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QUALITY PAPER

Risk assessment in Iranian oil and gas construction industry: a process approach

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Abstract

Purpose – Successful risk management is influential in different phases of construction projects. It can play a critical role in reducing the possibility of claims as well as related disputes. The risk management knowledge area in large capital projects such as oil and gas is considered a questionable problem in the construction industry. The present study makes an effort to identify the importance of process groups in improving risk management performance.

Design/methodology/approach – This study is selected and ranked 36 factors leading to the claim in Iran's oil and gas industry through the Delphi method and a questionnaire. Factors categorized into a risk breakdown structure (RBS) include eight groups. Factors are linked to one of the process groups by a Delphi method. Finally, the relationship between RBS and the five process groups is analyzed using partial least squares *structural equation modeling (*PLS-SEM).

Findings – Findings showed that the planning process group had more confirmed factors than others. Most of the supported communications belonged to the contractor and the owner parties. Also, the cause of delay in the implementation phase due to the contractor performance had a higher relative importance index.

Originality/value – This article, from a project life-cycle perspective, considers the new structure between the risks leading to claims and the key parties to the project. It can be a good criterion for identifying risks and a timelier response to them before the risks turn into disagreements.

Keywords Risk management, Construction industry, Claim, Process groups, Oil and gas projects

Paper type Research paper

Introduction

Risks in the construction industry are uncertain events that affect project objectives in various aspects (Beltrão and Carvalho, 2018). Although the effect of risks associated with construction projects achieve some advantages, in many instances, what they bring to the owners and contractors is an increase in project time and costs (Abad *et al.*, 2019). In industrial projects, risk assessment is strategic and determines the success of projects (Yazdani *et al.*, 2019). A high level of uncertainty with a variety of causes is evident in construction projects. Completing these projects within a predetermined schedule, despite the complexity and dynamics of the projects and the existence of multiple stakeholders, seems demanding (Zarei *et al.*, 2018). Suitable risk allocation in the beginning phases can lead to improved interaction and better cooperation of working groups. However, it is challenging to reach an agreement with comprehensive provisions and an interactive approach. Also, various internal and external factors in complex construction projects have led to claims by different participant parties. Unprofessional and unbalanced risk management allows the contractor to engage in opportunistic behaviors. This defect can lead to higher costs or lower quality. Contrastingly an appropriate allocation of risks identified at the outset of the project increases the chance of establishing a reliable relationship

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between the parties (Xu *et al.*, 2018; Shen *et al.*, 2017). Even with a reasonable and standard contract, and appropriate risk distribution, claims in projects are inevitable given poor management (Bakhary *et al.*, 2015). Disputes and claims will cause many problems for project stakeholders, while claim management specialists, like other areas of project management, do not have an active presence in projects (Vidogah and Ndekugri, 1997).

The construction industry includes diverse projects such as infrastructure, transportation, oil and gas, and others (Gharouni Jafari and Noorzai, 2021; Noorzai *et al.*, 2020). Due to the dynamic, multifaceted and unique environment, different groups participating always face the possibility of conflicts (Zaneldin, 2006; Bakhary *et al.*, 2015). Large capital projects such as oil and gas are of great economic importance and macro-development plans in different countries (Mortezaei Farizhendy *et al.*, 2021). Large capital projects such as oil and gas are of high value in macro-economic development in countries (Van Thuyet *et al.*, 2007). Failure to achieve the goal set in these projects will waste enormous funding, and it slows down the development of the respective countries (Mortezaei Farizhendy *et al.*, 2020). According to reputable oil and gas companies, about 40% of projects have increased time and cost (Ruqaishi and Bashir, 2013). Almost half of the world's oil and gas resources (54% of the world's oil and 40% of the world's known gas resources) are in the Middle East (OPEC, 2017). The value of investing in these project types is significant in the Middle East and other developing countries such as Malaysia and Vietnam (Bakhary *et al.*, 2015; Van Thuyet *et al.*, 2007; Zarei *et al.*, 2018; Sweis *et al.*, 2018; Fallahnejad, 2013; Hasheminasab and Mortaheb, 2014).

The claims originate from the risks perceived in the project, and they affect the project plans in various financial and time aspects (Stamatiou *et al.*, 2019). Researchers have proposed different approaches to dealing with disputes and claims in construction projects. Some studies have suggested methods to resolve conflicts after they occur. Other researchers have recommended preventive measures to reduce the possibility of claims that takes place in projects. Zaneldin (2006) categorized the causes of the claim into six general groups, including changes, delays, different site conditions, contract ambiguity, acceleration and extra-work. Numerous studies have examined the factors and risks associated with claims from different perspectives (Table 1). Despite the extensive communication between the parties involved in construction projects, eliminating the risks seems impossible. What has been used extensively in previous studies is related to rating the factors and risks identified. These approaches do not fit well with the complex requirements of construction industry contracts. For this reason, a well-organized process requires minimizing the root causes of claims, a process that provides a context to identify and allocate risks within the project lifecycle.

Previously, Zarei *et al.* (2018) investigated the relationship between delay factors and project process groups. The present paper takes a new approach to the risks related to the claim, considering the previous studies and identified research gaps. This article analyzes the effect of the internal and external groups of risk breakdown structure (RBS) in the five process groups through the identified factors. Factors were identified through the Delphi method. The data were surveyed by experts who had sufficient knowledge in the field of risk management and claims. In this paper, according to Table 2, the RBS that was previously proposed by El-Sayegh (2008) was used to classify the identified risks. For data analysis, the partial least squares method was used to determine the existing relationship. The results of the proposed approach will evaluate the relationship between each of the three levels of risk failure structure, including identified factors (36 factors), and the role of each internal (owner, designer and contractor) and external group (political, natural, social and cultural, economic and others) with process groups.

Literature review and research background

Risks in the construction industry

Nowadays, risk assessment has become a challenge for researchers (Noorzai, 2021). The authors point out the importance of various risks in increasing the cost of construction

Table 1.
Various perspectives on risks and claim

Article/scope of research	Classification	Important causes	Process done
(Arditi *et al.*, 1985)/delays in infrastructure projects	Reasons for delays	Difficulties in preparing materials Contractors' problems with government financing Contractors' financial problems	Ranking delays and explaining causes
(Aibinu and Odeyinka, 2006)/delays in Nigerian construction	Related to different working groups, external risks	Contractors' financial problems Problems with the employer's financial flow	Analyzed the importance of each factor
(Zaneldin, 2006)/claims on the UAE construction industry	Changes, extra tasks, delays, different site conditions, expedited tasks, uncertain contract terms	Change orders Owner delay Owner verbal change orders	Providing solutions with regard to claims handling practices
(Van Thuyet *et al.*, 2007)/risk in Vietnam's oil and gas projects	Project risks	The bureaucratic structure of government and its long processes Poor design Unqualified project team	Identification of appropriate strategies to deal with the important risks
(Motawa *et al.*, 2006)/change orders in construction projects	Reasons for changes	Owner revised needs Comprehensive planning Insufficient design information	Providing a fuzzy approach to change
(Sweis *et al.*, 2008)/delays in Jordan construction projects	Human resources, materials and equipment, project environmental and external factors, government laws and regulations	Financial problems caused by the contractor a lot of change orders of owner Unskilled workforce	Use of analysis of variance and determination of each of the main factors of construction
(Ruqaishi and Bashir, 2013)/delays in Gulf oil and gas projects	Related to working groups, materials, labor and equipment, contractual, contractual relations, external causes	Poor site management and oversight by the contactor Problems with subcontractors Improper planning and scheduling of the project by the contractor	Providing solutions to respond appropriately to identified key factors
(Fallahnejad, 2013)/delays in gas industry projects	Workgroups, communications, contracts, labor and equipment, materials, external agents, interface	Contractor inability to import the required materials Unlawful contract length provided by the owner Slow delivery of materials by the employer	Ranking the effective identified factors

(*continued*)

Article/scope of research	Classification	Important causes	Process done
(González *et al.*, 2013)/delays in construction	Design stages, weather, materials and equipment	Subcontracts Planning Materials and equipment	Analyzing the time using the identified factors
(Hasheminasab and Mortaheb, 2014)/claim management in Iranian oil and gas industry	Change of conditions, extra work, delays, contract duration	External risks, financial problems in the contractor organization, financial problems in the owner organization	Providing the solution to respond appropriately to the important risks identified
(Yusuwan and Adnan, 2013)/claim on Malaysia's oil and gas projects	EOT-related claims	Concurrent delay Includes knowing every delay for extended times Failure of the contractor to comply with the terms of the contract	Identification of the effective factors and providing the right solution
(Bakhary *et al.*, 2015)/claim on Malaysia construction projects	Reasons for claims	Changes in design after bidding Inadequate research at the beginning of the project Insufficient research and unclear scope of the contract	Identification problems in different claims management processes
(Yousefi *et al.*, 2016)/claim on Iran construction projects	Project management knowledge areas	Economic inflation and rising resource prices Doing overtime at no price specified in the contract Insufficient funds at the beginning of the project	Using a multilayer neural network to predict cost and time-related claims
(Kazemi *et al.*, 2020)/delays in Iran's oil and gas projects	Owner, contractor, consultant, equipment, labor, materials, design, contract and contractual Relations, laws and regulations, environmental factors	Lack of feedback in case of any deviations in time and cost Economic changes such as changes in the exchange rate Inflation	Using fuzzy Delphi method
(Arditi *et al.*, 2017)/delays in the construction industry	Reasons for delays	Delay in contractor payments by employer Design changes during construction Incomplete design (high frequent)	The impact of organizational culture on the occurrence of delays

(*continued*)

Table 1.

Article/scope of research	Classification	Important causes	Process done
(Shen *et al.*, 2017)/delays in the construction industry	External risks, client organizational behavior, project definition in contract, claim	Unspecified technical specifications Frequency of claims untimely payment	Impact of external risks on claims
(Beltrão and Carvalho, 2018)/risks of construction companies	Social, project, construction, financial, economic, political, environmental, managerial	Problems getting licenses Design changes during construction Corruption	Ranking using fuzzy AHP
(Zarei *et al.*, 2018)/delays in Iranian oil and gas	Reasons for delays	Time-consuming processes for reviewing and approving control proposals and programs Wrong financial estimates in the early stages	Assessing the impact of risks on the project according to the phases of the project using SNA
(Stamatiou *et al.*, 2019)/claims in the construction industry	Reasons for claims	Increase in scope Acceleration Delays (high frequent)	Providing a model based on supply chain management
(Yana *et al.*, 2015)/changes in the construction industry	Design changes	Owner Consultants Construction management consultant	Determination each of the factors in design changes using PLS
(Sweis *et al.*, 2018)/delays in Iranian oil and gas	Reasons for delays	Planning and scheduling problems Problems with the financial flows of the employer, contractor, and subcontractors Political situation	Analysis of the effective factors identified using ANOVA and fishbone chart
(Baloi and Price, 2003)/claim on the construction industry	Reasons for claims	Financial problems Problems in the supplies program Change orders	Determination of the likelihood of claims using BIM

Table 1.

projects and the performance of the schedule (Sadeh *et al.*, 2021; Mukilan *et al.*, 2021). Although it may be the most cost-effective way to manage risks by eliminating them, many highly profitable projects have a higher degree of complexity and uncertainty in their lifecycle (Gharouni Jafari *et al.*, 2021; Szymański, 2017). Costs for oil and gas projects are over-expected. It can be due to inadequate risk management at the planning stage (Rui *et al.*, 2017). Oil and gas projects are exposed to numerous internal and external risks (Dadkani *et al.*, 2021). This is due to many stakeholders involved in the relevant contracts and high technical complexity. The occurrence of these can have negative effects on different parts of the project (Sweis *et al.*, 2018). Risk management involves the areas of cost, time, quality and scope (Golabchi and Noorzai, 2013). These domains are interdependent and can lead to project failure or success (Beltrão and Carvalho, 2018; Yazdani *et al.*, 2019; Sadeh *et al.*, 2021). In many developing countries, contractors do not have adequate information about risks. At the beginning of the project, they are allocated a high proportion of uncertainty which is not properly managed due to their lack of knowledge. This weakness will lead to problems such as disputes, late delivery and poor quality in the next phases (Baloi and Price, 2003). There are two approaches to investigating claims management. The first one looks at the terms of the contract to try to resolve the litigation. The other approach examines claims in terms of risks assigned to the parties to the contract (Vidogah and Ndekugri, 1997). The second approach highlights the importance of preventive approaches in claim management. This approach allows potential claims to be anticipated and timely action is taken if necessary (Marzouk *et al.*, 2018). Proper risk allocation at the beginning of the project helps the parties to know what the risks are before the end of the project. This can create a positive attitude among contractors (Xu *et al.*, 2018). Researchers attribute many of the adverse events in the projects to potential factors that occur in the projects. These can affect different aspects of the project. Delays are one of the cases that many researchers have identified the causes of, depending on their area of research (Ndekugri *et al.*, 2008; Sweis *et al.*, 2008, 2018; Ruqaishi and Bashir, 2013; Fallahnejad, 2013; Guévremont and Hammad, 2018; Zarei *et al.*, 2018, Kazemi *et al.*, 2020). As can be seen in Table 1, in many cases, researchers have categorized the identified causes using the views and objectives of their study. They have investigated these factors using different approaches and methods. Van Thuyet *et al.* (2007) collected 56 items to identify the risks of Vietnam's oil and gas industry. They rate these factors through questionnaires as well as using X^2 analysis. The five important factors evaluated are bureaucracy, poor design, project team incompetence, unfavorable bidding conditions and employer delays. Kazemi *et al.* (2020) categorized the most important causes of delays in Iran's oil construction projects into ten groups. They used a logical fuzzy approach to determine the most important factors. In their results, they mention environmental factors as the most important cause of delay. Fallahnejad (2013) examines 24 gas pipeline projects, dividing the identified factors into eight groups. He cites important causes of delays in pipeline projects as being related to the supply

Level 1	Level 2	References
Internal risk (IR)	Owner (Ow) Designer (D) Contractor (Co)	Yusuwan and Adnan (2013), Marzouk *et al.* (2018), Arditi *et al.* (2017), Sweis *et al.* (2008), Aibinu and Odeyinka (2006), Zarei *et al.* (2018), Hasheminasab and Mortaheb (2014), Bakhary *et al.* (2015), Yousefi *et al.* (2016), Yana *et al.* (2015), Stamatiou *et al.* (2019), Arditi *et al.* (1985), Zaneldin (2006), Shen *et al.* (2017), Bakhary *et al.* (2015), Baloi and Price (2003), Fallahnejad (2013), El-Sayegh (2008)
External risk (ER)	Political (Po) Natural (N) Social and cultural (S&C) Economic (Ec) Other (Ot)	

Table 2. Risk breakdown structure and references

of materials within the scope of client and contractor duties, as well as inappropriate project schedules caused by the client. They first identified important factors behind the delay in oil, gas and petrochemical projects. Then, using semantic network analysis (SNA), they analyze each factor according to project process groups. Abbasi *et al.* (2020) consider delays in construction projects as one of the main causes of conflict. In their studies, they mention the contractor factor and financial problems related to the contractor as the most important factor in the delay in their results. Changes are another factor that researchers have investigated (Motawa *et al.*, 2006; Yana *et al.*, 2015; Motawa, 2007; Artan Ilter and Bakioglu, 2017). Changes have been studied as a key cause of delay. This is especially important in large projects, as it is a key factor in disputes (Motawa *et al.*, 2006; Karimidorabati *et al.*, 2016). A precautionary perspective considers change as an event that is likely to occur in the next stages of the project. Therefore, project management can plan to mitigate its effects (Abad *et al.*, 2019). Many decision-making criteria in the construction industry are interdependent (Gharouni Jafari *et al.*, 2014), for example, in items where the causes of project delays are examined, the issue of change can be influential. Fallahnejad (2013) acknowledges owner change orders as one of the important factors in delays. On the contrary, Karimidorabati *et al.* (2016) regard change as one of the main sources of delay. Many of the uncertainties in oil and gas projects initially seem non-significant. Failure to identify the different working groups and their degree of importance may result in different problems in the project phases. It can lead to claims by different groups (Yousefi *et al.*, 2016). The breakdown structure used in this study divides the identified factors based on the responding party into the internal sector and external influential domains (Table 2). Using RBS not only gives the management team better insight into risk assessment, but it also allows for an appropriate overlap with the Work Breakdown Structure (WBS) in the project implementation process (Yazdani *et al.*, 2019).

Claims in the construction industry

The claims are a direct result of the complexities of the project (El-Adaway and Kandil, 2009). The formation of claims in construction projects is almost inevitable, as it is also evident in successful projects (Yusovan and Adnan, 2013). Statistics in North America show that about half of the claims are equal to one-third of the value of the contract, 30% of them are worth more than 60% of the contract, while in some cases the cost is equal to the whole (El-Adaway and Kandil, 2009). Although a good contract can reduce future claims to some extent, it cannot eliminate the likelihood of such occurrences (Hasheminasab and Mortaheb, 2014). Any of the risks involved in the construction industry can lead to high-cost litigation and influence the success of the project by creating disputes (Artan Ilter and Bakioglu, 2017). One of the major sources of risk in construction is the changes that occur in later phases due to the ambiguity of the contract conditions at the beginning of the project (Motawa, 2007). On the other hand, the volume of disputes caused by another important factor in claims, namely delay, is increasing (Chester and Hendrickson, 2005). Bilgin *et al.* (2018) found it helpful to have a common understanding of the concept of delay. It can help with risk analysis and claim management as well as avoid delays. Diekmann and Girard (1995) considered the identification and evaluation of features in the early stages of the project as a good approach to address the causes and risks that lead to claims. Shen *et al.* (2017) pointed out three precautionary approaches to claim management, one of them considering fair risk allocation to reduce uncertainties. They note that there is an interdisciplinary relationship between risk management and other areas of management. In six phases, Bakhary *et al.* (2015) examine claims management, the first of which is introduced as the identifying phase. After reviewing the questionnaire, they explain that one of the important problems with this phase is the lack of awareness about claims and inadequate knowledge of the terms of the contract. In exploring claims in the Malaysian construction industry, Yusuwan and Adnan (2013) explain that quantitative contracts include correct definitions and legal clauses. By analyzing the questionnaire, they cited concurrent delays as a key factor. Using the modified particle swarm optimization (MPSO) algorithm, Mukilan *et al.* (2021) introduced a new approach to claim management. In order to reduce the cost and time of the project, they divided the identified factors into four groups and mentioned the deadline factor as the most important factor. Yousefi *et al.* (2016) examine 60 causes related to time and cost claims, and then categorize them into nine areas of project management knowledge. Using the analytic hierarchy process (AHP) method, they identify economic inflation, the uncertainty associated with overtime in the contract, and the lack of proper funding at the beginning of the project as three main causes. The complexity of construction increases from small projects to complicated projects such as oil and gas. Consequently, both the owners and the contractor groups face an increase in time and cost in these industries. The importance of this industry is more significant in countries where the economy is heavily dependent on oil. In the Middle East, Iran is one of the countries with huge oil and gas fields. The industry is prone to attracting domestic and foreign investment. The oil and gas industries account for about 60% of gross domestic product (GDP) and 80% of foreign exchange earnings (Hasheminasab and Mortaheb, 2014).

A large part of the previous studies is dedicated to identifying and ranking the risks' importance. Despite strategies proposed for the appropriate allocation of identified risks, no study has so far investigated the risks by considering the risk failure structure and project management process groups. This article aims to examine the relationship between risk-generating levels and each of the project process groups. This approach could give the parties a better insight before starting the project such that they can identify any risks that have the potential of leading to disputes. Furthermore, this approach aims to manage the risks with a preventive approach by determining the appropriate process group for each risk and identifying the risk-generating groups.

Research method

The present study aimed to provide a useful link between construction industry risks and project process groups in four general stages that have been created (Figure 1). To this end, it was necessary to identify the risks associated with the research area. For a better understanding, these factors were placed in an appropriate category. Then, a model of relationships was created that showed a proper relationship between each of the process groups and the identified risks. Existing relationships were considered research hypotheses to determine the extent of the effect of each factor on internal and external groups (Figure 2). Finally, the hypotheses were analyzed using a quantitative method. The partial least squares (PLS) method was used to evaluate the model and determine the correctness of the relationships (hypotheses).

Data collection

In this research, previous studies (including 18 papers) were used to prepare an initial list of risks (Table 2). Previous studies have also used this procedure. These articles cover a wide range of risks in the construction industry. Previous studies have also used this procedure. These articles cover a wide range of risks in the construction industry. This procedure has also been used by previous researchers (Beltrão and Carvalho, 2018; Arditi *et al.*, 2017). These studies cover a wide range of risks in the construction industry. Regarding the scope of this study, studies related to the oil and gas industry, especially articles related to Iran, were used for risk identification. Investigations related to the construction industry, claims and risks were considered to improve the range of risks identified (Table 2). In the first step, the risks with high frequencies in the articles were selected. Previous researchers have also used this procedure. Many factors in literature were expressed in different phrases but with the same meaning. These were considered integrated into the next step; e.g. the problems of contractors in literature, "Contractor's poor cash flow management" (Fallahnejad, 2013) and "Financial and cash flow problems facing owners, contractors, and subcontractors"

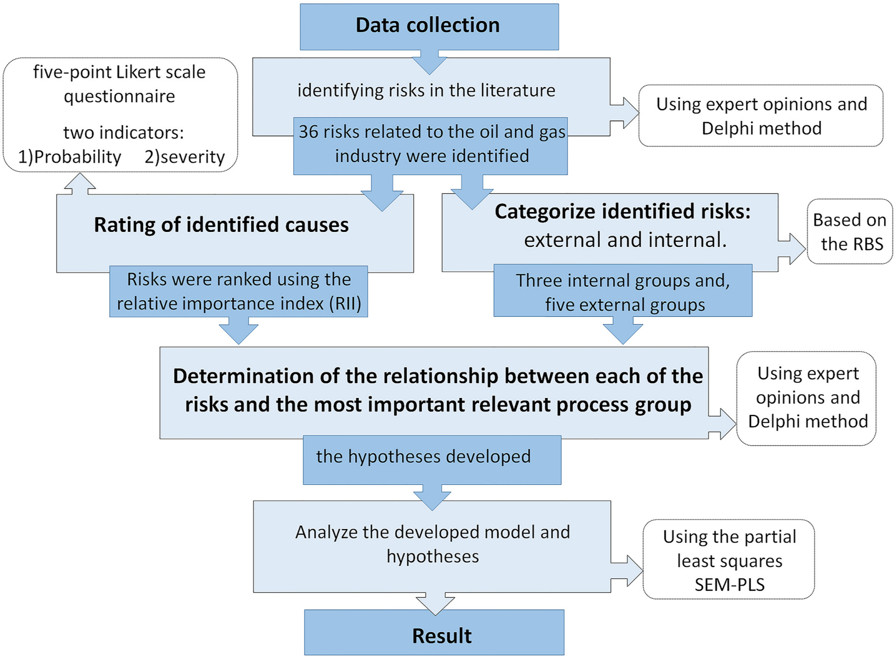

Figure 1.
A schematic diagram of the research methodology

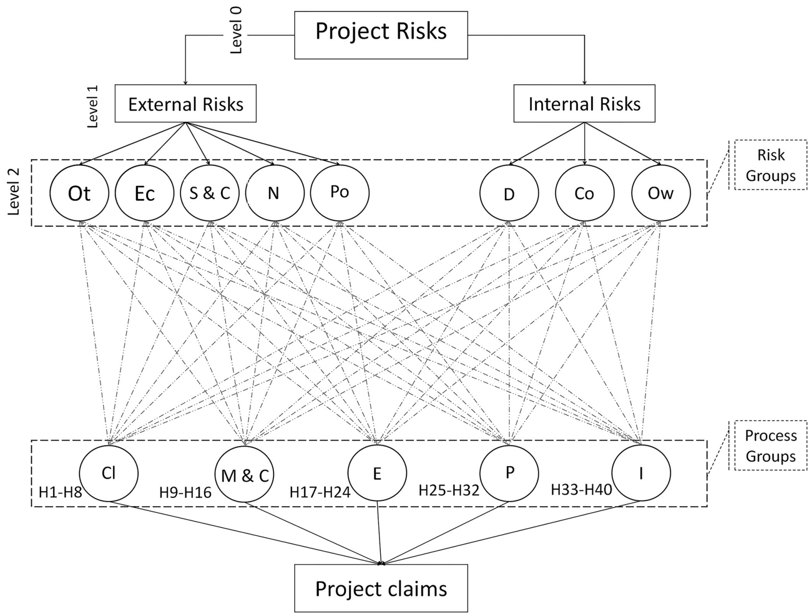

Figure 2.
Conceptual model of research hypotheses

(Sweis *et al.*, 2018). At the end of this section, it was tried to identify the potential risks associated with Iran's oil and gas construction projects because the literature review reveals that previous works have studied risks related to other sectors of the construction industry.

Moreover, as Arditi *et al.* (2017) pointed out, causes and factors vary across geographic regions. For these reasons, interviews were conducted with four groups of experts. These groups include consulting and contracting firms in oil and gas projects. In total, 11 people participated in the process, with a minimum of a master's degree and more than 20 years of experience in the field. They had the experience of working in consulting teams and as executives of the contractor organization (Tables 3 and 4). These experts were asked to identify the factors associated with oil and gas projects in Iran by specifying two responses, whether they agree or disagree. Experts conducted the interview using the Delphi method. The interviews were conducted with each of the respondents in two different periods. After informing the experts about various factors and risks identified in previous studies, they were asked to identify the causes of the claims in Iran's oil and gas projects and the factors they consider effective in shaping conflicts among project stakeholders. In the first time, the respondents identified the relevant factors, and in the second round, they corrected their opinions by knowing the opinions of other experts. After the expert discussions, 36 factors were finally selected (Table 5).

Categorizing identified risks

After identifying risks, these factors were classified into two main external and internal domains based on the RBS presented by El-Sayegh (2008) (Figure 1). In the internal risks section, due to more integration, the risk related to the subcontractors, which included one case, was placed in the section of the risks associated with the contractors (Table 2). Also, due to the identified risks, suppliers were excluded from the RBS. In the risk allocation section, it should be noted that the risks are shifted to a point where they can better monitor and control them (Xu *et al.*, 2018).

Rating of identified causes

In this section, 36 identified risks were ranked with the criterion of relative importance index. A questionnaire method was used for this purpose. First, due to the limitations of the statistical community (Iranian oil and gas industry projects), the characteristics of the statistical community include (1) work experience, (2) the presence of all working groups, (3) sufficient knowledge of risk management and (4) knowledge of the provisions of contracts were determined (Table 3). The statistical population was limited to 220 people, and 140 people were selected according to Cochran's formula (Kotrlik and Higgins, 2001). After sending the questionnaires, 136 questionnaires were collected. The statistical sample was asked to answer

Indicators	Experience	Number	Percent (%)
Owner	10–15 years	8	38
	16–20 years	9	42
	21 to up years	5	23
	Total	21	
Contractor	10–15 years	14	21
	16–20 years	25	38
	21 to up years	26	40
	Total	65	
Designer	10–15 years	11	20
	16–20 years	24	44
	21 to up years	19	35
	Total	54	
Type of project	Gas fields	37	26
	Petroleum	56	40
	Pipelines	31	22
	Others	16	11

Table 3. Respondents' indicators

Table 4.
Participants' characteristics

Gas fields		Petroleum		Pipelines		Contract managers		
Work experience	Frequency	Work experience	Frequency	Work experience	Frequency	Work experience	Frequency	Total *
Over than 20 years	3	Over than 20 years	5	Over than 20 years	2	Over than 20 years	1	11
Function	Frequency	Function	Frequency	Function	Frequency	Function	Frequency	
Consulting teams	2	Consulting teams	2	Consulting teams	1	Consulting teams	1	6
contractor organization	1	contractor organization	3	contractor organization	1	contractor organization	0	5

Note(s): All participants have relative knowledge in the field of risk management and construction project claims

Code (level 3)	Causes	RPI	RSI	RII
O1	Change orders, (materials and technical specifications)	3/69	3/90	2/88
O2	New requirements after the bidding stages	3/07	3/75	2/31
O3	Delay in progress payment	3/42	4/01	2/74
O4	Lack of timely supply of equipment and materials	3/25	3/70	2/41
O5	No access to the site/limited access to site services (water/electricity/telephone)	3/22	3/01	1/94
O6	Lack of adequate control over disagreements between contractors and designer	2/99	3/01	1/80
O7	Failure to timely review work orders and project approvals by the owner or his representative	3/04	3/45	2/10
O8	Lack of attention to the qualification of the contractor at the time of the tender and excessive attention to the bid price	3/53	3/06	2/16
D1	Delay in inspections	2/94	3/82	2/25
D2	Errors and inconsistencies in plans	3/74	2/94	2/20
D3	Poor knowledge of scheduling and problems associated with project management	3/40	3/92	2/67
D4	Failure to transfer technology due to improper definition in the contract	2/99	2/99	1/79
D5	Incomplete and ambiguous design documents and instructions	2/96	3/88	2/30
D6	Incorrect estimation and adjusting the contract based on unrealistic values	3/31	3/47	2/30
D7	Lack of a specified price for overtime in the contract	2/88	2/68	1/54
C1	Delay in the implementation phase due to the contractor performance	3/98	3/70	2/94
C2	Lack of timely supply of materials	3/14	3/24	2/03
C3	Late delivery of operations and site to subcontractors	3/01	3/80	2/29
C4	Financial problems and failure to make timely payments	3/17	3/59	2/28
C5	Poor team building and low productivity	2/85	3/80	2/16
C6	Problems in product operation due to inadequate training of operators	3/50	2/90	2/03
C7	Inefficient quality control	4/10	3/45	2/83
C8	Accidents due to non-compliance with safety principles	3/01	3/97	2/39
C9	Mistakes in the implementation stage	3/32	3/70	2/45
C10	Lack of labor (specialist and non-specialist)	2/69	3/40	1/83
C11	Poor work quality of subcontractors	3/59	3/16	2/27
P1	Government laws and regulations and licensing problems	3/26	3/33	2/17
P2	Suspension due to force majeure cases/strikes	3/54	2/37	1/68
P3	The negative effects of political problems between governments	3/50	3/37	2/36
N1	Unforeseen site conditions	3/01	3/15	1/90
N2	Act of god/flood/storm	2/95	3/65	2/15
S&C	Fake practices/robbery	2/81	3/80	2/13
E1	Financial instability and market fluctuations	3/23	4/16	2/69
E2	Lack of sufficient and efficient equipment in the market	2/93	3/39	1/99
E3	Changes in foreign exchange rates	3/00	3/96	2/38
Ot	Different interpretations of the laws	3/10	3/75	2/33

Table 5. Identified causes (risks)

questions regarding their latest projects. Previously, researchers have used this type of relative index as a ranking of factors (Sambshivan and Sun, 2007; Fallahnejad, 2013). Using a five-point Likert questionnaire, respondents were asked to determine two intensity and probability indicators for each of the 36 identified risks (Figure 1). The first one is the probability of occurrence of factors and the second is the severity of the occurrence (probability includes 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost always), (for severity of risks if they occurred 1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Very, 5 = Extremely). The results are presented in three columns, which indicate the relative probability index (RPI), the relative severity index (RSI) and the relative importance index (RII) (Table 5). The following formulas were used to calculate each index.

(1) $RPI = \sum P_i / A * N$

(2) $RSI = \sum S_i / A * N$

(3) $RII = \sum W_i / A * N$

where A is the highest weight (i.e. 5 in this case), N is the total number of respondents, P_i is the probability given to each factor by the respondents, S_i is the severity given to each factor by the respondents as well as $W_i = P_{i^*} S_i$. The validity of the questionnaire was analyzed by SPSS 16 software. Cronbach's alpha for the severity and probability questionnaires were 0.86 and 0.92, respectively.

Determination of the relationship with process groups using SEM-PLS

In the fourth section, to determine the relationship between identified factors and process groups using the Delphi method, another interview was conducted with experts. Previously, and in the literature, researchers found a significant relationship between risks and disputes (Artan Ilter and Bakioglu, 2017). The questionnaire consisted of 36 identified risks. Experts were asked to identify one of the five process groups for each risk (according to the definition of PMBOK (PMI, 2013), five groups are included initiating, planning, executing, monitoring and controlling, and closing). They were aware that the approach was chosen to look at the project life cycle, identifying the process groups in which risks should be mitigated or eliminated. Given that the identified causes can be considered as the basis for adopting appropriate strategies to reduce their occurrence (Yana *et al.*, 2015). According to Figure 2, the relationship of each of the eight claim-causing factors to the five process groups was examined. Each expert group was interviewed three times in total by the Delphi method (Table 4). After the expert discussions, each of the risks was eventually linked to one of the process groups (Figure 2). The PLS method was used to determine the validity of these hypotheses and the relationships formed. The *structural equation modeling (*SEM) in previous studies has been used by researchers to prioritize the risks and validity of relationships (Yana *et al.*, 2015; Feng *et al.*, 2017). In this paper, due to the SEM-PLS features of method, this tool was used (Figure 3). Features like, those that do not require large sample sizes are intended to provide a predictive model, and this tool is used for theories that are not yet well-formed.

Analysis and results

Analysis

Evaluation of PLS-SEM in two phases, the first stage involves the evaluation of the measurement model (outer) that determines the validity of the model relationships between latent variables and items. In the second stage, the evaluation of the structural model (inner) is carried out in and this section examines the explanatory power and path coefficients between the relationships of endogenous and exogenous variables as well as examines the different paths of the hypotheses.

Measurement model. To evaluate the fit of the first part, namely the measurement model, three items are considered: index reliability, convergent validity and divergent validity (Hulland, 1999), and the reliability of the index itself is examined by three criteria: (1) Cronbach's alpha, (2) composite reliability and (3) factors loading. Cronbach's alpha values above 0.7 are acceptable reliability markers (Cronbach, 1951). The composite reliability is also a better measure of alpha and indicates good inner sustainability if the value is above 0.7 (Vinzi *et al.*, 2010). The factor loading coefficients indicate the correlation of the constructs with the indicators of the variable itself, and those whose loads are less than 0.4 should be reduced (Hulland, 1999). As a result of the measured model, the three Cronbach's alpha criteria, composite reliability and model factors loading in all constructs have acceptable coefficients according to Table 6. The convergent validity of the SEM-PLS models is measured by the average variance extracted (AVE) criterion which indicates the degree of correlation of each construct with its indicators (items). The minimum AVE is 0.5, but the values above 0.4 can also be considered acceptable, given that Fornell and Larcker (1981) states that if AVE is less than 0.5 but composite reliability is higher than 0.6, construct

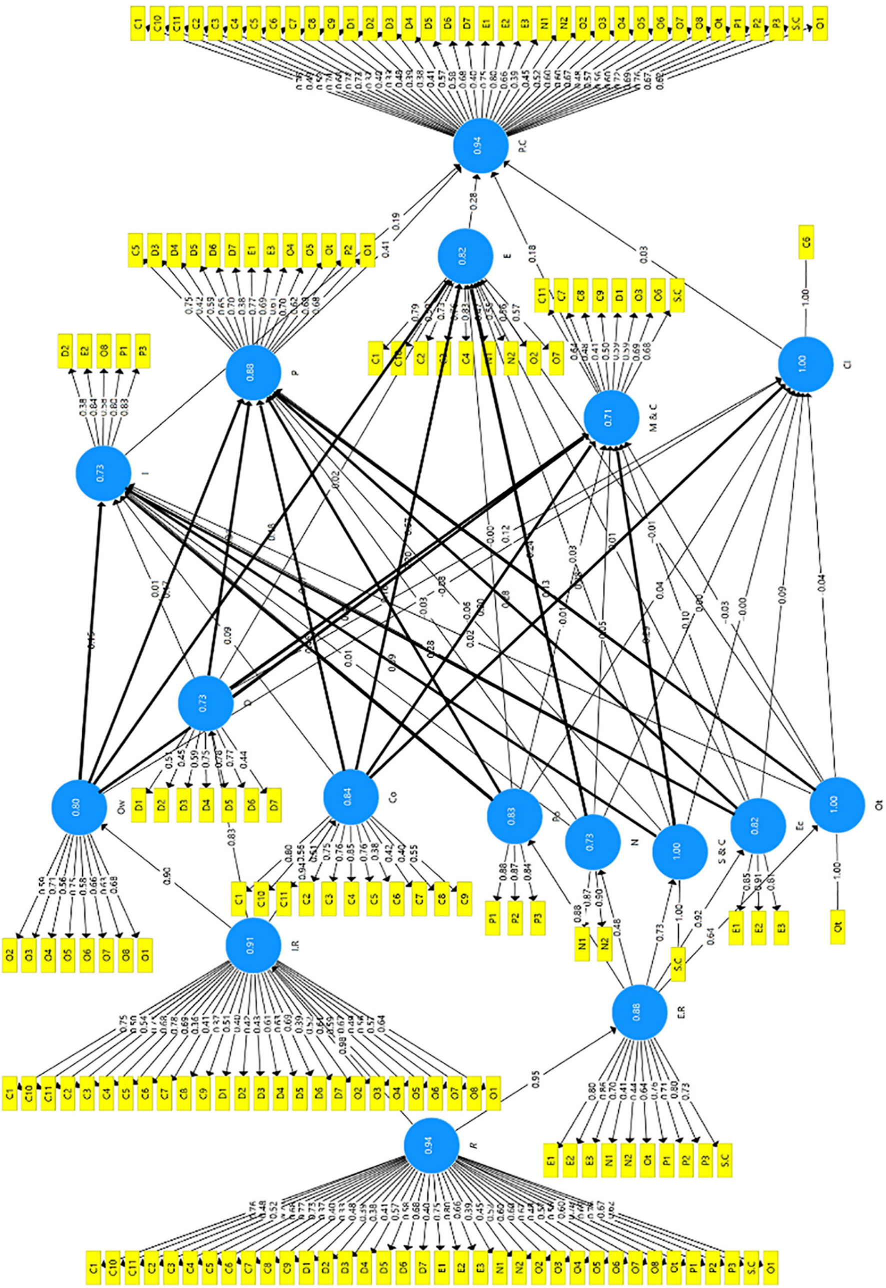

Figure 3.
Results of path coefficients and determination coefficients – confirmed hypotheses

Construct	Item	Factor loading	Significance	Cronbach's alpha	Composite reliability
Ow	O1	0.69	12.78	0.800	0.851
	O2	0.58	8.66		
	O3	0.71	11.22		
	O4	0.56	7.00		
	O5	0.75	14.91		
	O6	0.57	7.81		
	O7	0.65	9.39		
	O8	0.63	9.13		
D	D1	0.50	5.60	0.727	0.812
	D2	0.45	4.75		
	D3	0.59	8.54		
	D4	0.76	16.22		
	D5	0.79	18.94		
	D6	0.77	19.54		
	D7	0.42	4.03		
Co	C1	0.80	22.15	0.844	0.878
	C2	0.74	14.30		
	C3	0.76	18.24		
	C4	0.84	32.87		
	C5	0.75	19.69		
	C6	0.52	6.01		
	C7	0.44	5.48		
	C8	0.41	4.27		
	C9	0.55	8.17		
	C10	0.56	8.27		
	C11	0.53	6.75		
Po	P1	0.87	36.45	0.828	0.897
	P2	0.87	38.73		
	P3	0.84	32.53		
N	N1	0.88	19.06	0.727	0.880
	N2	0.89	27.02		
S&C	S.C	1.00		1.000	1.000
Ec	E1	0.85	27.96	0.823	0.895
	E2	0.91	51.90		
	E3	0.81	17.96		
Ot	Ot	1.00		1.000	1.000

Table 6.
Measurement model and reliability evaluation indicators

convergence validity remains (Huang *et al.*, 2013). Divergent validity is calculated by the Fornell and Locker method. According to Fornell and Larcker (1981), divergent validity is acceptable at a level where the AVE value for each construct is greater than the shared variance between that construct and other constructs. Table 7 shows convergent validity and divergent validity, both of which demonstrate the validity of the model.

Structural model. At this stage, the causal relationship between constructs is investigated using the structural model. In fact, considering the results of investigating the relationships between constructs using the relevant coefficients, it is possible to investigate the significance of the effects among research constructs. The importance of each pathway was evaluated using the bootstrapping technique with 5,000 samples. According to the data analysis algorithm in the PLS method, the research hypotheses were tested at this stage by examining the significance coefficients (t) for each path and standardized factors loading related to the paths (beta). The results of the conceptual model of the research, in terms of the significance of coefficients, are described in Table 8. The R-squares criterion is used to connect the measurement section and the structural section. It indicates the effect that an endogenous variable has on the exogenous variables. Hulland (1999) believes that researchers using the PLS method should report R-square values on all their endogenous variables. Chin (1998) introduces the three values of 0.19, 0.33 and 0.67 as weak, medium and strong values for the intensity of the relationship. The coefficients of determination of endogenous variables according to Table 8 are acceptable. In testing the hypotheses, the path coefficients indicate the extent of the impact of the internal risks of the project (including the three sections of the owner, the contractor and the designer) as well as the external risks of the project on dimensions of the project claims (process groups). The t-value statistic for that path coefficient indicates a significance; that is, if the t-value is greater than 1.96, it is significant at the 95% confidence level. The goodness of fit (GOF) criterion relates to the general section of structural equation models which, after examining the fit of the measurement section and the structural section of the model, also controls the fit of the general section. Finally, 18 hypotheses related to process groups were confirmed at a significant level ($p < 0.5$).

Result

Before addressing the hypotheses, path coefficients and significance coefficients of dimensions project risks (internal and external) on project risks (PR), the dimensions of each internal and external risk to themselves as well as the dimensions of the project claims

	Variable	AVE	1	2	3	4	5	6	7	8
1	Ow	0.42	0.65							
2	D	0.40	0.56	0.63						
3	Co	0.41	0.56	0.57	0.64					
4	Po	0.74	0.62	0.58	0.54	0.86				
5	N	0.79	0.48	0.41	0.37	0.26	0.89			
6	S&C	1.00	0.48	0.56	0.59	0.55	0.32	1.00		
7	Ec	0.74	0.60	0.61	0.76	0.71	0.33	0.65	0.86	
8	Ot	1.00	0.58	0.33	0.51	0.49	0.22	0.34	0.53	1.00

Table 7. Convergent validity index and divergent validity matrix by Fornell and Larker method

Path (direct hypotheses)	R-squared	Path coefficient (β)	t-value	p-value	Inference
Ow → I	0.73	0.153	3.145	0.002	Supported
Po → I		0.454	10.489	0.000	Supported
S&C → I		0.094	2.191	0.029	Supported
Ec → I		0.277	6.112	0.000	Supported
Ow → P	0.88	0.173	4.168	0.000	Supported
D → P		0.311	8.514	0.000	Supported
Co → P		0.156	3.467	0.001	Supported
Po → P		0.17	4.749	0.000	Supported
Ec → P		0.286	7.770	0.000	Supported
Ot → P		0.135	4.249	0.000	Supported
Ow → E	0.82	0.189	3.483	0.001	Supported
Co → E		0.634	10.614	0.000	Supported
N → E		0.217	3.385	0.001	Supported
Ow → M&C	0.71	0.447	5.516	0.000	Supported
D → M&C		0.208	2.704	0.007	Supported
Co → M&C		0.218	2.124	0.034	Supported
S&C → M&C		0.285	3.854	0.000	Supported
Co → Cl		0.285	4.293	0.000	Supported
Other paths	–	–	–	–	Not supported

Table 8. Results of direct hypotheses test (IR and ER on PC)

(process groups) on project claims (PC) which included five process groups, were analyzed which all paths were approved (Figures 4 and 5). Then, structural analysis of the effect of external risk (ER) and internal risk (IR) variables on PC factors (hypotheses) were evaluated (Figures 4 and 5). According to Table 8, political, economic, owner, and finally cultural and social factors were identified (Figures 4 and 5). They have a positive impact on the initiating process group respectively. Their path coefficients were equal to Po (β = 0.45, t = 10.49, p < 0.001), Ec (β = 0.28, t = 6.11, p < 0.001), Ow (β = 0.15, t = 3.14, p < 0.01) and S&C (β = 0.094, t = 2.19, p < 0.05). In the planning process group, as shown in Figures 4 and 5, has the most approved relationships. A total of six factors including designer (β = 0.31, t = 8.51, p < 0.001), economic (β = 0.28, t = 7.77, p < 0.001), owner (Ow) (t = 0.17, t = 4.17, p < 0.001), political (β = 0.17, t = 4.75, p < 0.001), contractor (β = 0.15, t = 3.46, p < 0.001) and others,

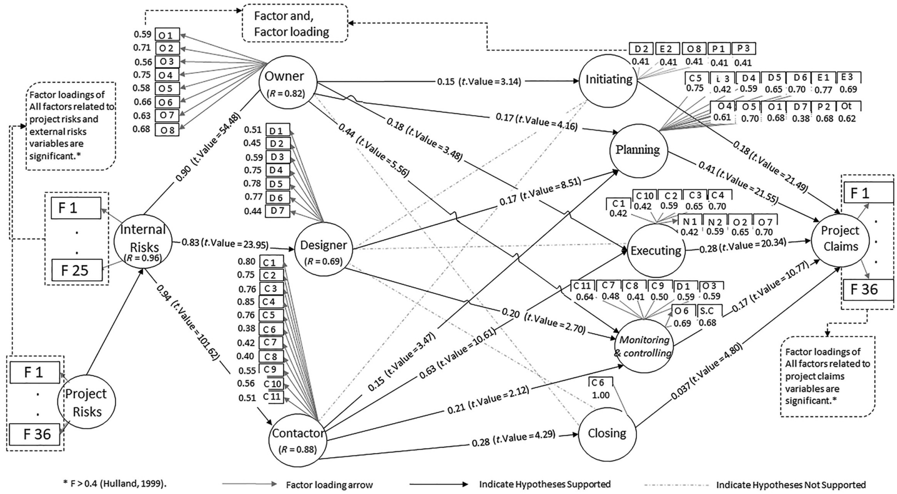

Figure 4.
Results of path coefficients and determination coefficients – confirmed hypotheses (Internal risks)

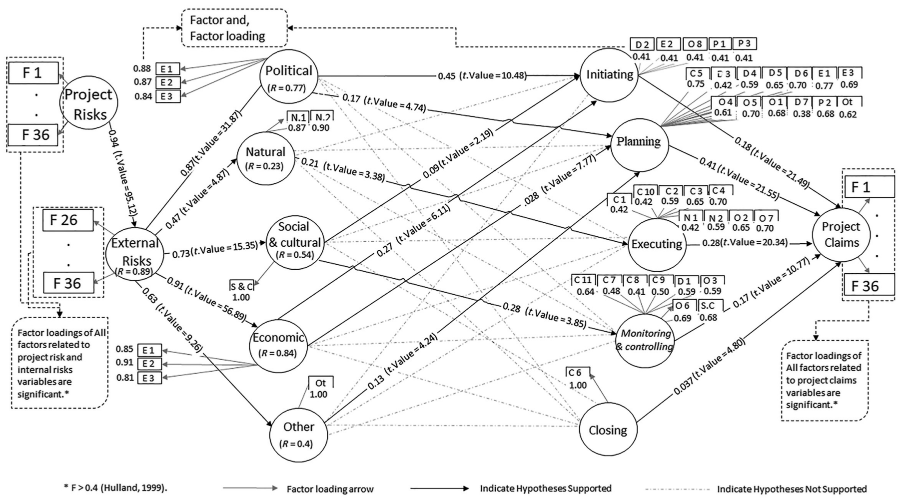

Figure 5.
Results of path coefficients and determination coefficients – confirmed hypotheses (External risks)

which includes different interpretations of laws and regulations ($\beta = 0.13, t = 4.25, p < 0.001$), have a positive and significant effect. Three factors include contractor ($\beta = 0.63$, $t = 10.61$, $p < 0.001$), natural factors ($\beta = 1.21$, $t = 0.39$, $p < 0.001$) and owner ($\beta = 0.19$ $T = 3.48$, $p < 0.001$) were confirmed in the executing process group (Figures 4 and 5). In the monitoring and controlling process group, all factors of internal groups (Figure 4) including owner ($\beta = 0.44, t = 5.51, p < 0.001$), contractor ($\beta = 0.22, t = 2.12, p < 0.05$) and designer ($\beta = 0.21$, $t = 2.70, p < 0.01$) as well as cultural and social ($\beta = 0.28, t = 3.85, p < 0.001$) were significantly correlated (Figure 5). In the last process group, the closing process, contractor variable ($\beta = 0.28$, $t = 4.29$, $p < 0.001$) has an effective relationship (Figure 4).

Discussion

As detailed in Table 3, the relative importance index of each risk associated with the claims is shown in Table 3. Factor C1, the contractor's financial delays, indicates the highest importance index in all factors. Among the factors related to the owner, the change orders (O1) have the highest index. Also, poor knowledge in project planning (D3) linked to the designer group has the highest RII in the self-group. As mentioned in a large part of previous studies, the issue of delays, the results of this study also indicate its high importance. Also, it was predicted that economic factors would have a high relative index among foreign groups because of the economic situation of Iran. Among the external factors, market instability and changes in foreign exchange rates (E1, E3) are of higher importance. The results analyzed the relationship between risks associated with the second-level groups and process groups. The results of the probability index and SMART-PLS software were used for analysis. Sambasivan and Soon (2007), who analyzed frequency indexes in their research, previously used this method. Out of 40 hypotheses between process groups and IR and ER groups (second level), 18 were confirmed. According to the preventive approach of this study, we analyze the obtained results according to the process groups and the second and third levels of the RBS. The second level of the risk failure structure identifies the risk-making groups. Effective groups can work together to reduce the likelihood of identified factors. Improving communication and cooperation between the participating groups is associated with reducing problems and disputes due to insufficient information between the project parties (Mukilan *et al.*, 2021). This section discusses the results of each identified risk and the responsible groups relative to each project process group.

Initiating process group

The initiating process group has a high degree of uncertainties (PMI, 2013), according to Table 8 political risks, economic and owner causes had the greatest impact on this group (Figure 6). Among the political risks, as shown in Table 5, the negative effects of political problems between governments have the highest relative importance index. The highest RII according to Table 5 was set at the lack of sufficient and efficient equipment in the market. As Yousefi *et al.* (2016) stated, political causes, like the sanctions, will cause further economic problems.

Planning process group

According to the results of the hypotheses, this process has the most risks (items) and groups (constructs) whose effect was confirmed (Figures 4 and 5). Previously in the literature, Zarei *et al.* (2018) in examining factors related to delays, introduced the planning group as a process group with the most delay factors. As shown in Figure 6 in the planning process group, the hypotheses related to the IRs group all have significant path coefficients. Beta coefficients of risk associated with designer and owner are higher than the contractor. Among the factors associated with the designer, according to Table 5, the risk of poor knowledge of scheduling

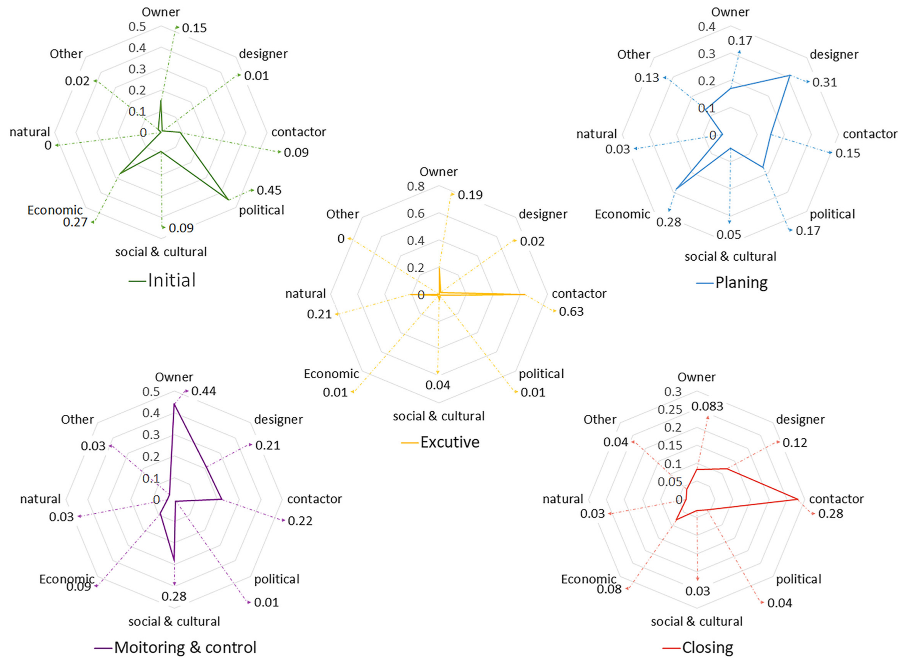

Figure 6.
Results of path coefficients in process groups

and problems associated with project management has an index of 2.67. The importance of this factor has been mentioned by Fallahnejad (2013). Among the ERs identified in Figure 5, economic groups and others were approved. In ERs, the factor of financial instability and market fluctuations related to economic issues has the highest coefficient in Table 5, which can make planning difficult.

Executing process group

In the hypotheses related to the executing process group, as shown in Figures 4 and 5, the three groups had a positive and significant relationship. Among them, the contractor group has the highest effect coefficient (Table 8). Also, five of its causes were categorized by experts in this group (Figure 3). According to Table 5, delays due to contractor performance as well as late delivery of operations and site to subcontractors have the highest relative importance factor among contractor-related risks. Also, the risk of new requirements of the owner after the bidding stages earned the highest index coefficient among the owner factors.

Monitoring and controlling process group

According to Figure 6, the hypotheses endorsed in this process group include three sides of the triangle of internal groups as well as cultural and social items. To sum up, among the factors assigned to this process group, the risk associated with inefficient quality control by the contractor has the highest index in Table 5. The importance of this factor in causing delays as one of the influential parts of claims has been acknowledged (Sweis *et al.*, 2008). Among the ERs, cultural and social factors have a positive and significant effect (Figure 5). In previous studies, the role of cultural and social factors in creating delays and increasing construction costs have been introduced as important indicators (Arditi *et al.*, 2017; Sadeh *et al.*, 2021).

Closing process group

As shown in Figure 4, the contractor factor in the IRs group has a significant relationship with this process group. The closing group includes processes to finalize all activities in the project that formally complete the project. Given this definition, among the identified risks, the risk of problems in project exploitation due to inadequate training of operators by experts associated with this group and was confirmed in the analysis obtained in Table 8.

Summary

In summary, the results obtained in this study according to the selected approach include four parts: (1) identification and ranking of factors, (2) classification of factors in the risk breakdown structure (RBS), (3) significant assessment of the relationship between factors and process groups and (4) significant assessment of internal and external groups of risk failure structure and process groups.

For example, the factor of delays due to the contractor's performance (C1) shows the highest relative importance index (2.94) (Table 5). This factor (C1), which was categorized in the contractor group (RBS), showed a significant relationship with its item, i.e. the executive group (Figure 4). Finally, in part D, the significance of the relationship between project risk groups and executive process groups was examined. According to the obtained results (Table 8), the owner, contractor and natural groups show a statistically significant relationship with the executive process group (Figure 6). The approach proposed in this study tries to give the groups participating in the project proper prior knowledge before starting the project. Therefore, according to Figures 4 and 5, employers can take the necessary preparation and appropriate strategies to deal with the problems caused by it and possible claims. In addition, contractors who intend to collaborate on these projects can improve their performance by identifying and reducing the likelihood of risks before the project begins and prevent further consequences. On the other hand, according to the results of this study, both the contractor team and the project employer can minimize the impact of natural risks as an important factor in the executive process group by making appropriate decisions and through cooperation.

In addition, according to Table 5, change commands is another factor that displays a higher RII (2.88). Based on the research method and views of experts (Figure 1), the planning process group was associated with this factor to adopt appropriate strategies and reduce the likelihood of this risk. In the second level of risk failure structure (Figure 2), the design group has a higher degree of credibility. According to Table 8, the planning process group shows the most supported relationship with IR and ER groups (Figures 4 and 5). All internal groups, including the designer, owner and contractor, have a significant relationship with the planning process group. These parties can help lower the incidence of this factor and possible disputes as much as possible by identifying ERs (E1, E3 and Ot) and making appropriate decisions with each other.

Conclusion

Due to the competitive environment in construction projects, the risks leading to disputes are on the rise. Investment in the oil and gas industry is expected to be $1tn by 2035. While 80% of projects in this area face cost increases, various work teams do not place much value on risk management in their organizations. Besides, with the first signs of disagreement in the projects, the participating organizations face a shortage of experts and insufficient knowledge in claim management. Previous studies identified risks with different approaches and tools, and factors have been ranked from various aspects. This method includes many existing studies and their major results. Nevertheless, no study has evaluated the risks leading to the claim in the form of a risk failure structure and a process-based model.

In the present study, in addition to identifying and ranking the risks, each of these factors is related to the appropriate process group for a better understanding of the time of occurrence, adopting an effective strategy and better preventive management. Also, the second level of risk breakdown structure (RBS) (including 8 constructs) and process groups (including 5 constructs) were evaluated using PLS. The proposed approach helps stakeholders make better decisions before starting a project by assessing the relationship of process groups with each identified factor and the second level of risk failure structure (8 groups of IR and ERs). They can identify influential risk groups and essential factors according to process groups and work together to mitigate its adverse effects before starting the project. Besides, the present study can give the working groups participating in the Iranian oil and gas industry a better understanding of the factors leading to the disputes and claims. In this model, although different factors in IR and external groups cover various aspects (e.g. delays, changes and economics), the impact of each identified factor on the other is not taken into account. However, the existing limitation can be studied further in future research (Yana *et al.*, 2015; Feng *et al.*, 2017). The approach presented in this paper enables researchers and academics to explore other aspects of risk in future research, such as safety risks.

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