client, consultant,
2.4	None	4.17	Client	8.4	Client, consultant, bidder
3.0 Coordination and Communication		4.18	Client, consultant, bidder	8.5	Client, consultant,
3.1	Client, Consultant, Contractor	5.0 Human Resources		8.6	Client, consultant,
3.2	Client, Consultant	5.1	Client, Contractor	8.7	Client, consultant,
3.3	Client, Consultant	5.2	Client, Contractor	8.8	Client, consultant,
3.4	Client, Consultant	5.3	Client, Contractor	8.9	Client, consultant,
4.0 Documentation		5.4	Client, Legal, Contractor	8.10	Client, consultant, bidder
4.1	Client, Consultant, legal	6.0 HSE and Security		8.11	Client, consultant, bidder
4.2	Client, Consultant	6.1	Client, Contractor	8.12	Client, consultant,
4.3	Legal	6.2	Client, Contractor	8.13	Client, consultant,
4.4	Client, Contractor	6.3	Client, Contractor	8.14	Client, consultant,

5.4 Stability of response using McNemar test

The Chi-Square statistic was 3.84 using 1 degree of freedom with P=0.05; any value of less than 3.84 was considered acceptable. The McNamara's test was carried out in four different ways as follows:

5.4.1 Application of the McNemar test to the aggregated responses to the risk factors.

When the McNemar test was applied to the entire set of questions, the Chi-square statistic was found to be 2.78, which is within the acceptable range of the statistic hence confirming the responses to the set of risks as a whole were stable.

5.4.2 Application of the McNemar test to the responses to the individual risk factors.

There were sixty-one risk factors, with each being potentially linked to the four stakeholders, i.e., Client, Consultant, legal, and bidders, making a possibility of two hundred and forty-four possible links. Each of these links was tested for stability of responses, and it was observed that thirty-three of these links changed from round one to round 02. Computations for the chi-square statistic showed that thirty-two of these links had a chi-square statistic of 1 while one had a chi-square statistic of 2. The acceptable statistic was up to 3.8, confirming the stability of response to the individual linking risk factors to stakeholders. There was no change in the risk to stakeholder linking for 211 links, accounting for eighty-six percent of the responses.

5.4.3 Application of the McNemar test to the aggregated responses by the respondents.

When the McNemar test was applied to the entire group of respondents, the Chi-square statistic was found to be 2.78, which is within the acceptable range of the statistic, confirming the group as a whole was stable.

5.4.4 Application of McNamara's test to the responses of the individual responses.

In this scenario, where the stability of each respondent was checked, it was observed that there was no change in individual responses between rounds for eighteen respondents, which accounted for almost eighty-two percent of the group. The remaining four individuals changed their response to the extent to which a particular focus group would be appropriate to respond. Two individuals did not respond in round two and are excluded from the calculations, and the total number is considered as twenty-two. The chi-square statistic for those who changed their opinion was less than 3.84, which was considered acceptable except for individuals for whom the Chi-square statistic was 5.33, which shows the individual to have a non-stable response. This being an isolated case, accounting for 4.5 percent of the population, was ignored. Hence the null hypothesis was validated for more than 95 percent of the population leading to the conclusion that the responses of the individuals in the focus group were stable. The details of the change in response between rounds are illustrated in Fig. 4.

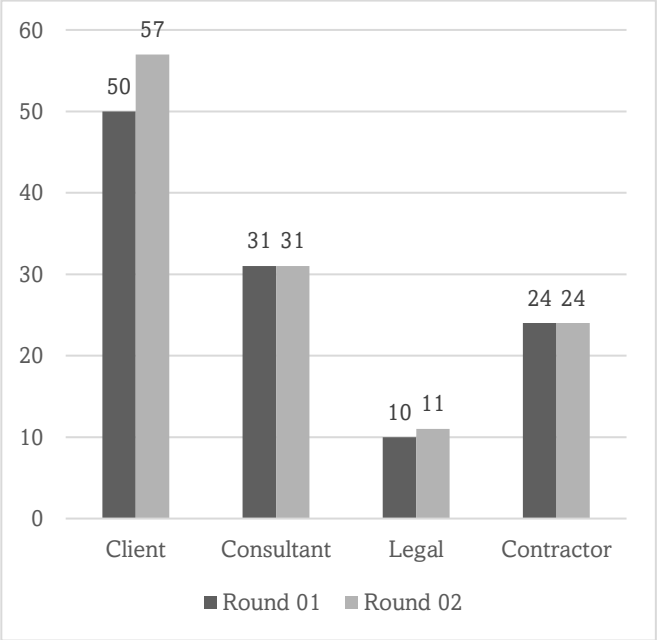

Fig. 4. Change of response between Delphi rounds

5.5 Stability of response to each contractual risk factor using McNamara's test.

In this scenario, the responses to individual risk factors were checked. It was observed that responses to 39 risk factors remained unchanged, which accounts for 64 percent of the total risk factors.

Responses to the remaining 22 risk factors, which account for 36 percent of the total risk factors, did change to the extent to which the focus group would have a predominant influence on these factors. The acceptability of the factors themselves remained the same. The McNemar test was applied to check the stability of the shift in focus groups. It was observed that all changes were within the acceptable range of the F statistic, confirming the null hypothesis and confirming that the responses to the risk factors were stable within the two rounds. The McNemar test was applied to the individual risk factors and the combined risk factors as a whole by summing the individual Responses. A deeper look was taken into which group of risk factors saw the most significant changes, and it was observed that the highest percentage change was in the area of health, safety, and environment (HSE) and Security, and the lowest change was in design. In this research, the McNemar test was applied. It was observed that while respondents tended to change their views on which category of respondents should be responsible for addressing the risk, there was no change in the risk factors themselves. With this degree of conformance, the Delphi process was stopped at round two.

The disagreement in the views of the general population with the relevant focus group highlights a key concern that while the general population is working on the premise that a particular focus group is responsible for certain risk factors, the general population would leave it to that particular stakeholder to ensure inclusion in the contract. However, the particular stakeholder does not consider that risk to be mapped to them, hence may overlook its inclusion in the contract.

6. Conclusion and Recommendations

Oil and Gas Sector experts tested the risk factors identified through the literature review in Pakistan. These experts represented the viewpoint of clients, consultants, legal representatives, and bidders. The experts agreed on the applicability of these risk factors in the Oil and Gas sector of Pakistan. The Delphi technique, which was applied to authenticate this applicability, proved successful both in the level of agreements reached and the stability of the respondent's stability of the applicability of the risk factor. It is recommended that these factors be used as a checklist when developing tender and contract documents, improving project success. This checklist should be applied using an Artificial intelligence system which will help avoid human error, reduce the workload and expedite the process. This Artificial intelligence system can be supported by a solutions database based on

lessons learned from previous projects and complemented by solutions available in academic literature. It is further recommended that studies be carried out for the oil and gas sector in Pakistan to establish a) Pre-Contract risks that have to do with the client organization, including processes issues, and b) Allied risks that the client should be aware of and tackled outside of the contract.

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