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Analysis of Sustainable Supply Chain Risks Based on FMEA Method in Oil and Gas Industry and Factors Affecting Risk Management

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ABSTRACT

Supply chain sustainability as a new and very influential issue has recently attracted the attention of researchers in the field of supply chain management. This concept is of particular importance in oil and gas industry due to its nature and the risks and sustainability risks related to this industry, especially environmental hazards. In this context, the purpose of this study is to assess the risks related to supply chain sustainability in oil and gas industry based on the failure mode and effect analysis (FMEA) technique. This work is an applied research in terms of the purpose and a descriptive one in terms of data collecting. The statistical population of this study, in the first dimension, consisted of all the experts familiar with the concept of sustainability in oil and gas industry; 10 experts were selected through snowball sampling, and their opinions and views were examined. In the second dimension of the research, which designs and explains a model for evaluating a sustainable supply chain based on the structural equation model in oil and gas industry, 252 companies active in oil and gas industry were selected as a sample by an available sampling method; of these, 240 acceptable questionnaires were returned. The results of research show that among the risks posed in the field of supply chain sustainability in oil and gas industry, risks such as failure and pollution in surface (hydrological) and groundwater (hydrogeological) systems and flows, energy price fluctuations, sanctions, the emissions of hazardous and greenhouse gases, the reduction of air quality, and climate change were prioritized over other risks. Moreover, commitment to sustainability, management readiness, and external factors can all play an important role in managing the risks associated with this industry.

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1. Introduction

In general, one of the requirements of a company is the adoption of a type of supply chain strategies (Estampe, 2013). These strategies emphasize how internal and external business processes are coordinated so that, as a result of this coordination, the best possible service is delivered to end users and customers; also, the performance of the individual members of the organization is enhanced. For effective supply chain management, it is imperative that suppliers and customers interact with each other in a coordinated manner with full information partnerships and communications. This rapid flow of information among the components of the chain enables them to create a high-performing supply chain. If a company can design and build a supply chain that responds to market demand, it can be transformed from a small company into a large company. Efficient supply chain operations are central to profitably satisfying the market demand. A company needs to know when and where its supply chain performs well. Then, to have more value added, it has to decide what the main activities are. (Bastas and Liyanage, 2018).

One of the issues in the supply chain is the concept of sustainability. In general, today, companies have to face multiple new challenges such as identifying the issues related to the climate change, facing the negative effects of financial crises and prices, addressing the general benefits of ecology such as green logistics and green design, and ensuring environmental sustainability and energy adequacy. There has also been an extra pressure on companies through environmental legislation (including EU environmental law), mass media and public opinions in general, and consumers' growing and increasing demand for transparency and increased awareness about the conditions of manufacturing and distribution of goods, including environmental, safety, and human rights issues. This has led to the concept of sustainability (Castillo et al., 2018). It should be noted that supply chain sustainability is a new and highly influential debate that has attracted the attention of researchers in the field of supply chain management (Ashrafi and Chahar Souqi, 2011). An evaluation, which includes aspects of sustainability, is different from the evaluation of traditional performance, which is business-oriented. When considering sustainability dimensions, the scope of evaluation should be extended. Sustainable development encompasses not only economic dimensions, but also environmental and social dimensions. (Cetinkaya, 2011).

Shrivastava defines sustainability as the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management; Sikdar considers sustainability as a wise balance between economic development, environmental stewardship, and social equity (Osheni, 2018).

There is a continuing importance for measuring the performance of a sustainable supply chain as a result of changing the competition between organizations whose competition is with each other in the supply chain. Therefore, the evaluation and the enhancement of supply chain performance require the development of a performance measurement system for a sustainable supply chain. Formerly a performance measurement system consisted solely of economic benchmarks. By adding sustainability, currently, the scope of measurement includes social, environmental, and resource benchmarks (Roy et al., 2018).

Also, according to Vany et al. (2009), today, due to increased supply chain uncertainties and factors such as political issues, demand fluctuations, technology changes, financial instability, and natural disasters and in order to reduce vulnerability and increase their supply chain sustainability, organizations have to spend resources on forecasting demand, supply, and internal uncertainties. Considering these uncertainties and risk factors has led to the issue of risk management in the supply chain.

Carter (2009) also argues that system sustainability is entirely dependent on the system ability to adapt, evolve, and respond to the environment, and since the environment is constantly changing consequently, this adaptation process of the system should be a dynamic and sensitive process. Sustainability, the strategic achievement and the integration of the social, environmental, and economic goals of the organization in the systematic coordination of intra-organizational business processes, is the key to improving the long-term economic performance of the individual company and its value network. Using these definitions, sustainability strategy must take into account the level of future uncertainty (Alam Tabriz et al., 2017).

It is worth noting that little research has been conducted into the analysis and the evaluation of supply chain risks as well as the sustainability risks based on the failure mode and effect analysis (FMEA) methods for risk analysis such as the works of Curkovic et al. (2013) and Faizal and Palaniappan (2014). However, no research has been reported to use this approach to analyze supply chain sustainability risk in oil and gas industry, so, for the first time, this study analyzes the risk of the sustainable supply chain in oil and gas industry using the FMEA method. This research seeks to answer how the analysis of the risk of the sustainable supply chain based on the FMEA method is performed and what factors affect the risk management in this area.

2. Theoretical Framework and Research Background

2.1 Research Background

In general, researchers and scholars in the field of research have achieved the following results:

- The identification and prioritization of the factors affecting the risk management of the sustainable supply chain;
- The evaluation of the external forces affecting the risk management of sustainable supply chain;
- The risk management strategies for a sustainable supply chain.

For the first time, this study analyzes the risk of the sustainable supply chain in oil and gas industry based on the FMEA method and examines how the risk analysis of the sustainable supply chain based on the FMEA method is performed.

Table 1 outlines some of the researches on the risk management of the sustainable supply chain, particularly in oil and gas industry.

Table 1. Research background.

Researcher	Year of Research	Title	Findings
Sadaghiani	2014	Evaluation of external forces affecting supply chain sustainability in oil and gas industry using best worst method	Investment programs, investment in environmental protection programs, international oil and gas companies, instability in government policies in the field of energy, and investment in social programs are five of the most important external factors effective on sustainable oil and gas supply chain operations.
Shuen et al.	2014	Dynamic capabilities in the upstream oil and gas sector: managing next generation competition	The researchers showed that adopting the management practices of the sustainable supply chain is influenced by organizational culture in sustainability issues.
Thurner et al.	2014	The rising importance of environmental management in the corporate governance of Russian oil and gas producers	The researchers found that top management leadership and transparency can help drive sustainable supply chain action.
Andersen and Mostue	2012	Risk analysis and risk management approaches applied to the petroleum industry and their applicability to IO concepts	The researchers found that the involvement of interdisciplinary teams, experts, and supply chain partners play an important role in reducing the risks of operations in the petrochemical industry.
Karimi	2014	The identification and prioritization of factors affecting green supply chain management in offshore industry using network analysis process approach: case study of Iranian Offshore Engineering and Construction Company	According to the results, the dimensions of supplier management and organizational participation as well as the indicators of employee's participation and supplier's evaluation and selection are the most important factors in the sustainability performance of the green supply chain in this industry.

2.2. Theoretical Foundations of Research

Risk is generally considered as a negative aspect. Uncertainty, which is a newer concept, has always had both positive and negative aspects. Positive aspects are often referred to as opportunities. In the International Standard ISO 2003, risk is used to mean uncertainty, that is, it includes both positive and negative aspects. Nigel describes risk as follows: Risk is the probability of an unknown event in a situation that the event can cause problems. In other words, risk depends on the situation that the real result of something is probably affected by an unknown event, while the probability and the effects of that event can be precisely determined (Ziaei, 2005: 62–59).

Risk management is also all the processes related to identifying, analyzing, and responding to any uncertainty, which include maximizing the results of favorable events and minimizing the consequences of adverse events. Six phases have been introduced for the risk management process: risk management planning, identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control. According to Bohm, the risk management process consists of two main phases: the risk estimation phase—including identification, analysis, and prioritization—and the risk control phase—including the stages of risk management planning, risk monitoring planning, and corrective actions.

Risk analysis is performed by two methods, namely qualitative and quantitative methods. The qualitative risk analysis is the process of measuring the impact and chance of the occurrence of identified risks. This process prioritizes risks based on their potential effects on project objectives and can lead to further analysis in quantitative risk analysis or directly to risk response planning. In this process, there is a matrix that determines the risk rating, namely very high, high, medium, low, and very low, for the risks based on the combination of probability and impact scales. The method of quantitative risk analysis is the stage of converting the program from being definite to being probable. Also, at this stage, the quantitative and more precise impact of the risks on the project objectives is obtained. According to the risk rating in the qualitative analysis, the risk management policy at this stage can be based on considering all the risks or eliminating part of them which are usually low-grade risks. One of the methods used in this analysis is Monte Carlo simulation. This method is a statistical technique that is a very important tool for risk analysts to assess project uncertainty. In quantitative risk analysis, project activities are included in the schedule with a list of risks. At this stage, the relationship between risks and project activities is determined. These relationships determine how the time and cost of each activity change with respect to each critical risk; thus, each activity has a probabilistic state, and a distribution function must be specified between the activities; a careful selection of probability distributions is of particular importance (Smith et al., 2009).

a. Concept of supply chain in oil and gas industry

A supply chain includes all the activities related to the flow of goods and conversion of materials from the stage of the preparation of raw materials to the stage of the delivery of the final goods to the consumer. A supply chain consists of a core view that is directly or indirectly involved in meeting customer’s demands. The supply chain includes not only manufacturers and suppliers, but also shipping, warehousing, retailers, and even customers. Thus, a supply chain consists of various activities, including procurement, inventory, sourcing and purchasing, production planning, inter-organizational relationships, and performance measurement (Bastas and Lianag, 2018).

Supply chain management involves the integration of supply chain activities and the flow of the related information through improved chain relationships to achieve a reliable competitive advantage. Therefore, supply chain management is the process of integrating supply chain activities, and the related information flows through the coordination of activities in the supply chain of the production and supply of products. Supply chain can be considered for both production and service systems (Nazeri and Nosratpour, 2016). Although chain complexity may vary greatly from industry to industry and from organization to organization, the overall goal of supply chain management in many industries is largely the same. The purpose of supply chain management is to reduce the overall cost of storage, which needs the mutual cooperation of the components of the supply chain. Coordination in the supply chain is improved if all of its components take coordinated action, and as a result, the whole chain benefits as a whole (Naghadeh, 2012). Just as people interact with each other to use their skills, knowledge, and abilities, companies are interested in building relationships and collaborating with companies that have more complete skills, knowledge, abilities, and perhaps resources than themselves. They show. If a company can design and create a supply chain that meets the market demand, it can grow from a small company to a large one. To this end and in order to fulfill the market demand profitably, efficient supply chain operations play a pivotal role. A company needs to know what works well in what areas and where in the supply chain. It must then decide what activities it should focus on in order to have more added value. Supply chain seeks effective methods to create more value for the customer (Sadeghiani, 2014).

In designing the supply chain network in oil and gas industry, several long-term and key decisions about finding the most suitable location for crude oil terminals, refineries, product storage, and optimal routing of materials and products are made. Today, oil and gas industry has caused fundamental changes and transformations in the process of growth and development of our country, and today the need for oil products and their various applications in different fields, as well as our country's potential in this field, has made Iran to have a viable investment in this field. In this context, the first step is to provide devices and equipment that can be used to transfer these fossil resources to refineries and produce the necessary products by performing the necessary operations. Any pieces of the equipment can be provided in a shorter time and with an appropriate quality; the supply chain is also effective, and the organizational goals are met. Having a dynamic and efficient supply chain in oil and gas industry can be useful for accelerating the response and the possible change of the needs of the chain members in response to environmental changes and competitive conditions. A dynamic process also involves learning and acquiring simultaneously and continuously and examining the status of partners, technologies, and organizational structures. Due to the high flexibility of commercial institutions, a good opportunity is provided for them so as to identify, discover, or create and invest in active and dynamic capacities and potentials. However, the change of environmental conditions in oil and gas industry has led to the need for greater reliability and flexibility in supply chain planning and control systems.

b. Concept of sustainability

According to Linton et al. (2007), sustainability is the use of resources to meet the needs of the present without compromising the ability of the next generation (Amini Far and Arabi, 2015). Sustainability has been increasingly discussed by politicians (US Policy Council in 2004 and European Chamber of Commerce in 1996), popular presses such as Anon in 2001, and various technical journals (Mudgal et al., 2010). According to Gasparatos et al. (2008), the concept of sustainability was first introduced in the seventies and early eighties, but sustainability was generally defined in the report of the World Commission on Environment and Development in 1987; based on this definition, sustainability is defined as a development that satisfies the needs of the current generation without limiting the ability of future generations to meet their own needs (Safari, 2017: 19).

It is clear from the literature that the definition of the term sustainability can change from an intra-organizational philosophy to a multidimensional term. In-house philosophy focuses on making sure that the next generation will not be negatively affected by our present-day activities. The multidimensional focus emphasizes on balancing different social, environmental, and economic dimensions. For social sustainability, there is a need to ensure that people's needs are met. According to Zhou et al. (2000), for economic sustainability, profit must be maximized. For environmental sustainability, the consumption of nonrenewable materials and waste generation should be minimized, and the permanent damage to the environment must be avoided. Gasparatos et al. (2008), after long studies, have defined sustainability as:

- Integrating social, economic, environmental, and business issues as well as considering the interactions between them;
- Considering the results of current activities in the future;
- Acknowledging that our current activities may have negative impacts, so we need to be cautious;
- Considering the rights of the people;
- Considering shareholders' equity (Safari, 2017: 21).

c. Risk management of sustainable supply chain

Generally, the formation of supply chain begins with the process of supplier selection, in which the selection of appropriate criteria for the supplier selection is crucial (Rasool Khorrami, 2015). In recent years, supply chain management has received a great deal of attention from businesses and researchers. In a manufacturing company environment, external resources form an integral part of supply chain management. This suggests that the role of the supply chain management should be to ensure supply chain competitiveness. In addition, supply chain sustainability relies on sustainable supply management. Given the fact that production has become more marketed as commodities traded from different sources, supply chain sustainability is critical to the success of supply chain management (Ageron et al., 2012: 168–182).

The risk management of the sustainable supply chain refers to two complementary activities at the enterprise level, namely supplier collaboration and supplier evaluation, and deals with suppliers to evaluate and improve environmental performance and social performance (Gavaronski et al., 2011: 872–885). Sustainable supply chains in partnership with environmental and social suppliers can play an important role in achieving social, environmental, and economic "triple net profit". The selection of the supplier plays a vital role in supply chain management. Traditionally, organizations consider criteria such as price, quality, flexibility, and so on in choosing a supplier. Alongside these traditional criteria, the selection criteria based on the sustainability approach have a special place (Rasool Khorrami, 2015). It should be noted that supply chain management performs the planning and control of business-related activities, trading, and support management, and most importantly establishes collaboration and coordination among new suppliers, agents, and customers. As customers are more aware and rules are becoming more stringent, industries are starting to integrate environmental factors across their organizations. In addition, with the integration of green technologies into the design, production, and distribution processes of products, they have become the backbone of the environment. Such efforts have led to the development of green supply chain management (Safari, 2017: 17).

d. Supply chain sustainability measurement from the perspective of economic, social, and environmental risks

In 1997, The U.S. Environmental Protection Agency together with US nongovernmental organizations (NGOs) created a program for an environmentally responsible economy, which resulted in the global reporting initiative (GRI) index. Its purpose was to enhance the quality, accuracy, and usefulness of sustainability reports (GRI2913). This is a lengthy process that has several stakeholders at the international level, and its mission is to guide the development of a sustainability report in a globally acceptable way. This method is the most well-known way of measuring sustainability (Olfat et al., 2012: 1–26). It should be noted that this index has three main categories of economic, environmental, and social performance, which are divided into the following categories: human rights, good working practices, and product and community responsibilities. Its other indicators include financial services, logistics, transportation, warehousing and materials, public agencies, telecommunications, tour operators, and motor vehicles. In this method, seventy key indicators are introduced, and methodological descriptions of the scope of the use of indicators and other technical references are provided. One of the benefits of the GRI method is the possibility of patterning; one of its disadvantages is the number of indicators because, since it is a method for many industries, a large number of indicators are defined which make it difficult to select the right indicators for an industry (Olfat et al., 2012: 1–26). The following are three main areas of the index.

Sustainability and no risk from an economic perspective

Various studies have been conducted using the supply chain model that traditionally focuses on various economic aspects with the goals of minimizing cost (or maximizing profit) and maximizing service levels. In a study, Gunasekaran (2007) presented the main conventional indicators of economic performance of supply chain management as quality, speed, flexibility, and cost (Rizki Rostami, 2017: 149–165). In general, economic performance is the backbone of a company activities. There is no doubt that the company must be profitable in order to be sustainable in the long run. Practical practices, which are called green and sustainable practices but are not profitable in the long run, cannot always remain sustainable. As long as the positive economic impacts increase, it is likely that certain processes and activities can continue and be sustained. Economic impacts include three dimensions of quality, efficiency, and responsiveness (Jafarnejad and Mahmoudi, 2014). According to Pinches et al. (1979) a number of economic performance indicators presented by researchers include total asset turnover, sales-to-capital ratio, current ratio, inventory turnover, total asset return, and capital return. The summary of these dimensions is presented in Table 2.

Nidumolu et al. (2009) found that striving for sustainability can lead to organizational and technological innovation both of which, or the lack thereof, play a significant role in return on capital and profitability (Bhardwaj, 2016: 456–468). In order to be profitable in the long run, these dimensions are needed. The quality of logistics services and customer satisfaction are key issues in making a profit in the long run, which can be measured by a variety of criteria. In order to measure quality, information such as the number of complaints, delays, return of goods, damage, waste, number of errors in documentation, etc. can be taken into account and measured in the company (Safari, 2017: 24). Out-of-company information such as customer surveys can also be used to determine the quality of the service received and receive feedback from business partners. In either case, the metrics should reflect the strategy of the company and the different customer-related topics. The same quality level may be accepted by a group of customers but may not be acceptable to all customer groups (Nazeri and Nosratpour, 2016).

Table 2. The Economic dimension and its sub-dimensions (Jafarnejad and Mahmoudi, 2014).

Dimensions	Examples of Benefits and Improvements	Examples of Criteria
Quality	Quality of service and products	Lack of excessive inventory, customer response, product delivery delay, timely delivery, customer satisfaction, customer complaints, product availability, asset return rate cycle, inventory level, total logistics cost, value added, productivity, return on capital, inventory use, product loading rate, warehouse operation, delivery cost, the duration of the product launch to the market, the order cycle time, product tracking function, order flexibility, and delay time.
Efficiency	Level of customer service Availability Productivity Reduction in costs	
Responsiveness	Meeting customer needs Respond to market changes Flexibility	

The second dimension, responsiveness, reflects how the company can respond to customer's needs and the changing environment. In many cases, this is also related to the quality of service. Responsiveness can be measured by looking at product availability in the supply chain. How can a company respond quickly to new customers' needs when the customers require change? How can it manage the design process to deliver the product at a fast pace? How long does it take for the company to redesign its distribution system? How much is the demand forecast? Responsiveness partly disagrees with the last dimension, i.e. efficiency. Creating a more responsive system requires the capacity used and designing a process that is not highly specialized; therefore, it is necessary to strike a balance between the dimensions (Jafarnejad and Mahmoudi, 2014). Therefore, and according to Lan and Unhelkar (2006), supply chain responsiveness is an important issue in supply chain management today. For better customers' satisfaction and better understanding of the market, companies are trying to achieve the best performance through different supply chain indicators. The performance dimension is the most recognizable dimension for all managers. This dimension is about eliminating costs, increasing resource utilization, and reducing time. This dimension can be reflected through a variety of partial criteria (Safari, 2017: 25).

Sustainability and no risk from an environmental perspective

Some of the major environmental concerns in the literature of chain management include greenhouse gas emissions, waste generation, energy use, water use, and the use of toxic substances in products, which have been addressed at various local, regional, and global levels (Gupta and Pulsule-Desai, 2011: 234–245). According to Jellali et al. (2015), environmental indicators include items such as management (IS) (investment in environmental protection and respect for environmental laws), renewable energy sources, recycling, natural environment (biodiversity conservation and ecosystem services), sustainability of products, and human health (Rizki Rostami, 2017: 149–165).

Overall, in the last 70 years, much of the research on sustainable provision has focused on its environmental aspects. The environment has been one of the key elements of the tripartite sustainability policy and an intermediary for issues such as climate change and rising energy prices. To some extent, both the term sustainability and the environment are used interchangeably by researchers and managers. This misunderstanding has been especially common in recent years. The environment, however, has been seen as the beginning of a vision for starting a sustainable supply chain, and there is now a growing understanding of the same use of the term sustainability as a triple policy, namely economy, environment, and community (Carter and Easton, 2011: 46–62).

According to Zhu et al. (2007), increasing concerns about environmental warnings are forcing producers to attempt to apply environmental management strategies. Meanwhile, since adverse environmental impacts occur in all stages of the product life cycle, and environmental management plans and operations are not confined to the organization boundaries, understanding environmental responsibility can lead to gaining competitive advantage and increasing market share through the process of improving environmental impacts of products. (Safari, 2017: 25).

While the economic dimension is a prelude to long-term profitability, considering this dimension alone in relation to the overall impacts of the company is not sufficient for sustainable development, and the environmental dimension is another aspect of sustainability which should be addressed. Environmental group criteria focus on legislation on the negative impact of transportation and the impact of other activities of the company on the environment. The environmental dimension includes the sub-dimensions of hazardous gas emissions, the exploitation of natural resources, and waste and recycling. Table 3 summarizes the sub-dimensions of this dimension (Jafarnejad and Mahmoudi, 2014).

Table 3. The environmental dimension and its sub-dimensions (Jafarnejad and Mahmoudi, 2014).

Dimensions	Examples of Benefits and Improvements	Examples of Criteria
Emissions of hazardous gases	CO_2 emissions Release of other pollutants	Reduction in carbon dioxide emissions, saving fuel, saving water, harnessing the energy spent in each warehouse, the reduced need for road transport, the percentage of reusable packaging, the reduction of damage to equipment, the reduction of damage to maritime cargo, the reduction of waste and backlog, the reduction of equipment disability, and outdated products.
Exploitation of natural resources	Fuel consumption Water consumption Energy consumption Land use	
Waste and recycling	Waste reduction Percentage of recycled materials and products Use of environmentally damaging materials	

So far, the environmental aspects of the measurement systems used by companies have been largely ignored. Thus, there is a lack of commonly accepted measurement standards and norms. Hence, when analyzing the impact of the company, how its activities affect the environment must also be taken into account (Mahmoudi, 2017: 26). One of these effects is the emissions of carbon dioxide gas which national and international organizations are seeking to reduce. The measurement of carbon dioxide is under development. There are various software packages and approaches in this context, but there is no universal agreement that is accurate and can be universally accepted in the future. Fossil fuels are also under the category of natural resource exploitation, where issues such as land, water, and fuel use are raised. All of these aspects are easily measurable, and the data are available from various databases. In addition to carbon dioxide, another class of harmful and greenhouse gases should also be calculated (Jafarnejad and Mahmoudi, 2014).

According to Grossmann (2004), waste and recycling is another class of environmental effects that can be reflected through the percentage of waste and different waste streams sent to the landfill and recycling of waste. Process system engineering plays an important role in each of the above areas, contributing toward an overall life cycle assessment to achieve the goals. The development of systematic approaches and tools that guarantee the design of environmentally safe products and processes related to sustainable supply chains are goals for implementation (Safari, 2017: 27).

Sustainability and no risk from a social perspective

The social dimension has not yet been directly and generally addressed in organizational performance measurement systems. For example, they are used in human resources. However, individuals, their skills, and their impact on society are key issues in sustainability. The social dimension includes health and safety aspects, impact on staff, and noise emissions. The dimensions listed are summarized in Table 4 (Jafarnejad and Mahmoudi, 2014).

Criteria for the health and safety dimension include the number and types of work-related accidents. In many countries, there are legal requirements for collecting such data, especially in relation to major and fatal injuries, but there is no common standardization and definition in this context. This class should also include all accidents involving contractors and employees of agencies operating in the company and not exclusively employees within the company (Jafarnejad and Mahmoudi, 2012).

Recruitment can be measured at different levels. The creation or reduction of jobs at the company level reflects the working conditions and norms of employees. Such discussions can be measured by such criteria as absenteeism, the number of new employees, the turnover percentage of key employees, etc. (Nazeri and Nosratpour, 2016).

Table 4. The social dimension and its sub-dimensions (Jafarnejad and Mahmoudi, 2014).

Dimensions	Examples of Benefits and Improvements	Examples of Criteria
Health and safety	Emissions of toxic and dangerous gases Accidents Working conditions	Training staff and suppliers on health and safety issues, the amount of accidents within the company, the extent of accidents caused by interactions between three-tier supply chains, the reduction of accidents resulting in surgery and death, the reduction of disabled and deceased staff, the reduction in the chance of accidents, the decrease in employment, inadequate training for staff to adopt new systems, lack of long-term employment contracts with staff, the percentage of trained staff, lack of appropriate training for drivers, staff retention, absenteeism, the reduction in traffic caused by truck transport, the reduction in congestion caused by operations in warehouses, and the amount of activity in industrial areas.
Staff	Recruitment Education Job security	
Sound pollution	Noise level Noise time Noise location	

A company should also consider the impact on business partners, especially small and medium-sized companies. This impact can be reflected in the percentage of employees' engagement, the number of collaborative initiatives, and staff training. In this dimension, knowledge and education play a vital role, but calculating both is difficult. This can be reflected in the amount of training costs and the percentage of staff with a certain level of training or vocational training and their changes over time. Sound pollution (noise emissions) is also in the social dimension. This dimension is generally less important in industrial contexts. Noise pollution is more common in residential areas. Apart from the amount of the noise, the time of the noise and whether it is day or night are also important (Safari, 2017: 28).

3. Research Method

This research is applied by purpose and is descriptive in terms of the method of data collection. It is an applied research because it follows new knowledge that has a specific application in a product or process that is real. Also, it is descriptive due to the fact that it describes and interprets what exists and focuses on the existing conditions or relationships, common beliefs, current processes, tangible effects, or expanding trends. The library information method was used to compile the background, and a questionnaire was used to evaluate the research questions. The validity of the questionnaire was tested using the Lawshe's content validity ratio, that is, $CVR = \frac{n_e - \frac{N}{۲}}{\frac{N}{۲}}$, and the reliability of the questionnaire was estimated using Cronbach's alpha coefficient. The value of Lawshe's content validity ratio was 0.79, which according to the number of the experts ($n = 10$), indicated the validity of the content of the research instrument. The Cronbach's alpha coefficient of the questionnaire was 0.78 which confirmed the appropriate reliability of the research instrument.

3.1. Statistical Population and Sample

The statistical population of the study in the first dimension of the research, which assesses the risks associated with sustainability in the oil and gas supply chain, consisted of all the experts who were aware of the concept of sustainability in oil and gas industry. Among them, 10 experts were selected by purposeful sampling and based on the snowball technique. The experts in this stage were those with at least a bachelor's degree and at least five years of experience in oil and gas industry. In the second dimension of the research, which designs and explains a model of evaluating sustainable supply chain based on the structural equation model in oil and gas industry, to determine the required sample size, the minimum sample size needed to implement structural equations was cited. There is generally no general agreement on determining the minimum sample required to test structural equations, but researchers recommend using linear structural relations (LISREL) or covariance-based methods with the help of other software such as AMOS and EQS; there should be at least 200 samples available (Mohsenin and Esfidani, 2013). Accordingly, 252 companies active in oil and gas industry were selected as a sample by available sampling method; 240 acceptable questionnaires were returned.

3.2. Method of Data Analysis

a. FMEA technique

The FMEA approach is most often used when it is intended to design or implement a new product, service, process, method, or action to meet the organization intended purpose, where the error and the amount of the risk are not properly identified. In this study, the FMEA method is used because the assessment of sustainability risks has not yet been carried out in a real sense or in accordance with international standards in oil and gas industry, and a more comprehensive review should be conducted to identify and prioritize these risks. This procedure is done to prevent failure (before it occurs).

In general, the FMEA method has seven basic steps as follows:

Step One: Identifying Area of Activity in Oil and Gas Industry: In this section, the area of activity in oil and gas industry is identified.

Step Two: Identifying Error Modes: Since the most important step in risk-based management is error state detection, one will be able to identify the error modes by visiting the experts in oil and gas industry. Then, the error modes, for each of the activity domains investigated, will be identified by the experts and will be recorded in the worksheet. It is necessary to explain that the study of the empirical and theoretical background of the research has helped to identify the error modes in this industry.

Step Three: Determining the Difficulty of the Error Mode (Intensity): In this step, the hardness of each error mode is evaluated with the help of experienced experts in the ranking table. A degree of difficulty ranging from 1 to 10 with no difficulty to dangerous no alert for error modes is recorded in the worksheet. It should be noted that since each worksheet is given to the experts separately, the degree of difficulty for each of the error modes is the mean of the experts’ response to that error.

Step Four: Determining the Probability of Occurrence: At this point, the probability of the occurrence of any of the error modes specified is set at 1 to 10, such that number 1 indicates the least probability and number 10 denotes the highest probability of occurrence, and is finally recorded in the worksheet. It should be noted that since each worksheet is given to the experts separately, the probability of the occurrence of each of the error modes is the mean of the experts’ response to that error.

Step Five: Determining the Likelihood of Detection: In this stage, after consulting with experienced experts, the degree of error detection and control will be assessed according to the ranking table. The rate of diagnosis is specified in the special table from 1 to 10, such that number 10 represents the weakest control, and number 1 indicates the strongest control, and is then recorded in the worksheet. It should be noted that since each worksheet will be given to the experts separately, the effectiveness of the control of each of the error modes is the mean of the experts’ response to that error.

Step Six: Calculating Risk Priority Number: In this step, risk priority number (RPN) is calculated for each error mode. The risk priority number is the product of the difficulty rating, occurrence rating, and detection rating, which is recorded in the worksheet. In order to determine the level of risk and analyze the data, the mean and standard deviation of all the risks will be calculated first. The identified risks are then calculated based on the RPN Index.

Step Seven: Determining Control Action to Reduce the Risk of Error Mode (Risk Management): After prioritizing the risks, the risk management is performed to reduce the level of risk. The risk management will reduce the impact and probability of occurrence. In the following, the structure of the research is presented in Figure 1.

4. Data Analysis

Step One: Identifying Risk and Error Modes

Prior to starting the technique, a dedicated team was formed. The team involved 10 experts from oil and gas industry. The worksheet of the researcher was distributed among them, and the most important risks related to supply chain sustainability were examined. A review of the research literature and research background in this field has also helped to identify the error modes in the field of supply chain sustainability. The number of potential errors per segment is presented in Table 5.

Step Two: Determining the Occurrence of Failure

In this stage, due to lack of access to historical data, experts’ knowledge and experience are used, and according to the ranking table, the probability of the occurrence of any error modes is determined and is finally recorded in the worksheet. It should be noted that since each worksheet is given to the experts separately, the probability of the occurrence of each of the error modes is the mean of the experts’ response to that error. Error modes with the highest probability are tabulated in Table 6.

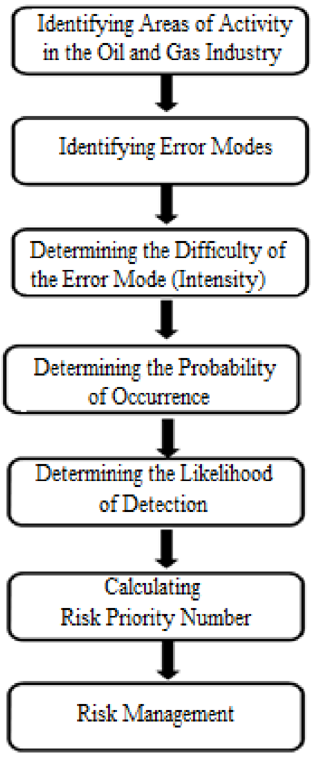

Figure 1. The structure of the research.

Table 5: The identification of risk and error modes.

Risk Type	Category	Number of Risks and Errors
Environmental risk	Discovery	6 Risks
	Development and transportation of oil fields (pipelines and tanks)	17 Risks
	Refinement	5 Risks
Social risk	Discovery	3 Risks
	Development and transportation of oil fields (pipelines and tanks)	15 Risks
	Refinement	4 Risks
Economic risk		6 Risks

Table 6. The determination of the probability of failure.

Potential Error Mode	Probability of Occurrence
Energy price fluctuations	9.4
Emissions of greenhouse gases, reduction of air quality, and climate change (environmental risk)	9.4

Potential Error Mode	Probability of Occurrence
Sanctions	8.8
Mud and sludge from the use of drills for drilling (environmental risk)	8.6
Community health and safety such as noise, vibration, dust, vehicle movement, pressure on transportation networks and indigenous infrastructure, greenhouse gas emissions, and air quality reduction (social risk)	8.3
Pressure on infrastructure and public disturbance such as noise; vehicle movement; air quality; and social ability to attract new and external resources, including water, power, health, education, and housing (social risk)	8.1
Infectious diseases (the prevalence of a disease among internal and external staff)	8

Step Three: Detection Rate

The probability of detection is a measure of the system ability to detect the occurrence of an error. In this rating, team members reviewed existing control for supply chain sustainability, and in the absence of the current control, they considered the probability of detection to be very low, resulting in a very high detection rate of 9 or 10. Error modes with the highest degree of detection are listed in Table 7.

Table 7. The determination of the probability of detection.

Potential Error Mode	Probability of Occurrence
Energy price fluctuations	9.3
Sanctions	9.1
Failure and pollution in surface (hydrological) and groundwater (hydrogeological) systems and flows (environmental risk)	9
Community health and safety such as noise, vibration, dust, vehicle movement, pressure on transportation networks and indigenous infrastructure, greenhouse gas emissions, and air quality reduction (social risk)	8.8
Mud and sludge from the use of drills for drilling (environmental risk)	8.7
Health and safety risks for employees, employment, and labor standards such as low-level standards that create hazardous working conditions for employees (environmental risk)	8.4
Risks of the national economy and income transparency: risks like inflation, bribery, corruption and extortion, and income transparency (social risk)	8.4
Natural hazards and risks such as explosion of wells, combustion and explosions, contamination of land or water, toxic leaks (environmental risk)	8.3

Potential Error Mode	Probability of Occurrence
Land acquisition and relocation: temporary and permanent ownership of the land leads to poverty, social disruption, immigration, involuntary resettlement, and compensation claims. (social risk)	8.2
Emissions of greenhouse gases, reduction of air quality, and climate change (environmental risk)	8.1

Step Four: Severity Determination

In this step, the difficulty of each of the risks related to supply chain sustainability is evaluated with the help of experienced experts in the ranking table. A difficulty rating of 1–10 with normal to sensitive hardness is recorded for error modes in the worksheet. It should be noted that since each worksheet is given to experts separately, the degree of difficulty for each of the error modes is the mean of the experts' response to that error. In this section, the error modes with the highest degree of difficulty are presented in Table 8.

Table 8. The degree of difficulty.

Potential Error Mode	Difficulty of Risk Mode
Failure and pollution in surface (hydrological) and groundwater (hydrogeological) systems and flows (environmental risk)	9.4
Emissions of greenhouse gases, reduction of air quality, and climate change (environmental risk)	9.3
Sanctions (economic risk)	9.2
Energy price fluctuations (economic risk)	9.2
Pressure on infrastructure and public disturbance such as noise; vehicle movement; air quality; and social ability to attract new and external resources, including water, power, health, education, and housing (social risk)	8.2
Risks of the national economy and income transparency: risks like inflation, bribery, corruption and extortion, and income transparency (social risk)	8.1

Step Five: Calculating Risk Priority Number

In this step, the risk priority number is calculated for each of the error modes. The risk priority number is the product of the difficulty rating, occurrence rating, and detection rating that is recorded in the worksheet. In order to determine the level of risk and analyze the data, mean and standard deviation of 57 risks were calculated. The identified risks were then prioritized. Based on the statistical results using SPSS19 software, a mean of 269.171 and a standard deviation of 33.54 were calculated for 57 risks. In order to determine the cut-off point of a standard deviation above and below, the mean was chosen as the cut-off point as listed in Table 9.

Accordingly, the risks with a priority number below the lower limit of the RPN (235.631) have normal conditions, and the risks with a priority number higher than the upper limit of the RPN (302.711) are abnormal; the risks with a priority number between the lower limit of the RPN and the upper limit of the RPN (235.631 to 302.711) have abnormal and moderate conditions. Based on the results of the above table, the risks are tabulated in Table 10.

Table 9. The mean and standard deviation of the RPN.

Description	Mean	Standard Deviation
RPN	269.171	33.54
Upper limit of RPN > 302.711	٣٠٢,٧١١ = ١٧١,٥٤ + ٢٦٩,٣٣	
Average RPN	302.711 to 235.631	
Lower limit of RPN < 235.631	٢٣٥,٦٣١ = ١٧١,٥٤ –٢٦٩,٣٣	

Table 10. The RPN.

Risk Group	Life Cycle and Activity	Risk Type	Risk Title	RPN	Rank
Environmental Risks	Discovery	Seismic evaluation	١. Disrupting the land surface, loss of vegetation, soil erosion, inaccessibility of land for agriculture and development, habitat destruction, and use of explosives	339.50	1
			٢. Emission of pollutants from vehicles and factories such as production of volatile organic compounds (VOCs), NO_x, SO_x, particulate matter (PM10), CO, CO_2, etc., as well as greenhouse gas emissions and noise pollution in the area	161	3
			٣. Visual pollution of the area due to habitat destruction	362.10	1
		Exploratory drilling	٤. Mud and sludge from the use of drills for drilling	560.80	1
			٥. Discharge of gases from drilling and the danger of fire	310.30	1
			٦. Natural hazards and risks from the explosion of wells, land subsidence, and water and soil pollution	340.70	1
	Oil field development and transportation (pipelines and tanks)		٧. Emissions in the environment: • Pollutants such as VOCs, NO_x, SO_x, PM10, CO, CO_2, etc. • Emissions of greenhouse gases and flammable gases, unfavorable odors in the atmosphere, and in general climate change in the region • Causing noise pollution in the area	388.80	1
			٨. Natural hazards and risks such as the explosion of wells, combustion and explosions, contamination of land or water, and toxic leaks	479.80	1
			٩. Mud caused by drilling and contamination of soil and water	208.70	3
			١٠. Failure and pollution in surface (hydrological) and groundwater (hydrogeological) systems and flows	854.30	1
			١١. Pressure on natural resources and habitat loss	134	3

Risk Group	Life Cycle and Activity	Risk Type	Risk Title	RPN	Rank
		Isolation, compression and dehydration of the product	١٢. Failure and pollution in surface (hydrological) and groundwater (hydrogeological) systems and flows (hydraulic failure)	78.80	3
			١٣. Unfavorable odor emissions due to sulfur production	107.60	3
			١٤. Atmospheric emissions: the production of hazardous gases, greenhouse gases, air quality change, and climate change	141.20	3
		Pipelines	١٥. Disruption of land surface, loss of vegetation, soil erosion; inaccessibility of land for agriculture and development, and habitat destruction	67.50	3
			١٦. Native and regional geotechnical hazards such as land subsidence	75	3
			١٧. Natural hazards and risks such as pipeline/pumping site leakage that results in ground and water pollution	37.20	3
			١٨. Engineering activities that affect the environment	91.50	3
			١٩. Hydrostatic experiments	205.60	3
			٢٠. Production and disposal of liquid and solid waste such as sludge removal and disposal	151.70	3
		Tankers (road and marine tankers and tanks)	٢١. Atmospheric emissions of pollutants such as VOCs, NO_x, SO_x, PM10, CO, CO_2, etc.; greenhouse gas emissions; and noise from vehicles	132.20	3
			٢٢. Risks caused by road and sea transport such as oil spills, residual discharge of tanker and oil tankers, and ballast water along the route	151.80	3
			٢٣. Disposal of solid and liquid waste during loading and unloading of tankers and tanks	81.10	3
	Refinement	Building new sites and factories	٢٤. Habitat fragmentation and degradation: disturbance at ground level, loss of vegetation, soil erosion, inaccessibility of land for agriculture and development, and habitat destruction	255.30	2
		Facilities operations	٢٥. Emissions of greenhouse gases, reduction of air quality, and climate change	709	1
			٢٦. Pressure on natural resources such as water use and hot water discharge	482	1
			٢٧. Emissions of unfavorable odor in the area	119.60	3
			٢٨. Leaks of toxins	107.80	3

Risk Group	Life Cycle and Activity	Risk Type	Risk Title	RPN	Rank
Social Risks	Discovery	Seismic evaluation and exploratory drilling	٢٩. Community health and safety such as noise, vibration, dust, vehicle movement, pressure on transportation networks and native infrastructure, greenhouse gas emissions, and air quality reduction	135.30	3
			٣٠. Infectious diseases (prevalence of a disease among the inhabitants of indigenous areas)	161.30	3
			٣١. Cultural/archaeological heritage (damage to religious, historical, cultural, and archaeological sites)	576	1
	Oil field development and transportation (pipelines and tanks)	Product exploration and drilling, separation, compression, and dehydration process and pipelines	٣٢. Land acquisition or displacement: temporary and permanent ownership of the land leads to poverty, social disruption, migration, involuntary resettlement, and compensation claims.	70.50	3
			٣٣. Possession of high-quality agricultural land and use of crop nutrition resources	181.30	3
			٣٤. Loss of livelihoods, income, and employment due to economic displacement and job competition; impact on livelihoods and land value	178.50	3
			٣٥. Risks to the health and safety of employees: employment and labor standards such as low-level standards that also enable people of a younger age to do dangerous work.	108.40	3
			٣٦. Socio-economic deprivation of ethnic minorities and indigenous peoples	63.70	3
			٣٧. Cultural–social tensions between indigenous and nonindigenous labor forces due to the influx of migrants/temporary workers into the project area	77	3
			٣٨. Inadequate information counseling and disclosure to NGOs, local and national advocacy groups, and poorly managed social relations	69	3
			٣٩. Impact on local businesses such as illegal businesses	282.60	2
			٤٠. Risks of the national economy and income transparency: risks like inflation, bribery, corruption and extortion, and income transparency	337.50	1
			٤١. Community health and safety such as noise, vibration, dust, vehicle overload, pressure on transport networks and indigenous infrastructure, greenhouse gas emissions, and air quality depletion	341.70	1
			٤٢. Infectious diseases (the prevalence of a disease among the internal and external staff)	479.20	1

Risk Group	Life Cycle and Activity	Risk Type	Risk Title	RPN	Rank
		Risks related to road and sea tankers and tanks and the risks associated with the refining activity cycle (site construction and new plant)	٤٣. Inadequate information counseling and disclosure to NGOs, local and national advocacy groups, and poorly managed social relations	382.50	1
			٤٤. Impact on local businesses such as illegal businesses	382.40	1
			٤٥. Risks of the national economy and income transparency: risks like inflation, bribery, corruption and extortion, and income transparency	412.80	1
			٤٦. Prevalence of communicable diseases to native and nonnative residents	465.40	1
	Refinement		٤٧. Health and safety of the community such as dust generation, environmental emissions, and air quality	381.10	1
			٤٨. Pressure on infrastructure and public disturbance such as noise; vehicle movement; air quality; and social ability to attract new and external resources, including water, power, health, education, and housing	624	1
			٤٩. Infectious diseases (prevalence of a disease among native and nonnative inhabitants)	190	3
			٥٠. Risks related to employees' health and safety: employment and labor standards such as low-level standards that create hazardous working conditions for employees.	122.60	3
Economic risks			٥١. False claims/dishonesty	85.50	3
			٥٢. Allegations of corruption	57.50	3
			٥٣. Tax evasion	90	3
			٥٤. Sanctions	741.60	1
			٥٥. Energy price fluctuations	805.70	1
			٥٦. Financial crises	127.70	3
			٥٧. Litigation	274.10	2

5. Discussion and Conclusions

In general, the process of sustainable risk management in the area of the supply chain, or rather sustainable supply chain management, can play a crucial role in controlling the risks related to this area. Based on previous studies, to control sustainability risks, control measures are suggested as follows:

- **Supplier Selection**: it refers to the extent of the organization attention to such criteria as the ability of the supplier company to fulfill the firm enduring needs, the supplier's business codes of conduct, and so on when selecting a supplier.
- **Local supplier management**: it refers to the extent of the organization teamwork to create business opportunities, annually update local strategies, and communicate directly with local suppliers.

- **Operations management**: it refers to the extent of the organization management in cases such as the use of renewable resources, waste recycling, hazardous waste, etc.
- **Product Monitoring**: it refers to the extent to which the organization focuses on monitoring the use of environmentally friendly alternatives, safe and environmentally friendly packaging, and so on.
- **Logistics management**: it refers to the extent to which an organization uses environmentally friendly transport methods, applies recyclable packaging systems, and, in general, pays attention to the issue of sustainability in the procurement process (Van et al., 2016: 13–42).

It should be noted that several factors affect the risk management and sustainable supply chain management. In the following, the effective factors in this area will be explained.

5.1. Sustainability Commitment (Organizational Culture, Top Management Leadership, and Transparency)

Organizational Culture: Among the factors of sustainability commitment, the results indicate that organizational culture has a positive and significant relationship with the risk management of sustainable supply chain. This indicates that companies with cultures such as team collaboration, competitiveness, risk-taking, and preventive behavior are more likely to adopt measures to ensure safety and prevent contaminants from being released during the production process, as well as throughout the life cycle of a product. The findings of this section of the study are in line with the works of Pagell and Wu (2009), Walker and Jones (2012), and Shuen et al. (2014) which demonstrate the adoption of the management practices of sustainable supply chain is influenced by sustainability culture and ability to acquire and develop new capabilities in the area of sustainability issues.

In general, it is expected that a supportive corporate culture can help companies operating in oil and gas industry to develop dynamic capabilities that play a critical role in improving the health, safety, security, and environmental management of operations. The capabilities also enable companies to manage the complex issues of their business ecosystem arising from fierce competition for access to oil and gas resources, as well as the need to adopt new technologies quickly and perform operations in unstable operating environments. To take advantage of these capabilities, companies must expand their engagement with supplier and stakeholder partners to minimize the risks related to their activities. The results of this hypothesis are in agreement with the findings of Shuen et al. (2014).

Top Management Leadership and Transparency: Various studies have also shown that in the area of sustainability commitment, top management leadership and transparency can contribute to sustainable supply chain actions. In this context, Thurner and Proskuryakova (2014) and Harms et al. (2013) reported that these two factors can play a crucial role in sustainability and risk management measures. However, it should be noted that the commitment of top management and the enhancement of transparency in sustainability measures may not be sufficient for the acceptance of sustainability, and the commitment of top management should be supported by an organizational culture to transform that commitment into actual plans and actions.

5.2. Management Readiness (Risk Management, Cross-Functional Teams, and Performance Management)

In terms of management readiness factors, management readiness appears to play a significant role in sustainability risks in the field of sustainable supply chain management.

Risk Management: In general, it can be acknowledged that risk management and increased monitoring of different sources of the operational risks of oil and gas supply chain lead to greater emphasis on firm resource supply measures and can improve a supplier's social and environmental performance. This management can also lead to the creation of mutually beneficial relationships between supply chain partners to find solutions to sustainability issues. Similarly, companies are encouraged to implement better product monitoring initiatives and innovations if they have a greater understanding of the dangers of oil and gas products during production and delivery.

Cross-Functional Teams: The cross-functional integration of the actions taken by companies as another component of management readiness also plays a significant role in managing the risks associated with sustainability in the supply chain, and according to Porter (1991), it is able to create a coherent work environment and enable different functional departments to work together so as to achieve common sustainability goals. This is particularly important in oil and gas industry because of the global nature of its operations, and, according to Escobar and Vredenburg (2011), it necessitates the use of sustainable strategies that can be applied across the different functional areas and networks of functions of the company. According to the researchers, deploying sustainability strategies in the different areas of the oil and gas supply chain should be guided by business-level strategies such as green consumerism, reducing legal liability, and disclosure of risk and cost. These strategies should also be complemented by environmental capabilities such as pollution control and prevention. In line with this, a study by Andersen and Mostue (2012) also showed that the involvement of interdisciplinary teams, experts, and supply chain partners is important for reducing the risks of operations in the petrochemical industry.

Performance Management: Performance management can also have a significant impact on sustainability measures and the management of sustainability risks in the supply chain. In general, it can be mentioned that the operations of oil and gas industry include complex networks of specialized service suppliers and providers who are increasingly under pressure to improve the traceability of materials used in manufacturing processes so as to reduce environmental impacts. The management of these complex processes requires performance management systems that can help the company improve the coordination and efficiency of the supply chain and identify suppliers that can help them integrate environmental and safety measures into the supply chain. Similarly, Hervani et al. (2005) found that the development of performance measurement systems and the related requirements can facilitate the introduction and implementation of sustainable actions in the supply chain. According to Faisal (2010), using performance measurement metrics can help company measure performance and identify the measures needed to improve the management performance of the sustainable supply chain.

5.3. External Factors (Political Stability, Economic **Stability, Stakeholder Pressure, Energy Transition Policies, and Laws and Regulations)**

Political Stability: Government's efforts to increase political stability play a key role in managing sustainability risks in the oil and gas supply chain. In general, the relationship between the energy issue and politics in recent crises is clearly evident. According to previous research, there are two sources of political risk: A source of government risk that is related to official decisions and activities which can affect capital or profit; a source of social risk created by public interest groups which can lead to unrest, civil war, and industrial sanctions. For example, government decisions and actions on tax and fiscal policies, protection of foreign investment, administrative efficiency, and transparency can influence the decision on the firm location. Political instability could also threaten the security of the oil and gas supply chain. Euroville et al. (2014) also acknowledged that conflicts due to instability can result in disastrous consequences and can consequently cause financial losses and environmental disasters as well as affecting staff and infrastructure safety. The unstable environment also increases the difficulty of developing international cooperation.

Economic Stability: Government's efforts to enhance economic stability are other external factors that play a major role in managing sustainability risks in the oil and gas supply chain. In explaining this, it can be argued that a slowing economic growth reduces energy demand and prices, and many producing countries rely on revenues from oil and gas production to finance their development projects. Low income affects the government's political will to incentivize sustainable energy projects and manage the risks associated with this area. It also affects the company's ability to maintain and invest in technology and infrastructure such as reconstruction plans aimed at a low-carbon energy system. Likewise, Pascual and Zambetakis (2008) emphasized the importance of the role of economic stability in the sustainability measures of companies and risk management in this area.

Stakeholder Pressure: This is another effective external factor that can play a central role in managing the risks of the supply chain sustainability. In explaining this finding, it can be stated that companies, when exposed to greater pressure from stakeholders, namely government, investors, suppliers, political groups, communities, or competitors, are more concerned with adopting environmental strategies. Further, due to stakeholders' concerns, more and more companies in oil and gas industry are increasingly engaging in corporate social responsibility and action. Karsz-Ayrb et al. (2012) emphasized the management of sustainability risks in the supply chain.

Energy Transition Policies: In general, government's intervention is essential for the successful transfer of energy and the management of risks associated with this process, especially from an environmental point of view. In other words, the use of transitional support such as tax, green certificates, subsidies, and loans can play a key role in motivating the forces involved in the supply chain to pursue low-carbon energy projects and can manage sustainability risks in the supply chain of oil and gas industry. The results of this test are also consistent with the findings of Roy et al. (2018).

Laws and Regulations: The role of laws and regulations (regulatory pressure) in examining the influence of external factors on supply chain sustainability is also undeniable. In explaining this, one can point to the 2010 incident in the Diopater area. In general, the activities of oil and gas industry are extremely detrimental to the environment and the health of the community. The 2010 incident in the Diopater area shows the severity of the accidents of oil and gas industry. This was due to the lack of regulatory pressure on the safety, health, and environment of offshore oil and gas operations. Therefore, it is expected that laws, regulations, and regulatory pressure play an important role in enhancing corporate social responsibility, in preventing economic and environmental disasters, and in managing the risks associated with sustainability in the supply chain. The findings of Wu et al. (2012) also indicate the key role of laws, regulations, and regulatory pressure on the management of sustainability risks in the supply chain.

6. Research Suggestions

Finally, given the significant role of the external factors in managing sustainability risks in the supply chain of oil and gas industry, it is suggested that the government should support alternative energy forms by for instance paying subsidies to reduce carbon emissions from oil and gas industry activities and should cautiously act on current surveillance so as to reduce emissions. It is also recommended that suppliers, governments, stakeholders, educational institutions, and NGOs exert more pressure on oil and gas industry to adopt more sustainable policies. Finally, it appears that taxation and other measures to promote the use of low-carbon and renewable energies in the operation processes of oil and gas industry can also play a vital role in adopting sustainable actions in this industry.

Also, given the central role of the commitment of oil and gas industry to sustainability in managing the risks of the supply chain sustainability, it is recommended that top management should encourage strategic thinking in the field of sustainable development and should provide the necessary resources such as training for the staff to learn sustainability knowledge. Also, in the area of transparency and regular updating of the organization's sustainability performance on the corporate website, inviting stakeholders to visit the company, responding promptly to sustainability reports, and disclosing organizational performance based on sustainability guidelines such as the global reporting initiative and International and Environmental Conference of Petrochemical Industry can be highly influential.

Finally, considering the key role of management readiness in managing the sustainability risks of the supply chain of oil and gas industry, the management of the organization—in order to manage the safety, health, and environmental impacts of operations; safety risks; health and environmental risks of the products; and the environmental risks of logistics activities—should utilize cross-functional teams composed of people with different skills working toward a common goal such as interdisciplinary teams, experts, and supply chain partners and should prioritize the use of formal indicators to measure sustainability performance, to determine sustainability benefits using formal criteria, and to link the sustainability of the organization to the measurement and reward systems.

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