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Open Access Survey Paper

Identification and Evaluation of the Design Risks in Iran's Oil, Gas and Petrochemical Industry

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Abstract

Proper risk assessment and management are considered important issues in design improvement. This tendency has been due to the continuing uncertainty of the global economy and the advancement of information technology. Despite the most important and valuable benefits, developed design topics are more vulnerable and can expose the organization to higher levels of risk. Achieving sustainability is recognized as a growing and effective strategy to meet today's global design challenges. Design in the oil, gas and petrochemical industry is important due to its characteristics and high risk in different countries, especially Iran, due to its different effects on the environmental dimension. The issue of identifying and evaluating design risks has also been neglected in recent research. Therefore, the purpose of this study is to identify and evaluate design risks in Iran’s oil, gas and petrochemical industry. The present research is descriptive-survey and is qualitative and quantitative in terms of technique and data used. Based on the literature review, 13 risk factors affecting the design were identified, in two stages, in-depth interviews were conducted with the opinions of experts, and by collecting opinions through a questionnaire, and 10 key risk factors were finally confirmed. In the first stage, the validity of the questionnaire was finally confirmed based on the opinions of 5 experts and in the second stage, using the opinions of 8 experts in this industry. Cronbach's alpha coefficient of the risk questionnaire is higher than 0.7, which indicates the reliability of the research tool. According to the research findings, two factors such as weak technology / knowledge sustainability and environmental pollution, compared to other risk factors, have a higher priority in design projects in Iran's oil, gas and petrochemical industry. It is suggested that industry owners take serious and continuous measures in the field of "improving the level of process knowledge".

Keywords: Risk, Design, Oil, Gas and Petrochemical of Iran

1. Introduction

In the last decade, industry pioneers have recognized that the key to achieving greater market share depends on meeting customer needs. Today, addressing consumer needs is even more important. And organizations try to provide high-quality goods and services according to their needs (Charmchi, 2001). Facilitating the relationship between customer needs, distribution networks, and the organization's internal operations requires a scientific approach in itself. Design can provide this for companies, and also has a significant impact on organizational performance, sustainability, and stakeholder satisfaction. The goal of each designer is to maximize the total production value and customer satisfaction. The profitability of the design process should be divided among all design steps. Accordingly, the success of a design is defined in terms of its profitability and satisfaction, thus, today, sustainable development is considered as one of the key elements of design (Nikabadi, 2013). Sustainable development was first addressed in 1987 in the Environment Committee and United Nations Development Report, and since then, this issue has been recognized as one of the biggest challenges facing the world. Over the past two decades, as globalization has expanded, sustainability and sustainable development have shifted from a technical concept to the political mainstream and then commercial concept (Sheikh, 2011). The most important factors disrupting sustainable development are the destruction of water resources and their excessive pollution, air pollution, noise pollution and waste in cities, and how nuclear waste is disposed of. In this report, for the first time, the terms "sustainable development" and "sustainability" entered the environmental literature and then entered the field of economic literature (Bagheri et al, 2015). Naturally, every activity is associated with risk, and human beings have always sought to identify its causes and resources. Another issue that arises in today's organizational and decision-making environments is the complexity of the situation and the composition of the information, which has made it extremely difficult to make the right decisions, therefore, the rules of thumb and speculation will be ineffective (Boroujerdi, 2015).

Arefi (2016) noted that understanding and risk management in engineering and design projects is a challenging task in the early stages. The failure of engineering and design projects increasingly emphasizes the importance of risk management, especially in the defense industry, the construction industry, and the oil industry due to the significant damage that may occur (Hajiabadi, 2012). Numerous studies have examined active modeling and project management methodologies to develop a systematic approach and an integrated project risk management methodology (Hajiabadi, 2012). Also in recent years, many researchers have focused on identifying, analyzing, prioritizing, and managing risk (Hosseini et a, 2012). Research has identified many reasons for project overpayments, including inaccuracies, project complexity, poor risk assessment, and management (Safaei et al, 2013). Research has provided many reasons for risk control and risk management, which include: Extending safety risk assessments to prevent or reduce their occurrence (Arefi, 2016). Due to dealing with numerous errors and accidents in process industries (oil and gas, etc.), and in order to analyze the risk and prevent events and reduce them, various risk assessment methods have been developed and used (Hadizadeh, 2014). Risk management and understanding in large engineering projects, especially in the initial phase is very challenging (Agi, 2016). This is usually very difficult, even due to the lack of sufficient information, and it is almost impossible to extract the potential amount of risks (Zhang, 2011). Examining the relevant literature for project risk assessment, we found that there are many advanced methods, such as fuzzy logic, analytic hierarchy process [13], analytical network process [14], failure mode and effects analysis [15], fault tree analysis, event tree analysis, fishbone diagram, Monte Carlo [16] construction and structural equation modeling [17] (Bastas, 2018). The Bayesian belief Network 18 performs better than other methods because it can address the potential causal relationships of the risks posed by expert judgment and update previous beliefs and probabilities learned from new information. Oil and gas projects have a complex system and there are numerous dependencies among the risk factors in the fuzzy concept. Therefore, the aim of this study is to develop a Fuzzy-Bayesian model for risk assessment, identification, and prioritization of risks in oil, gas, and petrochemical projects. To create this model, a review of the printed works has been done and the shortcomings of the previous models have been revealed, observations indicate that Bayesian belief network systems have been less studied in risk analysis. And since large oil and gas projects pose numerous risks to the national capital, list the risks of engineering services in the various parts of an oil and gas consulting firm (industrial plumbing, architecture, Process, etc.) and their effects on the environment (leakage of hazardous fluids, etc.), as well as their control strategies, are examined in this study. Since most decision-makers and managers rate risk factors with linguistic values (for example, very high, high, medium, low, very low, etc.), thus, fuzzy theories provide a useful tool for examining ambiguities in the data evaluation process. In this research, using the fuzzy approach, a new method for identifying, measuring, and ranking the risks (technical and environmental) on oil, gas, and petrochemical projects (detailed phase) in consulting engineering companies will be presented. In this research, we intend to change the current system (current situation) and achieve the desired situation (optimal situation) in consulting companies, to evaluate the design risks of oil, gas, and petrochemical projects, and present the relevant model.

2. Literature Review

According to ISO 31000 standard, risk management is a set of coordinated activities in the organization, in order to guide and control the organization according to the type of risk (ISO 31000 standard). This set of activities can include a plan for risk response, follow-up, or risk control. In relation to risk management, it is necessary for the organization to define its attitude towards risk; Attitude to risk in the organization includes the organization's overall view of risk, pursuing, eliminating risk, or ultimately avoiding risk (Cetin et al, 2011). In fact, the systematic process of risk management, based on Deming's cycle: Plan-Do-Check-Act (PDCA), according to which, the process does not have a one-step algorithm, but the process cycle is repeated many times and in each cycle, an improvement is achieved and the risk management program is updated (Christopher et al, 2011). Risk management involves contingency planning for the design of upstream and downstream processes and supply chains (Chiu et al, 2006). Risk and risk management are among the factors that are indirectly discussed in the topic of design. In design studies, in addition to the short-term profitability of organizations, risk management has been considered, which includes factors such as work-related injuries due to production, loss of environmental resources, public safety, and employee health (Corbett, 2007). Based on the results of studies, it can be concluded that in the sustainable development of design, the concept of security should be considered, which includes security against severe environmental threats, protection against the extinction of generations, climate change, famines, food shortages, and population growth. In this way, organizations can manage the risks associated with these factors in the long run (Dakov and Novkov, 2008). In general, risk can be defined as the probability of deviation from a predicted output. In the field of design, risk and risk management are relatively new concepts and several definitions have been provided about them. Dorli et al. have defined design risk as the potential for an internal process occurrence in a way that affects the needs of industry customers (Corbett, 2007). Design risks can occur under the following headings: natural disasters (Atkinson [21], 2006), legal requirements (Qureshi, 2015), inadequate demand forecasting, and failure to coordinate demand requirements across organizational processes (Christopher and Lee[23], 2004), changes in the prices of raw materials including energy (Zailani, 2012), poor quality of suppliers and insufficient accuracy in the number of deliveries, poor performance of the organization and its suppliers in environmental and social contexts that lead to costly legal measures; (Xu et al, 2013). One dimension of risk will be related to the organization's sense of social responsibility and can disrupt the reputation of the design output, which, through its activities, provokes emotions and dissatisfaction in society, and even worse, can lead to delinquent behaviors, which severely affect the reputation of design outputs (Hou et al, 2019). In sustainable design, the organization's ability to understand and manage the economic, environmental, and social risks of design (Zhao et al, 2018). HP, for example, has conducted a preliminary risk assessment in the design process of its products and, accordingly, has set its own risk management priorities. Significant and critical HP risks include geographical location, chemical processes or hazardous work, length of time with HP, commitment to citizens, and globalization (Qureshi and Ansari, 2015). These researchers address the risks associated with sustainable design in Table 1 through a combination of different categories found in the thematic literature (Sajjad et al, 2015; Tseng et al, 2018; Xu et al, 2013) and provided interviews with selected design managers.

Factors	Internal	External
Environmental	1-Environmental accidents (such as fire and explosion), 2- Pollution (air, water and soil), 3- Non-compliance with sustainability laws, 4- Emission of greenhouse gases, depletion of the ozone layer, 5- Energy consumption (incorrect energy consumption), 6-	1-Natural disasters (such as storms, floods and earthquakes), 2- Water shortage, 3- Heat wave, drought

	Unnecessary and double packaging, 7-Waste of products.	
Social (society)	1-Extraordinary working hours, imbalance between life and work, 2-Inadequate wages, 3- Child labor / forced labor, 4- Discrimination (race, gender, religion, disability, age, political views), 5- Environment Safety, 6-Exploitative employment policies, 7-Immoral treatment of animals	1-pervasive (universal), 2-social instability, 3-demographic challenges / elderly population
Financial (economic)	1-Bribery, 2- False claims / dishonesty, 3- Price fixing charges, 4- Unreliable claims, 5- Patent infringement (copyright), 6- Tax evasion	1-Sanctions, 2- Lawsuits, 3-Fluctuations in energy prices, 4- Financial crises

Table 1. Effective risks in sustainable design

Table 2 shows the differences between (design-related risk management) and (common risk management) activities from different aspects:

	Common design risks	Design-related risks
Risk identification	Design disorders (delays, forecast errors, intellectual property, inventories, capacity, etc.)	Ecosystem degradation, impact on social values and accountability
Risk Assessment	Based on financial or operational criteria / methods	Inferential studies (deductive)
Risk-taking behaviors	Share and understand it throughout the organization through testing and adapting risks	A portfolio of strategies for managing all three dimensions of sustainability
Proposed methods for dealing with risk	Based on risk management and evaluation and proper business planning	Scenario-based planning and simulation, Automatic tracking of faults, Auto repair and recovery
Opportunities for risk management	Opportunities to improve and enhance (internal) business and overcome competitors	Competitive Advantages and Chances for Business Excellence

Table 2. Risk management for common and design-related risks

The results of Tseng et al (2018) showed that the top 8 risk factors associated with sustainable design are: natural disasters, greenhouse gas emissions, forced labor/child labor, financial crisis, bribery charges, pollution, Non-compliance with the rules of sustainability, and energy consumption; Of course, considering that the relevant study was conducted in the southern region of Europe, it can be stated that the priorities obtained are due to the climatic, socio-economic conditions and regulations governing this region. Hou et al. (2019) have developed a framework for assessing and measuring sustainable design risk by measuring various risks to create a comprehensive standard. Sustainable design risks are expressed in three dimensions and components as described in Table 3.

Operational risks	**Supply, process, demand and organization risks of the organization**
Environmental risks	Individual health, ecosystem quality, resource deficiencies
Social risks	Social indicators (global), governance indicators (global)

Table 3. Sustainable Design Risks

These researchers have used the risk assessment gap analysis technique to analyze the risk of sustainable design. They also used two distinct design case studies to evaluate the proposed framework. The results show that the differences in the design structure and size of companies are the two main factors of sustainable design.

Major research in the field of risk management and sustainable design is presented in Tables 4 and 5.

	Factors											
Basic model	The human factor	control-ability	Error	Insurability	Control cost	Probability of discovery	Extent of pollution	Rate of exposure	Impact intensity	Probability of occurrence	Year (AD/Solar)	**Researcher / researchers**
FTA[1] / HAZOP[2]			*								2017	Hou et al
BBN[3]									*	*	2009	Cetin et al
FMEA[4]						*	*		*	*	2017	Tseng et al
William Fine					*			*	*	*	2016	Dorli et al
FMEA				*		*			*	*	2018	Corbett
BBN		*							*	*	2017	Xu et al
FBN[5]									*	*	2016	Zailani et al
FBN										*	2009	Sajjad et al
Monte Carlo	*		*								2016	Qureshi
		*				*			*	*	2012	Zhang

Table 4. Major research related to sustainable design and analysis methods and risk management

[1] Fault Tree Analysis
[2] Hazard & Operability study
[3] Bayesian Belief Network
[4] Failure Modes and Effects Analysis
[5] Fuzzy Bayesian Network

Researcher/ Researchers	Year	Risks															
		environmental	Safety and Occupational	Political	Legislation	Economical	Research and exploration	Technical	Budgeting (people, hours,	Import of materials and	Technical knowledge	Work partners	investment	Management(Internal)	Build/making	Change the scope of work	social
Hou et al	2019							*									
Cetin et al	2013					*		*					*				
Tseng et al	2018	*	*														
Dorli et al	2012	*	*														
Corbett	2007														*		
Xu et al	2013					*						*		*		*	
Zailani et al	2012	*	*												*		
Sajjad et al	2015		*														
Qureshi	2015			*	*	*	*		*			*		*			*

Table 5. Major research conducted in the areas of sustainable design and risk management

Critical risks in design

According to the review of the thematic literature and the identification of various risk factors presented in previous research, this study has extracted the most important risk factors affecting the design (13 risk factors) as described in Table 6.

Risk factors	Description
Inflexibility of security sources	Supplier inflexibility to environmental changes (including Inflexible capacity)
Complexity of the coordination process	Extraordinary coordination responsibilities due to information distortion, different goals of design members, conflicts among partners.
IT Risks	Lack of necessary IT infrastructure and mechanisms in order to receive and disseminate information among design members in a timely manner.
Weakness of technology / knowledge sustainability	Weakness and lack of knowledge and correct understanding of technology, operations and sustainable methods among partners.
Undermining brand / reputation	The credibility and reputation of the organization becomes vulnerable when customers do

	not look at the organization as a possible source to meet their needs.
Errors	Human error / machine / method.
Inefficient use of resources	Inefficient resources (e.g., energy, reversible waste) are used to produce and deliver goods and services.
Environmental pollution	Air, water, soil, or other contaminants caused by operations, equipment, or products.
Production of hazardous waste	Unused and unwanted materials or goods produced during or as a result of a process such as production or distribution.
Violation/ breach of Human Rights	Behavior that violates the dignity of a person or humiliates the person. Such as forced labor and child labor, discrimination, long working hours beyond legal needs.
Weakness in fulfilling social obligations	Lack of involvement in local technological, cultural, educational and social development, job creation, health care, social investment.
Violation of Business Ethics	Behavior that violates business ethics such as corruption, unfair trade, and invasion of privacy and so on.
Regulations	Laws / Regulations /Internal and External Codes.

Table 6. Primary risk factors affecting the design of the research literature review

3. Research Methods

The present study is a descriptive-survey research, and in terms of techniques and data used, it is qualitative and quantitative. In two quantitative and qualitative phases, in order to identify and evaluate the risks of sustainable design in the oil, gas and petrochemical industry, the opinions of experts were used. The qualitative phase includes two-part sampling. In the first part of the qualitative phase, to hold in-depth interview sessions (Delphi method), 5 experts in a non-random and judgmental manner appropriate to the type of activity of related companies, among senior managers of the organization (CEOs and strategists) with related fields of study (Management) and at least 10 years of work experience are selected. In the second part of the qualitative phase, 8 experts (including 5 experts participating in in-depth interviews) again participated non-randomly and according to the type and scope of activities of companies, often among senior and middle -level managers of the organization and related to design, management Risk and decision-making. It should be noted that in this part of the study, using data collected through a questionnaire (opinions of 8 academic and industrial experts), 13 risk factors identified through review of thematic literature and structured interviews were examined.

This study used the depth study method to review the literature for extracting initial critical risk factors. The field study (interview and questionnaire) method was then employed for final confirming the risk factors and assessing their validity and reliability, as well as collecting and structurally testing the data required for analyzing critical risks. The questionnaires were scored based on a 5-point Likert scale. A questionnaire on the "risk factors" was used for the final verification of risk factors, construct validity assessment, and structural testing. Another questionnaire was employed to elicit experts' views on various topics such as the impact of risk factors, the impact of risk, risk probability, and risk detectability. The third questionnaire was used to evaluate the interaction of risk factors. The second and third questionnaires were filled out during specialized interviews with eight experts. Risk factors were confirmed after two round-Delphi method according to figure 1. The construct validity for sustainable design risks is confirmed in Table 7.

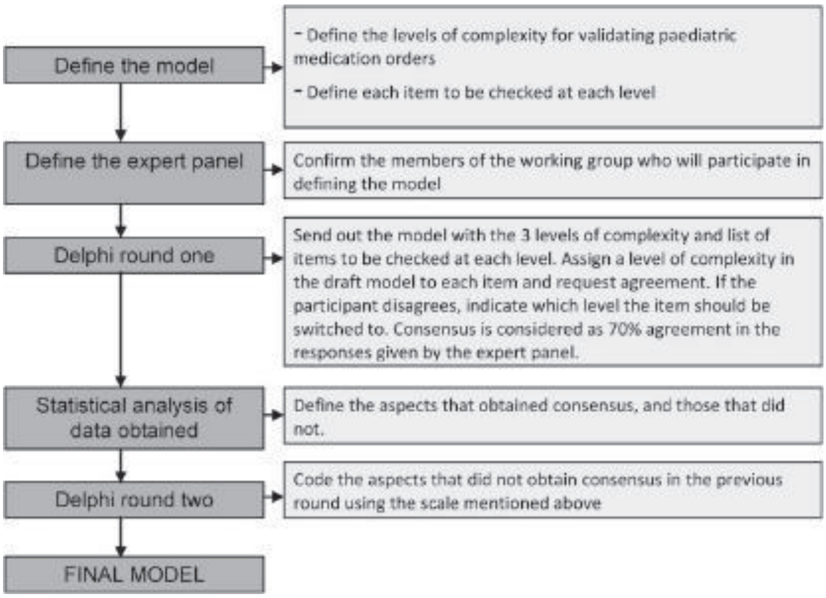

Figure 1. Two round-Delphi method for selecting risk factors

In round one of the Delphi process, the questionnaire contained 13 items for evaluation and it was sent out to the 8 panel members. A total of 8 questionnaires were answered and returned in the first round and consensus was reached in 13 items. In the interim results' report, details were given on the items that did not obtain consensus, how responses were distributed and a proposal was made for new features arising from the non-consensual items. In round two of the Delphi process, the questionnaire contained 10 items for evaluation and it was sent out to the 8 panel members. A total of 8 questionnaires were answered and returned in the second round and consensus was reached in 10 items. Finally, 10 risk factors were confirmed after two round-Delphi method.

Indicator	Average of answers *	Approval / disapproval
Inflexibility of supply sources	6.9	Approval
Complexity of the coordination process	6.9	Approval
IT Risks	7.1	Approval
Weakness of technology / knowledge sustainability	6.2	Approval
Undermining brand / reputation	4.7	Disapproval
Errors	6.3	Approval
Inefficient use of resources	6.4	Approval
Environmental pollution	6.6	Approval
Production of hazardous waste	6.3	Approval
Unsafe / dangerous workplace	6.8	Approval
Violation/breach of human rights	4.5	Disapproval
Weakness in fulfilling social obligations	6.1	Approval
Regulations	4.6	Disapproval

Table 7. Validity results of the questionnaire

In this research, library studies have been used to thematic literature review of research and the initial extraction of risk factors, also, the field method (interview and questionnaire) has been used for final confirmation of effective risk factors, validity and reliability, structural testing and data collection required for risk analysis. In questionnaires, a five-point Likert scale was used. In the section of final confirmation of risks, and in order to assess the reliability of the structure and structural test, the questionnaire "Risk factors affecting the design of sustainability" has been used.

The content validity of the questionnaires was assessed in two stages. In the first stage, the opinions of 5 experts who were familiar with the concepts of design and risk management as well as the industry were used. For this purpose, meetings were held with these people and the content validity of the questionnaires was examined. As a result of these discussions, changes were made in order to modify and validate the questionnaires. In the second stage, in order to validate the structure of the questionnaires, 8 experts in this industry were surveyed, and based on the announced opinions, the validity of the structure was confirmed. The opinions of the same experts (five people) were used to determine the face validity of the questionnaire, and the questions were modified to formulate exactly the same concept as the researcher. The reliability of the questionnaires was analyzed using information obtained from 181 return questionnaires in SPSS software. Considering the total number of statistical population (340 participants in field of design and risk management in Iran's oil, gas and petrochemical industry), and according to Krejcie & Morgan (1970) table, 181 people were determined as the minimum statistical sample, which were selected by simple random sampling method. Period of data collecting from survey, responses of the two round-Delphi method are collected during period of 3 weeks, and for questioners are collected during period of 3 months, also questionnaire used combined type for answering based on the online and in paper form. Also, the range for probability of occurrence and impact of a risk (sometimes called its consequence) are defined in terms of a discrete scale, such as 1=very low, 2=low, 3=medium, 4=high, and 5=very high.

Table 8 shows Cronbach's alpha related to risk factors.

Indicator	Number of data	Cronbach's alpha
Inflexibility of supply sources	181	0.738
Complexity of the coordination process	181	0.712
IT Risks	181	0.775
Weakness of technology / knowledge sustainability	181	0.789
Errors	181	0.795
Inefficient use of resources	181	0.722
Environmental pollution	181	0.739
Production of hazardous waste	181	0.741
Unsafe / dangerous workplace	181	0.786
Weakness in fulfilling social obligations	181	0.752

Table 8. Results of the reliability of the questionnaire

Based on the results in the table above, it can be seen that the Cronbach's alpha value for all indicators is greater than 0.7, which means the reliability of the survey tool. The results of the AVE (Average Variance Extracted) index are presented in Table 9.

Indicator	Convergent Validity	Variable Status
Inflexibility of supply sources	0.558	Acceptable
Complexity of the coordination process	0.462	Relatively acceptable
IT Risks	0.576	Acceptable
Weakness of technology / knowledge sustainability	0.522	Acceptable
Errors	0.5 3 8	Acceptable
Inefficient use of resources	0. 55 2	Relatively acceptable
Environmental pollution	0.5 17	Acceptable
Production of hazardous waste	0.5 41	Acceptable
Unsafe / dangerous workplace	0.5 47	Acceptable
Weakness in fulfilling social obligations	0.4 98	Relatively acceptable

Table 9. Convergent validity of research variables

The table above shows the convergence validity of the research variables. Given that the majority of values are close to 0.5, so convergent validity is acceptable for all research variables. To analyze different risk factors, quantitative calculation methods, risk priority, and risk matrices have been used in Excel and fuzzy DAMETEL software. SPSS software is used to analyze descriptive statistics of data.

4. Results

The results of descriptive statistics showed that in the qualitative phase, men constituted 100% of the statistical sample of this study. 17.65% of the statistical sample were under 35 years old, 47.06% were between 35 and 45 years old and 35.29% were over 40 years old. Also in terms of education level, 29.42% of members had a Ph.D. degree, 58.82% had a master's degree and 11.76% had a bachelor's degree. As can be seen from the statistics, the highest percentage of participants have a master's degree and in the next rank are people with a Ph.D. degree. In terms of work experience, 35.29% of people with less than 10 years of experience, 29.42% between 10 and 20 years, and similarly 35.29% of people over 20 years of experience. Also, 35.29% of the people were in the highest executive position of the organization (CEO or board of directors) and 64.71% were the middle-level managers of the organization in the field of oil, gas, and petrochemical industry. It should be noted that among the participants in this part of the study, all people have organizational management positions and 41.18% of people in addition to organizational positions have been working as university lecturers in the field of oil, gas, and petrochemical industry management.

Sustainable design risks: In summary, the conditions of each of the risk factors will be as described in Table 10.

Risk factor description	Probability of occurrence	impact Intensity	Risk Status
Inflexibility of supply sources	3.35	2.59	Medium
Complexity of the coordination process	2.32	2.99	Medium
IT Risks	2.81	2.40	Medium
Weakness of technology / knowledge sustainability	3.34	2.26	Medium
Errors	3.33	2.43	Medium
Inefficient use of resources	2.56	2.15	Medium
Environmental pollution	3.01	2.14	Medium
Production of hazardous waste	4.02	3.03	High
Unsafe / dangerous workplace	4.23	3.10	High
Weakness in fulfilling social obligations	2.35	49.2	Medium

Table 10. Risk matrix analysis (impact intensity)

The results show that in terms of the probability of occurrence and impact intensity in the design of the industry, 10% of risk factors have a low-risk status, 70% have medium risk factors and 20% have a high-risk status.

RPN-based critical risk rating:

At this stage, to determine the amount of risk of each of the risk factors affecting sustainable design, the risk priority number (RPN) has been used. For this purpose, based on the data collected through a questionnaire, risk numbers of probability, detectability, and impact intensity were calculated, and then the product of these three values was used as risk priority numbers (RPN). According to the risk priority numbers obtained in this step, the ranking of risk factors will be done and appropriate behavioral strategies will be provided. Based on the risk priority numbers obtained as described in the table above, the prioritization of risk factors affecting sustainable design will be as shown in Table 11.

Priority	Risk factor description	RPN
1	Environmental pollution	58.29
2	Weakness of technology / knowledge sustainability	41.99
3	Production of hazardous waste	36.89
4	Unsafe / dangerous workplace	33.76
5	Inefficient use of resources	32.74
6	Complexity of the coordination process	27.58
7	Errors	24.21
8	Inflexibility of supply sources	23.95
9	IT Risks	21.88
10	Weakness in fulfilling social obligations	16.21

Table 11. Prioritization of risk factors based on risk priority numbers (RPN)

According to the table above and the values obtained for risk priority numbers, it can be seen that risk factors such as environmental pollution, Weakness of technology / knowledge sustainability, and production of hazardous waste with RPN values of 58.29, 41.99, and 36.89, respectively, are of higher priority than others, and have been identified as key risks.

Risk response strategy:

Conducting specialized interviews with 3 industry experts and obtaining their opinions on risk response strategies (avoidance, exploitation, transfer/sharing, decrease/increase, acceptance) is presented in Table 12. It should be noted that in exclusive interviews with experts, each interviewee was asked to provide at least one suggested solution for each of the two key initial risks.

Risk description	Response strategy	Response solutions
Environmental pollution	avoid Decrease	- Upgrading the level of process knowledge - Development of recycling activities - Planning to hold training courses in the field of environment
Weakness of technology / knowledge sustainability	avoid Decrease	- Transfer of knowledge from other countries - Development of activities in the field of R & D - Planning to hold in-service training courses

Table 12. Key risk response strategies

5. Discussion

In this study, the identified risk factors in the sustainable design of the oil, gas, and petrochemical industries have been investigated. In this regard, first, by completing a questionnaire by 8 industry experts, the data required for analysis were collected and then in two phases, descriptive and quantitative data analysis was performed. In the statistical description of the data, after describing the demographic composition of the respondents, some information such as mean values, maximum and minimum impact intensity indicators (time, cost, and performance), probability of occurrence, and delectability were calculated and presented. Then, in the quantitative analysis section, the matrix of risk priority values was calculated. In the statistical analysis sections of the research data, according to the obtained results, risk priority factors were identified and appropriate behavioral strategies were determined. Obviously, by identifying the effective risk factors and determining and defining appropriate behavioral strategies and solutions, it will be possible to maintain efficiency inefficient units (time periods) and improve efficiency in inefficient units (time periods) in terms of design stability. By analyzing the risk factors affecting sustainable design, it was found that the two risk factors, weak technology/knowledge sustainability, and environmental pollution, have a higher priority than other risk factors. The table is below.

Risk factor	Thematic literature
Weakness of technology / knowledge sustainability	Tang and Tomlin, 2008
Environmental pollution	Blackburn, 2007

Table 13. Comparative Results of Risk Factors Analysis with Thematic Literature

6. Conclusion

The purpose of this study is to determine and identify the most important risk factors affecting design in the oil and gas and petrochemical industries was done using the opinions of experts and getting help from in-depth interviews with 5 industry experts and university professors, as well as completing a questionnaire by 8 experts (including 5 experts participating in in-depth interviews),.According to the research findings, one of the key risks in sustainable design has been "environmental pollution", regarding the key risk of "environmental pollution", it is suggested that industry owners take serious and continuous measures in the field of "upgrading the level of process knowledge" and "planning training courses in the field of the environment". Other measures, such as the "establishment and maintenance of integrated management systems (IMS)", can have functionally good results in design. Finally, difficult access to senior managers due to their high workload for conducting interviews and completing questionnaires is one of the key limitations of the research. For future studies, it is suggested that sustainable design risk assessment in the Iran's oil, gas and petrochemical industry be done using machine learning and deep learning. In the present study, the evaluation of sustainability and identification of risk factors in the Oil, Gas and Petrochemical Industry is considered, which can be developed for other industries, especially the electricity and energy industries.

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