Journal of Transportation and Logistics,
JTL 2025, 10 (2): 483–500

https://doi.org/10.26650/JTL.2025.1607805

Submitted 26.12.2024
Revision Requested 02.02.2025
Last Revision Received 25.03.2025
Accepted 01.05.2025
Published Online 17.07.2025

Journal of Transportation and Logistics

Research Article

Open Access

Understanding the green supply chain management barriers of cosmetic industry SMEs through the lens of the Sustainable Development Goals

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Abstract The cosmetic industry faces several challenges on its journey toward sustainability. Green supply chain management (GSCM) can be accepted as one of them. This study aims to provide a comprehensive understanding of the barriers that may affect GSCM from the perspective of the cosmetics industry by synthesizing the information obtained from literature and experts. The causal relationships between the identified barriers were analyzed, and their relative importance was assessed with the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach, which can support decision makers in prioritizing key issues and providing an understanding of how different elements influence each other. The results reveal interdependence between barriers while contextualizing these barriers within the framework of the Sustainable Development Goals (SDGs), illuminating their impact on broader societal and environmental goals. The results indicated that "lack of training", "lack of management commitment", and "lack of awareness in society were identified as the most important barriers. According to the results, the most important barriers can be associated with SDG12 Responsible Production and Consumption, SDG4 Quality Education, and SDG13 Climate Action, respectively. By revealing the dynamics of GSCM challenges in the cosmetics sector, this research provides valuable insights for policymakers and practitioners striving for sustainable development.

Keywords Sustainable Development Goals · Cosmetic Industry · Green Supply Chain Barriers · DEMATEL

Citation: Kocabey Çiftçi, P. (2025). Understanding the green supply chain management barriers of cosmetic industry SMEs through the lens of the Sustainable Development Goals. *Journal of Transportation and Logistics*, *10*(2), 483-500. https://doi.org/10.26650/JTL.2025.1607805

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Understanding the green supply chain management barriers of cosmetic industry SMEs through the lens of the Sustainable Development Goals

Sustainability concerns involve all sectors on a global basis. In order to ensure a better future, the Sustainable Development Goals (SDGs) are a set of 17 global goals that were established by the United Nations in 2015 (The 17 Goals -UN, 2023). The goals are basically to address the issues like poverty, inequality, climate change and so on.

Interest in sustainability solutions is also increasing day by day. The fact that the topic is being discussed in many channels and attracts the attention of consumers is expected to increase awareness of sustainable products. This situation creates the need to review existing products/services and production systems from a sustainability perspective. In this context, all processes from the design stage of products/services to the end of life may need to be reconsidered. A major transformation plan of this scale may bring many challenges.

One of the most important processes to be considered is green supply chain management (GSCM). GSCM was defined as "*integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end of life management of the product after its useful life*" by Srivastava (2007) and Yu et al., (2019). GSCM practices basically require that manufacturers cooperate with suppliers and consumers to enhance sustainability (Green et al., 2012). According to the life cycle assessment principles, it evaluates the life cycle of a product from cradle (or extraction) to grave (or disposal) (Côté et al., 2008).

Although the implementation of GSCM can result in better environmental performance by reducing the greenhouse gas emissions, waste water, solid waste production, and toxic substance usage, there are still concerns about whether these practices will ultimately transform into improvements in market share and profitability (Green et al., 2012). Updating existing supply chain management strategies with a more environmentally friendly and sustainable approach can be a tiring process for companies, both financially and emotionally, given the scope of issues involved in supply chain management mentioned above. Particularly when small- and medium-sized enterprises (SMEs) are already struggling with several different challenges. While SMEs play a critical role in driving innovation and increasing competitiveness, they often face resource constraints and operational complexities that can hinder their ability to effectively implement sustainable practices. In this context, it is critical to find productive GSCM strategies. However, many businesses have trouble to develop effective strategies under changing market in terms of green operations (Singh et. al., 2016).

Primarily, the improper strategies adopted in GSCM negatively affect the competition of businesses in their existing markets. They can lead to failure to provide the expected benefits from the process. In addition, with improper strategy practices, resources can be wasted and the path to sustainability can be deviated. This may have significant consequences for SMEs that cannot allocate funds for green transformation in the supply chain. In this context, it is expected that understanding the barriers that businesses will face in this process in order to determine the right strategies and taking these obstacles into consideration while determining their strategies may contribute to the prevention of the above-mentioned problems to a significant extent. The success of green supply chain management strategies of SMEs in the cosmetic industry is full of barriers arising from many internal and external factors, just like in other sectors.

The cosmetic industry significantly impacts and is influenced by sustainability concerns, including environmental responsibility, ethical sourcing, and social well-being. Aligning with the SDGs can enhance brand

reputation, increase consumer trust, drive innovation, and ensure long-term business resilience. In the light of the information supplied above, this paper performs a detailed analysis to provide a comprehensive investigation and understanding of the barriers that may affect green supply chain management from the perspective of the cosmetics industry by synthesizing the information obtained from the literature and expert opinions. For this purpose, the causal relationships between the identified barriers were analyzed and their relative importance was assessed using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach in order to reveal the complex interdependencies between the barriers. Lastly, illuminating the impact of the barriers to the Sustainable Development Goals (SDGs). The objectives of the presented study can be listed as follows:

1. To identify the barriers that small and medium-sized cosmetic product manufacturers in Türkiye face in green supply chain management that may affect the sustainability journey of the companies by using the literature and expert opinions
2. To reveal critical areas for intervention and strategic action by analyzing the causal relationships between identified barriers and their level of importance using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach
3. To discuss in detail the progress, social and environmental impacts of these obstacles in the green supply chain management of the cosmetics sector in terms of the UN Sustainable Development Goals (SDGs).

The novelties and contributions of the study presented in line with the above-mentioned objectives are as follows. The primary innovation and contribution is to identify the barriers affecting the green supply chain, which is one of the important points that can affect the sustainability process of cosmetics sector SMEs in Türkiye. This is an important gap to our best knowledge. The study is expected to create an important awareness of green supply chain management for the country and the sector by considering the identified factors.

This study, which aims to reveal the causal interactions and importance levels of the barriers identified using the DEMATEL method, is expected to help both the literature and sectoral practices in determining critical intervention points and strategic action areas for GSCM in the cosmetics sector. In this way, it will help companies in the relevant field to focus their GSCM efforts on priority factors and to move forward more easily and quickly in the sustainability process.

In addition, the GSCM barriers addressed in the study and the barriers that are important in the sector will be analyzed within the framework of the SDGs, the possible environmental and social impacts will be discussed, and the evaluation of the process from a broad perspective will be presented and will contribute to achieving the SDGs.

Literature Review

When a detailed literature search was performed for the studies related to “DEMATEL” and “green supply chain” or “sustainable supply chain”, a total of 211 research papers were found at Thomson Reuters Web of Science. %28.910 of them was in the Environmental Sciences category. The results of this simple bibliometric research indicated that the DEMATEL methodology created a vast body of literature for itself at GSCM literature.

The research that used the DEMATEL approach to analyze the barriers for GSCM or sustainable supply chain management (SSCM) can also be found in relevant literature. For example; Kaur et al., (2018) used the DEMATEL approach for analyzing the barriers for green supply chain management in the Canadian manufacturing industry. In recent years, Menon and Ravi, (2021) used Grey-DEMATEL to understand the barriers for

SSC in the electronics industry, while Jalali et al., (2022) used the Fuzzy-DEMATEL approach to investigate the same topic for Iran. In addition, Vishwakarma et al., (2022) used DEMATEL with ISM and fuzzy MICMAC to analyze the barriers of SSCM in the apparel and textile industry. These are some examples that are related to DEMATEL and GSCM or SSCM. However, there is a large body of literature on GSCM or SSCM in scientific literature.

The fact that the topic of GSCM has been studied in detail, focusing on different countries, regions, sectors, and perspectives, reveals that the factors affecting the topic can vary according to the countries, regions, and sectors in which it is applied. In order to illustrate this issue in detail, examples of GSCM studies conducted for different sectors in the last decade are given in Table 1 and examples of GSCM studies conducted from the perspective of different countries are given in Table 2. From the construction to the healthcare industry, several different studies focused on investigating barriers for GSCM, as shown in Table 1.

The variety of the industry-specific studies also proved the importance of understanding industries' own dynamics to obtain better GSCM performance. The study by Dhull and Narwal (2016) supports the importance of sectoral studies in GSCM mentioned above by drawing attention to different sectors. In this study, they aimed to review the literature for finding the barriers and drivers for implementing GSCM. A total of 41 drivers and 26 common barriers were composed due to the study. The authors also mentioned industry-specific drivers and barriers because each industry can have its own dynamics to manage the green supply chain processes.

Table 1

Barriers of GSCM studies on different sectors in the last decade

Sector	Articles
Agriculture	(Do et al., 2023)
Automotive	(Gahlot et al., 2023), (Silva et al., 2018), (Balon et al., 2016), (Jayant & Azhar, 2014)
Banking	(Herrador-Alcaide et al., 2023)
Cement	(Nteta & Mushonga, 2021)
Chemical	(Nigam, 2014)
Construction	(Banihashemi et al., 2023), (Handayani et al., 2021), (Ahmed et al., 2020)
Electronics	(Menon & Ravi, 2021), (Kaur et al., 2018)
Food and Beverage	(Mohamed, 2021)
Footwear	(Sarker et al., 2018)
Healthcare	(Ahmed et al., 2020)
IT	(Nigam, 2014)
Leather	(Uddin et al., 2019)
Manufacturing	(Chen et al., 2022), (Aggarwal, 2019), (Kumar et al., 2018), (Nigam, 2014)
Marble and Stone	(Soni et al., 2020)
Pharmaceutical	(Fetter & Zilahy, 2022), (Faisal, 2015)
Plastic	(Mathiyazhagan et al., 2016)
Rubber	(Narayanan et al., 2018)
Textile	(Vishwakarma et al., 2022), (Tumpa et al., 2019), (Majumdar & Sinha, 2019), (Majumdar & Sinha, 2018)

In the light of the presented literature review, there are still gaps in the literature for different regions and sectors, as understanding sectoral differences is crucial to be successful in the process GSCM. Therefore, this study aims to analyze the barriers faced by small and medium-sized cosmetic product manufacturers

in Türkiye in GSCM practices and the importance levels of these barriers with the DEMATEL approach. It also stresses on discussing the possible effects of these barriers on the SDGs.

Table 2

Barriers of GSCM studies on different countries in the last decade

Country, Region	Articles
Bangladesh	(Tumpa et al., 2019), (Uddin et al., 2019), (Sarker et al., 2018)
Brazil	(Silva et al., 2018)
Canada	(Kaur et al., 2018)
Egypt	(Mohamed, 2021)
India	(Gahlot et al., 2023), (Soni et al., 2020), (Aggarwal, 2019), (Narayanan et al., 2018), (Majumdar & Sinha, 2018), (Mathiyazhagan et al., 2016), (Balon et al., 2016), (Nigam, 2014), (Jayant & Azhar, 2014)
Indonesia	(Handayani et al., 2021)
Multiple countries	(Ahmed et al., 2020), (Majumdar & Sinha, 2019)
South Africa	(Nteta & Mushonga, 2021)
UK	(Kumar et al., 2018)
Vietnam	(Do et al., 2023), (Chen et al., 2022)

Methodology

The study used the Decision Making Trial and Evaluation Laboratory (DEMATEL) approach in order to identify the influence of the barriers for GSCM of the cosmetic industry. The DEMATEL technique was primarily presented by the Batelle Memorial Institute of Geneva between 1972 and 1976 in order to learn the complex and interwind problem group (Singh et al., 2020). It has been used widely by various disciplines. It helps to identify the cause-effect relationship between the factors of a complex system and find the critical factors through a visual structural model (Si et al., 2018). Different from the traditional techniques like Analytical Hierarchy Process (AHP) with the assumption that factors are independent, DEMATEL can reveal the interdependence between the studied factors of the system with the help of a casual diagram (Wu & Chang, 2015), (Shieh et. al., 2010), (Tzeng et.al., 2007). In this technique, the direct relation matric is primarily established by using the relations between factors supplied by experts, and then the influence of factors on each other and the degree of this influence are analyzed (Li & Wu, 2022).

The implementation process of the DEMATEL is initiated with the determination of the factors studied for the relevant system. After the identification of the factors, the relationship between the chosen factors is determined through comparison with each other using expert knowledge (Li & Wu, 2022). A group of experts defined the relations between factors using the influence level represented in Table 3.

Table 3

Influence level for the relations between factors

Influence Level	Score
No influence	0
Low influence	1
Moderate influence	2
Strong influence	3
Strong influence	4

The $n \times n$ relation matrices are created using each expert's opinions. Experts defines xij that represents the degree to which expert believes factor i affects factor j and subsequently, an average relations matrix (A) is calculated by using the Eq.1 (Wu & Chang, 2015) that is given below.

$$aij = \frac{1}{H}\sum_{k=1}^{H}\left(x_{ij}^{k}\right) \tag{1}$$

In this equation, k represents the number of experts while H represents the total number of experts. In addition, x_{ij}^{k} is the k'th expert's opinion for the impact of factor i on j. The calculated initial average direct relation matrix (A) is then normalized by using the Eq. 2 (Singh et. al., 2020).

$$X = \frac{A}{\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}}, \text{where } 0 \le a_{ij} \le 1 \tag{2}$$

The "X" represents the normalized matrix and the values of the normalized matrix must be between 0 and 1.Then, the following step is to calculate the total relation matrix T by using the Eq. 3 where I represent the unit matrix (Li & Wu, 2022).

$$T = X(I - X)^{-1} \tag{3}$$

After the calculation of the total relation matrix, the row- sum of the factors D and the column- sum of the factors R in T are calculated with Equations 4 and 5.

$$D = \sum_{j=1}^{n} d_{ij} \tag{4}$$

$$R = \sum_{i=1}^{n} r_{ij} \tag{5}$$

A threshold value (α) is calculated by using the Eq 6 (Singh et al.., 2020).

$$\propto = \frac{\sum_{j=1}^{n}\sum_{i=1}^{n} r_{ij}}{n^2} \tag{6}$$

Finally, a diagram is created using D+R and D-R, where the horizontal axis presents the values of D+R and the vertical axis presents the values of D-R.

Identification of Barriers of GCSM for the Cosmetic Industry

The presented study focuses on analyzing the barriers that small and medium-sized cosmetic manufacturers in Türkiye face in green supply chain management. Problems that may occur in green supply chain management can affect the sustainability journey of companies and lead to wastage of time and resources, causing companies to move away from the process. Supply chain management can focus on various areas, from the procurement of raw materials to the transportation of the manufactured product to the consumer. Therefore, it is one of the most important areas for transforming companies into more sustainable and environmentally friendly versions. Losses in this area are likely to have social and environmental consequences. In this study, which deals with the green supply chain management of the cosmetics industry, the primary literature was examined in detail in order to identify the barriers. Information related to the comprehensive literature review can be found in the literature review section. When the studies examining the barriers affecting GSCM are reviewed, it can be seen that most of the studies examined the effects of some common factors. In addition to these factors, the impacts of country- and industry-specific factors are also crucial for managing the supply chain with a sustainable perspective.

Dhull and Narwal conducted a entailed research in which the drivers and barriers affecting the green supply chain were thoroughly investigated and a detailed literature review was presented in 2016. The barriers that are presented in their study include:

- Internal barriers,
- External barriers,
- customer-related barriers,
- competition-related barriers,
- society-related barriers,
- supplier-related barriers
- and sectoral barriers.

Apart from sectoral barriers, they identified 26 barriers in their literature review. Therefore, the study by Dhull and Narwal (2016) has been an important starting point for this study.

In the presented study, the 26 barriers were identified in order to provide a comprehensive study for green supply chain management in the cosmetics industry by different studies and the sectoral barriers identified by the experts working in the cosmetics industry were added and a total of 30 different barriers were included in the study. Table 4 lists these barriers.

Table 4

Barriers of GSCM for cosmetic industry SMEs

Factors	Barriers	References
Internal	High cost	(Gahlot et al., 2023), (Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Nteta & Mushonga, 2021), (Handayani et al., 2021), (Chen et al., 2022), (Jalali et al., 2022)
	Lack of understanding to incorporate green buying	(Dhull & Narwal, 2016)
	Inappropriate organizational structure	(Dhull & Narwal, 2016)
	Cost reduction at the cost of the environment	(Dhull & Narwal, 2016)
	Lack of management commitment	(Gahlot et al., 2023), (Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Nteta & Mushonga, 2021), (Chen et al., 2022), (Jalali et al., 2022)
	Lack of adaptation of advancement in technology reluctance to change	(Dhull & Narwal, 2016), (Aggarwal, 2019), (Chen et al., 2022), (Jalali et al., 2022)
	Lack of training	(Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Chen et al., 2022), (Jalali et al., 2022)
	Too complex to implement	(Dhull & Narwal, 2016), (Chen et al., 2022)
	No/low return from investment	(Dhull & Narwal, 2016)
External	Cost of eco-friendly packaging	(Dhull & Narwal, 2016)
	Lack of technology infrastructure	(Dhull & Narwal, 2016), (Jalali et al., 2022)
	Inhabits innovations	(Balon et al., 2016), (Dhull & Narwal, 2016)
	Lack of skilled human resources in the implementation of GSCM	(Gahlot et al., 2023), (Dhull & Narwal, 2016), (Handayani et al., 2021), (Chen et al., 2022), (Jalali et al., 2022)
	Poor supplier commitment	(Gahlot et al., 2023), (Balon et al., 2016), (Dhull & Narwal, 2016), (Nteta & Mushonga, 2021), (Chen et al., 2022), (Jalali et al., 2022)

Factors	Barriers	References
	Not willing to change trade information	(Dhull & Narwal, 2016)
	Lack of government support	(Gahlot et al., 2023), (Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Nteta & Mushonga, 2021), (Chen et al., 2022), (Jalali et al., 2022)
	Lack of Information Technology	(Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019)
	Lack of ethical standards and corporate social responsibility	(Gahlot et al., 2023), (Balon et al., 2016), (Dhull & Narwal, 2016), (Chen et al., 2022)
Customers	Pressure for a lower price	(Dhull & Narwal, 2016), (Jalali et al., 2022)
	Lack of demand and public awareness	(Balon et al., 2016), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Nteta & Mushonga, 2021), (Chen et al., 2022), (Jalali et al., 2022)
Competition	Competition and uncertainty	(Gahlot et al., 2023), (Dhull & Narwal, 2016), (Aggarwal, 2019), (Chen et al., 2022)
	Pressure for lower price with competitors	(Dhull & Narwal, 2016), (Jalali et al., 2022)
Society	Lack of awareness in the society	(Dhull & Narwal, 2016), (Handayani et al., 2021)
Suppliers	Reluctant to change toward GSCM	(Dhull & Narwal, 2016)
	Lack of knowledge and experience among suppliers	(Dhull & Narwal, 2016), (Aggarwal, 2019)
	Lack of understanding among supply chain stakeholders	(Dhull & Narwal, 2016), (Nteta & Mushonga, 2021)
Sectoral	Efforts to attract consumers with different packaging	Experts
	High level of product diversity	Experts
	High number of producers	Experts
	High percentage of imported raw materials	Experts

The sectoral barriers for the cosmetic industry SMEs were identified by using expert knowledge and expertise. For determining these barriers, the opinions of experts in the fields of R&D, procurement, sales, marketing and production, one with 15 years of experience, one with 5 years of experience and 2 with 3 years of experience, and an academic advisor were utilized. A total of 4 sectoral barriers were included for the cosmetic industry. These are:

- Efforts to attract consumers with different packaging: Since consumers tend to prefer packaging that is as appealing to the eye as the content of cosmetic products, this criterion has been added as a barrier that may affect the GSCM.
- High level of product diversity: Cosmetic products can vary in terms of many criteria such as their structure, function, content, packaging, For example, even a simple shampoo can have many function-oriented varieties. This can make green supply chain management complex for the cosmetic industry.
- High number of producers: The number of cosmetic producers has been increasing. This can also cause several different problems in GSCM and the market.
- High percentage of imported raw materials: some of the main raw materials of the industry are generally imported from different countries in Türkiye. This can increase the greenhouse gas emissions that come from the transportation of raw materials and affect sustainability.

Application of DEMATEL on Barriers of GSCM of the Cosmetic Industry

The DEMATEL method was used to determine the causal relationships of the GSCM barriers for the cosmetic sector described in the previous section and the level of importance of these relationships. In

order to apply the DEMATEL approach, the effects of the defined factors on each other should be determined by experts and the average of these opinions should be used. In this study, the opinions of 4 different experts with experience in the fields of production, R&D, purchasing, sales and marketing in the cosmetics industry were used. Each expert was asked in detail about the impact of the 30 factors on each other via face-to-face and online meetings, and they were asked to give these relationships a score ranging from 0 to 4, as given in Table 3. The matrices obtained from the experts were summed and the average relationship matrix given was formed. The obtained matrix is presented in Table 5.

The average matrix obtained was normalized using Eq. 2. and the total relationship matrix was calculated using Eq. 3. The normalized relations are given in Table 6, while the total relations are given in Table 7.

Table 5

The normalized relations of the barriers of GSCM for the cosmetic industry

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	0	1	2.75	2.5	3.5	2.5	1.5	1.5	1.5	3.25	1.75	1.5	2.25	1.25	1.75	2	1.75	1	2	1	2.5	3	1.75	1.75	2.75	1	1.75	2	3.25	1.75
2	2	0	2.25	3.25	2.5	3.75	3.75	2.75	1.75	2	2.75	3	2.25	1.75	2	0.75	2	3.25	2	3.25	1.5	2.5	1.75	2.25	1.75	3.5	2	2.5	2.25	1.75
3	2.25	2	0	3.5	3.25	3.5	3	2.75	2	1	2.25	2.25	2.25	2	2	0.75	3	2.5	1	2	3	3.25	1.75	2	1.5	2	2.75	1.5	1.5	0.75
4	1.25	2	1.5	0	3.25	3	3	2	2	1.5	2.25	2.75	3	3	2	2.25	1	2.5	2.75	2	3.75	2.5	3	2.5	2.75	2.25	1	2	2.25	1.25
5	3	2.25	2.25	2.25	0	2.25	3.5	2	3	2.5	1.25	2.5	3	2.5	2.75	0.75	2.5	2.5	3.25	2	4	2.25	2	2.75	2	3	2.25	3	2.25	1.5
6	2.25	1.75	2	1.5	1.75	0	3	1.75	3.25	2.5	2.25	3.25	2.75	2.75	1.75	1.75	2.75	2	2.5	1.75	2.75	2.25	1.75	2.5	1.5	1.25	3	1.5	2.5	1.25
7	2.75	2.75	3.5	2.25	2.75	2.25	0	2.25	2.75	3.25	2.5	2.75	2.75	2.75	2.75	2.75	2.5	2.75	3.25	2.75	2.75	2.25	2	2.75	2.25	2.25	3.25	2	2.25	3.5
8	2	2.5	2.5	2.5	2	3	3.75	0	3.5	1.75	2	3	3	2	2.5	2	3	2.25	1.75	2.5	2	2	2.5	2	1.25	2	1.25	2.5	3	0.75
9	2.5	2.25	2	1.5	3.75	2	3	1.25	0	1.5	1.75	1.75	2	2.75	2.25	1.25	1.75	2.5	3	2.5	3	2	2	2.5	1.25	1.25	0.75	1.5	2	2
10	3	3	2.25	3.75	3.5	3	3.25	2.5	3.5	0	2	2.5	1.75	3	2.5	1.5	2	1.25	2.5	3	2.25	3.25	2.5	2	1.5	1	1	2.75	2.75	1.5
11	2.5	3.75	2	2	2	2.25	1.75	2.5	2	2.75	0	3.25	2	2.5	2.25	1.25	1.75	2.25	2	3	2.25	1.75	2	2	2.75	2.25	1.25	2	2.25	1.25
12	1.75	3.25	2.75	1.5	1.5	1.75	1.5	1.5	1.5	1.5	2	0	2.25	1.75	1.25	1	2	1.5	1.25	1.75	1.75	1.25	1.5	1.75	2	1.5	2.75	3.25	2.25	1.75
13	2	3.75	2.5	2.5	3.75	2.25	4	1.5	1.75	3.5	2	3.5	0	2.75	3	1.75	3.25	1.75	3	2.75	2.75	1.75	3	2.25	3.25	3.25	2.5	2	2	1
14	3.75	3.5	2	3.5	3.5	3	2.25	3	3	2.5	2.75	3	3	0	1.75	2.25	1.75	2	3.5	2.25	2.25	3.5	2.25	3.5	2.25	2.25	2	2	3.25	1.25
15	2.25	2.5	2.25	2	3	1.25	3.25	2.75	1.25	2.5	2.25	1.5	2.5	2.5	0	1.75	1.75	1.5	1.75	2	1.75	1.5	2.25	1.25	2.5	2.25	0.75	2.5	2.25	0.5
16	2.5	3.25	1.25	3.25	1.75	2.5	2	2	2	2.25	1.75	1.75	1.75	2.25	1.5	0	2.25	2.25	2	2	1.75	1.5	1.75	1.25	1.25	1.75	0.75	1.5	1.5	2
17	2.25	3	2.75	3	2.5	2.75	2.25	3	3	2.5	3.5	2.75	3	3	2	2.5	0	2.25	2.25	2.5	2.75	3	3	2.75	3.25	1.25	2	2.25	2.5	1.75
18	2.25	3.25	2.75	3	3	2.5	3.25	2.25	3	3.25	1.75	1.75	2.25	2.25	3.25	1.5	2.5	0	3	1.75	2.5	1.75	3	1.75	2.5	2.25	2	1.5	2.25	1.75
19	2	3.25	2.5	1.5	3	2.75	2.75	1	2.5	2.75	2.5	0.75	1.75	3	2.5	0.75	2.5	1.5	0	2.25	1.75	2.75	2.75	2.75	1.75	1.75	2	1.5	1.5	1.5
20	2	2.5	2.25	1.75	1.75	1.5	2	1.75	1.75	1.5	1.25	1.25	1.5	1.75	1.75	1	2.25	1.75	1.75	0	1.5	2.25	1.75	1.5	1.5	2.25	1.25	1	1.5	1.5
21	2.25	2.75	2.5	3	3	2	2.75	2.5	1.75	1.75	2.5	2.5	2.25	1.75	1.75	1	1.5	3	1.75	1.75	0	1.5	1.75	1.75	2	1.75	2.25	2.25	2.5	1.75
22	2	2.75	1.75	3	3	1.75	2.75	2.25	2.25	2.25	2	2	1.75	2.25	2.75	1.5	2.25	2.75	2.25	2.25	2.25	0	2.75	2.25	2.25	2.75	1.25	2	1.75	1.5
23	2.5	2.5	2.5	3.5	3.5	3	3.5	3	3.5	3	3	2.5	3.5	3	3.25	2.25	2.5	3	3.25	3.25	3.5	3.5	0	3	2.5	2	2	1	3	2
24	2.25	3	2.25	2	2.5	2.5	2.5	2.25	2.5	2.5	2.25	2.25	2.5	2.5	2.5	2	2.25	2.5	2.5	2.5	2.5	2.5	2.5	0	2	3	1.5	1.5	3	2
25	2	2	1.25	2.75	2.75	1.5	2.75	2.25	2.25	2.75	2.25	2	2	2.25	2	1.5	2	2.25	2	2	2.5	2.5	2	2.5	0	1.5	1.25	1.25	3	2.25
26	2	1.5	1.75	1.5	2.75	2.5	2.75	2.25	2.75	2.75	2	2	2	2.25	2.5	2	2	2.25	2.5	1	2.5	2.5	2	2.5	2.25	0	1.25	2.25	1.75	2.75
27	2.75	2.25	2.75	2	2.5	1.5	2.75	1.25	2.75	3.25	2.5	2.75	2	2	2	1.5	2.25	2	2.5	1.5	3	2.5	2.5	2.5	2.5	2	0	2.25	3	2.5
28	2.75	2.25	2.75	2	2	2	2.25	1.75	2.25	2.25	1.5	2.75	2	2	2.5	2	2.25	2	2	2	1.25	1.5	2	3	3	2	1.75	0	3	1
29	1.75	2.75	2.25	2.5	1.5	2.5	2.25	1.75	2.75	3.25	2.5	2.25	1.25	2.25	1.75	1	1.75	1.5	2.25	2.75	1.75	3.25	2.25	2.75	1.5	1.75	1.25	1.75	0	2.5
30	2.25	2.5	1.5	1.75	1.5	1	2.25	1.75	1.75	2	1.25	2.5	1.75	1.75	3	2	1	1.75	2	1.75	1.5	2.25	1.75	2.25	2.25	3.25	1.25	1.75	2.75	0

Table 6

The total relations of the barriers of GSCM for the cosmetic industry

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	0	0.012	0.033	0.03	0.042	0.03	0.018	0.018	0.018	0.039	0.021	0.018	0.027	0.015	0.021	0.024	0.021	0.012	0.024	0.012	0.03	0.036	0.021	0.021	0.033	0.012	0.021	0.024	0.039	0.021
2	0.024	0	0.027	0.039	0.03	0.045	0.045	0.033	0.021	0.024	0.033	0.036	0.027	0.021	0.024	0.009	0.024	0.039	0.024	0.039	0.018	0.03	0.021	0.027	0.021	0.042	0.024	0.03	0.027	0.021
3	0.027	0.024	0	0.042	0.039	0.042	0.036	0.033	0.024	0.012	0.027	0.027	0.027	0.024	0.024	0.009	0.036	0.03	0.012	0.024	0.036	0.039	0.021	0.024	0.018	0.024	0.033	0.018	0.018	0.009
4	0.015	0.024	0.018	0	0.039	0.036	0.036	0.024	0.024	0.018	0.027	0.033	0.036	0.036	0.024	0.027	0.012	0.03	0.033	0.024	0.045	0.03	0.036	0.03	0.033	0.027	0.012	0.024	0.027	0.015
5	0.036	0.027	0.027	0.027	0	0.027	0.042	0.024	0.036	0.03	0.015	0.03	0.036	0.03	0.033	0.009	0.03	0.03	0.039	0.024	0.048	0.027	0.024	0.033	0.024	0.036	0.027	0.036	0.027	0.018
6	0.027	0.021	0.024	0.018	0.021	0	0.036	0.021	0.039	0.03	0.027	0.039	0.033	0.033	0.021	0.021	0.033	0.024	0.03	0.021	0.033	0.027	0.021	0.03	0.018	0.015	0.036	0.018	0.03	0.015
7	0.033	0.033	0.042	0.027	0.033	0.027	0	0.027	0.033	0.039	0.03	0.033	0.033	0.033	0.033	0.033	0.03	0.033	0.039	0.033	0.033	0.027	0.024	0.033	0.027	0.027	0.039	0.024	0.027	0.042
8	0.024	0.03	0.03	0.03	0.024	0.036	0.045	0	0.042	0.021	0.024	0.036	0.036	0.024	0.03	0.024	0.036	0.027	0.021	0.03	0.024	0.024	0.03	0.024	0.015	0.024	0.015	0.03	0.036	0.009
9	0.03	0.027	0.024	0.018	0.045	0.024	0.036	0.015	0	0.018	0.021	0.021	0.024	0.033	0.027	0.015	0.021	0.03	0.036	0.03	0.036	0.024	0.024	0.03	0.015	0.015	0.009	0.018	0.024	0.024
10	0.036	0.036	0.027	0.045	0.042	0.036	0.039	0.03	0.042	0	0.024	0.03	0.021	0.036	0.03	0.018	0.024	0.015	0.03	0.036	0.027	0.039	0.03	0.024	0.018	0.012	0.012	0.033	0.033	0.018
11	0.03	0.045	0.024	0.024	0.024	0.027	0.021	0.03	0.024	0.033	0	0.039	0.024	0.03	0.027	0.015	0.021	0.027	0.024	0.036	0.027	0.021	0.024	0.024	0.033	0.027	0.015	0.024	0.027	0.015
12	0.021	0.039	0.033	0.018	0.018	0.021	0.018	0.018	0.018	0.018	0.024	0	0.027	0.021	0.015	0.012	0.024	0.018	0.015	0.021	0.021	0.015	0.018	0.021	0.024	0.018	0.033	0.039	0.027	0.021
13	0.024	0.045	0.03	0.03	0.045	0.027	0.048	0.018	0.021	0.042	0.024	0.042	0	0.033	0.036	0.021	0.039	0.021	0.036	0.033	0.033	0.021	0.036	0.027	0.039	0.039	0.03	0.024	0.024	0.012
14	0.045	0.042	0.024	0.042	0.042	0.036	0.027	0.036	0.036	0.03	0.033	0.036	0.036	0	0.021	0.027	0.021	0.024	0.042	0.027	0.027	0.042	0.027	0.042	0.027	0.027	0.024	0.024	0.039	0.015
15	0.027	0.03	0.027	0.024	0.036	0.015	0.039	0.033	0.015	0.03	0.027	0.018	0.03	0.03	0	0.021	0.021	0.018	0.021	0.024	0.021	0.018	0.027	0.015	0.03	0.027	0.009	0.03	0.027	0.006
16	0.03	0.039	0.015	0.039	0.021	0.03	0.024	0.024	0.024	0.027	0.021	0.021	0.021	0.027	0.018	0	0.027	0.027	0.024	0.024	0.021	0.018	0.021	0.015	0.015	0.021	0.009	0.018	0.018	0.024
17	0.027	0.036	0.033	0.036	0.03	0.033	0.027	0.036	0.036	0.03	0.042	0.033	0.036	0.036	0.024	0.03	0	0.027	0.027	0.03	0.033	0.036	0.036	0.033	0.039	0.015	0.024	0.027	0.03	0.021
18	0.027	0.039	0.033	0.036	0.036	0.03	0.039	0.027	0.036	0.039	0.021	0.021	0.027	0.027	0.039	0.018	0.03	0	0.036	0.021	0.03	0.021	0.036	0.021	0.03	0.027	0.024	0.018	0.027	0.021
19	0.024	0.039	0.03	0.018	0.036	0.033	0.033	0.012	0.03	0.033	0.03	0.009	0.021	0.036	0.03	0.009	0.03	0.018	0	0.027	0.021	0.033	0.033	0.033	0.021	0.021	0.024	0.018	0.018	0.018
20	0.024	0.03	0.027	0.021	0.021	0.018	0.024	0.021	0.021	0.018	0.015	0.015	0.018	0.021	0.021	0.012	0.027	0.021	0.021	0	0.018	0.027	0.021	0.018	0.018	0.027	0.015	0.012	0.018	0.018
21	0.027	0.033	0.03	0.036	0.036	0.024	0.033	0.03	0.021	0.021	0.03	0.03	0.027	0.021	0.021	0.012	0.018	0.036	0.021	0.021	0	0.018	0.021	0.021	0.024	0.021	0.027	0.027	0.03	0.021
22	0.024	0.033	0.021	0.036	0.036	0.021	0.033	0.027	0.027	0.027	0.024	0.024	0.021	0.027	0.033	0.018	0.027	0.033	0.027	0.027	0.027	0	0.033	0.027	0.027	0.033	0.015	0.024	0.021	0.018
23	0.03	0.03	0.03	0.042	0.042	0.036	0.042	0.036	0.042	0.036	0.036	0.03	0.042	0.036	0.039	0.027	0.03	0.036	0.039	0.039	0.042	0.042	0	0.036	0.03	0.024	0.024	0.012	0.036	0.024
24	0.027	0.036	0.027	0.024	0.03	0.03	0.03	0.027	0.03	0.03	0.027	0.027	0.03	0.03	0.03	0.024	0.027	0.03	0.03	0.03	0.03	0.03	0.03	0	0.024	0.036	0.018	0.018	0.036	0.024
25	0.024	0.024	0.015	0.033	0.033	0.018	0.033	0.027	0.027	0.033	0.027	0.024	0.024	0.027	0.024	0.018	0.024	0.027	0.024	0.024	0.03	0.03	0.024	0.03	0	0.018	0.015	0.015	0.036	0.027
26	0.024	0.018	0.021	0.018	0.033	0.03	0.033	0.027	0.033	0.033	0.024	0.024	0.024	0.027	0.03	0.024	0.024	0.027	0.03	0.012	0.03	0.03	0.024	0.03	0.027	0	0.015	0.027	0.021	0.033
27	0.033	0.027	0.033	0.024	0.03	0.018	0.033	0.015	0.033	0.039	0.03	0.033	0.024	0.024	0.024	0.018	0.027	0.024	0.03	0.018	0.036	0.03	0.03	0.03	0.03	0.024	0	0.027	0.036	0.03
28	0.033	0.027	0.033	0.024	0.024	0.024	0.027	0.021	0.027	0.027	0.018	0.033	0.024	0.024	0.03	0.024	0.027	0.024	0.024	0.024	0.015	0.018	0.024	0.036	0.036	0.024	0.021	0	0.036	0.012
29	0.021	0.033	0.027	0.03	0.018	0.03	0.027	0.021	0.033	0.039	0.03	0.027	0.015	0.027	0.021	0.012	0.021	0.018	0.027	0.033	0.021	0.039	0.027	0.033	0.018	0.021	0.015	0.021	0	0.03
30	0.027	0.03	0.018	0.021	0.018	0.012	0.027	0.021	0.021	0.024	0.015	0.03	0.021	0.021	0.036	0.024	0.012	0.021	0.024	0.021	0.018	0.027	0.021	0.027	0.027	0.039	0.015	0.021	0.033	0

Table 7

The total relations of the barriers of GSCM for the cosmetic industry

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	0.091	0.115	0.121	0.126	0.146	0.123	0.126	0.101	0.113	0.133	0.106	0.111	0.117	0.108	0.11	0.086	0.105	0.097	0.116	0.1	0.125	0.129	0.108	0.111	0.116	0.094	0.09	0.102	0.132	0.087
2	0.131	0.121	0.133	0.152	0.154	0.154	0.172	0.131	0.133	0.136	0.133	0.146	0.134	0.13	0.13	0.084	0.124	0.139	0.133	0.142	0.131	0.14	0.124	0.134	0.12	0.139	0.107	0.122	0.137	0.1
3	0.126	0.136	0.099	0.147	0.154	0.144	0.154	0.124	0.128	0.117	0.121	0.13	0.127	0.125	0.122	0.079	0.129	0.124	0.114	0.12	0.141	0.14	0.117	0.124	0.111	0.114	0.11	0.104	0.121	0.082
4	0.119	0.142	0.121	0.111	0.159	0.142	0.16	0.12	0.133	0.127	0.125	0.139	0.139	0.141	0.126	0.099	0.11	0.128	0.139	0.124	0.153	0.136	0.135	0.134	0.129	0.121	0.093	0.113	0.134	0.092
5	0.147	0.152	0.137	0.145	0.13	0.141	0.174	0.126	0.151	0.146	0.12	0.143	0.146	0.143	0.142	0.087	0.133	0.134	0.152	0.131	0.163	0.141	0.13	0.144	0.127	0.136	0.112	0.131	0.142	0.1
6	0.127	0.134	0.123	0.124	0.137	0.103	0.154	0.112	0.142	0.134	0.121	0.141	0.132	0.134	0.119	0.09	0.126	0.117	0.131	0.117	0.137	0.129	0.117	0.129	0.11	0.105	0.112	0.104	0.132	0.089
7	0.152	0.168	0.159	0.154	0.172	0.15	0.143	0.137	0.157	0.163	0.142	0.155	0.152	0.154	0.15	0.115	0.141	0.145	0.16	0.148	0.158	0.15	0.139	0.152	0.137	0.136	0.13	0.127	0.15	0.129
8	0.128	0.148	0.133	0.141	0.145	0.143	0.169	0.096	0.15	0.131	0.122	0.143	0.14	0.131	0.132	0.097	0.133	0.125	0.128	0.131	0.134	0.131	0.13	0.128	0.112	0.119	0.096	0.12	0.143	0.086
9	0.123	0.133	0.116	0.118	0.153	0.12	0.147	0.101	0.098	0.116	0.109	0.117	0.117	0.128	0.119	0.08	0.108	0.118	0.131	0.12	0.133	0.12	0.113	0.123	0.102	0.101	0.082	0.099	0.12	0.092
10	0.145	0.159	0.135	0.161	0.168	0.148	0.169	0.13	0.155	0.114	0.127	0.142	0.131	0.147	0.137	0.094	0.126	0.118	0.142	0.141	0.142	0.151	0.134	0.134	0.119	0.112	0.096	0.127	0.146	0.098
11	0.128	0.156	0.121	0.129	0.139	0.129	0.139	0.121	0.127	0.136	0.093	0.14	0.122	0.13	0.124	0.083	0.113	0.12	0.124	0.131	0.13	0.123	0.118	0.122	0.124	0.116	0.091	0.109	0.129	0.087

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
12	0.104	0.132	0.115	0.107	0.114	0.107	0.117	0.095	0.105	0.105	0.102	0.086	0.109	0.105	0.097	0.07	0.102	0.096	0.1	0.101	0.108	0.101	0.098	0.104	0.101	0.094	0.097	0.11	0.113	0.082
13	0.142	0.177	0.146	0.155	0.181	0.148	0.187	0.127	0.144	0.164	0.135	0.162	0.118	0.152	0.151	0.103	0.148	0.132	0.155	0.146	0.156	0.142	0.148	0.145	0.147	0.145	0.12	0.126	0.145	0.099
14	0.163	0.176	0.142	0.168	0.18	0.159	0.169	0.145	0.16	0.155	0.145	0.158	0.154	0.122	0.138	0.109	0.133	0.136	0.163	0.142	0.152	0.164	0.141	0.16	0.137	0.135	0.115	0.127	0.161	0.103
15	0.119	0.133	0.117	0.122	0.142	0.11	0.148	0.117	0.111	0.126	0.113	0.113	0.121	0.123	0.091	0.085	0.107	0.104	0.115	0.113	0.117	0.113	0.115	0.107	0.115	0.11	0.08	0.109	0.121	0.074
16	0.116	0.136	0.101	0.131	0.122	0.119	0.127	0.104	0.114	0.117	0.103	0.11	0.108	0.115	0.103	0.061	0.107	0.108	0.113	0.108	0.112	0.107	0.104	0.102	0.096	0.1	0.076	0.093	0.108	0.087
17	0.144	0.169	0.148	0.161	0.166	0.154	0.167	0.144	0.158	0.152	0.152	0.153	0.153	0.155	0.139	0.111	0.11	0.137	0.146	0.143	0.156	0.156	0.148	0.15	0.147	0.122	0.114	0.128	0.151	0.107
18	0.137	0.162	0.141	0.152	0.163	0.143	0.17	0.128	0.15	0.153	0.124	0.133	0.136	0.139	0.146	0.094	0.132	0.104	0.148	0.127	0.145	0.134	0.141	0.131	0.131	0.126	0.108	0.113	0.14	0.101
19	0.122	0.148	0.126	0.122	0.149	0.133	0.149	0.103	0.132	0.135	0.122	0.11	0.118	0.135	0.126	0.077	0.121	0.11	0.1	0.121	0.123	0.133	0.126	0.13	0.111	0.11	0.099	0.102	0.119	0.09
20	0.101	0.117	0.103	0.104	0.111	0.098	0.116	0.092	0.102	0.099	0.088	0.094	0.095	0.1	0.097	0.066	0.099	0.094	0.1	0.075	0.099	0.107	0.095	0.095	0.09	0.097	0.075	0.079	0.098	0.075
21	0.123	0.142	0.125	0.138	0.147	0.123	0.148	0.118	0.122	0.122	0.12	0.129	0.123	0.119	0.116	0.079	0.108	0.126	0.119	0.114	0.102	0.117	0.113	0.117	0.113	0.109	0.101	0.11	0.129	0.092
22	0.125	0.147	0.121	0.143	0.153	0.125	0.153	0.12	0.132	0.133	0.119	0.127	0.122	0.13	0.132	0.088	0.121	0.128	0.13	0.124	0.133	0.104	0.129	0.128	0.12	0.124	0.092	0.111	0.125	0.092
23	0.158	0.175	0.156	0.178	0.191	0.167	0.194	0.154	0.175	0.17	0.156	0.161	0.169	0.166	0.165	0.116	0.15	0.156	0.17	0.163	0.176	0.173	0.124	0.163	0.148	0.141	0.122	0.123	0.168	0.118
24	0.134	0.157	0.132	0.138	0.154	0.14	0.157	0.125	0.141	0.142	0.127	0.136	0.136	0.138	0.135	0.098	0.127	0.13	0.139	0.133	0.142	0.14	0.132	0.107	0.123	0.133	0.1	0.11	0.146	0.102
25	0.12	0.133	0.11	0.135	0.144	0.117	0.147	0.115	0.127	0.133	0.117	0.122	0.12	0.125	0.119	0.085	0.113	0.117	0.122	0.117	0.13	0.129	0.116	0.126	0.089	0.106	0.089	0.098	0.135	0.097
26	0.123	0.13	0.118	0.123	0.147	0.13	0.15	0.117	0.135	0.136	0.116	0.125	0.122	0.127	0.127	0.092	0.116	0.119	0.13	0.107	0.133	0.13	0.118	0.128	0.118	0.089	0.09	0.111	0.123	0.105
27	0.138	0.146	0.137	0.136	0.152	0.126	0.158	0.112	0.142	0.149	0.129	0.14	0.129	0.131	0.128	0.091	0.125	0.123	0.137	0.12	0.146	0.138	0.13	0.135	0.127	0.119	0.081	0.118	0.144	0.107
28	0.129	0.136	0.128	0.127	0.136	0.123	0.141	0.11	0.127	0.128	0.109	0.131	0.12	0.122	0.124	0.091	0.117	0.114	0.122	0.117	0.116	0.118	0.116	0.132	0.125	0.111	0.095	0.083	0.135	0.083
29	0.117	0.141	0.121	0.131	0.129	0.128	0.141	0.109	0.132	0.138	0.119	0.125	0.11	0.124	0.115	0.079	0.11	0.108	0.124	0.125	0.121	0.137	0.118	0.128	0.106	0.108	0.088	0.103	0.099	0.1
30	0.114	0.128	0.104	0.114	0.119	0.102	0.13	0.101	0.112	0.115	0.097	0.118	0.107	0.109	0.121	0.084	0.093	0.103	0.112	0.105	0.109	0.116	0.104	0.114	0.107	0.118	0.081	0.096	0.122	0.064

Findings

After all the stages of the DEMATEL approach were completed, the threshold value, D+R, and D-R values were calculated. The threshold value of the presented study is equal to 0.1253. The relation values that are lower than the threshold value can be eliminated.

According to the results obtained from the D+R values, the top five barriers can be ranked as 7th barrier, 5th barrier, 23rd barrier, 14th barrier, and 2nd barriers, as shown in Table 8. The 7th barrier (lack of training) was ranked 1st position with the value of 8.9979, while 5th barrier (lack of management commitment) took the second place with 8.5626. The 23rd barrier (lack of awareness in society) was at the 3rd rank with the value of 8.4274. The 14th barrier (poor supplier commitment) and 2nd barrier (lack of understanding to incorporate green buying) had relatively close scores to each other and took the 4th and 5th ranks subsequently. Among all studied barriers, the 16th barrier (lack of governmental support) was ranked on the 30th position, and this barrier was the least significant barrier. Meanwhile, the first-ranked 7th barrier affected all other barriers except 16th barrier while the second-ranked 5th barrier affected all other barriers except 11th, 16th, 27th, and 30th barriers, and the third-ranked 23rd barrier affected all others except 16th, 23rd, 27th, and 30th barriers.

The studied barriers were categorized into two groups based on the D-R values. The first one is “cause group” where all barriers can have (D-R)>0. The barriers whose D-R value is bigger than 0 were called as “cause barriers” and influenced the others directly. The second group is “effect group” where all barriers can have (D-R)<0. The barriers whose D-R value is lower than 0 were known as effect barriers and they are influenced by others. This analysis helps us understand which factors have an impact on others.

According to the results obtained from the D-R values, 8th, 10th, 11th, 13rd, 14th,16th, 17th, 18th, 23rd, 24th, 26th, 27th, 28th and 30th barriers are cause barriers while others are effect barriers and are influenced from the cause barriers. The 12th barrier (inhabit innovation) had the highest D-R value; thus, it was influenced mostly by the cause barriers.

The importance level of the barriers was also calculated in this study, and the weights of each barrier are presented in Table 8.

Table 8

The sum of the influences and the weight of the barriers of GSCM for the cosmetic industry

Number	Barriers	D+R	D-R	Weight
1	High cost	71916	−0.5009	0.0319
2	Lack of understanding to incorporate green buying	83143	−0.3848	0.0368
3	Inappropriate organizational structure	74739	−0.1024	0.0331
4	Cost reduction at the cost of the environment	79363	−0.2490	0.0351
5	Lack of management commitment	85626	−0.3533	0.0379
6	Lack of adaptation of advancement in technology reluctance to change	76320	−0.2685	0.0338
7	Lack of training	89979	−0.1497	0.0398
8	Too complex to implement	74030	0.3295	0.0328
9	No/low return from investment	74651	−0.5539	0.0331
10	Cost of eco-friendly packaging	80756	0.0223	0.0357
11	Lack of technology infrastructure	72646	0.0440	0.0321
12	Inhabits innovations	70176	−0.8638	0.0313
13	Lack of skilled human resources in the implementation of GSCM	81760	0.5180	0.0362
14	Poor supplier commitment	83179	0.5033	0.0369
15	Not willing to change trade information	71702	−0.3884	0.0318
16	Lack of government support	58830	0.5338	0.0261
17	Lack of Information Technology	79262	0.7516	0.0352
18	Lack of ethical standards and corporate social responsibility	76650	0.4398	0.0340
19	Pressure for a lower price	75161	−0.3134	0.0333
20	Lack of demand and public awareness	65689	−0.8459	0.0293
21	Competition and uncertainty	75868	−0.4519	0.0336
22	Pressure for lower price with competitors	76807	−0.2167	0.0340
23	Lack of awareness in the society	84274	10634	0.0376
24	Reluctant to change toward GSCM	77912	0.1174	0.0345
25	Lack of knowledge and experience among suppliers	71132	−0.0054	0.0315
26	Lack of understanding among supply chain stakeholders	71222	0.1454	0.0315
27	Efforts to attract consumers with different packaging	68379	0.9528	0.0305
28	High level of product diversity	68699	0.2574	0.0304
29	High number of producers	75018	−0.4320	0.0332
30	High percentage of imported raw materials	60426	0.4010	0.0268

Discussion with the Perspective of SDGs

In the previous sections of the study, the causal relationships of 30 factors affecting the GSCM process of small and medium-sized enterprises producing in the cosmetics sector were analyzed by the DEMATEL method and the results were presented.

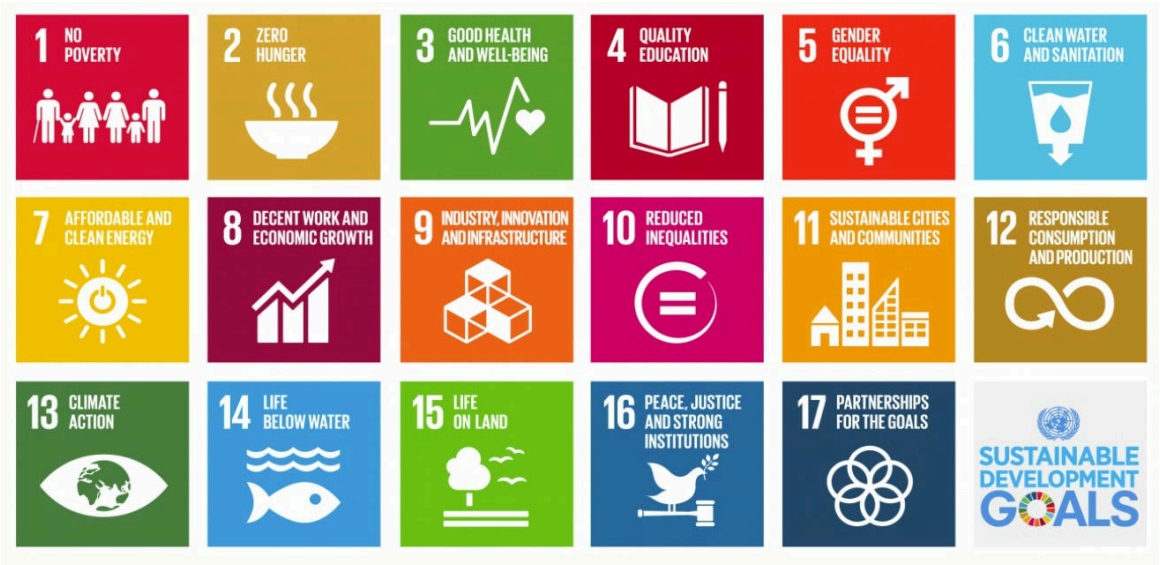
When the results are analyzed, the most important barriers for small and medium sized cosmetics manufacturers in Türkiye to manage the GSCM process are found as "lack of training", "lack of management

commitment", "lack of awareness in society", "poor supplier commitment", "lack of understanding to incorporate green buying", "lack of skilled human resource in implementation of GSCM", "cost of eco-friendly packaging", "lack of information technology", "cost of reduction at the cost of environment", and "reluctant to change towards GSCM". This study also aims to contribute to the related literature by discussing how the identified barriers can verify social and environmental impacts from the perspective of SDGs.

The SDGs, adopted by the United Nations in 2015, aim to promote sustainable development globally. Under the SDGs, 17 key targets have been defined that address vital issues facing the world, such as poverty, inequality and environmental problems. Figure 1 presents the 17 UN SDGs. By evaluating the possible relationships of the barriers identified in this study with the 17 goals, the SDGs that the barriers may affect are presented in Table 9. The DEMATEL results obtained in the previous section are discussed below, considering the possible SDG relations in this section.

Figure 1

The 17 UN Sustainable Development Goals (SDGs) (The 17 Goals | Sustainable Development, *2023)*



The "lack of training", which is identified as the most important barrier to GSCM for the sector, reveals that the sector does not receive adequate training and does not have sufficient knowledge about GSCM, its importance and its applications in its most basic form. The lack of knowledge and training on the subject may cause the process not to be designed correctly from the very beginning and not to be carried out efficiently. This situation also reveals that the importance of the issue is not effectively conveyed to all related areas, so employees are unaware of the contributions that the work can provide. This barrier is a major problem to reach SDG 4 Quality Education and SDG 8 Decent Work and Economic Growth because the lack of education on GSCM is a very critical problem to increase awareness on the subject. Thus, this can be linked to SDG 4. At the same time, the lack of training may influence the quality of work and the number of competent workers, so it can also be associated with SDG 8.

The second most important barrier found in the study is "lack of management commitment". In order to take strategic actions on green transformation issues in businesses, management support is essential. The fact that this factor was found to be the second most important barrier within the framework of the cosmetics sector reveals that the importance and gains of GSCM are not sufficiently understood by the managers. It is very difficult to perform productive work on an issue that management is not convinced of. This barrier can be linked to SDG 12 Responsible Production and Consumption and SDG 17 Partnership for the Goals. In order to overcome this barrier, the process can be made easier by raising awareness of

responsibility in production and consumption and creating beneficial partnership relationships for common goals.

The third significant barrier is "lack of awareness in society". In sectors such as the cosmetics sector, where the wishes and expectations of the end consumer are very important and lead the market, the awareness of the consumer helps businesses to adopt the green transformation process more easily. For the cosmetics sector in the Turkish market, the fact that the society is not aware of the importance of GSCM may cause producers not to receive a positive response from the consumer even if they attach importance to this issue. This, in turn, demotivates companies on the issue and decreases the importance given to the issue. Understanding the importance of green transformation as a society is essential for the sustainability journey of the sector. In this context, this barrier can be linked to SDG 4 Quality of Education, SDG 12 Responsible Production and Consumption and SDG13 Climate Action. Increasing the awareness of society through quality education and transforming them into responsible consumers and climate-conscious people will help eliminate this barrier.

"Poor supplier commitment" is the other critical barrier for the cosmetic sector. The lack of full GSCM awareness in society and companies has a significant impact on the sector. As discussed in the previous barrier from the consumer perspective, the supplier who does not give enough importance to the issue can also become a significant challenge for the sector. When the first 4 important barriers obtained in the study are searched, we can see that three of them are due to the fact that the three important stakeholders of the sector, namely producers, consumers/society and suppliers, do not attach sufficient importance to the issue or do not have sufficient knowledge about the subject. Therefore, the most important result obtained in this study is that increasing the awareness of all stakeholders on the issue is a critical intervention point because it has been determined with the barriers studied that the issue is not given the importance it should be given by the most important stakeholders.

Table 9

The sum of the influences and the weight of the barriers of GSCM for the cosmetic industry

Number	Barriers	SDG(s)
1	High cost	SDG8, SDG12
2	Lack of understanding to incorporate green buying	SDG4, SDG12, SDG13
3	Inappropriate organizational structure	SDG9, SDG17
4	Cost reduction at the cost of the environment	SDG12, SDG13
5	Lack of management commitment	SDG12, SDG17
6	Lack of adaptation of advancement in technology reluctance to change	SDG9
7	Lack of training	SDG4, SDG8
8	Too complex to implement	SDG9
9	No/low return from investment	SDG8, SDG12
10	Cost of eco-friendly packaging	SDG12, SDG13
11	Lack of technology infrastructure	SDG9
12	Inhabits innovations	SDG9
13	Lack of skilled human resources in the implementation of GSCM	SDG4, SDG8
14	Poor supplier commitment	SDG4, SDG12, SDG17
15	Not willing to change trade information	SDG9, SDG12
16	Lack of government support	SDG17
17	Lack of Information Technology	SDG9
18	Lack of ethical standards and corporate social responsibility	SDG12, SDG16

Number	Barriers	SDG(s)
19	Pressure for a lower price	SDG1, SDG8
20	Lack of demand and public awareness	SDG3, SDG12
21	Competition and uncertainty	SDG8, SDG9
22	Pressure for lower price with competitors	SDG1, SDG8
23	Lack of awareness in the society	SDG4, SDG12, SDG13
24	Reluctant to change toward GSCM	SDG4, SDG12
25	Lack of knowledge and experience among suppliers	SDG4, SDG8
26	Lack of understanding among supply chain stakeholders	SDG17
27	Efforts to attract consumers with different packaging	SDG12, SDG13
28	High level of product diversity	SDG12, SDG13, SDG14
29	High number of producers	SDG9, SDG12
30	High percentage of imported raw materials	SDG9, SDG12

When the ten most important barriers obtained because of the study are analyzed, the barriers can be classified into 3 main groups:

1. Barriers due to lack of training and knowledge (lack of training, lack of awareness in society, lack of understanding to incorporate green buying, lack of skilled human resource in implementation of GSCM, reluctant to change towards GSCM, cost of reduction at the cost of environment)
2. Barriers due to stakeholders not giving enough importance to the issue (lack of management commitment, lack of awareness in society, poor supplier commitment)
3. Cost barriers (cost of eco-friendly packaging, cost of reduction at the cost of environment)

Strategic interventions around these three key themes are likely to reduce or eliminate the impact of the most important barriers on the GSCM. When the most important factors are analyzed in relation to the SGDs, SDG12 Responsible Production and Consumption, SDG4 Quality Education, and SDG13 Climate Action emerge as critical targets.

Consequently, interventions and measures to be taken in consideration of the identified barriers and associated SDGs are expected to help the cosmetics industry to go through the GSCM process more efficiently.

Conclusions

Green supply chain management is an issue that can significantly affect the sustainability journey of businesses due to its scope. Therefore, it is essential to understand the challenges affecting the GSCM process in order to handle the process more efficiently. At this point, there may be general, geographical, and sectoral factors that affect the GSCM process of firms. This study aims to investigate the barriers that small and medium-sized enterprises in the cosmetics sector face in the GSCM process, to identify the barriers that have the most impact on the process, and to evaluate the results from the perspective of SDGs. In total, 30 barriers were identified, 4 of which were sector-specific. The causal effects of the barriers were investigated using the DEMATEL method and "lack of training", "lack of management commitment", "lack of awareness in society", "poor supplier commitment", and "lack of understanding to incorporate green buying" were identified as the most important barriers. When the results are analyzed in detail, the ten most effective barriers are clustered under three main headings: lack of education and information, lack of stakeholder attention to the issue, and costs.

In the study, all barriers were also matched with the SDGs that they could be associated with and it was emphasized that the most important barriers can be associated with SDG12 Responsible Production and Consumption, SDG4 Quality Education, and SDG13 Climate Action, respectively.

Limitations and Future Works

This study investigates the barriers faced by small- and medium-sized cosmetic manufacturers in Türkiye in the GSCM process using the DEMATEL method. This study contributes to the identification of important barriers and strategic intervention areas in the field of study.

The first limitation of the study is that it was conducted by focusing on cosmetic manufacturers in Türkiye. Although this helps us to identify geographical barriers, studies that examine the cosmetic sector on a global basis should also be conducted. In addition, the effect of possible bias can be reduced by working with more experts in future studies.

In the study, the DEMATEL method was used to determine the relationship levels of barriers. The performance of different methods on the subject can also be evaluated in future studies.

Peer Review Externally peer-reviewed.
Conflict of Interest Author declared no conflict of interest.
Grant Support Author declared no financial support.

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