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ORIGINAL ARTICLE

Analysis of interaction between the barriers for the implementation of sustainable supply chain management

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Abstract In the contemporary marketplace, it is essential for industries to offer environmentally conscious, "green" products. Because industries are aware of demands from both customers and from government policies towards environmental products, Indian industries are particularly pressured regarding issues of environmental adoption. At this point, they presently have less detailed research on the effects of the adoption of environmental practices using traditional supply chain management (TSCM). One sector that is less aware of environmental initiation practices in the TSCM is the fastener manufacturing industry, but they are in a good position to adopt and to improve their environmental performance. Sustainable supply chain management (SSCM) is an important concept to improve environmental performance in TSCM and to provide a useful green image in industrial products. However, there are many barriers to the successful implementation of SSCM, and it should be noted that not all the barriers carry an equal impact. We need to identify the dominant factors required to adopt the SSCM concept, so that industries need to analyze the barriers and their impacts. The main aim of this paper is to determine the relationship between the barriers and to identify the most influential barriers from the recommended barrier list with the help of interpretive structural modeling. In this study, 13 barriers are considered from the extensive literature available. This study has been conducted in two fastener manufacturing industries that are located in the southern part of India.

Keywords Traditional supply chain management · Sustainable supply chain management · Barriers

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1 Introduction

Today's international business environment has challenged many organizations to concentrate on supply chain management to gain a competitive advantage [1]. In particular, research from recent years demonstrates that sustainable development in supply chain management is a challenging and tough task [2–10]. It is clear from the extensive literature in the last two decades that industrial managers have given special attention to sustainable supply chain management (SSCM) initiation [5–8]. The SSCM is being achieved in traditional supply chain management (TSCM) with the help of the "triple bottom line" concept, addressing economic, environmental, and social concerns [8, 11]. Carter and Rogers [4] define SSCM as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains." Guide and Wassenhove [12] observe that now, researchers are giving special attention to resource reduction, product reuse, and recycling in the SSCM. During the initiation of sustainability in TSCM, many factors (barriers) result in negative impacts. Herren and Hadley [13] mentioned that small–medium enterprises (SMEs) face several barriers for environmental initiatives in industries, so these industries should address the impact of each barrier during the implementation of SSCM in TSCM. The main aim of this paper is to determine the relationship between the barriers and to identify the most influential barriers for the implementation of SSCM from the recommended barrier list. The relationship and influence barriers have been identified using ISM approach. This study was conducted in two fastener manufacturing industries that are located in the southern part of India.

2 Literature review

2.1 Sustainable supply chain management

Policy makers have expressed interest in sustainability concerns from literature and surveys [14], and from journals in various technical fields [15]. In recent years, the SSCM field has garnered special attention because of the demands from government regulations and customer expectations, and the field has matured to the next level of analysis [4, 8, 16–18]. Carter and Rogers [4] mentioned sustainability is a concept to achieve long-term economic benefits through the integration of environmental, social, and economic criteria. Also, research propositions have been developed based on the resource dependence theory, transaction cost economics, and population ecology, all based upon a view of the industries.

Most commonly, researchers in the SSCM field focus on the following categories:

- Pressure/drivers to adopt sustainable practices
- Barriers for the adoption of SSCM in industries, and
- Performance analysis for SSCM

More recently, many researchers have determined that SSCM becomes an integrated approach for reducing environmental pollution [4, 19–21]. Sustainability is motivated by legislation, public interest, or competitive opportunity [15]. Integrated sustainability within the TSCM area is designed to increase core operations such as product design and manufacturing by-products. By-products may be produced not only during product use, but also through product life extension, product end-of-life issues, and through recovery processes at the end of life [15]. Forbes and Silva [22] report on the utilization of environmental management systems (EMS) amongst New Zealand wineries; they explore the environmental, social, and economic benefits gained through the implementation of one or more EMS's. Ravet [23] explored the relationship between sustainable development, global supply chain, and the lean paradigm in the changing, competitive international environment.

Seuring and Muller [24] provided extensive literature about the SSCM based on the 191 papers published over the period of 13 years from 1994 to 2007. It covers all the sustainable dimensions such as economic and environmental dimensions (140), economic and social dimensions (20), and all the three dimensions (31). Beske [25] analyzed the SSCM in the twofold complements of dynamic capabilities (DC) and SSCM research, and then developed a framework that integrates DCs in SSCM practices. Similarly, Majid et al. [26] framed the relationship structure between small- to medium-sized enterprises based on the entrepreneurial orientation of sustainable management perspectives. Seidel et al. [27] analyzed barriers and enablers for the implementation of SSCM practices in IT software solution provider companies. Faisal [9] presented an effective approach to adopt sustainable practices in supply chain management (SCM) by understanding the dynamics between various enablers that help to transform a supply chain into a truly sustainable entity.

2.2 Barriers for SSCM

TSCM is focused on balancing benefits among multiple stakeholders, to improve the operating efficiency throughout the facilities, and to maximize the profitability of processes and activities. SSCM takes a somewhat narrower approach by focusing on environmental concerns, social responsibilities, and economic gains as its top priorities [28]. Integrating the sustainability approach with TSCM is a complicated process [15, 29, 30]. As small to medium enterprises (SMEs) seek to become more environmentally sustainable, they encounter a variety of barriers that, when compared to the large corporate arena, are either insignificant or may be nonexistent [13]. Seuring and Muller [24] observed several barriers during maintaining the supplier relationship in the perspective of environmental consideration. Many of the researchers found that the role of the public is less in the development of sustainability [8, 31–33]. Similarly, three researchers found low "eco-literacy" and the lack of understanding or expertise about laws, environmental management, and best practices as barriers [13, 34, 35]. Vijfvinkel et al. [36] mentioned that lack of knowledge and information regarding the issue of sustainability encourages firms to retain the status quo; such inaction is an important barrier to engaging the SSCM, not to mention increasing the level of sustainability. Lack of sharing information creates more gaps to executing SSCM. Carter and Rogers [4], Preuss [8], and Bowen et al. [37] mentioned lack of motivation towards employees (incentives) as one of the barriers for implementing SSCM in industries. The incentives should be aimed at decreasing the barriers that SMEs face; such incentives can be split into three main categories: financial, ease of implementation, and recognition. Bohdanowicz et al. [38] suggests a range of issues that limit the supplier's ability to respond to the buyer's requirements for sustainability. Lack of willingness or ability to engage means that the opportunity is not always demoralized. Secondly, human barriers which include resistance to change, lack of qualified staff and training programs, lack of understanding, and the inability to plan are also considered significant barriers for implementing SSCM [38–40]. Seidel et al. [27] mentioned that IT companies often have a lack of support from middle management within the organization, and this lack of transparency creates a negative impact while seeking to implement the SSCM concept.

The most understandable barrier to environmental sustainable development of industries is the fact that many wasteful and polluting goods are relatively inexpensive in monetary terms because ecological costs are not incorporated in the price [35]. Reinhardt [41] argued that replication on sustainable activities enhances the probability of profitable exploitation. Language barriers and cultural differences are also major obstacles for adopting of SSCM. Shrivastava [42] insisted that adoption of SSCM is unprofitable in industries and it needs more cost. Revell et al. [43] mentioned the list of barriers for adopting SSCM: namely, lack of understanding, lack of tools and resources, resistance due to perceived time cost and resources required, and disbelief of the business benefits.

Seuring and Muller [24] pointed out that the barriers of SSCM include higher costs, coordination effort and complexity, and insufficient or missing communication in the SCM. Herren and Hadley [13] analyzed the barriers to implement environmental systems in SMEs in the Durham, North Carolina, area. Lack of clear direction from the organizational leaders, incentive systems that failed to reward sustainability initiatives, ambiguous information, and competing objectives from the central government are the important barriers for SSCM adoption [8].

2.3 Research gap

From the extensive literature, we observed that many researchers analyzed performance and enablers for the adoption of SSCM [9, 24, 44–48]. However, only a few researchers address the barriers of relationships for implementing SSCM [8, 35, 37, 38]. Currently, there is no research completed that seeks to identify the dominant barriers for adopting SSCM in Indian fastener manufacturing industries. The main objective of this research is to analyze barriers to establishing relationships and to identify the most influential barriers for implementing SSCM. This paper addresses the gap in identification of dominant barriers for implementing the SSCM by a two-phase research approach as follows. Phase 1 presents an initial survey to identify the barriers for the SSCM, and phase 2 identifies the leading barriers by ISM approach.

3 Problem description

The Indian market is vast and produces a wide variety of products, for example, automobiles, electronics, power plants, etc., and worldwide, top companies are interested in selling their products only in the Indian market. For assembling any component, fasteners are essential. Without fasteners, we cannot connect parts; fasteners are used to connect any two movable or immovable parts. In India, the fasteners (bolt and nut) manufacturing industries are growing day by day. Multinational companies (MNCs) often prefer to buy fasteners from outside because the cost of a fastener is minimal compared to the other main product(s). Thus, many MNCs prefer to purchase fasteners from Indian industries. However, these very MNCs are committed to maintaining environmental standards, and therefore, they expect their suppliers to be environmentally conscious and to have adopted SSCM. For these reasons, Indian fastener industries are getting pressure to adopt SSCM in their activities. Traditional supply chain management starts from the procurement of raw materials to deliver the finished product(s) to the customer (known as the forward supply chain). The collection of used products from the customer is also a part of SCM (and is known as reverse supply chain management). SSCM adds the condition of sustainability to traditional SCM.

The basic reasons for the analysis of barrier issues in SSCM are summarized as follows:

- Due to ineffective resource utilization and increasing industrial pollution, Indian industries are under pressure to improve their environmental performance by means of reducing wastage from industries and consumption of less energy in their organizations for making supply chains sustainable.
- Due to MNC customer requirement and government environmental regulations, Indian industries have started to adopt sustainability in their supply chain to retain their customers and maintain competitive advantage. But they are struggling to adopt SSCM in their industry because of obstacles (barriers).

Therefore, adopting sustainable concepts in traditional supply chain management is very difficult, and there are many obstacles to integrating environmental consciousness in traditional SCM. One serious issue in Indian industries is environmental contamination. The fastener manufacturing industries have started to adopt sustainable concepts in their SCM in order to retain their customers. This study is helpful for industries to analyze the barriers for SSCM and to find the key barriers; industries will also be able to improve their sustainable performance by identifying the leading or dominant barriers for adopting sustainable supply chain management. It is difficult for industries to eradicate all the barriers in the initial stage of adopting sustainable concepts in traditional SCM. This research has been carried out in leading fastener manufacturing industries which are located in Tamilnadu, South India. This industry produces numerous sizes of bolts, nuts, washers, etc., and serves more than 16 automobile, electronic, and power plant companies. The following 13 barriers are listed below.

1. Too high cost for disposal of hazardous wastes (B1)
2. Cost for environmentally friendly packaging (B2)
3. Lack of clarity regarding sustainability (B3)
4. Cost of sustainability and economic conditions (B4)

5. Lack of sustainability standards and appropriate regulations (B5)
6. Misalignment of short-term and long-term strategic goals (B6)
7. Lack of effective evaluation measures about sustainability (B7)
8. Lack of training and education about sustainability (B8)
9. Complex in design to reduce consumption of resources and energy (B9)
10. Inadequate facility for adoptions of reverse logistic practices (B10)
11. Lack of IT implementation (B11)
12. Inadequate industrial self-regulation (B12)
13. Lack of top management commitment to initiate sustainability efforts (B13)

Sources [4, 8, 13, 31–35, 37, 38]

4 Solution methodology

The interpretive structural modeling (ISM) methodology is used to find the dominant barriers for implementing SSCM in the fastener industry in the southern part of India.

4.1 Interpretive structural modeling

The ISM technique is a well-known methodology for identifying and summarizing relationships between specific elements [49, 50]; this methodology allows an interactive learning practice and helps to understand the complex relationships among variables of systems [51, 52]. The ISM approach is proposed as a group of learning processes; in addition, it can be used individually [53]. The model frames the structure of complex issues using graphics as well as words [54, 55]. Ravi and Shankar [56] found interaction between the barriers of reverse logistics with the help of ISM. Faisal et al. [9] analyzed risk mitigation of supply chain in Indian manufacturing SMEs with the help of ISM. Ravi et al. [57] identified key variables in reverse logistic with the help of ISM, which improves the productivity and performance of the computer hardware supply chain. Kannan and Haq [58] also used the ISM approach to identify the interaction between attributes and sub-attributes of the vendor selection problem.

The various steps involved in the ISM methodology are described as follows, modified from: Kannan et al. [59]:

Step 1: Barriers (criteria) considered for the system under consideration are listed.

Step 2: From the barriers identified in step 1, a contextual relationship is established among the barriers in order to identify which pairs of barriers should be examined.

Step 3: A structural self-interaction matrix (SSIM) is developed for barriers, which indicates pairwise relationships among the barriers of the system under consideration.

Step 4: The reachability matrix is developed from the SSIM, and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a barrier A is related to B and B is related to C, then A is necessarily related to C.

Step 5: The reachability matrix obtained in step 4 is partitioned into different levels.

Step 6: Based on the relationships in the above given reachability matrix, a directed graph is drawn and the transitive links are removed.

Step 7: The resultant digraph is converted into an ISM, by replacing variable nodes with statements.

Step 8: The ISM model developed in step 7 is reviewed to check for conceptual inconsistency, and necessary modifications are made. The above steps are shown in Fig. 1.

4.2 Questionnaire development

To analyze the barriers for the adoption of SSCM in the fastener industry, 13 barriers are considered from extensive literature. Initially, seven fastener manufacturing industries are approached by mail, phone, and direct visit to explain the SSCM concept and the main objective of this research.

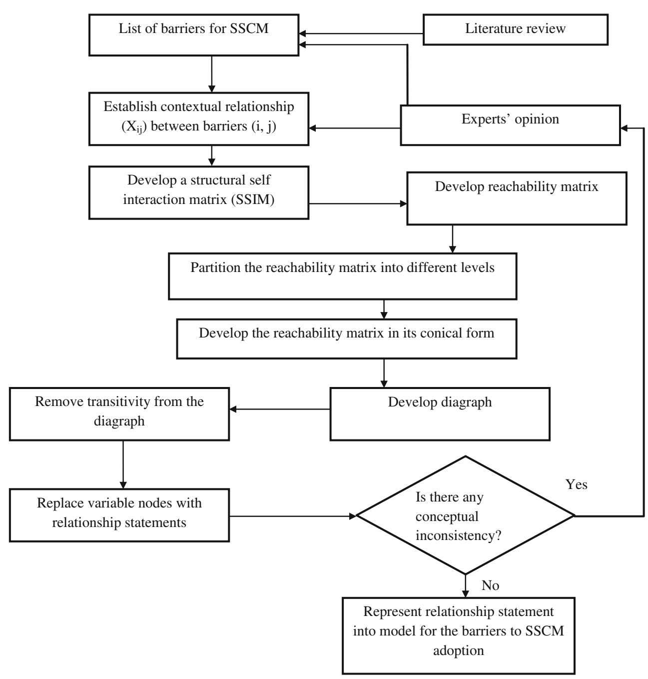

Fig. 1 Flow diagram for preparing the ISM model for barriers (modified from Kannan et al. [59] and Kannan and Haq [58])

After having a discussion with the industrial experts, only two of the seven express interest in research. This study is targeted at executive and manager levels in each industry. More than two individual responses have been received from each industry, and two responses are consolidated that have been sent to an expert of each industry who is asked to give one final response. After receiving five responses, only one response is being taken based on experts' discussion.

4.3 Data collection

Commonly, the ISM technique suggests the use of the expert opinions based on various management techniques such as brainstorming, nominal technique, etc., in developing the contextual relationship among the variables [53]. Hence, in this study for identifying the contextual relationship among the barriers for SSCM adoption, two experts, one from the two fastener component manufacturing industries in Tamilnadu and one from the academia, are consulted. For analyzing the barriers, a contextual relationship of "leads to" type is chosen. This means that one variable leads to another variable. Based on this principle, a contextual relationship between the variables is developed.

4.4 Structural self-interaction matrix

Kannan et al. [60] stated that various management techniques such as brainstorming nominal technique, etc., are used to develop the contextual relationship among the variables in the ISM based on the experts' opinion. Discussions with experts from the industries helped to identify the relationships among the dominant barriers from the recommended barriers. It should be kept in mind that the contextual relationship of each variable between any two barriers (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the barriers (i and j):

V: Barrier i will help to achieve barrier j;
A: Barrier j will help to achieve barrier i;
X: Barrier i and barrier j will help to achieve each other; and
O: Barrier i and barrier j are unrelated. The SSIM matrix is summarized in Table 1.

Table 1 Structural self-interaction matrix

Barriers	13	12	11	10	9	8	7	6	5	4	3	2
1	V	O	V	X	V	X	V	O	A	A	V	V
2	O	O	V	V	V	X	V	X	V	A	V	
3	V	O	X	A	O	X	V	V	V	A		
4	V	V	V	O	X	X	V	V	A			
5	A	A	A	V	A	O	V	X				
6	V	A	O	A	X	V	V					
7	O	O	O	V	V	A						
8	V	V	V	V	V							
9	V	X	V	O								
10	V	V	A									
11	V	O										
12	V											

4.5 Initial reachability matrix

In this step, the SSIM matrix is transformed into a binary matrix, called the initial reachability matrix. The SSIM format is initially converted into an initial reachability matrix format by transforming the information of each cell of SSIM into binary digits (i.e., ones or zeros) in the initial reachability matrix; the rules for the substitution of 1 and 0 are as follows [50, 59, 61]:

- If the entry in the cell (i, j) in the SSIM is V, then the cell (i, j) entry becomes 1 and the cell (j, i) entry becomes 0 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is A, then the cell (i, j) entry becomes 0 and the cell (j, i) entry becomes 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is X, then the entries in both the cells (i, j) and (j, i) become 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is O, then the entries in both the cells (i, j) and (j, i) become 0 in the initial reachability matrix. Following these rules, the initial reachability matrix is as given in Table 2.

Table 2 Initial reachability matrix

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	1	1	0	0	0	1	1	1	1	1	0	1
2	0	1	1	0	1	1	1	1	1	1	1	0	0
3	0	0	1	0	1	1	1	1	0	0	1	0	1
4	1	1	1	1	0	1	1	1	1	0	1	1	1
5	1	0	0	1	1	1	1	0	0	1	0	0	0
6	0	1	0	0	1	1	1	1	1	0	0	0	1
7	0	0	0	0	0	0	1	0	1	1	0	0	0
8	1	1	1	1	0	0	1	1	1	1	1	1	1
9	0	0	0	1	1	1	0	0	1	0	1	1	1
10	1	0	1	0	0	1	0	0	0	1	0	1	1
11	0	0	1	0	1	0	0	0	0	1	1	0	1
12	0	0	0	0	1	1	0	0	1	0	0	1	1
13	0	0	0	0	1	0	0	0	0	0	0	0	1

Table 3 Final reachability matrix

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	0	1	1	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	0	1	1	1	1	1	1	1	1	1
11	1	0	1	1	1	1	1	1	0	1	1	1	1
12	1	1	0	1	1	1	1	1	1	1	1	1	1
13	1	0	0	1	1	1	1	0	0	1	0	0	1

4.6 Final reachability matrix

The final reachability matrix for the attributes is obtained by incorporating the transitivity based on step 5. It is a basic assumption made in ISM. It states that if barrier 1 is related to 2, and barrier 2 is related to 3, then criterion 1 is necessarily related to 3 [53]. The final reachability matrix is given in Table 3.

4.7 Level partition

The fifth step involves extracting of a hierarchical ordering from the reachability matrix by level partitioning [62]. The reason for this step is to make easy construction of the digraph from the reachability matrix [62]. From the final reachability matrix, the reachability and antecedent sets for each barrier are established [53]. The level partition of this study is illustrated in Table 4.

4.8 ISM model

The ISM structural model is drawn from the final reachability matrix [53]. If the relationship exists between barriers j and i, an arrow pointing from i to j shows this. This graph result is called a digraph. The digraph is converted into an ISM model by replacing nodes of the elements. The ISM model structure is illustrated in Fig. 2. In this ISM model, all the 13 barriers are summarized in three levels. In the top level, six barriers appear, in the middle level four, and in the final level three barriers are found.

4.9 MICMAC analysis

The objective of the Matriced Impacts "croises-multipication applique" and classment (MICMAC) analysis is to analyze the driving power and the dependence power of the barriers. Based on this study, the barriers are classified into four clusters—autonomous, dependent, linkage, and driver/independent—and are given below:

1. Autonomous barriers: In this quadrant, barriers have weak driving power and weak dependence. They are relatively disconnected from the system, with which they have a few links, which may be very strong. These barriers are represented in quadrant I.
2. Dependent barriers: This category includes those barriers which have weak driving power but strong dependence power and placed in quadrant II.
3. Linkage barriers: In this quadrant, barriers have strong driving power as well as strong dependence and are placed in quadrant III. They are also unstable, so any

Table 4 Level partition

Barrier	Reachability set	Antecedent set	Intersection set	Iteration no. and level
1	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	I
5	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	I
6	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	I
7	1 3 4 5 6 7 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 3 4 5 6 7 9 10 11 12 13	I
10	1 2 3 5 6 7 8 9 10 11 12 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 2 3 5 6 7 8 9 10 11 12 13	I
13	1 4 5 6 7 10 13	1 2 3 4 5 6 7 8 9 10 11 12 13	1 4 5 6 7 10 13	I
4	2 3 4 8 9 11 12	1 2 3 4 5 6 7 8 9 11 12 13	2 3 4 8 9 11 12	II
8	2 3 4 8 9 11 12	1 2 3 4 5 6 8 9 10 11 12	2 3 4 8 9 11 12	II
11	3 4 8 11 12	1 2 3 4 5 6 7 8 9 10 11 12	3 4 8 11 12	II
12	2 4 8 9 11 12	1 2 3 4 5 6 7 8 9 10 11 12	2 4 8 9 11 12	II
2	2 3 9	1 2 3 4 5 6 8 9 10 12	2 3 9	III
3	2 3 9	1 2 3 4 5 6 7 8 9 10 11	2 3 9	III
9	2 3 9	1 2 3 4 5 6 7 8 9 10 12	2 3 9	III

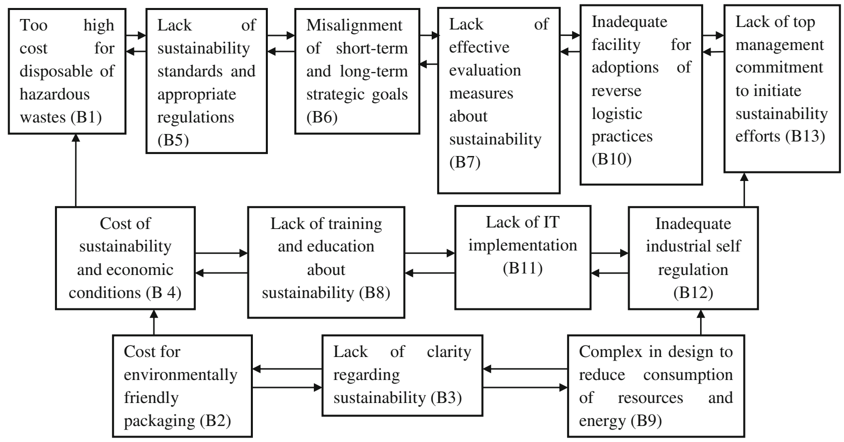

Fig. 2 ISM formation for barriers of SSCM

action on them will have an effect on the others and will feedback on themselves.

4. Independent barriers: In this quadrant, barriers have strong driving power but weak dependence power. These are represented in quadrant IV.

It is observed that a variable with a very strong driving power, called a key barrier, falls into the category of independent or linkage criteria. The driving power and dependence power of each of these barriers are shown in Table 5. More details of the full ISM model for barriers are given in Fig. 2.

The diagram of driving power vs. dependence power for the barriers is constructed as shown in Fig. 3. As an illustration, it is observed from Fig. 3 that there are no barriers in quadrant I, quadrant II, or quadrant IV. All the barriers appear in quadrant III based on their driving and dependence power.

5 Results and discussion

Generally, sustainable development is an important subject for researchers and practitioners. Environmental management and operations are stimulated from local optimization of environmental factors to consideration of the entire supply chain during the production, consumption, customer service, and postdisposal disposition of products [15]. In Indian industries, it is challenging to implement SSCM both at the executive engineers and managerial levels. However, the initiation of SSCM is not an easy process and it needs much analysis. The results of this study show that Indian industrial managers have started to adopt sustainability concerns in TSCM. But they are only in the initial stage and still have to eradicate barriers one by one. The driving and dependence power diagram illustrates the 13 barriers' positions in the four quadrants. This study of barrier analysis with the ISM approach results in the following interpretations.

Table 5 Dependence power and driving power

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	Driving power
1	1	1	1	1	1	1	1	1	1	1	1	1	1	13
2	1	1	1	1	1	1	1	1	1	1	1	1	1	13
3	1	1	1	1	1	1	1	1	1	1	1	1	1	13
4	1	1	1	1	1	1	1	1	1	1	1	1	1	13
5	1	1	1	1	1	1	1	1	1	1	1	1	1	13
6	1	1	1	1	1	1	1	1	1	1	1	1	1	13
7	1	0	1	1	1	1	1	0	1	1	1	1	1	11
8	1	1	1	1	1	1	1	1	1	1	1	1	1	13
9	1	1	1	1	1	1	1	1	1	1	1	1	1	13
10	1	1	1	0	1	1	1	1	1	1	1	1	1	12
11	1	0	1	1	1	1	1	1	0	1	1	1	1	11
12	1	1	0	1	1	1	1	1	1	1	1	1	1	12
13	1	0	0	1	1	1	1	0	0	1	0	0	1	7
Dependence power	13	10	11	12	13	13	13	11	11	13	12	12	13	

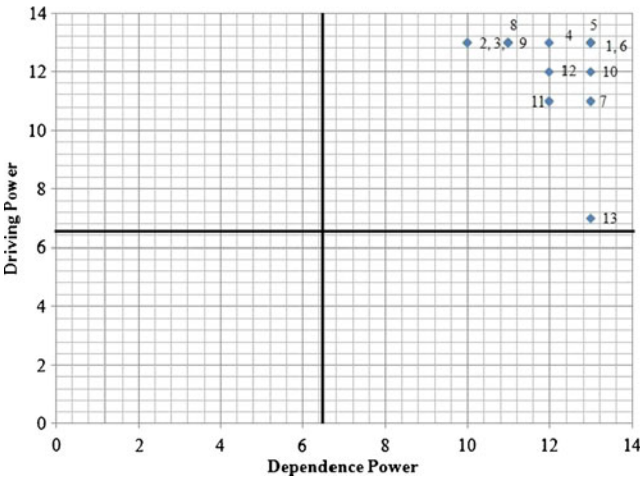

Fig. 3 Driving and dependence power diagram

- In quadrant I (autonomous barriers), no barriers appear. Generally, autonomous barriers are weak drivers and weak dependents and they do not have much influence. It shows that among the 13 barriers, all the barriers have good driving and dependence power. Also, it clearly states that all the barriers are given more obstacles during the adoption of SSCM in fastener manufacturing industries.
- Similarly, in quadrant II, there are also no barriers. This quadrant is called dependent quadrant, and it has low driving power and high dependence power.
- All the barriers appear in quadrant III. Barriers in this quadrant have strong driving and strong dependence power. These barriers are unstable. Any action on these variables will have an effect on the others and will also provide feedback. They may disturb the whole system [53, 59, 61]. A lack of management commitment to initiate the sustainability (B13) barrier has less driving power and high dependence power (7, 13). It shows that top management exhibits less awareness with respect to environmental initiatives; they have given much less attention to adopting environmental practices [63]. Many researchers found that lack of management commitment is a common barrier in all kinds of industries [64]. The lack of IT implementation (B11) has 12 driving powers and 11 dependence powers. Generally, the adoption of sustainability practices in the IT industry requires more funds and technology. The next barrier is lack of effective evaluation measures regarding sustainability (B7). It has 11 driving powers and 13 dependence powers. In industries, inefficient measurement systems are one of the most important barriers for poor environmental performance. Cetinkaya [63] pointed out lack of knowledge regarding the measurement and the assessment of environmental and social impact is an important obstacle for implementing SSCM.
- Inadequate facility for the adoption of reverse logistic practices (B10) occurs because of inefficient technologies and inefficient employees in the industries. This barrier has greater driving power when compared to B11, B7, and B13 barriers. The next barrier of this quadrant is inadequate industrial self-regulation (B12). The fastener industry is a small-scale industry, and it depends on multinational companies. It is understandable they are very lax in self regulations regarding environmental perspective. B12 obtained 12 driving and 12 dependence powers. The cost for environmentally friendly packaging (B2) is the next barrier and it has high driving power (13) and less dependence power (10). After manufacturing, packing the products in an environmentally friendly way requires additional cost. SMEs are less focused on environmentally friendly packaging. In Fig. 3, three barriers demonstrate the same driving and dependence power (13, 11): namely, the lack of clarity regarding sustainability (B3), the lack of training and education about sustainability (B8), and the complex design to reduce consumption of resources and energy (B9). Many industries do not have clear notions about sustainability goals and benefits. It is also one of the reasons that industries fail to adopt SSCM practices and why their employees do not demonstrate environmental awareness. Lack of top management commitment is one of the reasons for inefficient training of their employees. Due to less availability of resources, industries must design production processes with less consumption, but due to the lack of technology, it is difficult to achieve. Cost of sustainability and economic conditions (B4) is one of the barriers for adopting SSCM. It has 12 dependence powers and 13 driving powers. Herren and Hadley [13] found that financial cost is the main barrier, followed by a lack of time to devote to such measures, and a lack of knowledge regarding the kind of actions that can be undertaken. Finally, three barriers exhibit high driving and dependence power (13, 13), including the lack of sustainability standards and appropriate regulations (B5), too much cost for the disposal of hazardous wastes (B1), and the misalignment of short-term and long-term strategic goals (B6).
- In quadrant IV, no barriers appear. Of the 13 barriers, none has an independent character. This shows that all the barriers are dependent in fastener industries for the adoption of SSCM.

6 Conclusion

Academic and business societies are clearly interested in adopting sustainable management practices in traditional

SCM because of the tremendous business benefits [24]. While pressures come from many directions, industries are nonetheless motivated to adopt SSCM practices. From the literature review and during the survey visits in Indian industries, we observed that these industries face many barriers such as the lack of governing policies, too many agencies for SMEs, inadequate data and information for development of SMEs, and suppliers lacking the necessary environmental systems to adopt within their industries. Once they start implementing such practices, many barriers will still occur. It is necessary to investigate the impact of the barriers and the relationship between the barriers during the implementation of SSCM. Another useful approach would be to find the dominant barriers in the adoption of SSCM. Generally, the eradication of barriers is not easy and it needs further analysis. It is not possible to eradicate all kinds of barriers simultaneously. Hence, industries need to determine the most influential barrier. This study summarizes the barrier analysis and identifies several influential barriers with the help of ISM approach.

The ISM model diagram (Fig. 3) shows the interaction among the barriers. Six barriers appear in the top level, as follows: too much of cost for disposing hazardous wastes (B1), lack of sustainability standards and appropriate regulations (B5), misalignment of short-term and long-term strategic goals (B6), lack of effective evaluation measures about sustainability (B7), inadequate facility for adoptions of reverse logistic practices (B10), and lack of top management commitment to initiate sustainability practices (B13). These barriers are less dominant for the adoption of SSCM in fastener manufacturing industries. In the middle level, four barriers appear: inadequate industrial self-regulation (B12), lack of IT implementation (B11), lack of training and education about sustainability (B8), and cost of sustainability and economic conditions (B4). When compared to the top-level barriers, the four middle-level barriers create much impact (obstacles) on adoption. Industries need to give attention to these four barriers. Finally, the three barriers that occur in the bottom level act as dominant roles for implementing SSCM, including complex design to reduce consumption of resources and energy (B9), cost for environmentally friendly packaging (B2), and lack of clarity regarding sustainability (B3). The ISM results which identify the leading barriers in the fastener industries clearly help to simplify the process for adoption of SSCM. It improves the environmental performance and creates more green consciousness among the industries. In this study, the three enablers, namely cost for environmentally friendly packaging (B2), complex design to reduce consumption of resources and energy (B9), lack of clarity regarding sustainability (B3), demonstrate a more negative impact towards environmental development issues. However, industries are needed to give special attention to these barriers during their eradication, even in the initial stage. Without eradication of these barriers, fastener manufacturing industries will find it difficult to move to the next step for adopting SSCM practices.

As summarized above, this research helps to identify the principal barriers for the adoption of SSCM. This paper provides a solid framework for analyzing the barriers of SSCM adoption in the fastener manufacturing industries, which must have a degree of accountability when it comes to environmental consciousness. Since this study has been conducted only in two fastener manufacturing industries, involving more industries might give more insights into our barrier analysis. More sectors can also be considered for similar analysis. Only 13 barriers were considered in this research, although in reality additional barriers exist. This study identifies the most dominant barriers and makes no attempt to rank the barriers in any order. Such rankings can be implemented in future research. However, the ISM methodology utilized here does not provide the only valid model. Structural equation modeling is a good technique to validate the ISM model in future studies.

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