JEAS | Journal of Economics and Administrative Sciences
E-ISSN: 2148-1792 P- ISSN: 1302-2024
Volume 5, Supplement Issue 2
www.jeasweb.org

Identification and Prioritization of Sustainable Supply Chain Barriers in the Oil, Gas and Petrochemical Industries

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ABSTRACT

Introduction*: Iran is a country whose economy is heavily dependent on oil, gas and petrochemical industries. Given that environmental issues are one of the most important issues and challenges that have been considered by industries today, this study was conducted to identify and prioritize sustainable supply chain barriers in the oil, gas and petrochemical industries.*

Methods*: This research presents barriers to the implementation of sustainable supply chain in the oil and gas industry from the perspective of industry experts, so it falls under the category of qualitative research. Therefore, the statistical population of the study is composed of experts of which 12 were selected as a statistical sample through purposive sampling. The data collection tool was a Fuzzy Delphi questionnaire. The reliability and validity of the questionnaire were confirmed by professors and experts. In this sense, after collecting the components from the literature and rotating the Delphi technique questionnaire three times, it reached the model accepted by the experts. Finally, the AHP method was used to rank the identified barriers.*

Results*: The results indicate that distribution barriers are the most important barriers to sustainable supply chain implementation and distribution flexibility, supplier relationships and customer interactions were also among the most important distribution barriers.*

Discussion and Conclusion*: According to the local model obtained from this study, it was suggested that organizations should pay more attention to the identified barriers to the implementation of sustainable supply chain in the oil, gas and petrochemical industry and develop strategies to overcome these barriers.*
Keywords: Supply Chain Barriers, Sustainable Supply Chain, Oil Industry, Petrochemical Supply Chain.

Introduction and statement of the problem

In recent years, a lot of attention has been paid to the supply chain because the success and health of an organization depends on the health of the organization and the people interacting with the organization. In addition, the health of the environment and people depends on having a healthy organization. As people become more aware of environmental problems, as well as the impact of consumer goods on the environment, consumers are increasingly looking to use green products; therefore, many companies are considering this as an opportunity to the market and attracting new customers. It is worth noting that the realization of environmental goals should be accompanied by more attention to procurement activities, including the selection of suppliers. There is a lot of discussion about sustainable supply chains. Researchers have depicted a sustainable supply chain to achieve a balance between financial returns, social performance, and environmental concerns, and have argued that a sustainable supply chain should maintain relationships in which anthropology, political science, psychology, and sociology interact with the natural sciences and be interpreted in policy development, etc. (Linton et al., 2007).

Evaluation, which includes aspects of sustainability, is different from traditional and business-oriented performance appraisals; when the dimensions of sustainability are considered, the scope of the evaluation must be expanded. Sustainable development includes not only the economic aspect, but also the environmental and social aspects. Combining environmental activities with supply chain activities helps the organization gain many benefits. Many researchers believe that using a sustainable supply chain will help organizations reduce environmental risks, pollution, and improve environmental performance. Moreover, by using a sustainable supply chain, organizations will gain marketing benefits, improvement in the company's image and reputation. Reducing costs and improving customer relationships will be another benefit of using a sustainable supply chain. Thus, sustainable supply chain activities are not only considered as one of the most important profit-making approaches, but also an important factor in increasing market share and reducing the level of destructive environmental effects and environmental risks (Chen et al., 2014). The uncoordinated performance of the oil and gas industry has brought negative consequences for the country's economy. However, to some extent, problems can be solved through green supply chain integration (Setyadi, 2019). Oil industries are among the employment and parent industries that can play a key role in feeding the economies of developing countries as feeders for other sectors of industry (Ghorbanpour and Azimi, 2021). It is important to pay attention to the net performance of the oil and gas industry (Setyadi, 2019). But in Iran, there are few studies on sustainable supply chain and the obstacles to the implementation of sustainable supply chain have not been studied yet.

The questions of the research are:

1- What are the barriers and components of a sustainable supply chain?

2. How are sustainable supply chain barriers prioritized?

Theoretical Basis and research background

Supply Chain

The main activity of a supply chain is receiving raw materials from suppliers of the organization (value added) delivery to customers. A supply chain includes all partners who are directly or indirectly involved in meeting customer demand. The supply chain includes manufacturers, suppliers, carriers, warehousemen, retailers, and even customers themselves. Within each organization, like factories, the supply chain includes all operations involved in receiving and operating customer demand. These tasks include new product development, marketing, production, distribution, finance, customer service, and other operations that are in line with meeting customer needs (Sukati et al., 2012).

In 2013, Mangal outlined the importance of the supply chain as follows:

- Elimination of communication gaps between application departments to prevent delivery delays and quality complaints
- 5% reduction of all raw material costs in the competitive market
- Minimizing inventory levels
- Reducing delays in export documents and customs clearance of custom goods.

Environmental concerns related to production have led various organizations to use green practices in various supply chain processes, as Green Supply Chain Management (GSCM) is considered as an important

organizational philosophy to reduce environmental risks and as a preventive approach to increase the health of environment. Supply chain sustainability as a new and very effective sector has recently attracted the attention of supply chain experts. According to Carter & Rogers (2008) Sustainable supply chain means strategy, transparent integration and achievement of social, environmental and economic goals of an organization in systematic cooperation of key business processes within the organization to improve long-term economic performance of the company supply chain and its individual performance. Supply chain actors in industries that emit compressed greenhouse gases are likely to have no incentive to make appropriate green improvements because significant investment is needed to innovate and improve the process (Zhang & Yousaf, 2020). The green supply chain has many benefits including financial, environmental and social benefits. Financial benefits include increased revenue, reduced overall costs, increased asset utilization, and increased customer service. However, financial benefits can be disrupted through political influence on stock returns (Maqbool et al., 2018).

Research Background

The aim of Setyadi's study (2019) is to investigate the role of green supply chain integration on the sustainable performance of Indonesia's oil and gas industry. A survey questionnaire was used to collect data and the questionnaires were distributed among employees of oil and gas companies in Indonesia. Out of a total of three hundred (300) distributed questionnaires, two hundred and one (201) were returned and used for data analysis using Smart PLS 3. Findings show that green supply chain activities have a positive contribution to sustainable performance among oil and gas companies. Supplier integration, customer integration, and technology integration had a significant impact on sustainable economic performance and environmental performance. Ghorbanpour & Azimi (2021) present an interactive model for GSCM operations and its application in oil industry clustering to analyze their green performance. Therefore, the literature was studied and a total of 15 practices were obtained using the opinions of experts in academia and the oil industry. The results of the present study showed that "legal requirements and regulations", "internal environmental management", "green design" and "green technology" are among the root and effective procedures and are relatively more important than others. Zhang & Yousaf (2020) showed that stronger government intervention may not always lead to greater green recovery, and that in a high-cost green investment scenario, the government should shift from tax to a subsidy. In addition, the government can benefit from low-cost green technologies. This study shows that planned government intervention can increase supply chain performance and help achieve sustainable goals. Raut et al. (2017) examined the critical factors affecting the management of the sustainable supply chain in the oil and gas industry. The results of this study based on the ism approach showed that global pressure and lack of environmental resources are the most important factors influencing the implementation of sustainability measures. Nurul et al. (2016) examined the impact of external factors on supply chain sustainability goals in the oil and gas industry. The results showed that stakeholder pressure and political stability are the most effective factors in influencing sustainability goals. Competition in the oil and gas industry also had a direct impact on performance sustainability goals, but competition in the energy industry had a negative impact on strategic sustainability goals. Sadaghiani (2014) evaluated the external forces affecting the sustainable supply chain using the best-worst method. Examining external factors, investment plans, investing in environmental protection programs, international oil and gas companies, instability in government policies on energy, and investing in social programs are among five most important factors influencing chain actions. Shuen et al. (2014) examined the dynamic capabilities of the oil and gas industry and showed that the adoption of sustainable supply chain management measures is influenced by the culture of the organization in matters related to sustainability.

Thurner et al. (2014) studied the importance of environmental management in the management of Russian oil and gas companies and found that senior management leadership and transparency can help implement sustainable supply chain measures.

Methodology

In this study, after studying and reviewing past domestic and foreign studies in the field of supply chain sustainability and green supply chain and reviewing the identified components, an attempt was made to provide a theoretical framework by considering the theoretical foundations and obstacles to its implementation in Iran. In the first stage, using the identified knowledge and analysis, three options were presented for obstacles affecting the implementation of sustainable and green supply chain. Then, recognizing the importance and priority of the criteria and sub-criteria extracted from previous studies, the AHP hierarchical tree was drawn. Then, in order to receive the opinions of specialists and experts regarding the preference and prioritization of criteria and sub-criteria, we used the pairwise comparison questionnaire and its distribution to 12 experts by Delphi method. The results of the questionnaire were entered into the expert software of Choice and the preferred options were obtained.

Getting the opinion of experts by Delphi method

The Delphi method is the name given to a series of processes that are used to express and correct the opinions of a group that are usually experts. Delphi is a method based on the intuitive opinions of experts, in which a group of experts, after expressing their views on a particular issue, reach a consensus.

Although this collective judgment of experts may seem subjective, it is more valid than individual statements; Because it produces more objective results. The Delphi method can be considered as a way to structure a group communication process, so that this process allows group members as a whole to solve a complex problem more effectively. Regarding the selection and number of specialists, it should be noted that there is no strong and explicit law on how to select specialists, and their number depends on the Delphi goal and the scope of the solutions presented in the previous step. The number of participants is usually less than 50 and in most cases it was 15 to 20 people. Twelve people participated in this study.

The steps of the Delphi method process are as follows:

- Selecting a group of experts in the field of research
- Launching questionnaire preparation activities for the first round
- Analyzing the questionnaire in terms of writing (eliminating inferential ambiguities, etc.)
- Sending the first questionnaire to specialists
- Analysis of the answers received in the first round
- Preparing the second round questionnaire (with the required reviews)
- Sending the second round questionnaire to specialists
- Analysis of the answers received in the second round
- Report preparation by the researcher.

In this study, the adjusted pairwise comparison questionnaire was sent to 12 experts in the field of supply chain management in the oil, gas and petrochemical industries in two stages, and the obtained information was analyzed and summarized by Expert Choice software. Analytic Hierarchy Process (AHP) is one of the most popular multipurpose decision-making techniques, first developed by Thomas L. Saaty from Iraq in the 1970s. The method of evaluating the hierarchical analysis process is one of the multi-criteria evaluation methods in which it is possible to analyze and present all the available information about the options based on different and multidimensional criteria. This method of evaluation can be either very quantitative or very qualitative or a combination of both. Among the multi-criteria decision models, the AHP model was selected for better performance in this paper, which will be described in the following. The hierarchical analysis process begins with identifying and prioritizing decision elements. These elements include the objective, criteria, sub-criteria and possible options that are used in the prioritization. The process of identifying elements and the relationship between them that leads to the creation of a hierarchical structure is called hierarchical construction. Therefore, the first step in the process of hierarchical analysis is to create a hierarchical structure of the subject under study, in which the goals, criteria, sub-criteria and the relationship between them are represented. The next steps in the hierarchical analysis process include calculating the weight of the coefficient (importance) of the criteria (and sub-criteria if any), and examining the logical consistency of the judgments. In this research, the weight of coefficient of criteria and sub-criteria was calculated through hierarchical analysis software called Express Choice.

Steps to use the AHP method to select criteria, sub-criteria and drawing a decision hierarchy tree

After defining the criteria, sub-criteria and options (Table 2), the Delphi method was used to prioritize and weight the criteria, etc., and to form a hierarchical diagram. To do so, a questionnaire was distributed among experts familiar with the green supply chain and they were asked to estimate the importance and priority of each criterion or sub-criterion on a scale of 1 to 9 according to the table below. Scale 9, the hourly quantity, is the basis of judgments in determining the significance coefficients of criteria, sub-criteria, and options. The term "significance" is used to determine the significance coefficients of criteria and sub-criteria, and the term "preferred" is used to determine the significance coefficient of the options.

The results were averaged and redistributed among the initial statistical population and they were asked to apply the final changes to their desired values due to the deviations of their initial responses from the mean.

Table 1. Description of the degree of importance and priority of the numbers in the questionnaire

The Degree of Importance	Degree of Preference	Score
No matter	Equal preference	1
No significant	Poor preference	3
Medium importance	Relatively preferred	5
Very important	Highly preferred	7
Great importance	Absolutely preferred	9

Research Evaluation Framework

In Table 3, the research evaluation framework is summarized as follows:

Objective: The first column indicates the main purpose of the research model. That is, identifying sustainable supply chain barriers in the oil, gas and petrochemical industries. The components of the model are categorized in the following columns.

Criteria: The second column is considered as the criteria of the research decision model. The criteria code is shown in the third column.

Sub-criteria: In the fourth column, each of the criteria is broken down into the corresponding sub-criteria. The code of the sub-criteria is given in the fifth column.

Table 2. Research evaluation framework

Objective	Criterion	Criterion Code	Sub-Criterion	Sub-Criterion Code
Sustainable Supply Chain Barriers			Selection of Suppliers	A1
			Transportation and Logistics	A2
			Relationship between Suppliers	A3
			Intra-organizational Communications	A4
	Distribution Barriers	A	Trust among Suppliers	A5
			Distribution Flexiblity	A6
			Communication Infrastructure	A7
			Customer Interactions	A8
			Workplace Safety	B1
			Support from Superior Managers	B2
			Conflicts among the Rules	B3
	Environmental Legal Barriers	B	Cooperations among Institutions	B4
			Government Instructions	B5
			Financing	B6
			Acceptance of Social Responsibility	B7
			Culture of the Society	B8
			By-Products	C1
			Long-Term Policy	C2
			Product Re-design	C3
	Production Barriers	C	Product Development Capacity	C4
			Innovation and Creativity	C5
			Product Life Cycle	C6
			Old Factories	C7

Hierarchical analysis model of research (tree diagram)

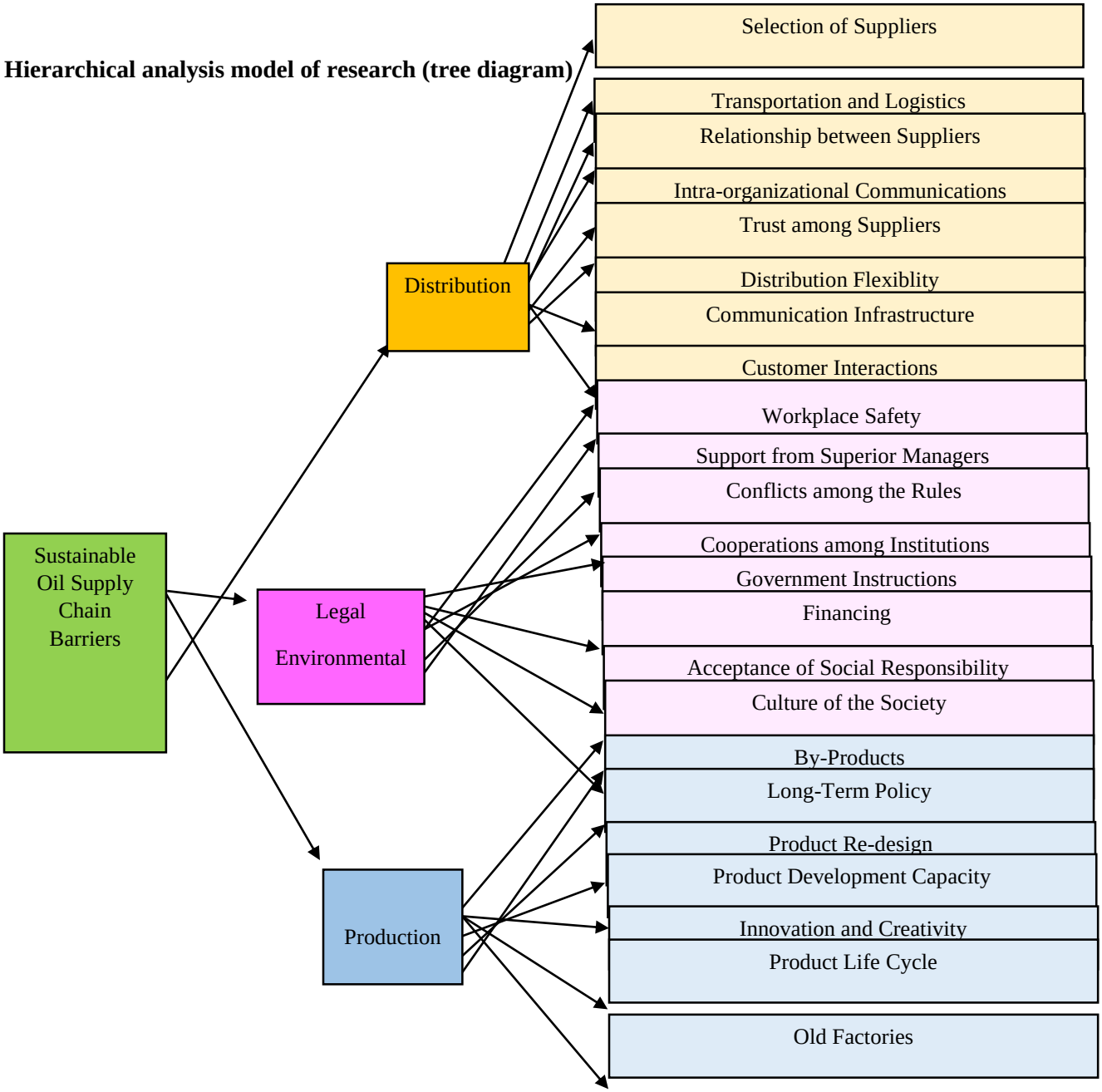

Figure 1. Hierarchical Analysis Model of Research

Designing a Pairwise Comparison Questionnaire

After drawing the model, the pairwise comparison questionnaire of the hierarchical analysis process has been designed according to the relationships between the criteria, which uses the range 1-9. The questionnaire is designed to collect the data needed to prioritize criteria, sub-criteria and options using the knowledge of experts. The designed questionnaire includes four types of pairwise comparison matrices as follows:

A) Comparison matrix of criteria in relation to each other in line with the goal

B) Comparison matrix of sub-criteria of the distribution sector in relation to eachother
C) Comparison matrix of the sub-criteria of the environmental legal sector with eachother
D) Comparison matrix of sub-criteria of the production sector in relation to each other
In the following, the analysis of the results of the four types of matrices mentioned is presented.

Findings

At this stage, the purpose, criteria, sub-criteria were entered into the software according to Table 2 (research evaluation framework) and a hierarchical tree was formed. In the second stage, the average opinions of experts were entered in the relevant questionnaire in the software and the following results were obtained:

- Results Related to the Criteria

According to the information in Figure 1 and Table 3, it is observed that the criterion of distribution barriers weighing 0.617 is more important than other criteria. In the second degree, the criterion of legal and environmental barriers with a weight of 0.3 and the criterion of production barriers with a weight of 0.083 are in the third degree. Therefore, managers and policy makers active in the oil and gas and petrochemical industries should pay more attention to the issues mentioned in the distribution barriers. The issue of distribution barriers will certainly affect the next steps because the most important barriers to sustainable supply chain are known.

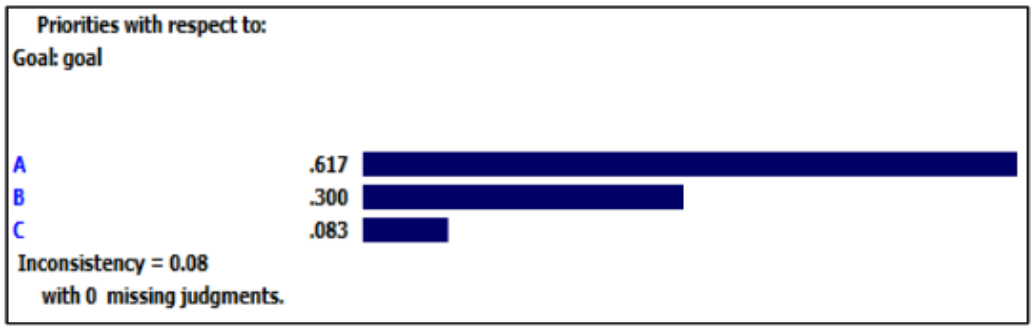

Figure 1. Comparison of Criteria Related to each other in Line with the Goal

Table 3- Weight and Rank of Main Criteria

Distribution Barriers	Code	Wieght	Rank
Distribution Barriers	A	0.617	1
Legal Environmental Barriers	B	0.3	2
Production Barriers	C	0.83	3

Results Related to Sub-criteria

Importance of distribution barrier sub-criteria relative to each other: As can be seen in Figure 2 and Table 4, sub-criterion A6, which is distribution flexibility, is more important than other sub-criteria. Sub-criteria A3 and A8 are then the relationships between suppliers and customer interactions, respectively.

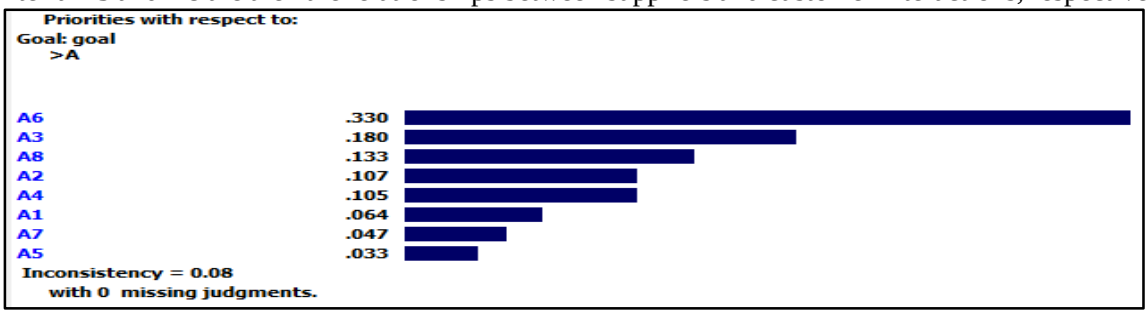

Figure 2. Comparison of the Importance of Sub-criteria of Distributional Barriers Relative to Each Other

Table 4- Weight and Rank of Sub-criteria of Distributional Barriers

Criterion Nam	Code	Wieght	Rank
Distribution Flexiblity	0.33	A6	1
Relationship between Suppliers	0.18	A3	2
Customer Interactions	0.133	A8	3
Transportaion and Logestics	0.107	A2	4
Intra-Organizational Communications	0.105	A4	5
Selection of Suppliers	0.064	A1	6
Communication Infrastracture	0.047	A7	7
Trust among Suppliers	0.033	A5	8

Importance of sub-criteria of environmental legal barriers relative to each other: As can be seen in Figure 3 and Table 5, sub-criterion B5, which is a government instruction, is more important than the other sub-criteria. Also, sub-criteria B1 and B4, which are workplace safety and cooperation among institutions, are in the second and third ranks, respectively.

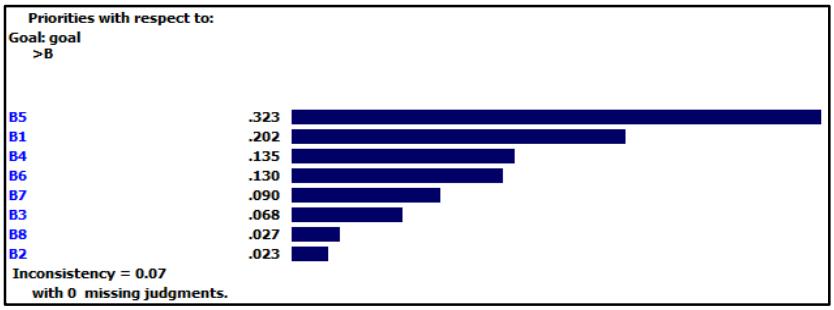

Figure 3. Comparison of the Importance of Sub-criteria of Environmental and Legal Barriers to Each Other

Table 5. Weight and Rank of Sub-criteria of Environmental and Legal Barriers

Criterion Name	Code	Wieght	Rank
Government Instructions	B5	0.323	1
Workplace Safety	B1	0.202	2
Cooperation among Institutions	B4	0.135	3
Financing	B6	0.13	4
Acceptance of Social Responsibility	B7	0.09	5
Conglicts among the Rules	B3	0.068	6
Culture of the Society	B8	0.027	7
Support from Superior Managers	B2	0.023	8

Importance of sub-criteria of production barriers relative to each other: As can be seen in Figure 4 and Table 6, sub-criterion C7, which is an old factory, is more important than the other sub-criteria. Sub-criteria C6 and C2, which are the product life cycle and long-term policy, respectively, are also important in the next ranks.

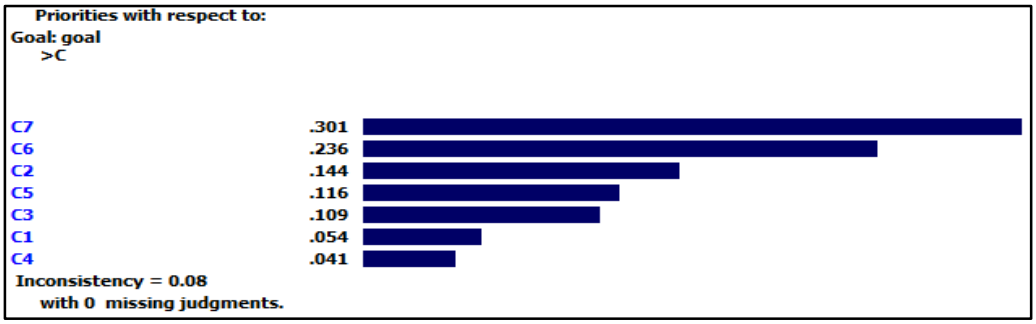

Figure 4. Comparison of the Importance of Sub-criteria of Production Barriers in Relation to Each Other

Table 6. Weight and Rank of Sub-criteria of Production Barriers

Criterion Name	Code	Weight	Rank
Old Factories	C7	0.301	1
Product Life Cycle	C6	0.236	2
Long-Term Policy	C2	0.144	3
Innovation and Creativity	C5	0.116	4
Product Re-design	C3	0.109	5
By-Products	C1	0.054	6
Product Development Capacity	C4	0.041	7

Conclusion

Based on the information obtained from the analysis performed in Expert Choice software, it can be concluded that according to experts, more attention should be paid to distribution barriers, because according to experts, this criterion is more important in the sustainable supply chain. Moreover, in response to the questions raised at the beginning of the study, it should be said that in the present study, the goal was to achieve sustainable supply chain barriers in Iran's oil, gas and petrochemical industry, including distribution barriers, legal-environmental barriers and production barriers. It was found that distribution barriers are more important for the implementation of sustainable supply chain in the oil and gas and petrochemical industries. In these barriers, barriers that include distribution flexibility, supplier relationships and customer interactions are also the most important issues to consider. First of all, the degree of distribution flexibility, that is, having a resilient distribution that can quickly build itself up and return to the status quo ante or better, is one of the things that can pave the way for a stable supply chain. Also, the role of suppliers and customers in the supply chain is not negligible. Among the legal factors of the environment, the second major obstacle is government instructions, safety and cooperation among institutions. Among the barriers to production that hinder sustainable development in the oil and gas industry supply chain are issues such as old factories, product life cycle, and long-term policy. Finally, it is suggested that these identified barriers be presented in a meeting of experts and that strategies be designed to address them and take steps towards a sustainable and green supply chain. Other researchers can also provide strategies for each of the following.

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