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Assessing Relationships in Industry and Optimizing Related Decisions with the Help of Fuzzy Properties

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ABSTRACT

The textile industry supply chains (SC) face numerous risks and disruptions due to the changing dynamics of high demand and limited resources. In this context, the textile sector in these economies must prioritize Sustainable Supply Chain Management (SSCM) to achieve cost reduction, enhance productivity, and improve profitability to sustain their business. Although research has examined several SSCM viewpoints, the barriers that prevent emerging economies from adopting SSCM in the textile sector to meet the Sustainable Development Goals (SDGs) are not sufficiently highlighted in the empirical literature that has already been published. This study analyzes different barriers and investigates how they are interconnected. From the literature research, 17 main barriers were first identified in the process. The barriers were then prioritized in order of significance using a combination of fuzzy theory, Pareto analysis, and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) framework. Finally, the cause-and-effect relationships among these barriers were established. A lack of commitment from the supplier's top management, insufficient financial incentives, and the absence of supportive government standards and regulations were identified as the three topmost significant barriers to SSCM adoption. For the textile sector, governments, and policymakers in emerging economies, the study's results are helpful since they will assist them create mitigation strategies to get rid of these barriers and achieve long-term sustainability.

1. Introduction

Balancing the world's ever-increasing demand with its very limited capacity is crucial. This issue is more worrying in developing countries where industrial production plays an important role in the national economy [1, 35]. Due to the size of the global textile market, which was estimated to be USD 993.6 billion in 2021 and is projected to in- crease at a compound annual growth rate of 4.0 % from 2023 to 2029, many emerging

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economies are heavily dependent on the textile sector [62]. Meanwhile, many of these emerging economies are still very unfavorable in terms of market stability due to unfavorable working conditions and payment methods [30]. Representatives of the European Union (EU) and major buyers continue to stress the vital need for workers' insurance, living standards requirements and decent wages. For the world's affluent and environmentally conscious mainstream consumers, emphasizing fast fashion with pricing as a brand value proposition is not enough. Procuring raw materials, transforming them into value added end items, and distributing the end items to customers are all components of supply chain management (SCM) [5,9]. Optimum and sustainable use in SC textile industry system is difficult because it is very complex and extensive [60]. Currency devaluation, global economic recession and adverse market liberalization, higher cost of imported inputs and domestic security concerns, and in addition, demand disruption and global demand decline, all create instability in the global textile industry and pose significant challenges [12,44]. In this context, a multicriteria decision-making model for selecting the appropriate supplier using fuzzy numbers was proposed to find generic suppliers for the knitted composite industry [24]. Appropriate adoption of a sustainable supply chain is the best measure to address this overall problem and sustain it over time [3,50].

With the contemporary environmental challenges driven by global warming, industries must prioritize aligning their business operations with responsibilities toward society, environment, and economy, emphasizing the crucial role of enablers in facilitating the adoption of Sustainable Supply Chain Management (SSCM), particularly in emerging economies. Amid global climate challenges, loss of biodiversity and resource depletion firms must act for sustainable performance (SP) and future well-being. It is crucial to understand the underlying mechanisms that enhance SP [27,28]. This approach requires solving global problems including corruption, fair labor practices, water security, deforestation and climate change. At a general level, businesses have improved working conditions, reduced carbon emissions, and reduced waste [8,14]. They follow several new methods, for example, prioritizing clean energies, supporting recycling, or encouraging more social responsibility among applicants by analyzing sustainability components in SCM systems [19]. While manufacturers tend to seek short term profits and care little about possible long-term profits, SSCM can provide the profitability and sustainability that factories desire [56]. Not only does having a sustainable SC system reduce emissions and costs, it also increases applicant loyalty and investor relations, avoids compliance issues, and increases profitability. It also strengthens the company culture [64]. The implementation of SSCM will be a complex process that requires a set of processes to implement it in classic textile operations, but if these extensive measures are taken, it will lead to the achievement of some Sustainable Development Goals (SDGs). Among them: participation in society, growth in the economy and preservation of the environment [68].

Recent research has also looked at many aspects of the SSCM problem, including the following: while Carmagnac [21] focused on extending the SSCM constraints based on the participation of non-traditional elements, Pavan et al. [46] suggested the ability to use advanced models in SSCM, and Lee et al. [46] used MCDM approaches for supplier analysis in SSCM based on system requirements. In this field, there is not much research that specifically addresses the use of SSCM. In addition, there are studies that have focused on SSCM adoption challenges [38], however, the methods and survey variables were diverse. In no previous study, the barriers to SSCM in the textile sector have been discussed, emphasizing the achievement of overall development goals. Rarely has research addressed the causal links between them to help managers and decision makers in developing economies mitigate these barriers, which represents a major gap in research. Given the review gaps, we address the following research questions (RQs):

RQ1: In the case of emerging economies, what are the challenges to implementing SCM methods?

RQ2: How do these challenges interact?

RQ3: Does the identification of existing challenges help to implement sustainable practices and realize part of sustainable development goals, and how do policy makers and governing institutions deal with the industry sector?

To find answers to these questions, this research tries to achieve the following general goals:

1) To identify the main challenges of SCM implementation.

2) To identify logistics bottlenecks and transportation challenges.

3) To offer the proper guidance to textiles organizations and decision- makers for the effective adoption of SSCM.

The study attempts to prioritize and show the interrelationships between the important im-lamentation barriers for SSCM to address the RQs. As a result, the study used a hybrid methodology that included Pareto analysis and fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach. The benefit of Pareto analysis is that it aids in locating and figuring out the major aspects. As a result, businesses can address flaws or problems in the greatest priority order. The DEMATEL method is employed to create a cause & effect diagram consisting of independent barriers. It is superior to other conventional approaches as it illustrates the relationship among barriers & rank them. Fuzzy linguistic modeling has been used to demonstrate the data. The advantages of fuzzy DEMATEL method are:

a. This method shows the relationship between the obstacles created.
b. Triangular Fuzzy Numbers (TFN) are used to identify obstacles, which provides more reliable and realistic results.
c. By using the fuzzy approach, the fuzziness and uncertainty of the data is reduced.
d. This process provides very effective and accurate results that help the applicant to take basic actions.

The findings of this research are very relevant for industry as well as government policy makers. These results provide useful information that can help develop mitigation plans for the effective deployment of SSCM in the textile sector of a dynamic economy. Managers can overcome problems and challenges that hinder long-term sustainability by identifying the current obstacles in the sector and focusing on applying sensitivities that support sustainable practices, including promoting production methods, reducing waste, adapting to the environment, and increasing resource productivity. They can also seek to develop supportive regulatory frameworks that encourage appropriate and rational behavior and promote innovation in the industry sector.

At first, a general review of the background and the opinion of experts led to the creation of obstacles, the use of which was studied and investigated with Pareto analysis. Since the use of components alone did not improve the study findings, their dependence was further investigated using fuzzy DEMATEL based on the tasks performed by the users. Finally, the study assessed significant barriers and how they interacted with one another. The integration of two advanced methods of Pareto analysis and fuzzy properties is what makes this work special. The findings of this study lead the textile industry to evaluate its current situation and strive for SC sustainability. A cause-and-effect diagram has the ability to help managers gain a clear knowledge of critical barriers and help them make wise decisions by considering how they are related. They can decide strategically which barriers they should focus on initially. The industry of conventional manufacturing practices will advance as a result of these measures.

The rest of the paper is arranged in the order listed below. The extensive literature review is discussed in Section 2. The methodological methodology is thoroughly described in Section 3, along with the exhaustive logic of relevant operations. A representative example of the research is shown in Section 4. The results and discussion are described in Sections 5 and 6, respectively. Section 7 offers a conclusion to the study, highlighting its drawbacks and emphasizing the need for more research opportunities.

2. Literature review

Adopting SSCM practices is a challenging process. The successful implementation of SSCM in the context of the textiles industry of an emerging economy is hampered by several barriers, each in their own way. Table 1 illustrates the barriers of adopting SSCM. Chien et al. [13] identified Insufficient financial incentives as a potential barrier to implement SSCM into textile sector. Businesses find it challenging to afford the substantial initial expenses linked to the implementation of SSCM without the provision of financial incentives. The information gap was pointed out by Khokhar et al. [37] as a significant barrier, while lack of practice in reverse logistics was highlighted by Fernando et al. [21]. Insufficient information results in inadequate collaboration among interconnected departments during the implementation of SSCM. To support SSCM, the amount of waste must be greatly reduced, but this is severely impeded by a lack of practice with reverse logistics. Another significant barrier is lack of training which further exacerbates the difficulty in understanding the significance of sustainable practices in SSCM [33]. The huge initial investment of establishing a sustainable SC network may be prohibitive for smaller enterprises, highlighting it as a major barrier [34]. Ogunsanya et al. [43] highlighted the lack of supplier's top management commitment, while Banik et al. [10] emphasized the absence of favorable government regulations and standards as crucial barriers to adopt SSCM. Sustainable supply chain management (SSCM) has become the key concept for every industry in managing their supply chain system by focusing on three aspects: economics, social, and environmental. Even though the implementation of SSCM will help the industry increase the efficiency of supply chain management, some challenges make the firms cannot implement the SSCM concept well and unsuccessful. The challenges of SSCM implementation need to be identified and managed to overcome these challenges and increase the efficiency of SSCM management. Sirisawat et al. [53] emphasized on lack of coordination and trust and Zhao et al. [66] focused on inadequate capacity of supplier as probable barriers. Concurrently, intense international competition has prompted the implementation of restriction policies. However, due to SSCM involving multiple manufacturing steps, each step comprising various SSCM-Tec, it presents challenges in researching how different types of policies affect SSCM-Tec in each step.

Table 1. Barriers of adopting SSCM.

Code	Barriers	Description	
T1	Insufficient financial incentives	Huge upfront costs are associated with SSCM implementation, which businesses cannot afford without financial incentives.	[13]
T2	Information gap	Lack of 'information causes poor coordination among related departments while adopting SSCM.	[37]
T3	Lack of practice in reverse logistics	Reverse logistics practice aids to mitigate the problem of ever rising waste. The quantity of waste must be decreased significantly to promote SSCM, but this is severely hampered by a lack of practice with reverse logistics.	[21]
T4	Lack of training	Since 'SSCM is a new concept for enterprises to adopt, understanding the significance of sustainable practices in this field is more challenging due to lack of adequate training.	[33]
T5	Huge initial investment	Smaller businesses may find it quite expensive up front to establish a sustainable SC network. These expenses affect product pricing as well, making it challenging for certain businesses to defend them to customers who might not be fully informed.	[34]
T6	Lack of supplier's top management Commitment	The level of productivity and performance is boosted because of the top management's commitment. The outcomes of the strategic decisions made by top management will influence the organization's overall success. It will be hard to pursue sustainability in SC operations if there is a lack of commitment from top management	[43]
T7	Absence 'of favorable government regulations and standards	In other instances, some of the practices that may enable SSCM are hampered by strict government regulations and standards.	[10]

T8	Lack of coordination and trust	Misaligned goals cause separate phases of the SC to optimize local goals rather than the profits of the entire chain, which is the main barrier to coordination. Other factors include a lack of information sharing, ineffective operations that result in long lead times for replenishment, and incentives for the sales force. All these factors lead to forward purchasing and a lack of trust that makes cooperation challenging.	[53]
T9	Inadequate capacity of supplier	If the associated supplier's capacity is constrained, the SC's performance will be significantly impacted and hinders the adoption of SSCM.	[66]
T10	Lack of supplier with sustainable approach	Being of diverse relevance to all the various stakeholders is one of the reasons why sustainability in SC is such a controversial subject. When manufacturers, especially those in developing nations, are under pressure to produce as cheaply as possible by companies that promote sustainability but do not adhere to its principles and have few if any laws enforced by the government. The sense of responsibility and sustainability that manufacturers and suppliers have differs from that of the brands they serve.	[35]
T11	Lack of suppliers awareness and advances in providing environment friendly packages	Suppliers play the key role in promoting SSCM by providing environmentally friendly packages. Companies find it challenging to implement SSCM due to supplier ignorance in developing eco-friendly packaging.	[29]
T12	Global competition factors	The primary aim of businesses is to produce goods in a way that is cost-effective to remain in business due to the competitive nature of the global market. However, adopting sustainable practices will raise production costs, leading firms to strive to shift the focus away from sustainable methods.	[10]
T13	Market uncertainty	Increased volatility in the conditions of a firm's consumers or more volatile economic situations among its suppliers can both contribute to uncertainty. This uncertainty acts as a barrier while incorporating SSCM	[7]
T14	Company's policies & strategies	Every firm has its own unique set of policies and strategies for operating. The choice between acting as a customer-responsive or cost-effective business may occasionally conflict with sustainable practices, which require financial assistance to operate.	[26]
T15	Lack of eco-literacy	The establishment of a sustainable SC strategy clearly is hampered by a lack of eco-literacy. Concerning the significance of including sustainability in SC, employees are not well informed. The workforce does not well understand the advantages of such integration.	[33]
T16	Resource efficiency	Understanding how resources are used and their effects is the first step in achieving resource efficiency in SC. The SSCM has mostly concentrated on measuring the usage of resources like labour, machinery, technology, transportation, or energy.	[40]
T17	Lack of enforcement and implementation of relevant laws	Lack of enforcement seriously undermines the effective implementation of SSCM and prevents compliance with laws, rules, standards, and social norms.	Exprt Feed back

Khan et al. [35] focused on lack of supplier with sustainable approach while Jum'a et al. [29] demonstrated lack of supplier's awareness and advances in providing environment-friendly packages as possible barriers to adopt SSCM. Manufacturers and suppliers have a different sense of duty and sustainability than the companies they support. The way suppliers do business has a significant effect on whether to embrace sustainable practices. Due to supplier incompetence in producing ecofriendly packaging, businesses find it difficult to apply SSCM. Adopting sustainable practices is less prevalent among firms due to the highly competitive global market since it would increase production costs and have an adverse effect on the profit margin [10]. Both more fluctuating customer conditions and more unstable economic conditions among a firm's suppliers can increase market uncertainty which negatively impact SSCM decisions [7]. Every company has its own distinct set of operational principles and strategies. This influences the choice to use SSCM and oscillates between being either customer-responsive or cost effective [26]. Due to a lack of ecological literacy, the labor force does not fully comprehend the benefits of combining SSCM with conventional production [33]. Resource efficiency in SC can only be attained by first comprehending resource utilization and its impacts [40]. The success of SSCM implementation will suffer from a lack of these understandings. Experts stated the lack of enforcement and implementation of relevant laws which undermine the effective adoption of SSCM.

Table 2. Recent works on SSCM.

Source (s)	Objective (s)	Applied tools
[20]	Analysing the recent significant increase in the number of publications exposes the contribution to the literature of SSCM and providing information on meta-heuristic methods used in SSCM.	Meta-heuristic algorithms
[41]	Providing the required models for minimizing the risk and disruptions and solving the complicated problems that occur in a supplier selection-order allocation scenario.	Interval type-2 Pythagorean fuzzy theory
[6]	Investigating some intriguing new ideas that could contribute new conceptual frameworks for SSCM and the circular economy (CE)	Systematic literature review
[55]	Recognizing the limit of fundamental understanding to facilitate further research and enable practical application of SSCM	Integrated 'systematic assessment'
[45]	Studying the MCDM techniques that are frequently used to examine the barriers, constraints, drivers, factors, parameters and practices of SSCM	Systematic literature review
(S. A. R.) [36]	Providing a comprehensive picture of the current advancements, new trends, and research needs in the area of SSCM.	Meta-analysis and systematic review
[50]	Integrating the three aspects of sustainability and how they affect SC performance becomes essential to investigate from an emerging economy viewpoint.	Systematic literature review

[15]	Validating the flexibility and applicability of Multitier Supply Chain (MTSC) and providing some recommendations for the practitioners to choose sustainable suppliers	Fuzzy SWARA, Bayesian Network

Identifying the chronological convergence of textiles and sustainability has been the goal of many researchers, who have tirelessly strived to include SSCM. Table 2 displays recent research on SSCM conducted by several researchers.

Table 2 shows that the field of SSCM has received significant attention from researchers. However, a thorough analysis of the significant barriers to SSCM adoption using Multi Criteria Decision Making (MCDM) methods has not yet been carried out focusing on emerging economies with the goal to achieve SDG goals. This study aims to fill the following research gaps in light of the earlier pertinent studies discussed in this section:'

1. SSCM has been the subject of several studies, but there haven't been many that focus on integrating the barriers to determine which ones should be prioritized.
2. The mutual links between the barriers, which appear to be lacking in the literature, are also crucial.
3. Another area for research is how the barriers will influence decisionmakers to formulate strategies for successfully integrating SSCM with conventional textile' manufacturing processes.
4. Although SSCM has been cited as one of the most important practices for the manufacturing sector, research that has looked at a wide range of affecting barriers preventing the adoption of SSCM while also supporting SDG targets are few and far between.

The application of MCDM tool like Fuzzy DEMATEL in the field of SSCM will only seem justified if the methodology is clearly stated which is presented in the later section.

3. Method

This study offers a methodical framework for identifying and assessing the barriers to the successful adoption of SSCM in emerging economies. Based on the literature, wise professional judgments, and the Pareto analysis, significant barriers were discovered and then further sorted. The interrelationship of the barriers was assessed using a fuzzy-based DEMATEL technique.

The integrated approaches of Pareto analysis and fuzzy DEMATEL were deployed in several studies such as analyzing SC vulnerability [51], healthcare management [17], formulating waste collection policies [52] and so on. This application to the sustainability of the SC sector is somewhat restricted, they may be seen as brand-new research areas for barrier analysis in the context of the textile business. Thus, to distinguish between driving barriers and driven barriers of SSCM, the authors choose to employ fuzzy DEMATEL. Both significant and insignificant barriers may be among those mentioned in the literature. Pareto analysis may be useful in identifying the important ones and eliminating the trivial ones. The chosen barriers still include those that directly impede the adoption of SSCM as well as those that are a result of earlier barriers, which are mostly to blame for the difficulty. These barriers are classified using the DEMATEL approach into cause-and-effect groups. Again, the fuzzy theory is used in conjunction with the DEMATEL approach to eliminate the uncertainty brought on by binary yes/no answers. As Fuzzy DEMATEL gives a two-way assessment for interactions as opposed to the conventional one-way technique, it is chosen because it provides both graphical and quantitative benefits for displaying the severity of the relationships and their relevance utilizing graph theories and matrix calculations. Fuzzy DEMATEL assesses the causal connections between barriers and dimensions that are constructed by expert judgments. The decision-makers are faced with a conundrum when dealing with several dynamic decision-making components since they need to be able to distinguish between causes and consequences [57]. Fuzzy DEMATEL categorizes barriers into categories and gives each group an equal weight. With the crucial knowledge, the important barriers may be more effectively concentrated, saving time and lowering operating costs. The most significant barriers to implementing SSCM were determined using Pareto analysis, which was then followed by a literature review and the collection of expert comments. Pareto analysis was chosen because it can distinguish between significant and unimportant drivers without the necessity for paired evaluation [31]. It seemed like there was no bias in the results because there was no comparable comparison. Later, fuzzy DEMATEL was used to represent the cause-and-effect diagram. The benefit of DEMATEL is that it can reveal the framework or structure of the intricate causal linkages among the systemic barriers and may demonstrate the degree to which each of the contributing components has an impact [65]. This opened the manager's options on how to raise SC efficiency and attain sustainability. Fuzzy systems integrated with DEMATEL allow decision-makers to quickly assess complicated circumstances (which are challenging to measure and often communicated through linguistic variables). The purpose of analyzing the interrelationship among barriers is to gain a better understanding of how each barrier influences the others. This analysis is important because when authorities aim to address the barriers to adopt SSCM, it can be challenging to tackle all of them simultaneously. Using a cause-and-effect diagram, they can identify the key barriers that have the greatest impact and prioritize their efforts accordingly.

3.1. Identifying the significant barriers by Pareto analysis

After examining the prior literature, the Pareto analysis has been used in this work to determine the main SSCM barriers in two phases. Through a series of organized questions, data is progressively gathered from a group of specialists and evaluated. This tool is widely used for complicated decision-making [48], the adoption of the circular economy in the construction sector [61], and environmental sustainability indicators in the manufacturing sector [22]. Experts used an initial question in Phase 1 to determine the most important barriers to SSCM in the context of the textile industry of an emerging economy. In step 2, the evaluators used a secondary questionnaire to assess the comprehensive links between these barriers. To identify and evaluate the barriers to achieving sustainability in their SC, 12 textile manufacturing companies were selected and subjected to a judgmental sampling approach [63]. The true names of these firms were substituted with symbolic names due to privacy concerns. 18 respondents were chosen for phase 1 using the purposive sampling approach [18]. Table 3 displays the expert profiles from textile manufacturing companies. After evaluating earlier research resources, a total of 16 barriers to SSCM were initially identified.

To choose the most pertinent SSCM barriers, the main questionnaire was emailed to the respondents. They were informed of the study's objectives and asked to offer input so that the validity of those SSCM barriers could be verified. They were given the option to add or remove any SSCM barriers. The barrier "Lack of enforcement and implementation of relevant laws" was introduced and no barriers were removed.

3.2. Fuzzy set theory

Lotfi A. Zadeh developed the fuzzy set theory [2]. The concept of fuzzy sets has seen several advancements in a variety of domains. Game theory [67], management information systems [42], artificial intelligence [54], multi criteria decision making [59] and other fields have all made extensive use of this theory. It can assess the quality of the judgments reached by people or specialists. In this study, a well-known and well-liked triangular fuzzy number (TFN) was considered. The conversion of fuzzy numbers into crisp values are a prerequisite for the application of fuzzy-based approaches (defuzzification). Several defuzzification methods, including CFCS (Converting fuzzy data into crisp scores), are cited in literary works. The CFCS approach was used in this investigation because, compared to other comparable procedures, it provides greater crisp values (Aicevarya

[16]).

3.3. Fuzzy DEMATEL method

The application procedures of the Fuzzy DEMATEL method are explicated as follows:

Step 1. Identify the barriers to work on.

Step 2. Select a group of specialists who will judge the criteria to ascertain the effect between barriers using pairwise comparison.

Step 3. Define the fuzzy linguistic scale for human evaluation. Singh et al. [52] suggested the linguistic variable "influence" is used with a five-level scale containing the following scale items in the group decision-making: No influence, very low influence, Low influence, High influence, and very high influence. These linguistic terms are valued with the triangular fuzzy number (TFN).

Step 4. Obtain an initial direct relation matrix with pairwise comparison [32]. Develop the initial fuzzy direct-relation matrix Z^k by having evaluators introduce the fuzzy pair-wise influence relationships between the components in a $n \times n$ matrix where k is the number of specialists. Accordingly, the direct-relation matrix is established as $Z^k = [z_{ij}^k]$ where Z is a $n \times n$ non-negative matrix; z_{ij} represents the direct impact of barrier i on barrier j; and, when $i = j$, the diagonal elements $z_{ij} = 0$.

For simplicity, denote Z^k as $z_{ij}^k = (l_{ij}, m_{ij}, n_{ij})$

$$Z^k = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} [0,0] & \otimes z_{12}^k & \cdots & \otimes z_{1n}^k \\ \otimes z_{21}^k & [0,0] & \cdots & \otimes z_{2n}^k \\ \vdots & \vdots & \vdots & \vdots \\ \otimes z_{n1}^k & \otimes z_{n2}^k & \cdots & [0,0] \end{bmatrix} \quad (1)$$

Step 5. Obtain the normalized fuzzy direct-relation matrix "D" using Expressions (2) related to the overall fuzzy direct-relation matrix Z.

$$\mathbf{D} = \frac{\mathbf{z^k}}{\underset{1 \le i \le n}{\mathbf{Max}} \sum_{j=1}^{n} \mathbf{z_{ij}}}; \; i, j = 1, 2, \ldots \ldots n \quad (2)$$

Step 6. Compute the total-relation matrix T using Expression (3), where n ×n identity matrix is represented with I. Upper and lower values are calculated separately.

$$T = D(I - D)^{-1} \quad (3)$$

Table 3. Background of experts.

Expert	Type of company	Working areas	Years of experience	Role
E1	Textile Company "A"	y Chain Management	l0 + years	ics manager
E2	Textile Company "B"	y Chain Management	10 +	or manager
E3	Textile Company "C"	ıess Administration	8 years	lanager
E4	Textile Company "D"	Production	12 years	ral Manager
E5	Textile Company "E "	uction Management	12 years	tion Manager
E6	Textile Company "F "	Procurement	14 years	or manager
E7	Textile Company "G"	ortation and Logistics	12 years	Chain Manager
E8	Textile Company "H"	ntory Management	20 years	ics manager

E9	Textile Company "I"	bution Management	12 years	:hain Manager
E10	Textile Company "J"	ntory Management	12 years	:hain Manager
E11	Textile Company "K"	Mechandising	12 years	chandiser
E12	Textile Company "L"	ations Management	15 years	erating Officer

Step 7. Determine row (r_i) and column (c_j) sums for each row i and column j from the T matrix, respectively, with following equations.

$$T = [t_{ij}]_{n\times m} \tag{4}$$

$$r_i = \sum_{1\le i\le n}^{n} t_{ij} \tag{5}$$

$$c_j = \sum_{1\le j\le n}^{n} t_{ij} \tag{6}$$

Step 8. The causal diagram is built with the horizontal axis $(\mathrm{r_i} + \mathrm{c_j})$ and the vertical axis $(\mathrm{r_i} - \mathrm{c_j})$. The horizontal axis "Prominence" refers to the importance degree of the barrier, whereas the vertical axis "Relation" show the extent of the influence. If the $(\mathrm{r_i} - \mathrm{c_j})$ axis is positive, the barrier is in the cause group. Otherwise, if the $(\mathrm{r_i} - \mathrm{c_j})$ axis is negative, the barrier is in the effect group. Causal diagrams can convert complex relationships of barriers into an easy-to-understand structural model, providing awareness for problem solving.

3.4. A real-life instance using specific circumstances

A knit composite textile company was chosen to examine the barriers and forecast the SC's resilience level as a means of validating the suggested technique. The name of the case company has been withheld out of respect for privacy. Five evaluators were chosen to examine the connections between the SSCM barriers using fuzzy DEMATEL for the case firm. 4–12 evaluators are acceptable for data collecting in fuzzy DEMATEL. Five evaluators were chosen for this study to make the calculation simpler. They were chosen based on their positions in the pertinent departments and work history. Table 4 displays the profiles of these five assessors.

3.5. Evaluation of the barriers

In this phase of the study, the fuzzy DEMATEL approach was used to evaluate the SSCM barriers of the selected textile company. Fuzzy DEMATEL approach was used for eleven barriers determined by Pareto analysis. Then, information was collected from five expert evaluators for Fuzzy DEMATEL using a secondary questionnaire.

The second half of this study presents the findings of using the above methods.

Table 4. Profile of the five evaluators.

valuator	Job Title	ience
aluator 1	luction Manager	ears
aluator 2	ly Chain Manager	ears
aluator 3	ly Chain Manager	ears
aluator 4	ly Chain Manager	ears

aluator 5	Operating Officer	ears

4. Results and Discussions

The investigation could only concentrate on the pertinent barriers after using the Pareto analysis to differentiate the relevant barriers from the irrelevant ones. It is based on the 80/20 rule, which states that only 20 % of causes lead to 80 % of results [49]. According to this theory, the remaining 80 % of barriers will not significantly affect how well SSCM is put into practice. As a result, the cut off point for choosing important barriers was set at 80 % of the cumulative proportion.

After filtering through 12 complete replies, the average priority ratings for the drivers were collated and calculated in cumulative percentages. Based on the percentage score, the main barriers to the effective use of SSCM in the textile sector in the context of a developing economy were highlighted for further inquiry. This study eliminated six unnecessary barriers while keeping the remaining thirteen significant ones.’ The canceled barriers were depicted as “Information gap (T2), Lack of training (T4), Lack of supplier with sustainable approach (T10), Market uncertainty (T13), Company’s policies & strategies (T14) and Resource efficiency (T16).

4.1. Evaluation of interrelationship of the barriers through fuzzy DEMATEL

The research results from using fuzzy DEMATEL have been mentioned in this part. The relative relevance of the SSCM barriers is shown by the $r_i + c_j$ ratings. As a result, in the ranking system, a greater indication barrier score denotes a higher priority. The prominent vector of the barriers derived from the fuzzy DEMATEL is shown in Table 5. "Insufficient financial incentives (T1)", "Lack of coordination and trust (T8)", "Lack of enforcement and implementation of relevant laws (T17)" are the top three SSCM barriers, according to the prominence vector, which was sorted based on $r_i + c_j$ scores. The last three barriers in the prominence ranking, "Lack of supplier’s top management commitment (T6)," "Lack of Eco literacy (T15)," and " Huge initial investment (T5)," all have a substantial effect on the adoption of SSCM.

The relation vector shown in Table 6 can be employed to identify the cause-and-effect connections between different SSCM barriers. The relationship features of the barriers are represented by the $r_i - c_j$ score. The cause group is represented by a positive $r_i - c_j$ score, whereas the effect group is represented by a negative $r_i - c_j$ score.’ "Global competition fac- tors (T12)", "Lack of supplier’s top management commitment (T6)", "Insufficient financial incentives (T1)", "Absence of favorable government regulations and standards (T7)" and "Huge initial investment (T5)" were classified into the cause category by the relation vector because they had positive $r_i - c_j$ ratings.

The results of this study show that Global competition factors (T12) have the highest correlation with the other established barriers, as shown in Figure 1. Because implementing sustainable practices may initially impair the profit margin, an effective SSCM implementation heavily depends on the state of the global market. Again, In-sufficient financial incentives (T1) and Lack of supplier’s top management commitment (T6)" are barriers that are strongly correlated with other barriers, while Lack of supplier’s awareness and advances in providing environment-friendly packages (T11) and Inadequate capacity of supplier (T9) are barriers that are least correlated with other barriers.

Table 5. Prominence vector of barriers of SSCM.

rriers	$i + cj$	nk
$T1$	6.36	1
$T8$	*6.12*	2
$T17$	5.72	3
$T7$	5.43	4
$T3$	5.32	5

$T12$	5.16	5
$T11$	4.9	7
$T9$	4.74	3
$T5$	4.57	9
$T15$	4.33	0
$T6$	3.9	1

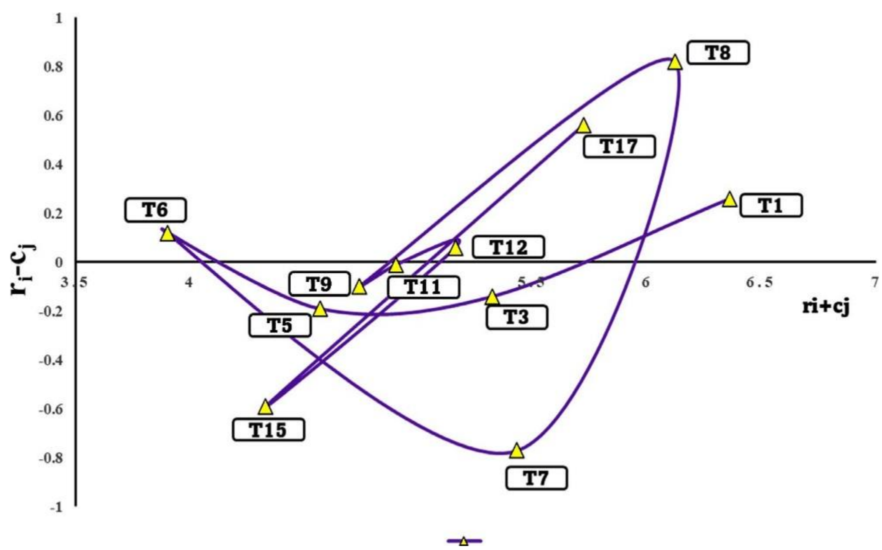

Figure 1. Cause and effect diagram of barriers of SSCM.

Table 6. Relation vector of barriers of SSCM.

Cause Group					
Rank	Cause Group	$r_i - c_i$	Rank	Effect Group	$r_i - c_i$
1	T12	0.82	1	T3	− 0.77
2	T6	0.56	2	T15	− 0.59
3	T1	0.26	3	T17	− 0.19
4	T7	0.12	4	T8	− 0.14
5	T5	0.06	5	T11	− 0.1
			6	T9	− 0.01

The effect category, however, contained “Lack of practice in reverse logistics (T3)”, “Lack of eco-literacy (T15)”, “Lack of enforcement and implementation of relevant laws (T17)”, “Lack of coordination and trust (T8)”, “Lack of supplier’s awareness and advances in providing environment-friendly packages (T11)” and “Inadequate capacity of supplier (T9)”. Other barriers have an impact on each of these six barriers.

The results of this study show that "Global competition factors (T12)" have the highest correlation with the other established barriers. Because implementing sustainable practices may initially impair the profit margin, an effective SSCM implementation heavily depends on the state of the global market. Again, "Insufficient financial incentives (T1)" and "Lack of supplier’s top management commitment (T6)" are barriers that are strongly correlated with other barriers, while "Lack of supplier’s awareness and advances in providing environment-friendly packages (T11)" and "Inadequate capacity of supplier (T9)" are barriers that are least correlated with other barriers.

In light of the real world, prior research, and the perspectives of experts, the aforementioned findings required justification which has been demonstrated in the discussion section.

We must eliminate the barriers we are up against to attain SSCM to get a reliable and sustainable market position. From the cause and effect diagram the most prominent barrier from the cause group was found to be “Global competition factors (T12)”. ‘Due to the fierce competition on the global market, Banik et al. [10] made the point that businesses must deliver goods as economically as possible to stay in operation. Ali et al. [5] also stressed that this increased global competitiveness will deter suppliers from pursuing sustainability, ultimately increase their processing costs, and put them at grave risk in the short term on the global market.’ “Lack of supplier’s top management commitment (T6)” was discovered to be the second most noticeable barrier from the cause group. ‘Ogunsanya et al. [43] stressed the need of top management support for the supplier’s commitment to sustainable manufacturing, consumption, and producing sustainable packages for delivery. Given the supplier’s senior management’s lack of commitment, it is challenging for the whole SC to achieve sustainability [23].’ “Insufficient financial incentives (T1)” was identified as the third-ranked barrier from the cause category. ‘The adoption of SSCM comes with significant initial investments that firms cannot afford on their own and require financial inducements from formal and informal entities [13]. Roy et al. [5] pointed out that businesses are discouraged from adopting SSCM because of the lack of financial incentives provided by the government, for instance, the adoption of sustainable manufacturing practices like using renewable energy sources and waste reduction. The final two barriers from the cause group were "Absence of favourable government regulations and standards (T7)" and "Huge initial investment (T5)". Banik et al. [10] highlighted a lack of supportive legislation and government regulations as the reason why the SC of the textiles industry has not yet achieved sustainability, while Kazancoglu et al. [33] focused on the enormous initial expenditure needed to adopt SSCM. These two barriers were also recognized by Grover et al. [25] and Liu et al. [39] in their respective studies while addressing concerns of SC to adopt sustainable practices.

The barriers in the cause group severely impact the six barriers in the effect category. The top spot in the effect group belonged to “Lack of practice in reverse logistics (T3)”. ‘Fierce competition in the global market, significant startup costs, and a lack of incentives from official and informal entities all contribute to this barrier. The high cost of adopting reverse logistics, lack of knowledge and expertise, a lack of supporting policies, and a dysfunctional organizational culture, according to Pourmehdi et al. [47], all contribute to the lack of practice in reverse logistics, which negatively affects SC performance.’ “Lack of eco-literacy (T15)” comes next, occupying the second spot. ‘According to Vishwakarma et al. [58] this barrier is impacted by the top management’s lack of commitment.’ "Lack of enforcement and implementation of relevant laws (T17)", which is influenced by a lack of appropriate governmental norms and regulations, is in third place. The execution of pertinent legislation will quicken company operations and assist to achieve higher efficiency of SC allowing it to migrate to SSCM. The next two barriers from the effect group are “Lack of coordination and trust (T8)” and “Lack of supplier’s awareness and advances in providing environment friendly packages (T11)”, which are impaired by the supplier’s top management’s lack of support. The significant initial investment required to increase the supplier’s capacity contributes to “Inadequate capacity of supplier (T9)”, the last barrier in the effect group. Suppliers enable companies to manage their collaborative relationships, identify potential risks, and make necessary changes to encourage flexibility in the SC.

4.2. Limitations and future scope

Even though this research offers fresh perspectives on the subject of SC sustainability, it is inescapably subject to constraints in terms of data collection and validation. The evaluation of the barriers to the successful implementation of SSCM was accomplished through qualitative methodologies, thus the research is not devoid of subjective bias. Although experts are chosen from a variety of professions, the population is still too small and undiversified to entirely eliminate misunderstandings. Such biases are projected to be overcome in further research efforts if grey theory-based methodologies are employed in the future. The presence of barriers in other economies will require more investigation. Again, this study identified 17 major barriers to SSCM, however this may not be an all-inclusive list. Future researchers might investigate numerous relevant activities in pertinent industries and discover additional appropriate barriers to generate a more comprehensive evaluation. However, as technology, governmental legislation, and administrative techniques advance, the list of significant barriers may vary. Consequently, the study would need to be repeated in around 10 years to confirm its validity and usefulness. Future research might concentrate on the cluster of barriers independently to build a more trustworthy and inclusive framework. Another significant issue with the fuzzy DEMATEL technique is that it becomes much more complicated and ineffective as the number of factors rises. If future studies need to deal with a greater variety of barriers, they should take more adaptable methodologies into account. Future research can also employ structured equation modelling with partial least square regression (PLS-SEM) or Fuzzy TISM-MICMAC to statistically confirm the relationships between the barriers.

The next part, which clarifies how this study will have an impact, presents the research's practical implications. The section on implications covers theoretical implications, implications for businesses, and sustainability.

4.3. Implications

The findings of this study have a wide variety of theoretical implications for the researchers. The study's main source of innovation is its capacity to demonstrate sustainability in traditional SC in the context of the textile sector of an emerging economy. This study is a structural attempt to develop an intelligent MCDM-based framework to find, rank, and reveal the connections between the barriers using the joint integration of Pareto analysis and fuzzy DEMATEL techniques. The analysis drew a cause-and-effect diagram for barriers and emphasized the crucial relationships between them. Businesses and policymakers may use the suggested approach to pinpoint the major barriers that may affect how well SSCM is implemented. If future research applies the suggested paradigm to this form of integration with other methodologies to assess the relevance of the barriers to successful SSCM integration, they may gain new insights. Again, the findings of this study may be applicable to countries with various economic conditions. Second, although receiving little investigation, our findings expand our knowledge of textile manufacturing and its connection to sustainability. Most importantly, this study contributes to the body of knowledge in identifying and evaluating the barriers that affect the implementation of SSCM in the context of the textile industry. The present study is one of the first attempts to investigate these barriers in the context of the region. Additionally, this study has given greater emphasis to changing the conventional methods for producing textiles and implementing sustainability. Finally, this study can work as a standard for the textile sector in emerging economies and assist businesspeople and industry professionals in understanding the theoretical foundations and taking the necessary steps to safeguard the global textile sector.

5. Conclusion

One of the biggest difficulties the textile industry facing today is achieving sustainability in the SC. However, to pinpoint the barriers to an effective SSCM implementation, a systematic framework is needed. This study presents an integrated approach (Pareto analysis and fuzzy DEMATEL) for evaluating the contextual relationships among the barriers and predicting the way to adopt SSCM. It is motivated by the limitations of prior research as well as the current unprecedented situation caused. We considered an integrated location-inventory model with stochastic demand and multiple customer priority classes. The investigation came to three main conclusions. 11 significant barriers to the implementation of SSCM were first discovered from the Pareto analysis. Second, Fuzzy DEMATEL was used in this work to ascertain the causal connections between the recognized barriers.' By examining the connections between the SSCM barriers and providing direction for achieving sustainability, this study adds to the body of knowledge already available on SC.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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