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RESEARCH ARTICLE

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Hard dimensions evaluation in sustainable supply chain management for environmentally adaptive and mitigated adverse eco-effect environmental policies

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Abstract

In the oil and gas industry, adopting policies that can reduce the negative environmental effect is vital. Environmentally Sustainable Supply Chain Management (ESSCM) is an approach to carrying out Supply Chain Management (SCM) in an eco-friendly manner and according to environmental requirements. There are different environmental policies that companies can apply based on their resource availability. Therefore, this study aims to evaluate the impact of hard dimensions on Environmentally Adaptive (EA) and Mitigated Adverse Eco-Effect (MAE) policies in the oil and gas industry. To rank the data, Bayesian Best-Worst Method (BWM) and Ordinal Priority Approach (OPA) have been applied. Cause-and-effect relationships are then calculated by employing the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique. The results indicate that the ranking of the hard dimensions varies based on the companies' business policies and their new product/technology development projects. In other words, the findings of this research demonstrate that 'innovation' is the crucial dimension in companies that are focussed on developing eco-friendly products while 'technologies for cleaner production' is the most important dimension in the companies attempting to reduce destructive consequences on the environment. In both types of the company policies, 'lean manufacturing', 'total quality management', and 'institutional pressures' are the key dimensions for a successful implementation of ESSCM while the least important dimensions include 'supplier relationship management', 'green purchasing', and 'green logistics'. The findings of this research can assist the decision-makers in the oil and gas sector in prioritising and identifying the interrelationship of the dimensions that significantly impact the ESSCM.

KEYWORDS
Bayesian best-worst method, DEMATEL, environmental policies, environmentally sustainable supply chain management, hard dimensions, ordinal priority approach

1 | INTRODUCTION

The oil and gas industry contributes to climate change and global warming as it is the main source of carbon emission, in addition to exhausting a non-renewable resource. As a result, sustainability is a vital concept that is required to be in place for this industry (Ihlen, 2009). In the late 20th century, it was understood that in order to protect the planet and circumvent changes in the planetary systems, life-threatening disasters and also environmental changes need to be managed. As a result, the Brundtland report was published in 1987 to guide the nations of the world towards sustainable development. In other words, according to this report having a sustainable development obliges us to ensure that the current needs are met while the future generations are capable of meeting their own needs. (Brundtland, 1987). With regard to organisation, due to the significant role of firms in economic productivity, their sustainability is crucial. The policies in this article (Environmentally Adaptive [EA] and Mitigated Adverse Eco-Effect [MAE]) are rooted in two main theories of sustainability of firms evolving from sustainable development concept. This include (1) Corporate Sustainability, which refers to maintaining a balance between social, environmental, and economic aspects within corporate operations as well as achieving stakeholder satisfaction and (2) Green Economics which states that society should be integrated into the ecosystem and markets and economies should reflect the needs and interests of society. Green economy should enhance social well-being while mitigating the impact of environmental risks (Cato, 2012; Chang et al., 2017; Kantabutra & Ketprapakorn, 2020). This could be achieved by aligning the Supply Chain Management (SCM) with an ecological system to assist the sustainable development process. Since the 1990s, industrial countries began to encourage the use of eco-friendly practices and more rigid regulations to reduce the negative effects on the environment (Zhang et al., 1997). From the year 2008 onwards, climate change and global warming have forced industries to adopt Green Supply Chain Management (GSCM), which is also called Environmentally Sustainable Supply Chain Management (ESSCM), in order to commensurate with the environment (Goyal et al., 2019; Hong et al., 2018). Adoption of ESSCM is required to restore environmental degradation resulting from human activities (Suhi et al., 2019). In developing countries, reaching ESSCM can be challenging due to Pollution Haven Hypothesis (PHH). This concept was formed after the increasing rate of globalisation, international trade and the flow of Foreign Direct Investment (FDI) into other countries. In this process, the developed countries learned that since the environmental laws and regulations are not strictly implemented in developing countries, they could transfer their polluting industries to these countries (Salehnia et al., 2020). Also, in some cases, the governments of developing countries themselves grant permission to polluting industries to operate with the aim of contributing to the economic growth (Bulus & Koc, 2021). The climate change that we are facing is the outcome of an ecological deficit as a result of misuse of natural resources, waste production and depletion of the environment. Ecological deficit refers to when Ecological Footprint (EF), which is the exploitation of humans of a specific area, surpasses Biocapacity (BC), which is the ecosystem of a certain area. EF includes but is not limited to carbon footprint, cropland footprint, fishing grounds footprint, built-up land footprint, grazing land footprint and EF in forest products (Bag et al., 2021) (Świąder et al., 2020). In this study, EF is being looked at from a carbon footprint perspective as it is one of the major and most important EFs that directly impact global warming.

The present work considers the following situation:

- Greenhouse gases from human activities are responsible for worldwide warming as they trap the heat inside the planet. Carbon dioxide (CO_2) is one of the greenhouse gases that constitute the predominant part of the greenhouse gas emissions (EPA, 2019). According to the Statistical Review of World Energy 2021, an annual report published by British Petroleum (bp), Iran ranked the sixth country in 2020 to emit CO_2 (bp, 2021).
- The negative impact of global climate change is strongly obstructing the accomplishment of Sustainable Development Goals (SDGs) throughout the world, especially in low and middle-income countries, including Iran (Mousavi et al., 2020). It is estimated that in case of high emissions in Iran, the average annual temperature would escalate by approximately 5.2°C by the year 2100 (World Health Organization & United Nations, 2022).
- Iran is blessed with plenty of natural resources, among which oil is the main one. The government of Iran is heavily relying on its oil revenue as the main source of income; therefore, the oil production must be in compliance with environmental laws and regulations in order to reduce the destructive impact on the environment (Moshiri & Daneshmand, 2020).

To resolve the aforementioned issues and align them with the environmental policies, it is vital for oil companies to implement ESSCM. In developing countries, paying attention to the environmental issues of sustainability, such as carbon management, is more crucial than the social matters (Li & Mathiyazhagan, 2018). This study emphasises on the hard dimensions (concerning technology, policy and regulations) as they play a significant role in ESSCM. Given that the oil and gas industry plays an important role in global warming and carbon dioxide production, few studies have evaluated hard dimensions in empirical cases in the oil and gas industry, as indicated in the literature review in Section 2. To the best of our knowledge, no research has studied the comparison of the impact of hard dimensions on 'environmentally adaptive' and 'mitigated adverse eco-effect' policies in the oil and gas projects. Therefore, to fill this gap in the current literature and bring a novelty in this area, the objectives of the present study are as follows:

- to evaluate the hard dimensions in sustainable supply chains of the companies with EA and MAE policies in the oil and gas industry;
- to detect the key factors in the evaluation of ESSCM in the oil and gas sector;
- to investigate the ranking as well as the cause–effect relationships among the key factors in the oil and gas industry, and;

- to determine the main policies contributing to the decision-makers' effort in evaluating ESSCM in the oil and gas industry.

To accomplish these objectives, the present study utilises a combined approach of Bayesian Best-Worst Method (BWM), Ordinary Priority Approach (OPA) and Decision-Making Trial and Evaluation Laboratory (DEMATEL). Bayesian BWM and OPA are methods for prioritising any given variables in two cases. However, in order to identify the cause–effect relationship among factors, another method is required to provide such analysis. Therefore, DEMATEL is employed to construe the interrelationship among the factors (Yazdi et al., 2020). By ranking the variables, managers and decision-makers will be able to emphasise essential factors for successful implementation of ESSCM rather than less important ones (Kumar, 2020). DEMATEL analysis, on the other hand, distinguishes factors from each other and depicts the significant dimensions in ESSCM of the company and consequently could lead to the reduced destructive effect of the SCM on the environment (Walach, 2021).

The rest of this paper will consist of the following: Section 2 of this study provides the literature review. Methodology is explained in Section 3 which defines the methods that are utilised to analyse the data. The analysis of the data is then described in Section 4 followed by the discussion of the study in Section 5. Conclusion and implication to practice are stated in Section 6.

2 | LITERATURE REVIEW

This section overviews the current literature on the topic of ESSCM as well as the dimensions concerning policy, technology, and regulations that affect ESSCM.

2.1 | Environmentally sustainable supply chain management

In recent years, in the light of sustainability, concerns and challenges about climate change as well as environmental issues have gained significant attention and are considered to be a major problem that requires urgent action (Fransoo et al., 2014). Corporations are increasingly responsible for their negative impacts on the environment resulting from their operations (Koberg & Longoni, 2019). ESSCM are concepts that emphasise the integration of environmental concerns into SCM (Tseng et al., 2019). Experts in SCM including academics and practitioners are suggesting the concept of ESSCM as a possible answer for having eco-friendly SCMs. Since 1997, as mentioned by Handfield et al. (1997), the green movement or environmentally friendly concept has begun to rise, and thus, firms had to incorporate this concept into their operations in order to be in line with environmental rules and regulations and gain a competitive edge in the local and global market as considering environmental concerns would give them more popularity (Handfield et al., 1997). The idea of eco-friendly supply chain management has developed over the years. Zhang et al. (1997) suggested that implementing environmentally conscious design and manufacturing not only reduces companies' environmental risks but also results in a safer work environment and a reduction in costs for disposal and health risks. Green et al. (2012) found that practicing GSCM results in enhanced environmental and economic performance and, consequently, the operational performance of the organisation will improve (Green et al., 2012). With regard to global climate change, Glasgow Climate Change Conference was held from 31 October to 12 November 2021. The outcome of this conference was to reinforce the nations to adhere to the Paris Agreement target, limiting global average temperature to 1.5°C by restriction of greenhouse gas emissions, usage of coal energy and fossil fuels, and also provision of 100 billion dollars on annual basis by developed countries to developing countries as a support to prevent the climate change (United Nations-Climate Change, 2021). The study conducted by Kirchoff and Falasca (2022) surveying more than 300 US-based companies proposed that ESSCM practice benefits the firm performance (Kirchoff & Falasca, 2022).

2.2 | ESSCM in the oil and gas industry

Recently, as a result of climate change, businesses and their supply chains in the oil and gas industry are exposed to significant challenges and need to take action in order to reduce greenhouse gases particularly carbon dioxide, the gas that is responsible for most of the global warming (Dahlmann & Roehrich, 2019). Oil and gas industry is one of the main sources of energy that although is contributing tremendously to the climate change the transition to renewable energy is not feasible in the short time due to insufficiency and unavailability of advanced technology. As a result, decades are needed for the fossil fuels, especially oil and gas, to be phased out (Wang et al., 2023). Thus, green initiatives are crucial to be implemented in the oil and gas sector and make every effort to have environmental sustainability in place (Jaboui, 2021; Yeo et al., 2022). ESSCM in the oil and gas industry significantly contribute to alleviating the negative impact on the environment by bringing innovation into business operations which is meant to mitigate global warming (Albitar et al., 2022). Findings of Russo et al. (2021), which tested a sample of 782 worldwide publicly traded firms in different industries including oil and gas, indicate that companies with environmentally sustainable performances are capable of improving their cost-saving efficiency and, consequently, financial performances (Russo et al., 2021).

2.3 | Hard dimensions

In this study, after a comprehensive search through the existing literature regarding the eco-friendly SCM, the following dimensions with respect to the oil and gas industry were identified and verified as the suggested hard dimensions (Table 1). The verification of these dimensions was confirmed through data collected from the experts in the first part of the questionnaire which is indicated in Section 4.4.

TABLE 1 Hard dimensions and their definitions.

Hard dimensions	Definitions
Lean manufacturing (LM)	Lean manufacturing is outlined as a set of practices that are used in coordination with each other to increase operational performance, create an efficient and high-quality system, and produce the final products in accordance with the quantity demanded by customers with minimum waste (Assen, 2018). Successful implementation of lean manufacturing is highly beneficial as it is an effective factor toward improving organisational performance and also enhances the function of ESSCM (Chen et al., 2020; Singh et al., 2020). Lean manufacturing reinforces the operational performance of the organisations in the petroleum industry (Rachman & Ratnayake, 2019).
Total quality management (TQM)	Total quality management (TQM) enhances the quality of goods and services, reduces the defects, and enhances customers satisfaction. The purpose of TQM is to produce products with the maximum effectiveness and minimum cost and also delivery in the shortest possible time. Therefore, TQM can be introduced as an eco-friendly system of management. (Hassan & Jaaron, 2021). TQM practices are the core components for achieving a smooth operational performance (Sharma & Modgil, 2020). Effective implementation of TQM positively influences ESSCM practices (Akanmu et al., 2023).
Supplier relationship management (SRM)	A rise in outsourcing of the production resources as well as administrative processes has caused supplier relationship management to become a significant business process. SRM can be utilised as a tool for organisations to impact supplier behavior by interacting with them in activities such as reducing packaging, using transportation with less fuel consumption and entailing suppliers to engage in environmentally friendly activities. This can have a crucial impact on achieving organisation's sustainability goals (Adesanya et al., 2020).
Technologies for cleaner production (TCP)	TCP are needed in the production and supply of energy for consumer demands (Mensah et al., 2019). In addition, TCP, in addition to environmental sustainability, contribute to financial and social sustainability (Bhandari et al., 2019). Therefore, the use of technologies for cleaner production is a very important dimension to ease the employment of environmentally sustainable supply chain management. As per Brahmana and Kontesa (2021), adopting technology for cleaner production in oil and gas sector will not only minimise the company's environmental impact but also improves its eco-efficiency, eco-friendliness, reputation and, finally, sustainable development (Brahmana & Kontesa, 2021).
Institutional pressures (IP)	IP refer to restrictions of environmental exploitation set by the government and environmental institutions on organisations to comply with environmental laws and practices (Choudhary et al., 2020). In an unstable developing economy, in particular, institutional pressures have substantial impact on enhancing environmental performance (Ahmed et al., 2020). In today's world, it is imperative for organisations to employ environmental rules and regulations in order to have competitive advantage (Saeed et al., 2018). Since oil and gas industry is strictly controlled, companies in this industry have to be in compliance with institutional pressures to protect their reputation, achieve social legitimacy and prevent sanctions (Jain et al., 2020).
Green logistics (GL)	GL logistics include green shipping, eco-friendly packaging and transportation, and reverse logistics. As global supply and demand rises, the supply chain will expand, and shipments will spread throughout the world. Consequently, the emission of greenhouse gases will increase and intensify global warming. Green logistics practices can effectively reduce negative environmental impacts and reduce costs, save energy, and create a competitive advantage (Wang et al., 2018). Despite warnings about climate change as a result of the irreversible effects of human activities on the environment, fossil fuels are still used by logistics companies in a large amount. A rise in utilisation of fossil fuels as well as non-green energy sources will lead to an increase in adverse effect on the environment. By encouraging logistics companies to engage in green behaviors such as introduction of clean energy (e.g. electricity and solar energy), the negative effects of logistics on the environment can be avoided (Zhang et al., 2020).
Green purchasing (GP)	GP is purchasing initiative with environmental awareness that denotes that the purchased items are in line with environmental objectives (Yee et al., 2021). GP is achieved by incorporating sustainable practices into purchasing activities, and therefore, it is essential for the firm's ESSCM practices (Yu et al., 2019). In oil and gas sector, green purchasing includes but is not limited to usage of recyclable packaging, monitoring high-risk material and mitigation of greenhouse gas emissions. Green purchasing also enhances company's brand representation (Gardas et al., 2019).
Innovation (I)	Innovation in SCM encompasses utilisation of novel techniques in any aspect of supply process that can advance firm operations, diminish environmental adverse effects and lead to ESSCM (Silva et al., 2019). For implementing green innovation, factors such as cost efficiency, green process management, scarcity of natural resources and ecosystem need to be taken into account (Novitasari & Agustia, 2021). According to Ravetti et al. (2020), innovation in oil and gas industry can guide countries to alter to green growth paths and thus can efficiently lead to clean energy production (Ravetti et al., 2020).

Note: ESSCM, environmentally sustainable supply chain management; SCM, supply chain management.

As ESSCM has become a key concept in today's world, in order to preserve the environment, many researchers have studied the impact of this concept on various industries. In the oil and gas sector, however, there have been few studies conducted in this regard (Table 2).

As mentioned before, to fill the gap in the existing literature, this study aims to evaluate the hard dimensions using the combined approach of Bayesian BWM, OPA and DEMATEL in multiple cases in the oil and gas industry.

TABLE 2 Sample research conducted in ESSCM area.

Authors	Industry	Sample (geography)	Research methodology	LM	TQM	SRM	TCP	IP	GP	GL	I	Main findings
(Agi & Nishant, 2017)	Manufacturing including petrochemicals	Gulf countries (Middle East)	ISM and MICMAC		✓	✓	✓		✓			The factors with maximum influence on the implementation of GSCM include dependence, trust, and the durability of SC partners relationship, the size of the organisation, commitment of top management, industry sector, and region.
(Ahmad et al., 2017)	Oil and gas	Developing countries	BWM					✓				Key factors are economic and political stability as well as regulatory; however, energy transition has the lowest impact on SSCM in the O&G industry.
(Azadeh et al., 2017)	Oil and gas	Persian Gulf	MOEA-D, NSGA II and MOPSO		✓					✓		MOEA-D approach has the superiority over NSGA II and MOPSO to maximise NPV of the project and minimise the environmental issues in large size problems.
(Das, 2018)	Manufacturing including oil and gas	India	SEM	✓	✓				✓	✓		No significant relationship between EMP and OPR and competitiveness. In case of direct relationship, SPC and competitiveness have adverse relationship. This relationship can be mediated through CSP. Also, OPR mediates the OP and competitiveness association.
(Yusuf et al., 2018)	Oil and gas	Ghana	Semi-structured interviews and content analysis of documents		✓	✓						Developing a performance measurement model consisting of categories such as internal business operations, financial, HSE, learning and growth, customer management, and supplier management.
(Ngai et al., 2018)	Gas	China	Literature review		✓	✓	✓					Proposes a conceptual framework for sustainable development. The elements include employee, environment, investor, community, high-quality products and services, smooth supply chain, stable cash flow, loyal customers and good social image.
(Al-Sheyadi et al., 2019)	Manufacturing including oil and gas	Oman	Survey approach			✓		✓		✓		GSCM practices including EMS, eco-design, source reduction and external environmental practices lead to improved organisational performance. There is positive association between GSCM competency and environmental impact.
(Gardas et al., 2019)	Oil and gas	India	ISM and SEM			✓		✓	✓	✓		Regulatory pressure and collaborative green logistics have a significant influence on operational and business performance.
(Narimissa et al., 2019)	Oil and gas	Iran	Delphi			✓		✓	✓	✓		Developing a framework consisting of sustainability dimensions including but not limited to reliability, responsibility, flexibility, GSCM, EM, environmental hazards and pollution control, staff training, improve the working environment, and supplier evaluation.
(Narayanamurthy et al., 2020)	Manufacturing including petroleum	India	Graph-theoretic approach and literature review				✓	✓	✓	✓	✓	Developing a framework consisting of operation strategy practices, process practices, employee practices, regulatory practices, customer practices, competition practices, social practices, and supplier practices.

(Continues)

TABLE 2 (Continued)

Authors	Industry	Sample (geography)	Research methodology	LM	TQM	SRM	TCP	IP	GP	GL	I	Main findings
(Zhang & Yousef, 2020)	Petroleum	Pakistan	ISM and MICMAC					✓				Developed a two-part tariff (TPT) contract consisting of government intervention in terms of tax or subsidy.
(Piya et al., 2020)	Oil and gas	Oman	Literature review			✓	✓			✓		Top management commitment, strategic alignment, competency of management and integration of information technology are identified as the key drivers providing an agile supply chain.
(Trujillo-Gallego et al., 2021)	Manufacturing including oil and gas	Colombia	PLS-SEM				✓		✓	✓		The key findings indicate that internal environmental management, eco-design and green marketing have a direct and positive impact on environmental collaboration.
(Kumar & Barua, 2022a)	Petroleum	India	TOPSIS				✓	✓				Designed a framework proposing that the top three performance measurement criteria are the purity of the products, compliance with environmental laws and new technology adoption.
(Parast, 2021)	Petroleum	Iran	SEM		✓							The results propose the positive influence of CSR on internal quality and also the mediating role of internal quality which leads to the association between CSR and external quality outcomes.
(Tayebi et al., 2022)	Oil and gas	Iran	ANP and DEMATEL and MULTIMOORA				✓					Development of a decision support system by implementing air pollution control technologies including electrostatic precipitators, fabric filters, wet scrubbers, and cyclones.
(Kumar & Barua, 2022b)	Petroleum	India	Delphi				✓		✓	✓		Green information systems are independent and drive practices such as green procurement, green production, green distribution and investment recovery. Practices including internal environment management and co-operation with customers have high driving and high dependence power.
(Olugu et al., 2022)	Oil and gas	Malaysia	Literature review	✓	✓		✓	✓				Conceptual framework was developed consisting of components of oil drilling rings, maintenance strategies, inspection methods, sustainability performance dimensions, standards and government guidelines.
This paper	Oil and gas	Iran	Bayesian BWM, OPA and DEMATEL	✓	✓	✓	✓	✓	✓	✓	✓	Ranking of the influential dimensions varies based on companies' business strategies and new product/ technology development projects.

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; GSCM, Green Supply Chain Management; BWM, Best-Worst Method; OPA, Ordinal Priority Approach; DEMATEL, Decision-Making Trial and Evaluation Laboratory.

3 | METHODOLOGY

In the present study, collected data are ranked and their cause-and-effect relationships are identified. To achieve this, a hybrid approach of Bayesian BWM, OPA and DEMATEL is applied. For prioritising the data and comparing the resulted weights, Bayesian BWM and OPA are utilised. However, these two methods are not able to measure their cause-and-effect relationships. Hence, DEMATEL is employed to calculate these relationships. There are many advantages to using this combined approach which include but are not limited to (1) precisely prioritising the dimensions (2) comparing the weights obtained from Bayesian BWM and OPA, (3) detecting the interdependent relations among those dimensions and (4) assisting managers and decision-makers to properly identify the ranks of the factors based on their weights and their cause-and-effect relationships and, as a result, make wiser decisions. Based on the research gap in Choudhary et al. (2020), we have applied MCDM methods other than BWM (Bayesian BWM and OPA) to compute and compare the dimensions' weights in multiple cases in the oil and gas industry.

BBWM and OPA are two methods utilised for prioritising the dimensions. DEMATEL technique was employed in the article in order to determine the cause-and-effect relationship. The questionnaires used for these methods were independent; however, the results derived from DEMATEL are validating those extracted from BBWM and OPA methods. The dimensions with high priority are the dimensions that have the 'cause' impact on the other dimensions, whereas those with low rank are affected by others and are the 'effect' dimensions. Since BBWM and OPA cannot measure the intensity of dimensions and their cause–effect interrelationship, DEMATEL technique was used to detect this relationship (You & Yi, 2022). Therefore, in order to select the most appropriate policy by the case companies, the results from all these methods are required to validate this process (Liu et al., 2020). By using multicriteria approach, the organisation is able to avoid inconsistency in decision-making (Ortiz-Barrios et al., 2020).

3.1 | Bayesian BWM

The BWM, which is the basis of Bayesian BWM, is a method introduced by Rezaei (2015) as a Multi-Criteria Decision-Making Method (MCDM) that uses nonlinear programming and a consistency index to indicate an accurate result. In his article, Rezaei indicated the advantage of BWM over AHP (analytic hierarchy process which is another MCDM method similar to BWM in terms of pair-wise comparison) by solving a problem using both methods. The results confirmed that BWM provided more accurate answers by employing less computation (for BWM, the required number of comparisons is $2n - 3$, while for AHP, $n[n-1]/2$ comparisons are needed). In 2020, Mohammadi and Rezaei proposed the Bayesian BWM to aggregate the assessment of decision-makers' preferences as a group from a probabilistic aspect (Mohammadi & Rezaei, 2020; Rezaei, 2015).

3.2 | Ordinal priority approach

OPA is a method introduced by Ataei et al. (2020) in Multiple Attribute Decision-Making (MADM). In this method, individual or group decision-making can be utilised. In group decision-making, priorities of a group of experts regarding pre-defined attributes are determined. The advantage of this method is that pairwise comparison is not required, and the only required inputs are the priorities given by the experts. Once the priorities are collected, the final rankings of the attributes are calculated by using a linear programming model (Ataei et al., 2020).

3.3 | Decision-making trial and evaluation laboratory

The DEMATEL is a technique for mapping the causal relationships among the criteria and the intensity of their impact on each other. This technique was introduced in 1972 by Gabus and Fontela to solve complex group problems (Gabus & Fontela, 1972). This method constructs a network consisting of criteria as nodes and cause-and-effect relationships among them (Quezada et al., 2022).

The steps for conducting the research are depicted in a flowchart in Figure 1. The two pillars of the flowchart represent two processes undertaken in order to analyse the data and determine their priorities as well as their cause-and-effect relationship. The pillar on the left side of the flowcharts shows the steps of Bayesian BWM and OPA to prioritise the hard dimensions, whereas the pillar on the right presents the required steps for DEMATEL technique and determines the cause–effect relationship between dimensions.

This paper evaluates the dimensions that play a crucial role in aligning the supply chain with environmental policy. The reason for prioritising them is for the managers and decision-makers to be able to decide wisely and consider the dimensions in an orderly manner within their supply chain. Optimum sustainability in company's operations can be achieved through policy prioritisation (Agarwal et al., 2022). Recently with the rise in environmental concerns, industries are urged to adopt sustainable measures within their supply chains. In the case of not complying with the environmental regulations, manufacturers may face business risks such as reputational damage or financial loss. In order for them to avoid these risks, they must prioritise the dimensions (Rahman et al., 2020). By prioritisation, top management and project managers can be guided to make wise decisions regarding business operations within their company with respect to the environmental considerations (Mahmoudi et al., 2021). Due to the vast diversity of the dimensions, they are required to be prioritised in order to identify the areas that need more investment in their policies and infrastructures, including the training of the employees as well as the technologies that have to be used in that area.

The 'DEMATEL' is a two-way consideration technique that determines the cause-and-effect relationships between factors. In this technique, causal relationships are visualised using matrices or

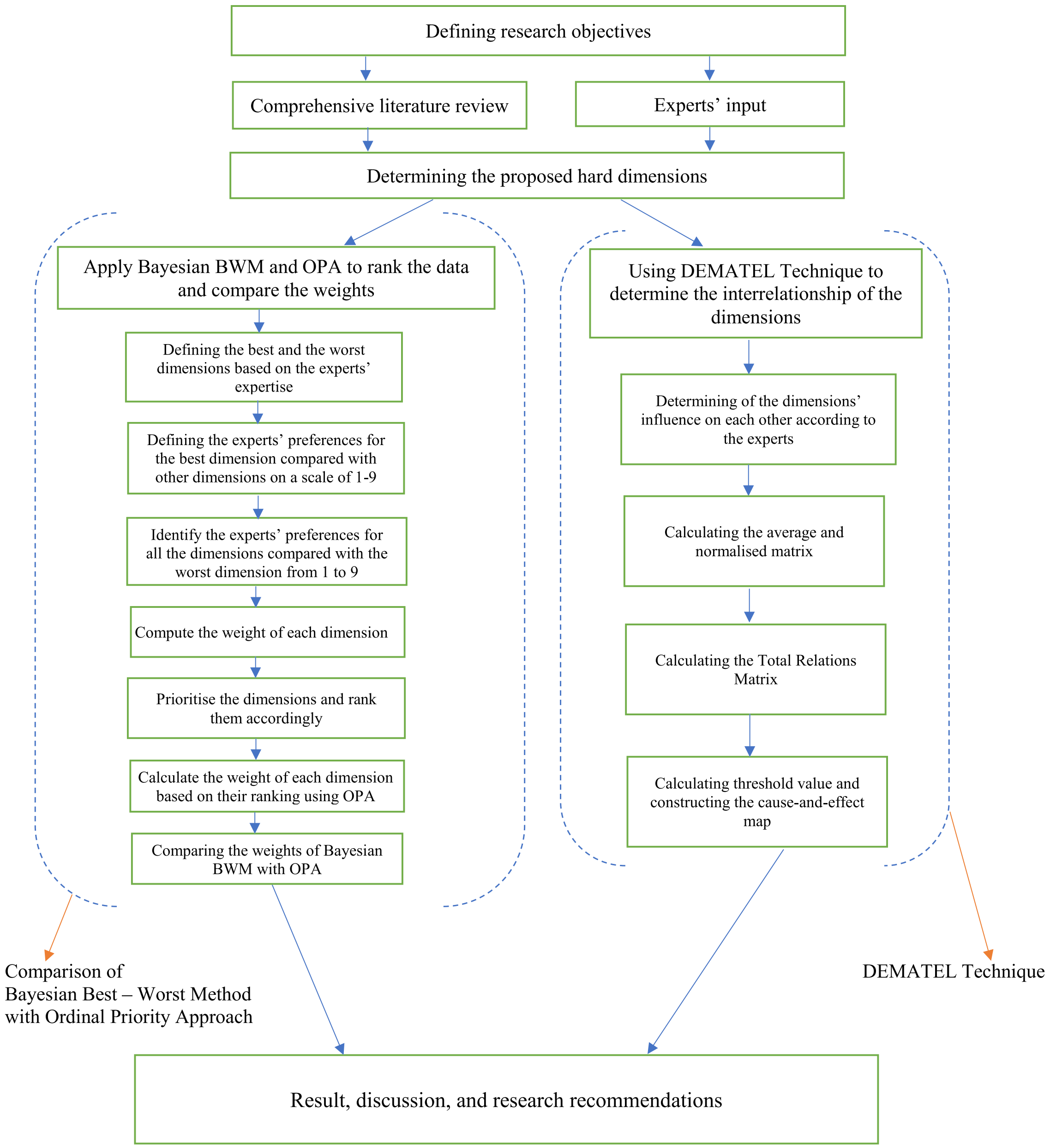

FIGURE 1 Research methodology. BWM, Bayesian Best-Worst Method; OPA, Ordinal Priority Approach; DEMATEL, Decision-Making Trial and Evaluation Laboratory.

digraphs. In this way, the cause-and-effect relationship between criteria can be turned into a unique structural model that clarifies problems' underlying causes and identifies policies for resolving them (Ullah et al., 2021; Zhao et al., 2021).

4 | REAL-WORLD CASES IN OIL AND GAS INDUSTRY

To examine ESSCM implementation in real-world cases, this research was executed in two oil companies which are described in brief in Section 4.2. In this study, we examined two companies with two different policies for environmental sustainability. We selected leading companies in the oil and gas industry that have EA as well as MAE policies in place. Moreover, the case companies we selected possessed a large market share and had their own R&D centers. These two companies have comprehensive processes for implementing the environmental policies with a wide verity of stakeholders and customers which are engaged and interested in environmental oil and gas processes. Therefore, it is expected that the outcomes of this study can be extended to the other companies in same field of industries in oil and gas.

4.1 | Oil and gas industry

The oil and gas industry plays an important role in the world's economy, politics, inflation, finance and stock market (Aslam et al., 2021). Organisations functioning in this sector need to be environmentally compliant by adopting the guidelines promulgated by regulators. Therefore, they are required to implement a unique business policy to reduce the negative impact on the environment without any detrimental effect on the financial achievements (Jain et al., 2020). This assists them in elevating their public image, which leads to more investments by environmentally concerned stakeholders (Shvarts et al., 2018). In Iran, the economy is highly dependent on oil production and its by-products as they are the primary sources of the government's revenue (The World Bank, 2021). Nevertheless, oil production could lead to hazardous damages to the environment, and thus, it is crucial to incorporate ESSCM practices into SCM in the oil and gas industry.

4.2 | Cases background

Iranol Oil Company (the company that has EA policy in place) was established in 1950, with two lube oil refineries in Tehran and Abadan. These plants have been designed to produce both engine and industrial lubricants. Iranol has been awarded for the quality of its products from the third International Quality Conference and received a national commendation for Environmental Protection. Iranol Oil Company holds ISO 14001 which is a certificate in the environmental management (Iranol Company, 2019). Iranol Co. had a total sale of approximately $200 million in 2021. The amount of the company's exports in 2021 was roughly $47 million. It produces and supplies lubricants and related products throughout Iran and the region, in accordance with national and international standards to protect the environment in addition to an emphasis on meeting the needs of stakeholders, especially shareholders and customers. This company has received a certificate of appreciation from the National Conference on Environmental Protection and a certificate for corporate social responsibility and organisational culture. Recently, Iranol Co. has installed an online monitoring system of furnace exhaust gases in order to measure the combustion gases coming out of the chimneys of operational units to become eco-friendly and protect the health of citizens.

Iranol Co. has implemented EA policy and emphasises the development of new eco-friendly products. In 2017, the company introduced a product called 'Tetra oil' which is an ultra-performance engine oil that is manufactured from synthetic-based oil, vegetable components and selective additives to meet environmental requirements. This product, which has the benefits of reducing air pollution, reducing fuel consumption, increasing engine life, and economic efficiency for the consumer, was sent to one of the most prestigious international laboratories, the BFB Petroleum and Research Laboratory of Belgium for environmental compatibility. After receiving the test results, it was found that Tetra oil has a high percentage of biodegradability, meaning that if this engine oil enters the environment, almost half of it decomposes and returns to the environment as non-toxic substances (Iranol Oil Company, 2017). The present study focusses on this product.

Sepahan Oil Company (the company with MAE policy), established in 1975, is among the largest producers and suppliers of engine oil in the Middle East and among the best producers of rubber process oil, slack wax, paraffin wax and various types of industrial lubricants, diesel and gasoline engine oils, automobile gear oils, greases, and antifreeze under the brand name 'Speedy'. Sepahan Oil Company has also been nationally awarded for its environmentally friendly activities in 2014 and accredited with ISO 14001 (Sepahan Oil Company, 2019). The total sales of this company were worth approximately $3 billion in 2021 of which $1.5 billion came from the exported product. The company was awarded with the international two-star certificate of quality, safety, health and environment management system by the International Risk Control Organisation (IRCA) as the first Iranian company to receive this certificate.

Sepahan Co.'s policy is MAE which means it lessens the negative environmental impact of its products by taking advantage of new technology. In December 2018, based on a contract with a German-based company, the company was able to construct Treated Distillate Aromatic Extract, known in the market as TDAE. This is one of the products under the green rubber process oil sub-category to create elasticity and vulcanisation properties in the rubber manufacturing process. This product was introduced and replaced by Distillate Aromatic Extract (DAE) in 2010 with enacting the DAE ban in the European Union. It is worth noting that this ban was implemented due to toxic and carcinogenic polycyclic aromatic compounds in DAE, which enter the environment during the wear of car tires. Once the European Union prohibited DAE usage, the United States, Canada, South Korea, Japan, China, Brazil and Russia also enforced the same law to avoid consuming DAE. It is expected that due to the adverse environmental effects of PCA compounds, the law will be implemented in other countries in the coming years (Sepahan Oil Company, 2019). This product is considered in the current research. As a general data that was published by Oil & Energy Milestones Agency in 2021, the amount of engine oil produced in Iran in 2021 by four major companies is as presented in Table 3.

It can be seen in Table 3 that Sepahan and Iranol oil companies are among the major companies with high engine oil production.

4.3 | Samples

In this study, we selected the experts who had at least 10 years of work experience, possessed a bachelor's degree or higher in an area related to SCM and sustainability, were familiar with the ESSCM concept and the environmental issues, and were involved in the projects regarding new product development. Eventually, 10 experts from each company were selected.

TABLE 3 Engine oil produced by four major companies in Iran in 2021.

Company name	Amount of production in 2021 (million liter)	Share in production (percentage)
Behran	214.234	42
Sepahan	114.752	22
Iranol	99.723	19
Pars	85.131	17
Total	**513.840**	**100**

TABLE 4 Hard dimensions.

Lean manufacturing	LM
Total quality management	TQM
Supplier relationship management	SRM
Technologies for cleaner production	TCP
Institutional pressures	IP
Green logistics	GL
Green purchasing	GP
Innovation	I

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation.

4.4 | Validation of dimensions

In order to determine the validation of dimensions, experts' opinions regarding the relevance of hard dimensions to their ESSCM were collected through the first part of a questionnaire, which was designed to collect the required data for the study. Experts were given flexibility to add or remove any of the dimensions; however, all identified dimensions were recognised as pertinent and no amendments were made. The complete questionnaire is presented in Appendix A and the hard dimensions are indicated in Table 4.

4.5 | Implementation of Bayesian BWM, OPA and DEMATEL

4.5.1 | BWM questionnaire and the implementation of Bayesian BWM

Once the dimensions are identified, respondents are requested to fill the second part of the questionnaire which is a BWM questionnaire. To implement Bayesian BWM, the first step is to use BWM questionnaire to collect the required data. In this part, based on their experiences and expertise, respondents were required to follow the steps of BWM:

The best-worst method consists of the following four steps:

1. Define a set of decision criteria
2. Define the best (most important) and the worst (least important) criteria

Upon gathering the required data through the questionnaire, answers provided by the respondents were inserted in a table as shown in Table A1.

3. compare the best criterion with all criteria using Equation (1):

$$(a_{B1}, a_{B2}, \ldots\ldots, a_{Bn}) \tag{1}$$

This step for EA and MAE policies (Iranol and Sepahan oil companies) is stated in Table A2.

4. Compare all criteria with the worst criterion using Equation (2):

$$A_W = (a_{1W}, a_{2W}, \ldots\ldots, a_{nW}) \tag{2}$$

The comparison of all criteria with the worst (least important) criterion are given in Table A3.

For analysing the data using Bayesian BWM, the MATLAB implementation is available on http://bestworstmethod.com/software/.

4.5.2 | OPA questionnaire and the implementation of the OPA

The required inputs for this section of the questionnaire are the preference of the resonance for each of the hard dimension. These data are then analysed using the following steps:

OPA consists of five steps as presented below:

Step 1: Determine the attributes

Step 2: Determine the experts and prioritise them (in the case of group decision-making)

Step 3: Rank the attributes

Step 4: Rank the alternatives in each attribute as presented in Equation (3)

$$\left(A_{ijk}^{(1)}, A_{ijk}^{(2)}, \ldots, A_{ijk}^{(m)}\right) \tag{3}$$

Step 5: Solve the model, find the weights of the attributes and rank the alternatives

In this step, a linear mathematical model (Equation 4) is employed to determine the optimal weight in group decision-making. By applying Equations (5) to (7), the final weights of the alternatives, attributes and experts are determined, as indicated in Equation (8).

Max Z

S.t:

$$Z \le i\left(j\left(r\left(W_{ijk}^{r} - W_{ijk}^{r+1}\right)\right)\right) \quad \forall i,\ j,\ k \text{ and } r$$
$$Z \le W_{ijk}^{m} \quad \forall i, j \text{ and } k \tag{4}$$

$$\sum_{i=1}^{p}\sum_{j=1}^{n}\sum_{k=1}^{m} W_{ijk} = 1$$

$$W_{ijk} \ge 0 \qquad \forall i,\ j \text{ and } k$$

where Z is unrestricted in sign.

The weights of the alternatives are defined as Equation (5):

$$W_k = \sum_{i=1}^{p}\sum_{j=1}^{n} W_{ijk} \qquad \forall k \tag{5}$$

The weights of the attributes are defined as Equation (6):

$$W_j = \sum_{i=1}^{p}\sum_{j=1}^{m} W_{ijk} \qquad \forall j \tag{6}$$

The weights of the experts are defined as follows (Equation (7) is only used for group decision-making).

$$W_i = \sum_{i=1}^{n}\sum_{j=1}^{m} W_{ijk} \qquad \forall i \tag{7}$$

$$\left(W_{ijk}^{(1)}, W_{ijk}^{(2)}, \ldots, W_{ijk}^{(m)}\right) \tag{8}$$

Some key advantages of the OPA are presented as follows:

- Instead of pairwise comparison, only the order of attributes and alternatives is required
- Since this approach only requires the experts' priorities of the criteria as the inputs, normalisation is not required
- No averaging method is needed because the experts' opinions are aggregated through the utilisation of a mathematical model

Table A4 presents the results of weight comparison between Bayesian BWM and OPA in EA and MAE policies (Iranol and Sepahan oil companies). The numbers in the table indicate the weights that is given by each employee of each company to each of the hard dimension.

In Table 5, the ranks and weights of the data are calculated and compared using Bayesian BWM and OPA.

4.5.3 | DEMATEL questionnaire

The third part of the questionnaire aims to collect data to be analysed using DEMATEL technique. To use the DEMATEL technique, there are five steps that need to be taken:

1. Identifying the set of criteria for which the interrelationship is to be determined.

For the first step, each expert is required to score the interrelationships of the dimensions on a scale of 0 (no influence) to 4 (very high influence). However, in the matrix that is formed to show the direct relations (d_{ij}), the average of the scores is inserted using Equation (9). These scores indicate the intensity of the direct relationship between the criteria. The result is presented in Table A5.

$$d_{ij} = \frac{1}{m}\sum_{n=1}^{m} d_{ij,}^{n} \quad i,j = 1,2,\ldots,n \ \text{ and } m \text{ is the number of experts} \tag{9}$$

2. Generating a normalised matrix $N = [n_{ij}]_{nxn}$ of direct relation matrix $D = [d_{ij}]_{nxn}$ ($i,j = 1, 2, \ldots, n$) with (n) influential characteristics {G_1, G_2, … …, G_n}, using Equation (10).

TABLE 5 Weight comparison between Bayesian BWM and OPA in EA and MAE policies (Iranol and Sepahan oil companies).

	EA policy (Iranol Co.)				MAE policy (Sepahan Co.)			
	Bayesian BWM		OPA		Bayesian BWM		OPA	
Hard dimensions	Weights	Rank	Weights	Rank	Weights	Rank	Weights	Rank
Lean manufacturing	0.118	4	0.141	3	0.148	2	0.164	2
Total quality management	0.152	2	0.188	2	0.127	4	0.157	3
Supplier relationship management	0.108	6	0.081	6	0.112	6	0.097	6
Technologies for cleaner production	0.117	5	0.086	5	0.167	1	0.215	1
Institutional pressures	0.136	3	0.137	4	0.139	3	0.148	4
Green logistics	0.092	8	0.073	8	0.093	8	0.053	8
Green purchasing	0.102	7	0.078	7	0.104	7	0.063	7
Innovation	0.175	1	0.216	1	0.110	5	0.103	5

Note: BWM, Best-Worst Method; OPA, Ordinal Priority Approach; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

$$N = \frac{D}{\max\left(\sum_{j=1}^{n} d_{ij}, \sum_{i=1}^{n} d_{ij}\right)} \tag{10}$$

Note that all elements in the matrix N must comply with $0 \leq n_{ij} < 1$, $0 \leq \sum_{j=1}^{n} n_{ij} \leq 1$, and at least one row such that $\sum_{j=1}^{n} d_{ij} \leq \max\left(\sum_{j=1}^{n} d_{ij}, \sum_{i=1}^{n} d_{ij}\right)$.

Normalised matrix was prepared according to the second step which is presented in Table A6.

3. Computing the total relationship matrix

In the third step, the matrix of total relations is calculated using Equation (11):

$$T = aD_1 + D_2 + D_3 + ... + D_n = D(I - D) - 1 \tag{11}$$

In Equation (11), (T) represents the total relationship matrix, (D) represents the direct relation matrix, and (I) represents the unit matrix. The total relationship matrix is formed to determine the direct and indirect relationships of the criteria as depicted in Table A7.

4. Construct a cause-and-effect map

In the fourth step, in order to draw a cause-and-effect diagram, the threshold value (α) is first calculated using Equation (12), and the individual elements of the total relation matrix are compared with it. The threshold value is equal to the average of the total relations matrix. At this stage, the values that are less than the threshold value are considered equal to 0, meaning that there is no relationship, and the rest are equal to 1, which indicates that the criteria influence the others. Using this information, a cause-and-effect diagram can be drawn as depicted in Figure 2a,b.

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [tij]}{N} \tag{12}$$

In Figure 2a,b, double-sided arrows indicate a two-way relationship between dimensions.

5. Calculating the impact of the factors

The last step is to calculate the influence and the intensity of the factors on each other using Equations (13) and (14), for which the sum of rows (R) and sum of columns (C) of the total relations matrix is calculated. R indicates the intensity of influence on other criteria, and C indicates the intensity of influence of other criteria on a given criterion. From the sum and subtraction of R and C, the cause dimension as well as the effect dimension can be obtained. If $R + C > 0$, it is called the cause dimension, and if $R + C < 0$, it is called the effect dimension (Gabus & Fontela, 1972) (Choudhary et al., 2020; Zhou et al., 2017).

$$R = [r_i]_{nx1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} \tag{13}$$

$$C = [c_i]_{1xn} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1xn} \tag{14}$$

The cause-and-effect dimensions for Iranol Co. (EA policy) and Sepahan Co. (MAE policy) were acquired using fifth step as mentioned above, and the results are shown in Table 6.

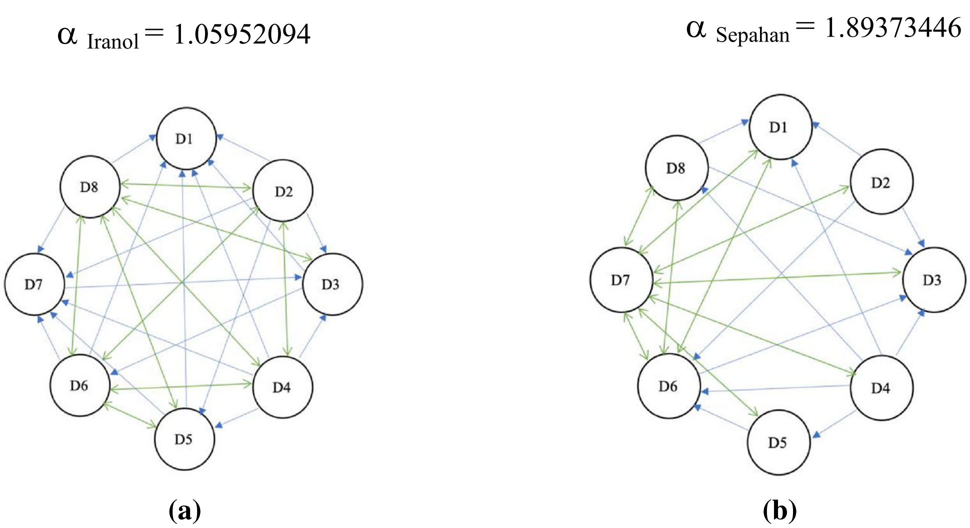

FIGURE 2 (a) Causal diagram of the hard dimensions in ESSCM (environmentally sustainable supply chain management) – EA policy (Iranol Co.). (b) Causal diagram of the hard dimensions in ESSCM (environmentally sustainable supply chain management) – MAE policy (Sepahan Co.). MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE 6 Impact of hard dimensions on ESSCM.

Hard dimensions	EA policy (Iranol Co.)			MAE policy (Sepahan Co.)		
	$R-C$	$R+C$	Impact	$R-C$	$R+C$	Impact
Lean manufacturing	−0.708	16.769	Effect	−0.641	30.422	Effect
Total quality management	0.521	17.098	Cause	0.696	29.359	Cause
Supplier relationship management	−0.015	16.381	Effect	−0.881	29.581	Effect
Technologies for cleaner production	0.531	17.448	Cause	1.135	30.324	Cause
Institutional pressure	0.045	16.608	Cause	0.085	28.945	Cause
Green logistics	−0.162	17.464	Effect	−0.552	30.922	Effect
Green purchasing	−1.125	16.042	Effect	−0.283	32.332	Effect
Innovation	0.913	17.806	Cause	0.442	30.510	Cause

Note: ESSCM, environmentally sustainable supply chain management; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

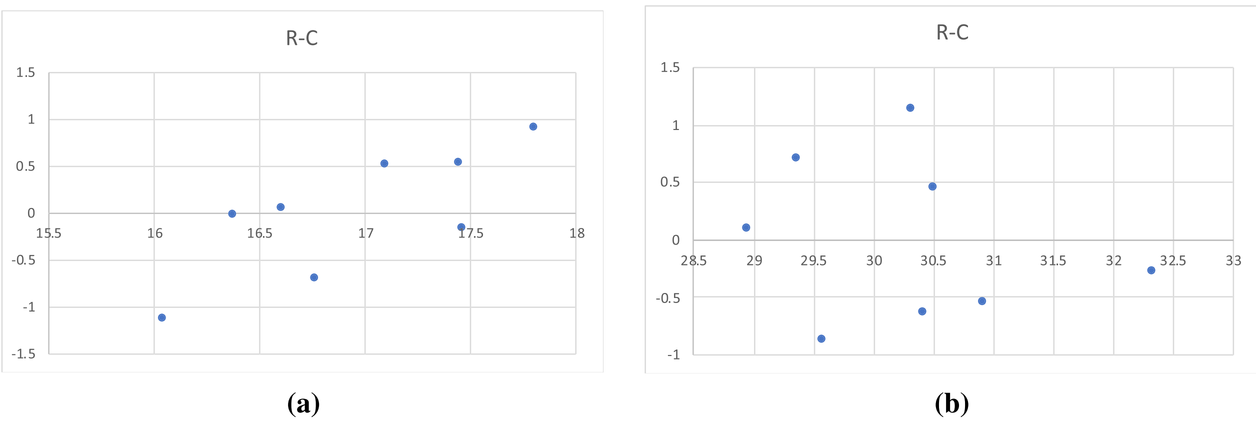

FIGURE 3 (a) Influences of hard dimensions in Iranol oil company ESSCM (EA policy). (b) Influences of hard dimensions in Sepahan oil company ESSCM (MAE policy). ESSCM, environmentally sustainable supply chain management; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

Using the information from Table A7, Figure 3a,b was prepared to illustrate the intensity of influence of hard dimensions in EA and MAE policies (Iranol and Sepahan oil companies).

5 | DISCUSSION

The final results of the ranking of hard dimensions and cause-and-effect relationships among them in the case study are shown in Table 7.

The rankings listed in Table 7 are illustrated in Figure 4 for further clarity.

According to Figure 4, there are some discrepancies in the outcomes of Iranol and Sepahan oil companies. The results of the Bayesian BWM in EA policy (Iranol Co.) indicate that ‘innovation’ is ranked as the first among the other hard dimensions. This result has been confirmed by OPA as well. DEMATEL analysis for this company shows that this dimension is among the ‘cause’ group. Also, the value of this dimension, 0.913, denotes that ‘innovation’ has the greatest impact on the other dimensions, which is illustrated in Figure 2 as well. The application of Bayesian BWM depicted that in MAE policy (Sepahan Co.), ‘technologies for cleaner production’ has achieved the top rank. The same finding was approved by OPA. DEMATEL positions this dimension among the ‘cause’ group. The value of this dimension is 1.135 which demonstrates the highest intensity of its impact on the other dimensions.

The differences in the findings are due to the projects related to new product/technology development in each company. Iranol Co. (the company with EA policy) focusses on the development of new products that are more environmentally adaptive and seeks to produce vegetable-based, non-toxic, and non-carbon engine oils such as ‘Iranol Tetra’; whereas Sepahan Co. (the company with MAE policy) utilises new technologies to reduce the adverse effects of its products on the environment which has led to the production of TDAE oil. It can be concluded that in companies intending to develop eco-friendly supply chain management, ‘innovation’ plays an important role; hence, more investment in this area is required. The findings of Ravetti et al. (2020) also acknowledged that ‘innovation’ has a positive and direct impact on the company's environmental performance. As such, companies in polluting industries need innovation to stay

TABLE 7 Ranking, cause-effect relationship and the intensity of influences of hard dimensions in EA and MAE policies (Iranol and Sepahan oil companies).

	EA policy (Iranol Co.)				MAE policy (Sepahan Co.)			
Hard dimensions	$R-C$	Ranking (OPA)	Ranking (BBWM)	Impact	$R-C$	Ranking (OPA)	Ranking (BBWM)	Impact
Lean manufacturing	−0.708	3	4	Effect	−0.641	2	2	Effect
Total quality management	0.521	2	2	Cause	0.696	3	4	Cause
Supplier relationship management	−0.015	6	6	Effect	−0.881	6	6	Effect
Technologies for cleaner production	0.531	5	5	Cause	1.135	1	1	Cause
Institutional pressure	0.045	4	3	Cause	0.085	4	3	Cause
Green logistics	−0.162	8	8	Effect	−0.552	8	8	Effect
Green purchasing	−1.125	7	7	Effect	−0.283	7	7	Effect
Innovation	0.913	1	1	Cause	0.442	5	5	Cause

Note: MAE, mitigated adverse eco-effect; EA, environmentally adaptive; BBWM, Bayesian Best-Worst Method; OPA, Ordinal Priority Approach.

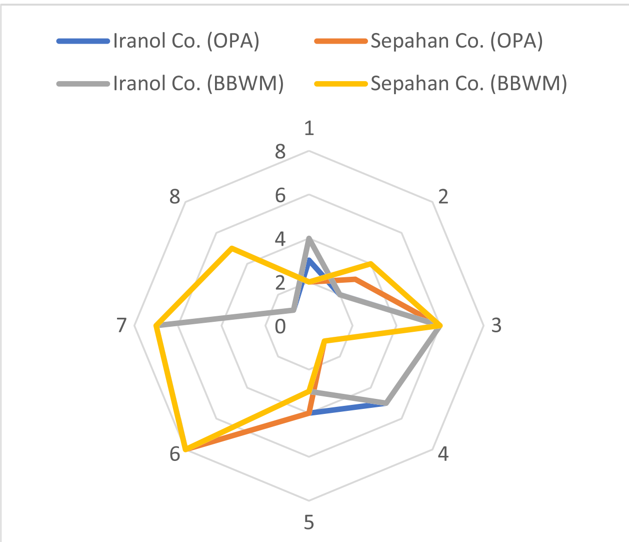

FIGURE 4 Rankings of hard dimensions in EA and MAE policies (Iranol and Sepahan oil companies). BBWM, Bayesian Best-Worst Method; OPA, Ordinal Priority Approach; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

active in a competitive market (Ravetti et al., 2020). On the other hand, the results imply that in companies that aim to mitigate the negative effects of their products on the environment, 'technologies for cleaner production' has a significant influence that assists their supply chain in becoming environmentally sustainable; therefore, investments in technologies are essential. The impact of technologies for cleaner production on ESSCM is also consistent with the results of the research conducted by Brahmana and Kontesa (2021). As indicated by the results of this study, 'lean manufacturing', 'total quality management' and 'institutional pressures' are crucial dimensions in achieving ESSCM. Accordingly, companies in the oil and gas industry must allocate high priority to these three dimensions for successful implementation of ESSCM. The research conducted by Rachman and Ratnayake (2019) in the oil and gas sector confirmed the necessity of 'lean manufacturing' in this industry. According to Abbas (2020), 'total quality management' positively impacts ESSCM by increasing organisational capabilities to achieve green performance goals, which is consistent with the results of this study. Jain et al. (2020) found that environmental performance is greatly impacted by the institutional pressures.

The last outcome of this study provides that regardless of the projects of the companies in the oil and gas sector, 'supplier relationship management', 'green purchasing' and 'green logistics' have the least prominence in an eco-friendly supply chain management.

6 | CONCLUSION AND IMPLICATION TO PRACTICE

The present study reviews the research literature in the field of ESSCM and evaluates the effectiveness of hard dimensions in multiple companies in the oil and gas industry and uses the combined approach of Bayesian BWM, OPA and DEMATEL to analyse the collected data. To do this, a questionnaire was distributed among the experts in two oil companies with EA and MAE policies. These hard dimensions were ranked using the Bayesian BWM and OPA; cause-and-effect relationships were then identified by applying the DEMATEL technique. In this article, we used innovation to express designing a new product that has been developed within the company. Likewise, technology for cleaner production refers to the technologies that companies utilise to mitigate the environmental risk of their operations. In other words, innovation helps companies that use environmentally adaptive policy to develop a new product to perform in accordance with the environmental laws. Technology for cleaner production, on the other hand, is used in companies with mitigated adverse eco-effect to minimise the environmental damage. According to the findings of Kaipainen and Aarikka-Stenroos (2022), technology and innovation have a significant role on the business policy development (Kaipainen & Aarikka-Stenroos, 2022). If the managers do not apply technologies for cleaner production, their financial performance will not be improved (Brahmana & Kontesa, 2021). It is expected that decision-makers who intend to use the results of this study are familiar with the concepts of ranking and cause-and-effect relationships and analysing the findings in order to accurately adopt them in their supply chain management.

The main implication of the present research is that it assists the managers and decision-makers to operate their SCM more efficiently and in compliance with the environment. Furthermore, the application of the result of the current study allows businesses to benefit from the positive outcomes of ESSCM adoption that include but are not limited to cost reduction, competitive advantage, environment-friendly production process, etc.

6.1 | Managerial insights

Adoption of ESSCM is crucial for businesses, especially in the oil and gas industries, which contribute mostly to the carbon dioxide emission that eventually leads to global warming. In this study, we investigated two different business policies, EA and MAE policies, in two oil and gas companies. According to the findings of this study, in companies with environmentally adaptive policy, innovation has the first rank and has the highest influence on other dimensions, meaning that an increased emphasis should be placed on innovation by managers. In other words, since new product development leads to innovation and the production of eco-friendly products, more investment has to be made in this area in order to achieve innovation. In the companies adopting mitigating adverse eco-effect policy, the highest rank and influence on other dimensions belongs to technologies for cleaner production. Therefore, these companies can contribute to the mitigation of the negative effect on the environment by investing mainly in projects that involve technologies for cleaner production.

6.2 | Limitations and future studies

The limitation that the present study was facing was the restrictions on accessing the companies' documents to match them with the obtained results. For future studies, researchers can study the disposing/recycling process of engine oils after their useful life and check whether that process is environmentally friendly. It is also recommended that since in the existing literature, there is a lack of consistent studies regarding the impacts of TQM and SRM on the ESSCM in the oil and gas industry, future studies conduct research to cover these areas.

CONFLICT OF INTEREST STATEMENT

We confirm that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere. I also confirm that there is no conflict of interest with any of the suggested reviewers.

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APPENDIX A

TABLE A1 The best and the worst influential dimensions on Iranol and Sepahan oil companies' ESSCM.

Hard dimensions	EA policy (Iranol Co.) Best (most important) dimension according to the experts	EA policy (Iranol Co.) Worst (least important) dimension according to the experts	MAE policy (Sepahan Co.) Best (most important) dimension according to the experts	MAE policy (Sepahan Co.) Worst (least important) dimension according to the experts
LM	Expert 3,5	Expert 7,9	Expert 2,6	
TQM	Expert 2,10		Expert 1,5,9	Expert 2,4,8
SRM		Expert 2		Expert 6
TCP			Expert 3,7,8,10	
IP	Expert 7		Expert 4	
GL		Expert 1,3,5,6,8		Expert 3,5,7,10
GP		Expert 4,10		Expert 1,9
I	Expert 1,4,6,8,9			

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation.

TABLE A2 Comparison of the best dimension with other dimensions.

EA policy (Iranol Co.)									
Experts	**Best dimension**	**LM**	**TQM**	**SRM**	**TCP**	**IP**	**GL**	**GP**	**I**
Expert 1	I	3	4	5	5	4	9	8	1
Expert 2	TQM	7	1	9	6	8	5	3	6
Expert 3	LM	1	2	7	6	2	9	4	5
Expert 4	I	8	4	6	5	4	6	9	1
Expert 5	LM	1	5	8	6	4	9	6	4
Expert 6	I	4	5	2	7	6	9	7	1
Expert 7	IP	9	6	5	3	1	2	5	5
Expert 8	I	8	5	6	7	4	9	6	1
Expert 9	I	9	5	6	6	7	6	8	1
Expert 10	TQM	3	1	4	3	5	7	9	8
MAE policy (Sepahan Co.)									
Experts	**Best dimension**	**LM**	**TQM**	**SRM**	**TCP**	**IP**	**GL**	**GP**	**I**
Expert 1	TQM	3	1	4	5	4	8	9	5
Expert 2	LM	1	9	8	6	6	5	3	7
Expert 3	TCP	6	7	2	1	2	9	4	3
Expert 4	IP	6	9	4	4	1	8	6	5
Expert 5	TQM	3	1	4	4	5	9	6	6
Expert 6	LM	1	3	9	8	7	8	7	6
Expert 7	TCP	3	2	5	1	2	2	5	3
Expert 8	TCP	6	9	4	1	5	4	6	8
Expert 9	TQM	7	1	9	2	6	6	8	4
Expert 10	TCP	3	5	5	1	4	9	8	3

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE A3 Comparison of other dimensions with the worst dimension.

EA policy (Iranol Co.)										
Experts Worst dimension	**Expert 1 GL**	**Expert 2 SRM**	**Expert 3 GL**	**Expert 4 GP**	**Expert 5 GL**	**Expert 6 GL**	**Expert 7 LM**	**Expert 8 GL**	**Expert 9 LM**	**Expert 10 GP**
LM	5	3	9	4	9	5	1	4	1	5
TQM	3	9	8	6	4	3	2	6	5	9
SRM	3	1	5	3	6	8	2	3	2	6
TCP	6	8	4	4	3	2	4	3	6	3
IP	4	7	8	4	4	4	9	4	2	4
GL	1	8	1	5	1	1	5	1	5	6
GP	6	7	8	1	4	2	3	5	3	1
I	9	4	6	9	5	9	2	9	9	3
MAE policy (Sepahan Co.)										
Experts Worst dimension	**Expert 1 GP**	**Expert 2 TQM**	**Expert 3 GL**	**Expert 4 TQM**	**Expert 5 GL**	**Expert 6 SRM**	**Expert 7 GL**	**Expert 8 TQM**	**Expert 9 GP**	**Expert 10 GL**
LM	5	9	4	6	4	9	2	6	2	5
TQM	9	1	8	1	9	5	2	1	9	3
SRM	3	8	5	3	6	1	2	3	3	6
TCP	6	3	9	4	3	2	9	9	6	9
IP	4	7	8	9	4	4	3	4	2	4
GL	6	8	1	4	1	3	1	4	5	1
GP	1	7	8	4	4	2	3	5	1	6
I	3	4	6	5	5	2	2	2	2	3

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE A4 Weight comparison between Bayesian BWM and OPA in Iranol and Sepahan oil companies.

EA policy (Iranol Co.										
Hard dimensions	**E1 ranks**	**E2 ranks**	**E3 ranks**	**E4 ranks**	**E5 ranks**	**E6 ranks**	**E7 ranks**	**E8 ranks**	**E9 ranks**	**E10 ranks**
LM	2	6	1	7	1	3	8	7	8	2
TQM	3	1	2	2	4	4	7	3	2	1
SRM	5	8	7	6	7	2	5	5	4	4
TCP	6	4	6	4	6	7	3	6	5	3
IP	4	7	3	3	3	5	1	2	6	5
GL	8	3	8	5	8	8	2	8	3	6
GP	7	2	4	8	5	6	4	4	7	8
I	1	5	5	1	2	1	6	1	1	7
MAE policy (Sepahan Co.)										
Hard dimensions	**E1 ranks**	**E2 ranks**	**E3 ranks**	**E4 ranks**	**E5 ranks**	**E6 ranks**	**E7 ranks**	**E8 ranks**	**E9 ranks**	**E10 ranks**
LM	2	1	6	5	2	1	4	5	6	3
TQM	1	8	7	8	1	2	2	8	1	6
SRM	4	7	3	3	4	8	6	2	7	5
TCP	5	4	1	2	3	6	1	1	2	1
IP	3	4	2	1	5	5	2	4	4	4
GL	7	3	8	7	8	7	8	3	5	8
GP	8	2	5	6	7	4	7	6	8	7
I	6	6	4	4	6	3	5	7	3	2

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE A5 Average matrix.

EA policy (Iranol Co.)								
Hard dimensions	**LM**	**TQM**	**SRM**	**TCP**	**IP**	**GL**	**GP**	**I**
LM	0	2.5	2.5	2.3	2.5	2.3	2.5	2.5
TQM	2.3	0	2.7	2.5	2.7	3.3	3	2.5
SRM	2.7	2.3	0	2.5	2.5	2.8	2	2.6
TCP	2.9	2.8	3	0	2.8	2.7	2.5	2.7
IP	3	2.2	2.5	2.3	0	2.3	2.5	3
GL	2.8	2.4	2.4	3	2.5	0	2.9	2.6
GP	2	2.5	2.2	2.5	2	2.3	0	2.2
I	3.1	3	2.2	3	2.7	3.3	3	0
MAE policy (Sepahan Co.)								
Hard dimensions	**LM**	**TQM**	**SRM**	**TCP**	**IP**	**GL**	**GP**	**I**
LM	0	2.9	2.5	2.6	2.1	2.3	2.6	3
TQM	2.6	0	2.7	2.3	2.2	2.8	2.9	2.7
SRM	2.7	2.1	0	2.1	2.5	2.8	2.6	2.5
TCP	2.8	2.4	3	0	2.8	2.7	2.8	2.7
IP	2.5	2	2.7	3	0	2.5	2.8	2
GL	2.8	2.4	2.4	2.5	2.5	0	3	2.8
GP	2.7	3	3	3	2.6	2.8	0	2.5
I	2.8	2.4	2.2	2.1	2.7	3.3	3.3	0

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE A6 Normalised matrix.

EA policy (Iranol Co.)								
Hard dimensions	LM	TQM	SRM	TCP	IP	GL	GP	I
LM	0.000	0.123	0.123	0.113	0.123	0.113	0.123	0.123
TQM	0.113	0.000	0.133	0.123	0.133	0.163	0.148	0.123
SRM	0.133	0.113	0.000	0.123	0.123	0.138	0.099	0.128
TCP	0.143	0.138	0.148	0.000	0.138	0.133	0.123	0.133
IP	0.148	0.108	0.123	0.113	0.000	0.113	0.123	0.148
GL	0.138	0.118	0.118	0.148	0.123	0.000	0.143	0.128
GP	0.099	0.123	0.108	0.123	0.099	0.113	0.000	0.108
I	0.153	0.148	0.108	0.148	0.133	0.163	0.148	0.000
MAE policy (Sepahan Co.)								
Hard dimensions	LM	TQM	SRM	TCP	IP	GL	GP	I
LM	0.000	0.148	0.128	0.133	0.107	0.117	0.133	0.153
TQM	0.133	0.000	0.138	0.117	0.112	0.143	0.148	0.138
SRM	0.138	0.107	0.000	0.107	0.128	0.143	0.133	0.128
TCP	0.143	0.122	0.153	0.000	0.143	0.138	0.143	0.138
IP	0.128	0.102	0.138	0.153	0.000	0.128	0.143	0.102
GL	0.143	0.122	0.122	0.128	0.128	0.000	0.153	0.143
GP	0.138	0.153	0.153	0.153	0.133	0.143	0.000	0.128
I	0.143	0.122	0.112	0.107	0.138	0.168	0.168	0.000

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

TABLE A7 Total relationship matrix.

EA policy (Iranol Co.)								
Hard dimensions	LM	TQM	SRM	TCP	IP	GL	GP	I
LM	0.938	0.999	0.990	1.010	0.999	1.048	1.031	1.016
TQM	1.131	0.976	1.083	1.106	1.092	1.178	1.140	1.104
SRM	1.074	1.009	0.897	1.035	1.016	1.085	1.029	1.038
TCP	1.175	1.117	1.114	1.016	1.117	1.177	1.141	1.133
IP	1.102	1.021	1.022	1.043	0.922	1.083	1.065	1.069
GL	1.132	1.065	1.054	1.107	1.067	1.019	1.118	1.090
GP	0.961	0.936	0.915	0.953	0.916	0.981	0.856	0.940
I	1.226	1.166	1.124	1.187	1.153	1.243	1.204	1.057
MAE policy (Sepahan Co.)								
Hard dimensions	LM	TQM	SRM	TCP	IP	GL	GP	I
LM	1.804	1.794	1.882	1.812	1.773	1.934	2.012	1.880
TQM	1.938	1.681	1.906	1.816	1.793	1.970	2.041	1.884
SRM	1.860	1.701	1.705	1.731	1.728	1.886	1.943	1.796
TCP	2.031	1.867	2.002	1.791	1.896	2.052	2.126	1.966
IP	1.872	1.716	1.847	1.786	1.634	1.894	1.971	1.795
GL	1.965	1.807	1.913	1.842	1.822	1.864	2.065	1.906
GP	2.062	1.924	2.037	1.957	1.921	2.092	2.038	1.993
I	2.000	1.840	1.940	1.860	1.863	2.045	2.114	1.815

Note: LM, lean manufacturing; TQM, total quality management; SRM, supplier relationship management; TCP, technologies for cleaner production; IP, institutional pressures; GL, green logistics; GP, green purchasing; I, innovation; MAE, mitigated adverse eco-effect; EA, environmentally adaptive.

QUESTIONNAIRE

Dear respondent,

The present questionnaire has been designed and prepared in three parts with the aim of evaluating the effectiveness of hard dimensions in the implementation of ESSCM (environmentally sustainable supply chain management). As an expert in this field, you are sincerely requested to answer the following questions.

We sincerely thank you in advance for your cooperation.

Section 1: Validation of factors affecting ESSCM

In the first part, you are required to determine the relevance of the following dimensions regarding the implementation of ESSCM. Kindly provide your response as 1 (for relevant dimensions) and 0 (for irrelevant dimensions).

Effective hard dimensions for implementing ESSCM	Preference
Lean manufacturing	
Total quality management	
Supplier relationship management	
Technologies for cleaner production	
Institutional pressure	
Green logistics	
Green purchasing	
Innovation	
If you consider other factors in addition to the factors mentioned in the implementation of environmentally friendly supply chain management, please list them.	

Section 2: BWM – Assessing the hard dimensions affecting ESSCM

In the second part, you are asked to select the best (most important) dimension in the table below and compare it with other dimensions. Please determine the intensity of the impact on a scale of 1 to 9. (1 = very low impact; 9 = very high impact).

Best dimension:	
Effective hard dimensions for implementing ESSCM	**Preference**
Lean manufacturing	
Total quality management	
Supplier relationship management	
Technologies for cleaner production	
Institutional pressure	
Green logistics	
Green purchasing	
Innovation	

Also, please select the worst (least important) dimension in the table below and compare the other dimensions with it and determine the intensity of the impact on a scale of 1 to 9.

1 = very low impact; 9 = very high impact.

Worst dimension:	
Effective hard dimensions for implementing ESSCM	**Preference**
Lean manufacturing	
Total quality management	
Supplier relationship management	
Technologies for cleaner production	
Institutional pressure	
Green logistics	
Green purchasing	
Innovation	

Section 3: OPA – ordinal priority approach

In the third part, based on your expertise, kindly rank the hard dimension in the table below.

Effective hard dimensions for implementing ESSCM	Preference
Lean manufacturing	
Total quality management	
Supplier relationship management	
Technologies for cleaner production	
Institutional pressure	
Green logistics	
Green purchasing	
Innovation	

Section 4: DEMATEL – Causal and causal relationships between effective factors.

In the fourth part, the researcher seeks to determine the interrelationships between the dimensions expressed in relation to the implementation of environmentally friendly supply chain management. For this purpose, the following table has been prepared to measure the interrelationships of these dimensions on a scale of zero (0) to four (4). Please specify the relationship between each of the dimensions in the box.

0 = Ineffective, 1 = very low impact, 2 = low impact, 3 = high impact, 4 = very high impact.

Hard dimension	Lean manufacturing	Total quality management	Supplier relationship management	Technologies for cleaner production	Institutional pressure	Green logistics	Green purchasing	Innovation
Lean manufacturing	0							
Total quality management		0						
Supplier relationship management			0					
Technologies for cleaner production				0				
Institutional pressure					0			
Green logistics						0		
Green purchasing							0	
Innovation								0