E-ISSN: 2717-2937 | P-ISSN: 2783-1337

International Journal of Research in Industrial Engineering

IJRIE

www.riejournal.com

Int. J. Res. Ind. Eng. Vol. 11, No. 2 (2022) 165–187.

Paper Type: Research Paper

Evaluating of Effective Factors on Green Supply Chain Management Using Statistical Methods and SWARA Approach

Abbas Nasiri[1], Ali Mansory[2,*], Nabiollah Mohammadi[1]

[1] Department of Management, Zanjan Branch, Isamic Azad University, Zanjan, Iran; abbas.nasiri@gmail.com; nabi_mohammadi@yahoo.com.

[2] Department of Management, University of Zanjan, Zanjan, Iran; mansory.ali@znu.ac.ir.

Citation:

Nasiri, A., Mansory, A., & Mohammadi, N. (2022). Evaluating of effective factors on green supply chain management using statistical methods and SWARA approach. *International journal of research in industrial engineering, 11*(2), 165-187.

Received: 10/10/2021 Reviewed: 08/11/2021 Revised: 08/01/2022 Accepted: 17/02/2022

Abstract

Major purpose of this research is identification and evaluating of effective factors on implementation of Green Supply Chain Management (GSCM) at Fanavaran Petrochemical Company by using statistical methods of Kolmogorov-Smirnov, mean and decision making method by topic SWARA (Stepwise Weight Assessment Ratio Analysis). Research methodology of present research base on purpose is practical and based on data gathering method is descriptive-measurement. In order to extracting the effective factors on GSCM at the company, in first, by literature review, 22 factors were identified. Then data were gathered by using of opinions of population members containing 55 persons of experts and senior managers in the first class of company. Finally, after analyzing the questionnaires and statistical tests above, 11 factors were confirmed and selected. In continues, in order to evaluating the final factors and ranking them base on importance in success implementation of GSCM system, the SWARA technique is used. Final outcome of this technique showed that second factor as "Designing products to reduce energy and material consumption, reuse and recycling of materials, prevent the use of hazardous materials in the production process" by most weight is extracted as the most important factor. Such, the factors of "Materials and compliance with the standards required for the purchase of raw materials" and "Procurement, distribution and reverse logistics" placed in next ranks base on importance. The factor of "total environmental quality management" by least weight is identified as last factor in implementation of GSCM at the company. In the end of research, it is proposed that organizations focus on environmental problem to acquire skill green environment advantage through green supply chain activities.

Keywords: Performance, GSCM, Kolmogorov-Smirnov test, Mean test, SWARA technique.

1 | Introduction

All operations relevant to the circulation and transformation of products and services, along with their corresponding data flows, from material sources to end customers and management which control and integrate all such steps and processes, internally and externally are covered by the supply chain [35]. In recent years, the advent of new technologies and shifts in global markets have necessitated the Supply Chain Management (SCM), so that different organizations use SCM inevitably to create and maintain their competitive position. Supply chain includes all activities related to the flow and exchange of goods and services ranging from the consumable raw material stage to the final product stage. In addition to the material flow, these interactions include information flow and financial discussions [12] and [37].

Corresponding Author: mansory.ali@znu.ac.ir

http://dx.doi.org/10.22105/riej.2022.309927.1257

The primary goal of a chain is to provide and meet the customer needs in the value production process. The purpose of each chain is to maximize its total production value in a defined time interval. Chain profitability is the total profit that should be divided in all stages of the chain. Therefore, the success of a chain is defined in terms of its profitability, and SCM requires managing the flows between and within the steps of a chain to maximize its total profitability [50].

Nowadays, sustainable development depends on the optimal preservation and use of limited and non-replaceable resources in countries. Various measures have been taken by governments to deal with this issue including the use of environmental friendly raw materials in production and industrial centers, reducing the use of fossil and petroleum resources and reusing waste [21].

Observing government regulations to meet the environmental standards and growing consumer demand for green products in the supply chain, which cover all activities related to the flow of goods from the raw material stage to the delivery of goods to end consumers, including the flow of information across the chain, have led to the emergence of a new concept of Green Supply Chain Management (GSCM) that includes the stages of the product life cycle from design to recycling [19]. Srivastava [39] defines GSCM as considering the environmental issues in SCM, such as product design, material selection and sourcing, final product delivery to the customer, and product management after consumption and its useful life. Accordingly, GSCM is similar to the product life cycle. Global organizations are always seeking to achieve competitive advantage through the creation of innovations and new approaches. Some of these organizations gain competitive advantage by improving the environmental performance by adhering to environmental laws and standards, enhancing customer knowledge and reducing negative environmental impacts on their products and services [51].

Vafaei et al. [45] examined the mediating role of innovation and sustainable process management on the relationship between sustainable SCM and sustainable competitive advantage. The statistical population consists of 20 companies involved in the production of banking equipment. Since the size of the statistical population is very small, structural equations model and partial least squares approach were used to analyze the research data and to test the hypotheses of the research. The results showed that there is a positive and significant relationship between sustainable SCM and sustainable competitive advantage. Moreover, it was found that innovation and sustainable process management variables play a mediating and moderating role on the relationship between sustainable supply chain and sustainable competitive advantage.

Mohammed et al. [33] evaluated Green and Resilient Supplier Performance using AHP-Fuzzy TOPSIS Decision-Making Approach. They ranked suppliers with respect to their Traditional, Green and Resilience (TGR) characteristics. A set of criteria/sub-criteria were identified within a unified framework and their relative importance weighted using the Analytical Hierarchy Process (AHP) algorithm. In addition, the suppliers were evaluated and ranked based on their performance towards the identified TGR criteria using the fuzzy FTOPSIS algorithm through a real case study. The study provides a noteworthy aid to management who understand the necessity of building supply chain resilience while concurrently pursuing 'go green' responsibilities. Amani et al. [7] identified barriers to green supply chain acceptance using Fuzzy DEMATEl technique. Extracted factors in this research were outsourcing, technology, knowledge, finance and support. Govindan and Sivakumar [15] developed an integrated multicriteria decision-making and multi-objective linear programming approach as an aid to select the best green supplier. Gandhi et al. [68] evaluated the important factors associated with the successful implementation of GSCM. This paper proposes a DEMATEL approach to develop a structural model for evaluating the influential factors among recognized factors. To show the real-life applicability of the proposed DEMATEL based model, an empirical case study of an Indian manufacturing company is conducted. Research findings indicate that Top Management Commitment, Human Technical Expertise, Financial Factors, has obtained the highest influential power for accomplishing the successful GSCM adoption. Conclusions and implications for managers are also discussed. Tyagi et al. [44] identified seven green criteria (including saving energy, design for environment, waste minimization, reuse of hazardous waste, awareness about green concept, information sharing regarding environmental regulations and proper mode of transport) and three mutually important alternatives namely as suppliers, web based technologies and advanced manufacturing technologies. On the basis of considered criteria and alternatives, a hierarchy type performance model has been developed and analyzed using Fuzzy TOPSIS approach to select the best alternative in order to improve the performance of GSCM system. The findings suggested that alternative 'web-based technologies' is more desirable among considered alternatives and insert a significant role in enhancing the green supply chain performance of an industry.

Concurrent to increase of the environmental crises in the world, governments and policymakers have sought to improve the changes on the earth [26] and [43]. Also, by increase of public awareness on the environmental issues and concerns about future living conditions on earth, consumers pay more attention to the characteristics of the products available on the market when purchasing products and their tendency to environmental friendly products has been increased.

The manufacturers and businesses are also seeking to change their products production process due to customers changing attitudes and behavior as well as new government policies. Therefore, manufacturers and businesses are implementing GSCM issues in their business to improve their competitive advantage and profit [39].

Increasing concerns about environmental warnings have forced manufacturers to make an effort to apply environmental management strategies. Viewpoints such as GSCM, green productivity, cleaner production and environmental management systems have been employed for green management activities [47]. GSCM has a significant impact on the environment which is based on the integration of environmental management and SCM to control environmental effect on the product life cycle through information sharing and co-ordination [42].

The adverse environmental impacts are seen at all stages of the product life cycle and the management of environmental programs and operations is not confined to the boundaries of the organization. Thus, the GSCM perspective, which covers all flows from suppliers to manufacturers and ultimately consumers as a holistic view, has gained much attention [48]. According to above comments, the master contribution of this research is the implementation of statistical techniques and MCDM technique for identification and ranking the factors effective on GSCM at FANAVARAN Petrochemical Company in Iran. The combined approach is not used in internal and international researches. Such, the most important limitation in this research was the limited access to experts of company for gathering of research data.

Fanavaran Petrochemical Company (Public Joint Stock) was established on 1998/4/28 and registered with registration number of 201702 in the Office of Corporate Registration and Industrial Property. The company is active in the establishment, startup and operation of methanol, acetic acid and carbon monoxide units for export, utilization in the petrochemical industry and downstream industries and is consistent with the industry's major export goals, policies, employment creation, transfer of technical knowledge, specialist training and production of high value added petrochemical products from natural gas. Given the importance of GSCM at Fanavaran Petrochemical Company, the necessity for operational implementation of this system in this industry is obvious. For doing so, at first, designing and explaining the model of key factors affecting the implementation of GSCM in Fanavaran Petrochemical Company is essential. Master purposes of present research is: 1) identification the effective factors on implementation of GSCM at the Company in Iran by using statistical methods, 2) evaluating the factors by using a new method of MADM by topic SWARA and finally ranking them based on weight and importance.

SWARA is one of the new methods of MCDM which was used in 2010 to develop analysis of the differences between the criteria. In SWARA, each expert ranks the criteria at first. The most important criterion is scored one and the least important one receives low score. Finally, the criteria are prioritized according to average values of the relative importance [5].

Nasiri et al.| Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

To this end, this research aims to answer the basic question: what factors have a significant impact on the implementation of GSCM in Fanavaran Petrochemical Company and how is the rank (weight & importance) of these factors?

The organization of the remaining sections in this paper is as follows: Section 2, presents the research background, Section 3, presents the research methodology; the result and discussion is presented in Section 4. Section 5, presents the findings of research; finally, conclusion and suggestions (practical and future research) are presented in Section 6.

2 | Literature and Research Background

2.1 | Green Supply Chain Management (GSCM)

Supply Chain Management (SCM) emerged as the ultimate management strategy to ensure the competitive advantages of companies in their markets [4]. SCM is one of the most attractive issues among the related experts, according to its role in promoting the efficiency and income of different organizations [72]. Nowadays, SCM has received a lot of attention in several organizations. Customers demand more environmentally-friendly products. There is a growing pressure from strict government norms on industries due to increased environmental disruption, shortage of material resources, and increased levels of pollution (essentially carbon footprints). GSCM is a powerful way to compare an organization with competitors. This is the latest technique to improve SCM capabilities. Many companies have taken green steps in their day-to-day management. Green supply chain provides operational and financial benefits to an organization and at the same time benefits the sustainability of the work environment. GSCM has a competitive advantage and improves the economic situation of an organization. It refers to improve the environmental performance of a product and process at every stage of the organization, for example purchasing, manufacturing, marketing, and presentation. Effective implementation of GSCM leads to reduced waste and environmental pollution, optimized resource utilization, and costs' reduction [30].

2.2. | Multi Attribute Decision Making (MADM)

Multi Attribute Decision Making (MADM) is one of the quantitative research methods. It can give managers many dimensions to consider related elements, and evaluate all possible options under variable degrees. Some of MADM methodologies have been suggested for weighting of attributes in literature, for example, the AHP [23], Analytic Network Process (ANP) [14], Step-wise Weight Assessment Ratio Analysis (SWARA) [4], etc. In this research, we proposed a hybrid approach by combining of Statistical Methods and SWARA.

2.3 | Background

Table 1 shows the background of research related to the factors affecting the implementation of GSCM.

Table 1. Research background.

Row	Research Title	Author and Year	Extracted Factors
National Studies Background			
1	Proposing an integrated model for evaluation of green and resilient suppliers by path analysis, SWARA and TOPSIS.	Mansory et al. [30]	Adherence to the required standards, Compliance with environmental issues, Management Commitment and employees and customer requirements.

Row	Research Title	Author and Year	Extracted Factors
National Studies Background			
2	Design a green closed loop supply chain network by considering discount under uncertainty.	Ghahremani-Nahr et al. [13]	The designed network consists of raw material suppliers, plants, warehouses, distribution centers and customer zones in forward chain and collection centers, repair centers, recovery/decomposition center and disposal center in reverse chain.
3	Design a Green Closed Loop Supply Chain Network by Considering Discount under Uncertainty.	Ghahremani-Nahr et al. [13]	The designed network consists of raw material suppliers, plants, warehouses, distribution centers and customer zones in forward chain and collection centers, repair centers, recovery/decomposition center and disposal center in reverse chain.
4	Barriers to green supply chain acceptance using Fuzzy DEMATEl Technique.	Amani et al. [7]	Outsourcing, technology, knowledge, finance and support.
5	Identification and ranking of barriers to establishing green supply chain in small and medium industries in Qazvin Province.	Aqeleh and Hamidi [9]	Organizational, environmental and individual barriers, managerial, governmental, technological, awareness, competitive, belief and economic.
6	The impact of GSCM on sustainable competitive advantage (Case study of ISO 14001 holder companies).	Ahi [2]	Cost reduction, differentiation, concentration, sustainable competitive advantage.
7	Identifying and prioritizing factors affecting the green supply chain using the Path Analysis Approach.	Husseini et al. [19]	External stimuli, internal stimuli of GSCM operations.
8	Identifying and prioritizing factors affecting the green supply chain using the Path Analysis Approach.	Husseini et al. [19]	Applying green laws and principles such as the use of environmentally friendly raw materials in industrial sites, reducing the use of fossil and petroleum resources, recycling paper and reusing waste in public and private sector companies and organizations.
9	The impact of oil shocks on green production in Iran.	Jalaei Esfandabadi et al. [73]	Oil shocks.
Row	**Research Title**	**Author and Year**	**Extracted Factors**
International Studies Background			
1	Pricing strategies and profit coordination under a double echelon green supply chain.	Li et al. [36]	In order to investigate equilibrium decisions and profit coordination methods of green supply chain, a set of Stackelberg game models considering different pricing strategies, profit coordination modes and information pattens are constructed and analyzed, in which two competitive retailers purchase a type of green product from a manufacturer who commits to green investment.

Row International Studies Background	Research Title	Author and Year	Extracted Factors
2	GSCM drivers, practices and performance: A comprehensive study on the moderators.	Micheli et al. [16]	A number of possible moderators have been identified from the extant literature. The moderators have been tested through a survey in 169 Italian manufacturing firms; Many relationships among GSCM drivers, practices and performance are moderated.
3	Dual-channel GSCM with eco-label policy: A perspective of two types of green products.	Gao et al. [24]	Two types of green products with different green technologies.
4	A robust optimization model for sustainable and resilient closed-loop supply chain network design considering conditional value at risk.	Lotfi et al. [28]	The demand for and the returns of each product, The capacity of the centers in each period, the probability of availability in the chain centers, The fixed costs of the facilities.
5	The Investigation Of The Relationship Between Sustainable SCM And Sustainable Competitive Advantage According To The Mediating Role Of Innovation And Sustainable Process Management.	Vafaei et al. [45]	Innovation, sustainable process management, sustainable SCM and sustainable competitive advantage.
6	Evaluating the performance of resilient and green supplier using fuzzy TOPSIS hybrid approach and hierarchical analysis process.	Mohammad et al. [33]	A set of criteria and sub-criteria in a unified framework.
7	The Effect of Managerial Intention and Initiative on GSCM Adoption in Indonesian Manufacturing Performance.	Masudin et al. [31]	Initiative, Attitude, Subjective norm, Behavior control, Trust, Behavior intention, GrSCM application, Performance.
8	Investigation of wind farm location planning by considering budget constraints.	Lotfi et al. [29]	The fuzzy TOPSIS method is used to evaluate and rank the candidate cities, and the results are then used to develop a budget-constrained model by fuzzy linear programming with the Maxmin objective function. The resulting mathematical model is optimised with GAMS software. The modelling results show that in the presence of budget constraints, of 10 Khorasan cities considered as candidate locations, Afriz, Rudab, and Fadashk exhibit the best conditions for the construction of wind farms.
9	Critical success factors for GSCM adoption: case studies in the automotive battery industry.	Mauricio and Jabbour [8]	Information management, Total involvement of employees, Performance measures, Top management commitment, Supplier management, Training, Green product/process design.

Nasiri et al. | Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

Row International Studies Background	Research Title	Author and Year	Extracted Factors
10	Provide an integrated approach to supplier evaluation.	Song et al. [40]	Economic, social and green criteria.
11	A multi-objective and multi-product advertising billboard location model with attraction factor mathematical modeling and solutions.	Lotfi et al. [27]	Sales, Cost of installation, Cost of Design with desired Quality level, Attraction factor, Visitors, Billboard Location, Design Quality level, Product.
12	A location-allocation model in the multi-level supply chain with multi-objective evolutionary approach.	Saeedi Mehrabad et al. [32]	The main features of the resulting developed model would include determination of the number and location of the required factories, flow of the raw material from suppliers to factories, determination of the number and location of the distribution centers, flow of the material from factories to distribution centers, and finally allocation of the customers to distribution centers.
13	Critical factors analysis of humanitarian supply chain success: An application of interpretive structural modelling.	Yadav and Barve [10]	Government participation, materials (purchases), warehouses, transfers.
14	GSCM, Environmental Collaboration and Sustainability Performance.	Chin et al. [43]	Green Procurement, Green Manufacturing, Green Distribution, Green Logistics, Environmental Collaboration, Economic Performance Environmental Performance, Social Performance.
15	GSCM enablers.	Dubey et al. [52]	Top management commitment, organizational pressures, and customer and supplier relationship management.
16	The incentives for SMEs to participate in the green supply chain.	Lee [41]	Government participation, capital allocation, production, end-user.
17	SCM: A review of analyses.	Fahimnia et al. [11]	Corporate management, IT system support.
18	GSCM enablers.	Dubey et al. [52]	Top management commitment, organizational pressures, and customer and supplier relationship management.
19	The incentives for SMEs to participate in the green supply chain.	Lee [41]	Government participation, capital allocation, production, end-user.
20	SCM: A review of analyses.	Fahimnia et al. [11]	Corporate management, IT system support.
21	Overview of green supply chain processes.	Kumar et al. [53]	Concept and design, production, transmission.

Row International Studies Background	Research Title	Author and Year	Extracted Factors
22	A strategic approach to green supply chain development.	Masoumik et al. [54]	Government partnership, concept and design, corporate management, materials (purchasing), production, end-user, IT system support.
24	Green supply chains: A view of an immediate economy.	Jayaram and Avittathur [55]	Involvement of government, concept and design, end-user, procurement and distribution.
25	Adapting green innovation in the automobile supply chain.	Zailani et al.[25]	Government participation, concept and design, corporate management, production, end-user, employment management.
26	An analysis of the reactions among the critical success factors of applying GSCM for sustainability.	Luthra et al. [57]	Government partnership, concept and design, corporate management, materials (purchasing), capital allocation, warehousing, marketing, recycling, end user, IT system support.
27	An analysis of the connections among the critical success factors of applying GSCM for sustainability.	Luthra et al.[57]	Government partnership, concept and design, corporate management, materials (purchasing), capital allocation, warehousing, marketing, end user, recycling (reuse), IT system support.
28	Multi-objective decision modeling using interpretive structural modeling for green supply chains.	Mangla et al. [56]	Government regulations and standards, customer requirements, branding and brand image.
29	Evaluation of supply chain performance indicators using DEMATEL method.	Mangla et al. [58]	Provider role.
30	Analysis of pressures for implementing GSCM in Indian industries using Hierarchical Analysis Process.	Mathiyazhagan et al. [59]	Training of suppliers and staff.
31	The role of critical factors in implementing GSCM in Indian mining industries.	Muduli et al. [60]	Concept and design, capital allocation, employment management.
32	Critical factors for supplier management: A sustainable food supply chain perspective.	Grimm et al. [61]	Corporate management, materials (purchasing), employment management.
33	GSCM: An overview of barriers and drivers.	Dashore and Sohani [62]	Top management commitment, employee engagement, technical expertise, sustainability.
34	An interpretive structural modeling approach to analyze barriers to GSCM implementation.	Mathiyanzhagan et al. [59]	The Role of stakeholders, NGOs and the media, approval of new processes and technologies, training of suppliers and staff.
35	An Overview of GSCM in India.	Dheeraj and Vishal [18]	Materials (purchase), production, marketing, end-user, procurement and distribution.

Row International Studies Background	Research Title	Author and Year	Extracted Factors
37	Environmental retail supply chains.	Kotzab et al. [63]	Environmental management systems, energy use, inputs, product, packaging, transportation, consumption and waste.
38	Drivers of GSCM performance.	Large and Thomsen [64]	Green supply management capabilities, green purchasing, Environmental commitment, environmental assessment and collaborating with providers.
39	Modeling supply chain Performance and stability.	IP et al. [22]	Reliability, staff satisfaction, customer satisfaction, timely delivery, profitability and efficiency Growth.
40	An analysis of the drivers influencing the implementation of GSCM.	Diabat and Govindan [65]	Government participation, concept and design, capital allocation, production, end-user, reverse procurement, recycling, environmental certificates.
41	Implementation of GSCM operations in the electronics industry.	Ninlawan et al. [34]	Green logistics, green production, green distribution and logistics (materials, capital allocation, warehouse, production, packaging, transportation, reverse procurement, recycling, IT system support).
42	Supply chains, lean and green.	Mollenkopf et al. [66]	Competitiveness, financial factors.
43		Holt and Ghobadian [67]	Reverse logistics.
44	The priority of different approaches in implementing GSCM.	Hsu and Hu[20]	Building an environmental database for products, top management support and environmental assessment of suppliers.
45	GSCM operations for loop selection.	Zhu et al. [47]	Indoor environmental management, green shopping, customer engagement, recycling and environmental design concept and design, corporate management, materials (purchasing).
46	GSCM in the electronics industry.	Hsu and Hu [20]	Capital allocation, recycling, recruitment management, process and technology approvals.
47	GSCM: A literature review.	Srivastava [39]	Company management, materials (purchase), production, procurement and distribution, recycling.
48	Investigation of drives and pressures in GSCM implementation.	Zhu et al. [46]	Consumer pressure, resource scarcity, competitors’ green solutions, environmental mission of the organization and national and international laws and regulations.

Row International Studies Background	Research Title	Author and Year	Extracted Factors
49	Experimental study on critical factors of GSCM operations in electrical and electronics industries and its relationship with organizational performance.	Chien and Shih [74]	Government participation, concept and design, corporate management, materials (purchasing), capital allocation, end user, reverse procurement, IT system support.
50	Experimental study on critical factors of GSCM operations in the electricity and electronics industry of Taiwan.	Hu and Hsu [6]	Government partnership, concept and design, corporate management, materials (purchasing), production, marketing, end-user, recycling.
51	GSCM in China: pressures, actions and performance.	Zhu et al. [69]	Environmental government regulations, environmental buyout mission, potential liability for hazardous waste disposal and hazardous waste disposal costs.
52	Green production: a southeast Asian experience.	Rao and Holt [38]	Adaptation of the company's products or services to the environment; prevent source contamination; Reuse of materials; increase in volume of recyclable materials in production; optimizing processes to minimize both harmful and non-harmful waste; redesigning products to minimize adverse environmental impacts.
53	Greening the corporate culture.	Harris and Crane [70]	Incorporating environmental considerations across the value chain of the organization, modify economic goals, and consider ethics, spirituality, and foresight.
55	Green teams and environmental change management in the UK.	Beard and Rees [71]	Reviewing the environment, establishing an environmental plan, establishing a unit Environment, setting up workgroups for environmental activities, setting environmental goals for the organization, incorporating environmental issues with the organization's monitoring framework, and reviewing environmental plan achievements.

Based on the review of the extensive literature and background, the final effective factors and indicators extracted in the implementation of GSCM are as follows: 1) government participation; 2) product design to reduce energy and materials consumption, reuse and recycling; prevention of hazardous substances in the production process; 3) company management; 4) materials and compliance with the standards required for the purchase of raw materials from a technical and environmental point of view; 5) training, providing models, setting standards and criteria and applying new technologies for optimal energy consumption; 6) adhering to the necessary standards in the purchase of machinery, equipment and tools from a technical and environmental point of view; 7) continuous analysis of the working condition of the machines and their exhaustion status which does not cause environmental pollution and high energy consumption; 8) capital allocation; 9) warehouse; 10) green production; 11) green packaging; 12) gGreen marketing; 13) green transition; 14) consumers; 15) reverse procurement and distribution; 16) recycling and reuse of waste and inside and outside of the company; 17) water, soil and air pollution by end product and waste and reprocessing; 18) establishing control and surveillance systems to comply with environmental standards and informing employees; 19) IT system support; 20) employment management; 21) government regulations and standards; 22) top management commitment; 23) environmental certifications; 24) globalization; 25) competitiveness; 26) customer needs; provider role; 27) total environmental quality management; 28) financial factors; 29) branding and brand image; 30) staff engagement; 31) role of stakeholders, NGOs and Media; 32) human resources technical expertise; 33) new process and technology approvals; 34) sustainability; 35) reverse logistics; 36) training of suppliers and staff in designing and adhering to environmental objectives; after merging and initial approval by experts, finally 22 indicators were extracted as follows:

I. Government participation and regulations and standards.
II. Designing products to reduce energy and material consumption, reuse and recycling of materials, prevent the use of hazardous materials in the production process.
III. Materials and compliance with the standards required for the purchase of raw materials from a technical and environmental point of view.
IV. Training, providing models, setting the necessary standards and criteria, and using new processes and technologies to optimize energy use.
V. Observing the standards required for the purchase of machinery, equipment and tools from a technical and environmental point of view.
VI. Continuous analysis of the working condition of the machinery and its exhaustion which does not cause environmental pollution and high energy consumption.
VII. Green production and packaging.
VIII. Marketing and green transition.
IX. Procurement, distribution and reverse logistics.
X. Recycling and reuse of waste inside and outside the company.
XI. Establishment of control and surveillance systems to comply with environmental standards and to inform staff and their engagement and involvement.
XII. IT System support.
XIII. Human resources employment management and technical Assistance.
XIV. Top management commitment.
XV. Environmental certificates.
XVI. Globalization and competitiveness.
XVII. Customer requirements.
XVIII. Total environmental quality management.
XIX. Financial factors.
XX. Brand and brand image.
XXI. The Role of stakeholders, NGOs and the media.
XXII. Training of suppliers and staff in designing and meeting environmental and sustainability goals.

3 | Research Methodology

This study is an applied research in terms of purpose and descriptive-survey in terms of data collection. This research, as survey studies, systematically describes the current situation through a questionnaire tool and studies its characteristics. Data collection was performed through questionnaires and interviews. This research was conducted for studying the impact of identified factors and finally extract the final factors in Fanavaran Petrochemical Company's GSCM System with mean statistical test. The statistical population consisted of the experts and managers and specialists with useful experience and expertise in this system (55 people). All members of the community were participated because of their limitations. In order to implement the SWARA decision making technique, the viewpoints of at least 10 experts of the studied company (30 people in this study) were used in a second questionnaire designed for this purpose. This type of sampling is a non-probability random sampling method and usually 10 to 20 people are considered sufficient [75]. In this study, the researchers achieved this number of experts with theoretical saturation in the field because theoretical saturation occurs when the data that helps to define a class characteristic is no longer entered into the research and all comparisons are made. In fact, these experts are all first rank managers of Fanavaran Petrochemical Company and are fully knowledgeable on the subject. Then, these factors were entered into the present research questionnaire and were given to experts to express their views on the importance of factors in terms of impact. Next, using the SWARA technique steps, the questionnaire data were analyzed to weight these key factors and rank them.

In order to conduct of this research, steps followed are implemented:

- *Literature review of factors affecting the successful implementation of GSCM from journals reported from 2000 to 2021.*
- *Designing, distributing and collecting 55 questionnaires through the opinions of experts and managers of Iran Petrochemical Company.*
- *Performing statistical tests (Kolmogorov-Smirnov and mean) in order to investigate the influence of factors on the mentioned company.*
- *Applying SWARA technique to determine the weight (importance) of the factors and finally prioritizing them through the opinions of 30 experts.*
- *Providing practical recommendations to the studied company for successful implementation of the GSCM system.*

Fig. 1 shows the flowchart of the methodology presented in this research:

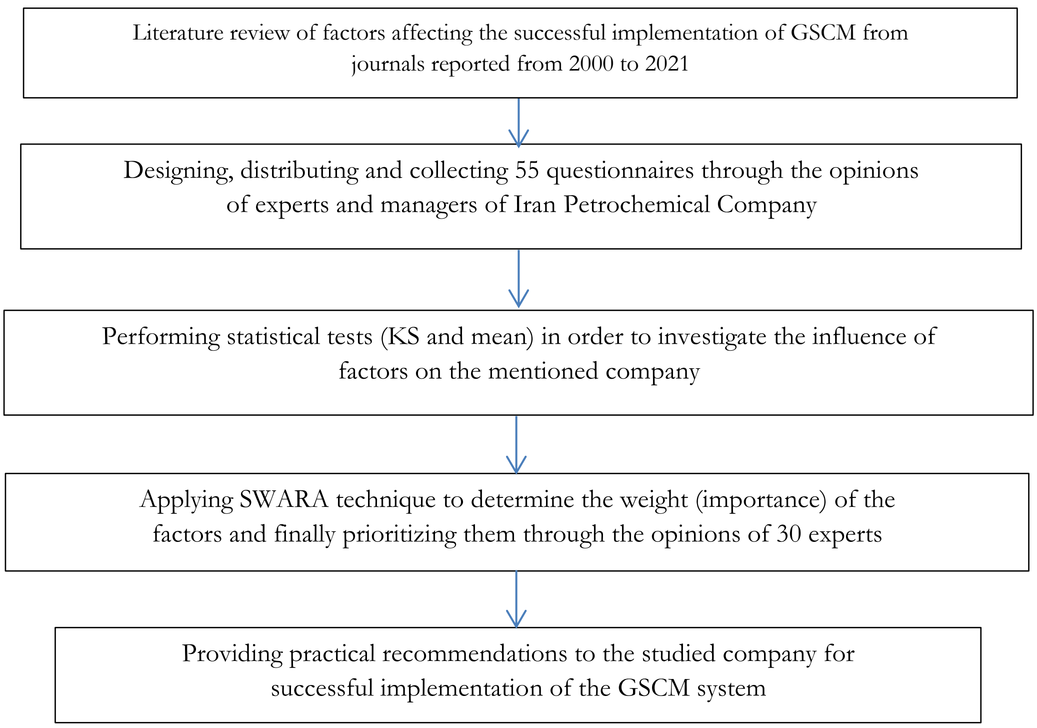

Fig. 1. the flowchart of the methodology presented in this research.

4| Results and Discussion

Kolmogorov-Smirnov (KS) and mean tests were used to answer the first question of the research (what factors have a significant impact on the implementation of GSCM in Fanavaran Petrochemical Company?). In this section, we used the software SPSS for analyzing. Also, in order to answer the second question of the research (what is the ranking of these factors in terms of importance?), the SWARA technique as one of the MCDM techniques was used which is followed in each of the approaches. In this section, we used the software EXCEL for calculating.

4.1 | Kolmogorov-Smirnov (KS) Statistical Test

The following hypotheses were used to perform this test:

H0: Distribution of the factors data is normal

H1: Distribution of the factors data is not normal

The software output for testing the above hypothesis is presented in *Table 2*.

Table 2. The software output for testing.

		Factors
N		55
Normal Parameters	Mean	2.89
	Std. Deviation	0.532
Most Extreme	Absolute	0.384
Differences	Positive	0.312
	Negative	-0.219
Kolmogorov-Smirnov Z		1.68
Asymp. Sig. (2-tailed)		0.052

Because Sig is greater than 5%, the H0 hypothesis cannot be rejected and the claim of data distribution normality is accepted. The above test was performed on the data for each of the factors and since all the outputs of the Sig were higher than 5%, the normality of each data was accepted. Therefore, the mean statistical test was used.

4.2 | Mean Statistical Test

In order to determine which of the identified factors are effective in successful implementation of GSCM in the study company, "mean test" was used and the optimal value (test number) was determined three shown in *Table 3*.

As represented in *Table 3*, a total of 11 factors have a significant impact on the implementation of the technology SCM of Iran Petrochemical Company and are considered in the final evaluation and ranking using the SWARA technique.

4.3 | Factor Analysis and Final Evaluating of the Key Factors

After designing the conceptual model, using SPLS software, the factor coefficients of factors were calculated. The values of the coefficients mentioned in *Table 4* indicate that the reliability and validity of the research factors are appropriate. In other words, the components (factors) specified in *Table 4* are well able to measure the concept under consideration.

Table 3. Effective Factors on GSCM in the company.

	Factors of GSCM	Amount of Testing: 3 t	Degree free	Sig. (2-Tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper	Effective Factors on GSCM in the Company
1	Government participation and regulations and standards.	-2.831	54	0.000	-0.097	-0.176	0.18	Confirmed
2	Designing products to reduce energy and material consumption, reuse and recycling of materials, prevent the use of hazardous materials in the production process.	5.673	54	0.000	0.643	0.564	0.727	Confirmed
3	Materials and compliance with the standards required for the purchase of raw materials from a technical and environmental point of view.	3.476	54	0.032	0.412	0.376	0.528	Confirmed
7	Green production and packaging.	7.837	54	0.000	0.536	0.456	0.696	Confirmed
9	Procurement, distribution and reverse logistics.	6.392	54	0.000	0.109	0.154	0.243	Confirmed
10	Recycling and reuse of waste inside and outside the company.	-3.298	54	0.000	0.287	0.321	0.523	Confirmed
13	Human resources employment management and technical Assistance.	4.287	54	0.001	0.536	0.398	0.604	Confirmed
14	Top management commitment.	3.927	54	0.000	0.342	0.276	0.448	Confirmed
15	Environmental certificates.	5.298	54	0.000	0.573	0.472	0.684	Confirmed
17	Customer requirements.	8.398	54	0.026	0.436	0.327	0.579	Confirmed
18	Total environmental quality management.	4.746	54	0.003	0.234	0.195	0.392	Confirmed
	GSCM	6.276	54	0.000	**123.**	**156.**	**268.**	**Confirmed**

Table 4. The reliability and validity of the research factors.

Factors	Alpha Coefficient	AVE	CR
Government participation and regulations and standards.	0.625	0.653	0.672
Designing products to reduce energy and material consumption.	0.762	0.781	0.798
Materials and compliance with the standards required for the purchase of raw materials.	0.685	0.703	0.734
Green production and packaging.	0.734	0.761	0.777
Procurement, distribution and reverse logistics.	0.685	0.713	0.736
Recycling and reuse of waste inside and outside the company.	0.723	0.765	0.801
Human resources employment management and technical Assistance.	0.759	0.788	0.807
Environmental certificates.	0.645	0.662	0.689
Top management commitment.	0.765	0.793	0.815
Customer requirements.	0.678	0.699	0.727
Total environmental quality management.	0.732	0.758	0.769

Nasiri et al.| Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

4.4 | Calculating the Weight of Factors with SWARA

In order to calculating of weight of factors, SWARA technique is used. SWARA is one of the new methods of MCDM which was used in 2010 to develop analysis of the differences between the criteria. In SWARA, each expert ranks the criteria at first. The most important criterion is scored one and the least important one receives low score. Finally, the criteria are prioritized according to average values of the relative importance. In this method, the expert assesses the calculated weights. In addition, each expert specifies the importance of each criterion according to tacit knowledge, information and experience. Then according to the average value of the group's ranks obtained by experts, the weight of each criterion is determined [17]. Therefore, in this study, the interviews of 20 Iranian Industries experts were used. The weight of each criterion indicates its importance. Measuring of weight is an important topic in many issues of decision-making. SWARA is one of the weighting methods in which professionals play an important role in the calculation of their weight and final assessment. *Fig. 2* shows the technique executive steps [5] and [4].

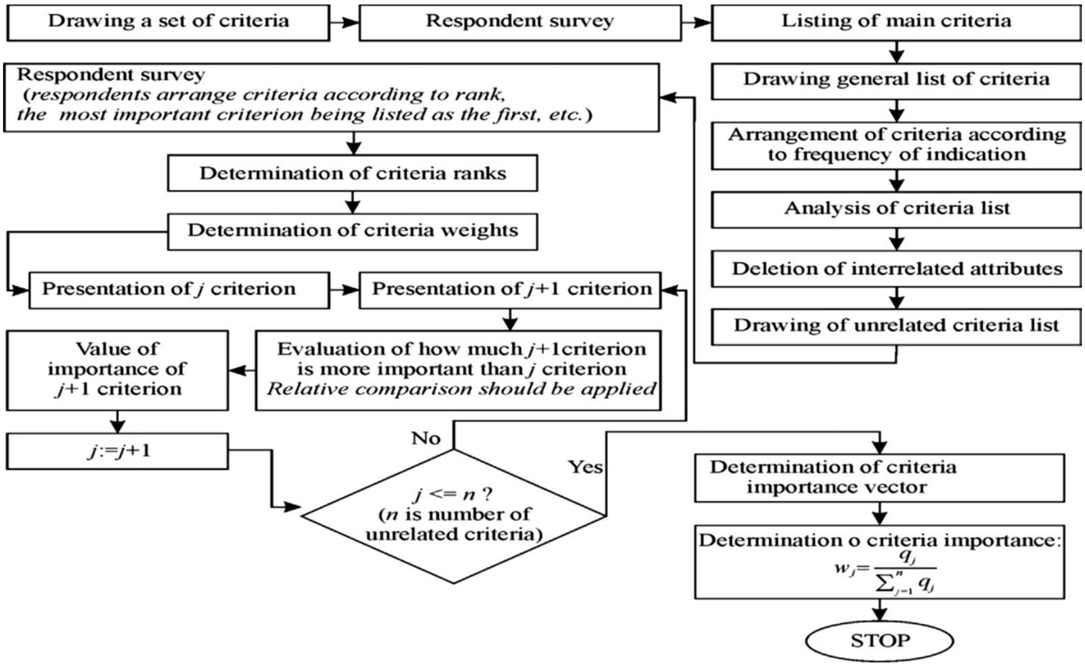

Fig. 2. The technique executive steps [49], [1], [3].

These factors were then evaluated using the SWARA technique. In this study, eleven key factors affecting the implementation of GSCM in Fanavaran Petrochemical Company were extracted presented in *Table 5*.

Table 5. Key factors in GSCM.

Key Factor	Description of Factor
F1	Government participation and regulations and standards
F2	Designing products to reduce energy and material consumption
F3	Materials and compliance with the standards required for the purchase of raw materials
F4	Green production and packaging
F5	Procurement, distribution and reverse logistics
F6	Recycling and reuse of waste inside and outside the company
F7	Human resources employment management and technical Assistance
F8	Environmental certificates
F9	Top management commitment
F10	Customer requirements
F11	Total environmental quality management

Then, 30 expert opinions were evaluated to examining the factors. Fanavaran Petrochemical Company (*Table 6*) was used in this field.

Table 6. Information of experts.

Group	Classification	Number
Age	Lower of 40 years	5
	Between 40 to 50 years	7
	Between 50 to 60 years	15
	Upper of 60 years	3
Position	Managers	8
	Assistant and Engineers	22
Education	Diploma	--
	Bachelor	11
	Master	17
	P.H.D.	2
Record of service	Lower of 10 years	3
	Between 10 to 20 years	7
	Between 20 to 25 years	12
	Upper of 25 years	8
Sexuality	Male	28
	Female	2

A step-by-step procedure of applying this technique to calculate the weight of the factors and their ranking is explained.

4.4.1| Implementation of steps

Step 1. By dividing the number of opinions of each indicator by the number of experts (30), the percentage of opinions of each index was obtained (*Table 7*).

Table 7. Opinions percentage and rank of each index.

INDEX	Description of Factor	Opinions Number	Opinions Percentage	Rank
F1	Government participation and regulations and standards	18	0.60	4
F2	Designing products to reduce energy and material consumption	25	0.83	1
F3	Materials and compliance with the standards required for the purchase of raw materials	14	0.47	6
F4	Green production and packaging	11	0.37	7
F5	Procurement, distribution and reverse logistics	10	0.33	8
F6	Recycling and reuse of waste inside and outside the company	8	0.27	10
F7	Human resources employment management and technical Assistance	20	0.67	3
F8	Environmental certificates	15	0.50	5
F9	Top management commitment	22	0.73	2
F10	Customer requirements	9	0.30	9
F11	Total environmental quality management	6	0.20	11

Step 2. Arrange the indicators in order of importance in *Table 8*.

Table 8. Arrangement of index in order to importance.

Rank	1	2	3	4	5	6	7	8	9	10	11
INDEX	**F2**	**F9**	**F7**	**F1**	**F8**	**F3**	**F4**	**F5**	**F10**	**F6**	**F11**
Opinions percentage	0.83	0.73	0.67	0.60	0.50	0.47	0.37	0.33	0.30	0.27	0.20

Step 3. Calculate the relative difference of views of each index to the next index, Sj, for each index (other than the first index); a number as Sj does not belong to the first index and S2 equals 0.83-0.73= 0.10 and S3 is 0.73- 0.67=0.07 (*Table 9*).

Nasiri et al.| Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

Table 9. Amount of sj.

INDEX	F2	F9	F7	F1	F8	F3	F4	F5	F10	F6	F11
s_j	……	0.10	0.07	0.07	0.10	0.03	0.10	0.03	0.03	0.03	0.07

Step 4. The growth value of kj for the first index is 1 and for the other indices is 1 + Sj. These values are given in *Table 10*.

Table 10. Growth amounts of k_j for each index.

INDEX	F2	F9	F7	F1	F8	F3	F4	F5	F10	F6	F11
k_j	1.00	1.10	1.07	1.07	1.10	1.03	1.10	1.03	1.03	1.03	1.07

Step 5. Restoring the importance of the first index (F2), q1= 1and subtract the previous index qj from the index kj to calculate the values of the other index qj, for example q1 = 1 and k2 = 1.1. So q2 = 1/1.1 = 0.91 and q3 = q2/k3 = 0.91/1.07 = 0.85. The extracted values of qj are presented in *Table 11*.

Table 11. Amounts of q_j for each index.

INDEX	F2	F9	F7	F1	F8	F3	F4	F5	F10	F6	F11
q_j	1.00	0.91	0.85	0.80	0.73	0.70	0.64	0.62	0.60	0.58	0.54

Step 6. Divide the qj into sums to calculate the weight of each index. For example, w1 equals:

$$w_1 = \frac{1}{7.97} = 0.126.$$

The weight of the indices given in *Table 12*.

Table 12. Weight of each index.

INDEX	F2	F9	F7	F1	F8	F3	F4	F5	F10	F6	F11
w_j	0.126	0.114	0.107	0.100	0.091	0.088	0.080	0.078	0.075	0.073	0.068

Finally, the weight of the indices after sorting is presented in *Table 13*.

Table 13. Weight of each index after arrangement.

INDEX	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
w_j	0.100	0.126	0.088	0.080	0.078	0.073	0.107	0.091	0.114	0.075	0.068

The second factor, "designing products to reduce energy and material consumption", has been extracted as the most important factor. Also ninth (senior management commitment) and seventh (human resource management and technical allocation management) are in the next rank in terms of importance in implementing GSCM of Fanavaran Petrochemical Company. Eleventh factor (total environmental quality management) is also identified as the least important factor in managing the company's green supply chain.

4.5 | Managerial Insights

A supply chain includes designing product, providing and selection of materials, production operations, transition from producer to final consumer with the support of top management and under government legal pressure to create a green environmental project. Nowadays, customers are eager to get familiar with purchased products, the origin of the products, what happen during production, the way the product is distributed, the impact on the environment, and so on. Customers demand more environmental friendly products. There is an increasing pressure due to the government's stricter norms on industries due to increased environmental disruption, scarcity of material resources, and increased levels of pollution (essentially carbon footprints). GSCM is a powerful way to compare an organization with competitors.

This is the latest technique to improve SCM capabilities. Many companies have taken green steps in managing their day-to-day operations. Greening the supply chain have both operational and financial benefits to an organization, while at the same time contribute in the sustainability of the work environment. GSCM has a competitive advantage and improves the economic status of an organization. GSCM refers to improve product and process of the environmental function in each phase of organization including production, marketing and presentation. Effective implementation of GSCM results in reduced waste, reduced environmental pollution, optimized resource use and reduced costs. Designing appropriate policies to address the various environmental issues, understanding of the likely steps leading to sustainability is essential and a clear perception of the system's barriers and consequences are also necessary before proceeding to implementation [76].

Iran's Environmental Performance Index (EPI) rating is low, indicating that there is a wide range of GSCM in Iran, and "green" awareness in Iran is below the average that depicts need to expand GSCM awareness among industries which can improve economic performance and reduce environmental pollution by adopting green GSCM.

5 | Conclusions and Suggestions (Practical and Future Research)

Nasiri et al.| Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

In this study, after reviewing the literature, effective factors on GSCM system implementation were extracted. Then, questionnaires were designed and distributed among 55 experts of Iran Petrochemical Company and collected by using KS statistical test, normality of data distribution was tested. The results of this test showed that the data have a normal distribution. Then, using the mean statistical test, factors affecting the successful implementation of GSCM system were identified. Finally, the identified factors were evaluated and ranked using the new SWARA decision making technique and expert opinions. According to the results obtained, organizations should to be centralized on applying the principles of GSCM in order to protect of environment; especially the company should focus on reducing waste; building an additional plant for the conversion of waste into raw materials; working with government officials and local communities to agree on disposal conditions; negotiating on emission standards and subsidies with local authorities; building a joint refinery plant with another company or local waste disposal agency; building a refinery plant using own staff and knowledge; establishing a high-level committee on energy and the environment to set targets for waste prevention.

Based on the results of the research, the following practical suggestions are recommended:

- *Given the increasing importance of the environmental issues in the world and high levels of pollution and environmental degradation in Iran, lack of importance of addressing environmental protection issues will be irreparable in the foreseeable future. Failure to address environmental issues will result in damages, such as the collection of contaminants, change of procedures and need for redesign. Therefore, it is necessary to implement projects related to execution of GSCM system in petrochemical industry, especially Fanavaran Petrochemical Company. For this purpose, priority is given to identifying key factors affecting the implementation of this system for solving environmental problems and managing it.*
- *By awareness on the relationship between the key factors in Qazvin Gas Company and taking into account of other provincial gas companies in the country, decision makers and executives can take the necessary steps to centralize multiple capacities to achieve sustainable and green supply chains in Gas Company and identify SCM system sustainability barriers and implementations.*

In general and according to the final result of this study, the followings are recommended in order to protect the environment for a producer such as Fanavaran Petrochemical Company:

- *Reducing waste by increasing productivity.*
- *Selling waste to another person.*
- *Building an additional plant for the conversion of waste into raw materials or products that are valuable to the company or other person.*

- *Working with government officials and local communities to agree on disposal conditions.*
- *Negotiating on emission standards and subsidies with local authorities.*
- *Building a joint refinery plant with another company or local waste disposal agency.*
- *Building a refinery plant using own staff and knowledge.*
- *Selling skills learned to others who have similar problems.*
- *Establishing a high-level committee on energy and the environment to set targets for waste prevention.*

The committee has the following responsibilities:

- *Creating work plans with store floor personnel;*
- *Identifying the legal process*
- *Predicting future waste costs in light of current costs;*
- *Reporting progress to management and*
- *Auditing savings.*

Finally, based on the above results, the following scientific suggestions can be presented:

- *Conducting similar research in other petrochemical, petroleum, gas and related industries.*
- *Classifying the key extractive factors into four clusters (linked, independent, dependent, and autonomous) by MICMAC clustering analysis.*
- *Approving the proposed interpretive structural model by using structural equation modeling approach and path analysis and applying SPLS software.*
- *Ranking the identified factors using ANP, AHP and Best-Worst Method (BWM) and comparing them with analytical results of this study.*
- *Conducting more research on green supply chain evaluation and using data envelopment analysis techniques and other techniques.*
- *According to this fact that for implementation of any system, identifying of the barriers is important, thus in future research, it can identify key and effective barriers to the implementation of the GSCM system in the petrochemical and related industries and specify the environmental and national issues and provide practical and appropriate solutions to eliminate these barriers and improve the system.*

References

[1] Aghdaie, M. H., Zolfani, S. H., & Zavadskas, E. K. (2013). Decision making in machine tool selection: an integrated approach with SWARA and COPRAS-G methods. *Engineering economics*, *24*(1), 5-17.

[2] Ahi, N. (2015). *Investigating the impact of GSCM on sustainable competitive advantage (Case study of ISO 14001 Holder Companies)* (MSc in Industrial Management, Shahid Beheshti University). (In Persian).

[3] Ajalli, M., & Asgharizadeh, E. (2016). Identification and ranking the key dimensions of lean manufacturing using new approach in gas industry. *Proceedings of international conference on science, technology, humanities and business management* (pp. 29-30).

[4] Ajalli, M., Saberifard, N., & Zinati, B. (2021). Evaluation and ranking the resilient suppliers with the combination of decision making techniques. *Management and production engineering review*, *12*(3), 29-40. DOI: 10.24425/mper.2021.137685

[5] Ajalli, M., Mozaffari, M. M., & Salahshori, R. (2019). Ranking the suppliers using a combined SWARA-FVIKOR approach. *International journal of supply chain management*, *8*(1), 907-915.

[6] Hu, A. H., & Hsu, C. W. (2006). Empirical study in the critical factors of green supply chain management (GSCM) practice in the Taiwanese electrical and electronics industries. *IEEE international conference on management of innovation and technology* (Vol. 2, pp. 853-857). IEEE. DOI: 10.1109/ICMIT.2006.262342

[7] Amani, M., Ashrafi, A., & Dehghanan, H. (2017). Assessing the barriers to green supply chain adoption using fuzzy DEMATEL technique. *BI management studies*, *5*(19), 147-179. https://ims.atu.ac.ir/article_7098_en.html

[8] Mauricio, A. L., & Jabbour, A. B. L. D. S. (2017). Critical success factors for GSCM adoption: case studies in the automotive battery industry. *Gestão & produção*, *24*(1), 78-94. https://doi.org/10.1590/0104-530X2267-16

[9] Aqeleh, H., & Hamidi, N. (2016). Identifying and ranking barriers to establishing the green supply chain in small and medium industries (case study of Qazvin province). *Journal of business research*, *20*(80), 173-197. (In Persian). http://pajooheshnameh.itsr.ir/article_24068.html?lang=en

[10] Yadav, D. K., & Barve, A. (2015). Analysis of critical success factors of humanitarian supply chain: An application of interpretive structural modeling. *International journal of disaster risk reduction*, *12*, 213-225. https://doi.org/10.1016/j.ijdrr.2015.01.008

[11] Fahimnia, B., Sarkis, J., & Eshragh, A. (2015). A tradeoff model for green supply chain planning: a leanness-versus-greenness analysis. *Omega*, *54*, 173-190. https://doi.org/10.1016/j.omega.2015.01.014

[12] Feng, T., Sun, L., & Zhang, Y. (2010). The effects of customer and supplier involvement on competitive advantage: an empirical study in China. *Industrial marketing management*, *39*(8), 1384-1394. https://doi.org/10.1016/j.indmarman.2010.04.006

[13] Ghahremani-Nahr, J., Nozari, H., & Najafi, S. E. (2020). Design a green closed loop supply chain network by considering discount under uncertainty. *Journal of applied research on industrial engineering*, *7*(3), 238-266. http://www.journal-aprie.com/article_119686_0.html

[14] Giannakis, M., Dubey, R., Vlachos, I., & Ju, Y. (2020). Supplier sustainability performance evaluation using the analytic network process. *Journal of cleaner production*, *247*, 119439. https://doi.org/10.1016/j.jclepro.2019.119439

[15] Govindan, K., & Sivakumar, R. (2016). Green supplier selection and order allocation in a low-carbon paper industry: integrated multi-criteria heterogeneous decision-making and multi-objective linear programming approaches. *Annals of operations research*, *238*(1), 243-276. https://doi.org/10.1007/s10479-015-2004-4

[16] Micheli, G. J., Cagno, E., Mustillo, G., & Trianni, A. (2020). Green supply chain management drivers, practices and performance: a comprehensive study on the moderators. *Journal of cleaner production*, *259*, 121024. https://doi.org/10.1016/j.jclepro.2020.121024

[17] Noorul Haq, A., & Kannan, G. (2006). Design of an integrated supplier selection and multi-echelon distribution inventory model in a built-to-order supply chain environment. *International journal of production research*, *44*(10), 1963-1985. https://doi.org/10.1080/00207540500381427

[18] Dheeraj, N., & Vishal, N. (2012). An overview of green supply chain management in India. *Research journal of recent sciences*, *1*(6), 77-82.

[19] Hosseini, S. A., Iranban, S. J., Mirjahan Mard, S. J. (2014). Identifying and prioritizing the factors affecting the green supply chain using path analysis. *Production and operations management approach*, *5*(2), 161-177. (In Persian). https://www.sid.ir/fa/journal/ViewPaper.aspx?id=231569

[20] Hsu, C. W., & Hu, A. H. (2008). Green supply chain management in the electronic industry. *International journal of environmental science & technology*, *5*(2), 205-216. https://doi.org/10.1007/BF03326014

[21] Imani, D. M. & Ahmadi. A. (2009). Green supply chain management for a new competitive advantage strategy. *Journal of automobile engineering and related industries*, *1*(10), 14-16. (In Persian). https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=164293

[22] Ip, W. H., Chan, S. L., & Lam, C. Y. (2011). Modeling supply chain performance and stability. *Industrial management & data systems*, *111*(8), 1332-1354. https://doi.org/10.1108/02635571111171649

[23] Jayant, A. (2018). An analytical hierarchy process (AHP) based approach for supplier selection: an automotive industry case study. *Int. J. Bus. Insights transform. (IJBIT) International journal of latest technology in engineering, management & applied science (IJLTEMAS)*, *11*, 36-45. *7*(1)102-114.

[24] Gao, J., Xiao, Z., Wei, H., & Zhou, G. (2020). Dual-channel green supply chain management with eco-label policy: a perspective of two types of green products. *Computers & industrial engineering*, *146*, 106613. https://doi.org/10.1016/j.cie.2020.106613

[25] Zailani, S., Govindan, K., Iranmanesh, M., Shaharudin, M. R., & Chong, Y. S. (2015). Green innovation adoption in automotive supply chain: the Malaysian case. *Journal of cleaner production*, *108*, 1115-1122. https://doi.org/10.1016/j.jclepro.2015.06.039

[26] Liu, H. C., You, J. X., Lu, C., & Chen, Y. Z. (2015). Evaluating health-care waste treatment technologies using a hybrid multi-criteria decision making model. *Renewable and sustainable energy reviews*, *41*, 932-942. https://doi.org/10.1016/j.rser.2014.08.061

[27] Lotfi, R., Mehrjerdi, Y. Z., & Mardani, N. (2017). A multi-objective and multi-product advertising billboard location model with attraction factor mathematical modeling and solutions. *International journal of applied logistics (IJAL)*, *7*(1), 64-86. DOI: 10.4018/IJAL.2017010104

[28] Lotfi, R., Mehrjerdi, Y. Z., Pishvaee, M. S., Sadeghieh, A., & Weber, G. W. (2021). A robust optimization model for sustainable and resilient closed-loop supply chain network design considering conditional value at risk. *Numerical algebra, control & optimization*, *11*(2), 221-253. DOI: 10.3934/naco.2020023

[29] Lotfi, R., Mostafaeipour, A., Mardani, N., & Mardani, S. (2018). Investigation of wind farm location planning by considering budget constraints. *International journal of sustainable energy*, *37*(8), 799-817. https://doi.org/10.1080/14786451.2018.1437160

[30] Mansory, A., Nasiri, A., & Mohammadi, N. (2021). Proposing an integrated model for evaluation of green and resilient suppliers by path analysis, SWARA and TOPSIS. *Journal of applied research on industrial engineering*, *8*(2), 129-149.

[31] Masudin, I., Wastono, T., & Zulfikarijah, F. (2018). The effect of managerial intention and initiative on green supply chain management adoption in Indonesian manufacturing performance. *Cogent business & management*, *5*(1), 1485212. https://doi.org/10.1080/23311975.2018.1485212

[32] Saeedi Mehrabad, M., Aazami, A., & Goli, A. (2017). A location-allocation model in the multi-level supply chain with multi-objective evolutionary approach. *Journal of industrial and systems engineering*, *10*(3), 140-160. http://www.jise.ir/article_44936.html

[33] Mohammed, A., Harris, I., Soroka, A., Naim, M. M., & Ramjaun, T. (2018, January). Evaluating green and resilient supplier performance: AHP-fuzzy topsis decision-making approach. In *ICORES* (pp. 209-216). DOI: 10.5220/0006619902090216

[34] Ninlawan, C., Seksan, P., Tossapol, K., & Pilada, W. (2010, March). The implementation of green supply chain management practices in electronics industry. *World congress on engineering 2012. July 4-6, 2012. London, UK.* (Vol. 2182, pp. 1563-1568). International Association of Engineers.

[35] Pantha, R. P., Islam, M., Akter, N., & Islam, E. (2020). Sustainable supplier selection using integrated data envelopment analysis and differential evolution model. *Journal of applied research on industrial engineering*, *7*(1), 25-35.

[36] Li, P., Rao, C., Goh, M., & Yang, Z. (2021). Pricing strategies and profit coordination under a double echelon green supply chain. *Journal of cleaner production*, *278*, 123694. https://doi.org/10.1016/j.jclepro.2020.123694

[37] Qin, Y., & Geng, Y. (2013). Production cost optimization model based on CODP in Mass Customization. *International journal of computer science issues (IJCSI)*, *10*(1), 610-618.

[38] Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International journal of operations & production management*.

[39] Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, *9*(1), 53-80. https://doi.org/10.1111/j.1468-2370.2007.00202.x

[40] Song, W., Xu, Z., & Liu, H. C. (2017). Developing sustainable supplier selection criteria for solar air-conditioner manufacturer: an integrated approach. *Renewable and sustainable energy reviews*, *79*, 1461-1471. https://doi.org/10.1016/j.rser.2017.05.081

[41] Lee, S. Y. (2008). Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply chain management: an international journal*, *13*(3), 185-198. https://doi.org/10.1108/13598540810871235

[42] Taghzadeh Yazdi, M. R., Amrollah Biuky, N., & Mohammadi Balani, A. (2017). Analyzing the relationships between green supply chain management implementation factors and ranking the organizations in the supply chain (case study: ceramic tile industry in Yazd province). *Industrial management journal*, *8*(4), 555-574. https://imj.ut.ac.ir/article_62696.html?lang=en

[43] Chin, T. A., Tat, H. H., & Sulaiman, Z. (2015). Green supply chain management, environmental collaboration and sustainability performance. *Procedia cirp*, *26*, 695-699. https://doi.org/10.1016/j.procir.2014.07.035

[44] Tyagi, M., Kumar, P., & Kumar, D. (2015). Parametric selection of alternatives to improve performance of green supply chain management system. *Procedia-social and behavioral sciences*, *189*, 449-457. https://doi.org/10.1016/j.sbspro.2015.03.197

[45] Vafaei, S., Bazrkar, A., & Hajimohammadi, M. (2019). The investigation of the relationship between sustainable supply chain management and sustainable competitive advantage according to the mediating role of innovation and sustainable process management. *Brazilian journal of operations & production management*, *16*(4), 572-580. https://doi.org/10.14488/BJOPM.2019.v16.n4.a3

[46] Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of cleaner production*, *15*(11-12), 1041-1052. https://doi.org/10.1016/j.jclepro.2006.05.021

[47] Zhu, Q., Sarkis, J., & Lai, K. H. (2008). Green supply chain management implications for "closing the loop". *Transportation research part E: logistics and transportation review*, *44*(1), 1-18. https://doi.org/10.1016/j.tre.2006.06.003

[48] Zhu, Q., Sarkis, J., Cordeiro, J. J., & Lai, K. H. (2008). Firm-level correlates of emergent green supply chain management practices in the Chinese context. *Omega*, *36*(4), 577-591. https://doi.org/10.1016/j.omega.2006.11.009

[49] Zolfani, S. H., Chen, I. S., Rezaeiniya, N., & Tamošaitienė, J. (2012). A hybrid MCDM model encompassing AHP and COPRAS-G methods for selecting company supplier in Iran. *Technological and economic development of economy*, *18*(3), 529-543. https://doi.org/10.3846/20294913.2012.709472

[50] Olhager, J. (2010). The role of the customer order decoupling point in production and supply chain management. *Computers in industry*, 61, 863-868. http://dx.doi.org/10.1016/j.compind.2010.07.011

[51] Koplin, J., Seuring, S., & Mesterharm, M. (2007). Incorporating sustainability into supply management in the automotive industry–the case of the Volkswagen AG. *Journal of cleaner production*, *15*(11-12), 1053-1062. https://doi.org/10.1016/j.jclepro.2006.05.024

[52] Dubey, R., Gunasekaran, A., Papadopoulos, T., & Childe, S. J. (2015). Green supply chain management enablers: mixed methods research. *Sustainable production and consumption*, *4*, 72-88. https://doi.org/10.1016/j.spc.2015.07.001

[53] Kumar, N., Agrahari, R. P., & Roy, D. (2015). Review of green supply chain processes. *Ifac-papersonline*, *48*(3), 374-381. https://doi.org/10.1016/j.ifacol.2015.06.110

[54] Masoumik, S. M., Abdul-Rashid, S. H., & Olugu, E. U. (2015). The development of a strategic prioritisation method for green supply chain initiatives. *PloS one*, *10*(11), e0143115.

[55] Jayaram, J., & Avittathur, B. (2015). Green supply chains: a perspective from an emerging economy. *International journal of production economics*, *164*, 234-244. https://doi.org/10.1016/j.ijpe.2014.12.003

[56] Mangla, S. K., Kumar, P., & Barua, M. K. (2014). Monte Carlo simulation based approach to manage risks in operational networks in green supply chain. *Procedia engineering*, *97*, 2186-2194. https://doi.org/10.1016/j.proeng.2014.12.462

[57] Luthra, S., Garg, D., & Haleem, A. (2015). Critical success factors of green supply chain management for achieving sustainability in Indian automobile industry. *Production planning & control*, *26*(5), 339-362.

[58] Mangla, S., Madaan, J., Sarma, P. R. S., & Gupta, M. P. (2014b). Multi-objective decision modelling using interpretive structural modelling for green supply chains. *International journal of logistics systems and management*, *17*(2), 125-142.

[59] Mathiyazhagan, K., Govindan, K., & Noorul Haq, A. (2014). Pressure analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International journal of production research*, *52*(1), 188-202. https://doi.org/10.1080/00207543.2013.831190

[60] Muduli, K., Govindan, K., Barve, A., Kannan, D., & Geng, Y. (2013). Role of behavioural factors in green supply chain management implementation in Indian mining industries. *Resources, conservation and recycling*, *76*, 50-60. https://doi.org/10.1016/j.resconrec.2013.03.006

[61] Grimm, J. H., Hofstetter, J. S., & Sarkis, J. (2014). Critical factors for sub-supplier management: a sustainable food supply chains perspective. *International journal of production economics*, *152*, 159-173. https://doi.org/10.1016/j.ijpe.2013.12.011

[62] Dashore, K., & Sohani, N. (2008). Green supply chain management: a hierarchical framework for barriers. *J. Sustain. Dev*, *5*.

[63] Kotzab, H., Munch, H. M., de Faultrier, B., & Teller, C. (2011). Environmental retail supply chains: when global Goliaths become environmental Davids. *International journal of retail & distribution management*, *39*(9), 658-681. https://doi.org/10.1108/09590551111159332

Nasiri et al.| Int. J. Res. Ind. Eng. 11(2) (2022) 165-187

[64] Large, R. O., & Thomsen, C. G. (2011). Drivers of green supply management performance: Evidence from Germany. *Journal of purchasing and supply management*, *17*(3), 176-184. https://doi.org/10.1016/j.pursup.2011.04.006

[65] Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, conservation and recycling*, *55*(6), 659-667. https://doi.org/10.1016/j.resconrec.2010.12.002

[66] Mollenkopf, D., Stolze, H., Tate, W. L., & Ueltschy, M. (2010). Green, lean, and global supply chains. *International journal of physical distribution & logistics management*, *40*(1/2), 14-41. https://doi.org/10.1108/09600031011018028

[67] Holt, D., & Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of manufacturing technology management*, *20*(7), 933-956. https://doi.org/10.1108/17410380910984212

[68] Gandhi, S., Mangla, S. K., Kumar, P., & Kumar, D. (2015). Evaluating factors in implementation of successful green supply chain management using DEMATEL: a case study. *International strategic management review*, 3(1-2), 96-109. https://doi.org/10.1016/j.ism.2015.05.001

[69] Zhu, Q., Sarkis, J., & Geng, Y. (2005). Green supply chain management in China: pressures, practices and performance. *International journal of operations & production management*, *25*(5), 449-468. https://doi.org/10.1108/01443570510593148

[70] Harris, L. C., & Crane, A. (2002). The greening of organizational culture: management views on the depth, degree and diffusion of change. *Journal of organizational change management*, *15*(3), 214-234. https://doi.org/10.1108/09534810210429273

[71] Beard, C., & Rees, S. (2000). Green teams and the management of environmental change in a UK county council. *Environmental management and health*, *11*(1), 27-38. https://doi.org/10.1108/09566160010314161

[72] Hosseini, Z. S., Flapper, S. D., & Pirayesh, M. (2022). Sustainable supplier selection and order allocation under demand, supplier availability and supplier grading uncertainties. *Computers & industrial engineering*, *165*, 107811. https://www.sciencedirect.com/science/article/pii/S0360835221007154

[73] Jalaei Esfandabadi, S. A., Abbasi, F., & Ghasemi, M. (2012). The impact of oil shocks on green production in Iran. *Quarterly journal of Iran's energy economy research journal*, *2*(5). (In Persian). https://civilica.com/doc/707621/

[74] Chien, M. K., & Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the lectrical and electronic industry and their relation to organizational performances. *International journal of environmental science and technology (IJEST)*, *3*(15), 383-394.

[75] Rebar, C. R., Gersch, C. J., Macnee, C. L., & McCabe, S. (2011). Using research in evidence-based practice. *Understanding nursing research*.

[76] Ying, J., & Li-jun, Z. (2012). Study on green supply chain management based on circular economy. *Physics procedia*, *25*, 1682-1688.