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Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process

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ABSTRACT

Manufacturing industries started adopting the green concept in their supply chain management recently to focus on environmental issues. But, industries still struggle to identify barriers hindering green supply chain management implementation. This work focuses on identifying barriers to the implementation of a green supply chain management (Green SCM) based on procurement effectiveness. A total of 47 barriers were identified, both through detailed literature and discussion with industrial experts and through a questionnaire-based survey from various industrial sectors. Essential barriers/priorities are identified through recourse to analytic hierarchy process. Finally, a sensitivity analysis investigates priority ranking stability.

1. Introduction

Supply chain management plays a vital role in the improvement and implementation of a firm's competitive advantage. Literature offers many studies and related evidence revealing the benefits of environmental initiatives for businesses (Mudgal et al., 2009, 2010; Sarkis et al., 2011; Perron, 2005; Shipeng, 2011; Kannan et al., 2008; Carter and Rogers, 2008; Hsu and Hu, 2008). The identification of benefits for environmental initiatives and performance by businesses is important for dissemination of such initiatives in Small and Medium Enterprises (SMEs) and large enterprises (Perron, 2005). Jung (2011) defined Green supply chain (GSC) as one of the "main efforts aiming to integrate environmental parameters (or requirements) with supply chain management systems." Most supply chain management innovations in the 20th century aimed to reduce waste for economic rather than environmental reasons, and it was not until the turn of the 21st century that the term *green*, with reference to protecting the environment, gained widespread use and recognition (Zhang et al., 2009). Recent studies mention that in the next couple of decades, most manufacturers will face environmental issues in Asia (Zhu et al., 2005; Shipeng., 2011; Jui and Ming-Lang Tseng, 2011; Diabat and Govindan, 2011; Zhu et al., 2012). Most Indian industries will have to develop supply chains from an environmental sustainability point of view by modifying traditional SCM to GSCM through initiation of green procurement strategies (Mudgal et al., 2010). Procurement/purchasing decisions will affect green supply chains through the purchase of materials which are either recyclable/reusable or have already been recycled (Sarkis, 2003; Chien and Shih, 2007). During adoption of GSCM in traditional SCM, some hurdles can be anticipated due to the expected transition. These hurdles are called barriers and industries must equip themselves to remove them. However, it will be impossible to eradicate all barriers simultaneously. Hence, industries should identify those barriers which have essentially to be removed in the initial stages of GSCM adoption. This paper has, as its goal, the identification of such essential barriers so that they might be eradicated during GSCM implementation in industries through the Analytical Hierarchy Process (AHP). This study was undertaken in various industries in South India. The results might also impact environmental adoption ensuring easier eradication of essential barriers. It can also be extended to all industries in India. The resulting discussions and conclusions are achieved from an extensive survey, site visits, and interviews.

2. Literature review

This section discusses in detail literature related to the GSCM concept and barriers related to its implementation.

2.1. GSCM

GSCM, a cross-disciplinary field, has been growing in recent years with increasing interest from both academia and industry (Sarkis et al., 2011). Environmental issues like local, regional, and

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global implications of air emissions, solid waste disposal, and natural resource usage have to be monitored and managed during these growth phases (Zhu et al., 2007). Increasing environmental consciousness and commitment of businesses, governments, groups and individuals have all inspired development of procurement and purchasing policies that incorporate environmental requirements, thereby proving their collective bargaining and buying power (Massoud et al., 2010; Kannan et al., 2010). GSCM is a tremendous concept to instill environmental thinking in traditional Supply Chain Management (Zhu et al., 2012). GSCM cuts across varied boundaries (business activities integrating sourcing, making, and delivery processes) of supply chain management (Min and Kim, 2012). Environmental or green purchasing or procurement can be referred to as the integration of environmental considerations into purchasing policies, programs and actions to reduce waste and to help achieve a GSCM (Russel, 1998; Varnäs et al., 2009).

GSCM considers emphasizing environmental issues in supply chain management, in both upstream and downstream business enterprises (Shipeng., 2011). Zhu et al. (2012) argued that "GSCM is still relatively novel (innovative) for most organizations in many industries (Lin and Ho, 2008) and countries (Seuring and Müller, 2008; Seuring et al., 2008)".

2.2. GSCM implementation: barriers

Research on GSCM usually focuses on aspects such as green purchasing, internal environmental operations management, or green logistics, as against taking an integrative, whole supply chain approach. Many authors suggest that green supply chain research should move from subjective studies towards an experimental and theory grounded approach (Gavaghan et al., 1998; Beamon, 1999; Carter and Carter, 1998; Zsidisin and Siferd, 2001). Barriers to GSCM implementation in SMEs are different from those of larger enterprises in many ways including: generation of less environmental data; fewer resources (less environmental expertise/experience, technical, financial, time), environmental performance being driven by personal views of business owners; no common access points and differences in organizational structure (Environment Canada, 2003).

Recent years have witnessed a growing interest in examining special challenges that hinder SMEs from taking up GSCM (Wooi and Zailani, 2010). Many studies confirm that adoption of GSCM in SMEs is unhurried (Mudgal et al., 2010; Sarkis et al., 2011; Perron, 2005; Shipeng., 2011; Kannan et al., 2008). Carter and Rogers (2008) mention that organizations fail to adopt environmental initiatives due to internal factors including sunk costs, improper communication structures, internal politics, and institutional norms. Hillary (2004) has classified internal and external barriers to implementation of environmental initiatives in SMEs. Kogg (2003) pointed out that lack of influence is an important barrier to implementing GSCM practices in industries. Similarly, Luken and Stares (2005) found significant road blocks among small and medium enterprise suppliers to provide green material. Then, Porter and Kramer (2006) mentioned that sometimes green products customers might switch over to other normal products, resulting in a negative motivation for new firms to engage in GSCM practices. Later, in 2009 Thun and Muller investigated the status quo of GSCM implementation in the German automotive industry from a practitioner's point of view. They also analyzed other perspectives including time of implementation, driving forces, relevance of intended goals, their specific realization and adoption of eco-programs with suppliers/customers, and also internal and external barriers. In addition, Zhu et al. (2010) pointed out that lack of external cooperation and diffusion are proven obstacles to GSCM's operational performance. Even with so many barriers against GSCM implementation, recent years have witnessed large changes in Indian SME's. Taking this further, Indian SME's have started manufacturing/ supplying products to multinational companies (MNC) (Diabat and Govindan, 2011).

2.3. Research gap

It is evident from literature that both academicians and practitioners are fully aware and are interested in analyzing barriers to GSCM adoption (Zhu and Sarkis, 2006; Walker et al., 2008; Diabat and Govindan, 2011). Min and Kim (2012) reviewed 519 articles on GSCM published between 1995 and December 31, 2010. Of these 519 articles, only a few were from developing countries, and specifically from an Indian context. Some Indian GSCM studies are summarized here. Mudgal et al. (2010) investigated and ranked barriers against GSCM adoption based on an exhaustive questionnaire from more than 100 industries in different sectors by using interpretative structural modeling (ISM). However, increasing an issue's or a problem's variables number makes ISM methodology more complex, so only a limited number of variables in the development of ISM model are considered. Another consideration is that ISM does not provide quantification for each factor's influence on greening supply chains (Mudgal et al., 2010). Luthra et al. (2011) analyzed important barriers to GSCM adoption from an Indian perspective and identified contextual relationships among 11 barriers helped by ISM. Toke et al. (2012) ranked interactions and evaluated critical success factors for GSCM adoption in the Indian manufacturing sector through an analytical hierarchy approach. Mathiyazhagan et al., (2013) analyzed the relationship between 26 barriers and identified the most influential in GSCM adoption in the automobile industry aided by ISM in the Indian perspective. Similarly, Muduli et al. (2013) analyzed factors and sub-factors for GSCM adoption in the Indian mining industry helped by graph theoretic and matrix approach (GTMA).

Diabat and Govindan (2011) analyzed drivers for GSCM implementation in the Indian perspective through a case study involving a manufacturing firm in south India. To date, only a few research studies have attempted to analyze barriers to GSCM implementation from an Indian industry perspective (Luthra et al., 2011; Mudgal et al., 2010). Most studies dealt with a limited number of barriers. In addition, researchers have not undertaken the analysis with different industrial perspectives from the Indian context. These research gaps helped to determine why this problem was chosen. Clearly, there is little work on the analysis and identification of important barriers to GSCM implementation in an Indian scenario.

There is also no work on the identification of essential barriers which need to be removed for GSCM adoption. Similar studies were conducted on industries in China and Malaysia (Wooi and Zailani, 2010; Zhu et al., 2007), but different industries have different opinions about GSCM adoption (Zhu and Sarkis, 2006). Furthermore, different countries will obviously have varied opinions about the pressures or barriers against GSCM implementation; every country has its own environmental policies and environmental regulations (Mathiyazhagan et al., In press). Regulations and policies vary depending on the people, culture, and the politics of that country. Similarly, Indian industries also have different opinions about barriers against GSCM adoption (Luthra et al., 2011; Diabat and Govindan, 2011; Mudgal et al., 2010). Mudgal et al. (2010) and Mathiyazhagan et al. (In press) found that various automotive industries had differing judgments about barriers to GSCM adoption. Hence, it is clear that globally, not all industries share similar opinions, so this study is essential. A literature gap exists in the identification of essential barriers against GSCM implementation. This paper addresses this gap through a two-phased research approach which includes Phase

1: Initial survey to identify common barriers, and Phase 2: Identification of essential barriers by the AHP approach.

3. Problem description

Applying green procurement preferences to promote environmental initiatives is encouraged by governments in many countries (Varnäs et al., 2009). While GSCM issues are currently highly relevant for export industries, this issue is expected to influence the whole Indian industry in a significant way. Industries should consider green issues as green/eco-products can provide them with great marketing advantages and a good corporate image (Mudgal et al., 2010). Also, by promoting eco-products, industries can make their own contribution to economic benefits (Kannan and Sasikumar, 2009; Zhu et al., 2012) and environmental protection for society at large (Sasikumar et al., 2010; Kannan et al., 2009 a, b). Hence, Indian industry should adopt a proactive approach to address issues of green supply chain/green purchasing for future competitiveness.

The basic reasons for attention to GSCM issues are summarized below:

- Increasing pollution and less resource availability has forced Indian industries to focus on low energy consumptions and less resource use which can be offset through GSCM.
- Increasing environmental consciousness by customers has made Indian industries adopt greenness in supply chains to ensure continued market share and sustained industrial environment.
- The presence of various barriers makes GSCM implementation complicated in Indian industries (Mudgal et al., 2010).

Many studies analyzed GSCM adoption in an Indian context, but they failed to analyze insights into barriers against GSCM adoption. Because every country has its own environmental policies and regulations, earlier studies in countries such as China do not seem to have had any impact in the Indian context (Zhu and Sarkis, 2006). Research is needed on the identification of essential barriers for GSCM adoption in an Indian scenario. Although Indian industries are geared up to eradicate barriers for green implementation, they are still at an initial stage (Mudgal et al., 2010; Luthra et al., 2011; Mathiyazhagan et al., In press) and they struggle to identify essential barriers for eradication in initial GSCM adoption. Through detailed literature and discussions with industrial experts, 47 barriers have been identified and categorized based on their meaning and similarities. Barriers with sources are illustrated in Table 1. Those with more than 10 years' experience in purchasing, supply chain management, and working in environmental management departments of industry were chosen as experts and targeted for this study. The most common barriers are identified through a questionnaire survey from various industrial sectors. (For details, please refer to Section 6). Hence, this study offers a novel approach to understanding the barriers to GSCM implementation from an Indian industry perspective.

4. Solution methodology

Based on literature reviews and discussions with the industrial experts, a detailed questionnaire was framed and circulated to various industries in the southern part of India. Later, the returned questionnaires were scrutinized and the most common barriers accepted by various organizations were identified. From these identified common barriers, the essential key barriers were picked using an AHP approach. The steps of solution methodology followed in this study are shown in Fig. 1.

5. Overview of AHP

AHP is a widely used and well-known decision support tool in business industries. The foundation of Analytic Hierarchy Process (AHP) is a set of axioms which carefully delimits the scope of the problem environment (Saaty, 1986). It is based on a well-defined mathematical structure of consistent matrices and their associated right Eigen vector's ability to generate true or approximate weights (Merkin, 1979; Saaty, 1980). The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pair-wise mode (Saaty, 1980). For more details about AHP, please see Borade et al. (2013).

The three steps of the AHP methodology are: (1) identifying barriers and structuring a hierarchy prioritization model, (2) constructing a questionnaire and collecting data, and (3) determining normalized weights for each barrier category and each specific barrier. Opinions from different industries including automobiles, electrical and electronics, textiles, paper, food, plastic, textiles and apparel, iron and steel, power plant, and chemical industries were collected through carefully designed questionnaires and then synthesized and analyzed by the AHP technique.

5.1. Consistency check for pair-wise comparison matrix

The consistency ratio is calculated based on the following steps (Haq and Kannan, 2006a, 2006b):

1 Calculate the eigenvector or relative weights and λ_{Max} for each matrix of order n
2 Compute the consistency index for each matrix of order n by the formulae:

$$CI = (\lambda_{max} - n)/(n-1) \quad (1)$$

The consistency ratio is then calculated using the formulae:

$$CR = CI/RI \quad (2)$$

6. Application of proposed model

6.1. Developing the questionnaire

Questionnaires were designed to facilitate data collection. Our data collection's two phases are discussed in the following Section 6.2.1, Phase 1: Initial survey to identify common barriers, and Section 6.2.2, Phase 2: Identification of essential barriers.

The demographic profile of the initial survey including respondent industry categories, employee size, ownership, and turnover are summarized in Table 2. The questionnaire was distributed to 373 participants located in South India (Tamilnadu), Of the 373 participants, 103 responded to the questionnaire. All 373 participants were selected with help of a [1]CII (Confederation of Indian Industry) directory.[1] All 373 industrial participants started adopting environmentally-friendly activities (ISO 14001 environmental management certification) and their commitment to green practices underscores the importance of this study.

After four months, email and telephone remainders were sent to the participants resulting in 103 participants responding to our questionnaire. In addition to industrial experts, we also identified academic experts who were working in related areas for more than ten years.

In AHP, pair-wise comparisons were conducted at two separate levels: first at the specific barrier level, and then at the barrier

[1] CII works to make and sustain an environment favorable for industrial growth in India.

Table 1
Description of green supply chain management barriers.

Barriers	Description	Sources
Outsourcing		
1. Problem in maintaining environmental suppliers	Due to traditional mindsets, suppliers' interests different from others in the total supply chain network.	Sarkar and Mohapatra (2006), Mudgal et al. (2010), Calleja et al. (2004) and Ninlawan et al. (2010).
2. Complexity in measuring and monitoring suppliers' environmental practices	Metrics misalignment thought to be primary source of inefficiency and disruption in supply chain interactions.	Faisal et al. 2000, Mudgal et al. (2010), Hervani et al. (2005) and Björklund et al. (2012).
3. Lack of an environmental partnership with suppliers	With environmental consciousness, industries find it difficult to maintain partnerships with suppliers.	Hamner (2006) and Wolf and Seuring (2010).
4. Products potentially conflict with laws	Most industries' products fail to conform to environmental laws.	Zhu and Sarkis (2006).
5. Lack of government support to adopt Environmental friendly policies	Government regulations are not strong enough to force industries to adopt environmental friendly policies.	AlKhidir and Zailani (2009) and Zhu et al. (2012).
6. No proper training/reward system for suppliers	Industries neither train/reward suppliers for adopting environment friendly concepts.	Massoud et al. (2010).
TECHNOLOGY		
7. Fear of failure	Fear of failure in adopting green supply chain; that firms could suffer monetary losses/product failure, lead to loss of competitive advantage.	Rao and Holt (2005), Perron (2005) and Revell and Rutherfoord (2003).
8. Lack of effective environmental measures	Industries reluctant to implement effective environmental measures.	Rao and Holt (2005).
9. Lack of human resources	Lack of enough laborers in the organization and/or their quality. Basically, the fundamental obstacle to improving environmental performance of SMEs is lack of human resources.	Perron (2005) and Hillary (2004).
10. Difficulty in transforming positive environmental attitudes into action	Though industries have positive environmental attitudes, they find it difficult to put them into action.	Revell and Rutherfoord (2003), Hillary (2004) and Perron (2005).
11. Lack of technical expertise	Inability to find an alternative to design a pollution free product to fulfill environmental requirements.	Perron (2005) and Revell and Rutherfoord (2003).
12. Complexity of design to reuse/recycle used products	Design of recycling used products difficult.	Beamon (1999).
13. Complexity of design to reduce consumption of resource/energy	Inability of design technology to reduce usage of resource/ energy.	Russel (1998) and Perron (2005).
14. Current practice lacks flexibility to switch over to new system	Present industrial practices incapable of switching to new systems.	Revell and Rutherfoord (2003).
15. Lack of new technology, materials and processes	Non-availability of appropriate technology/process within organizations to adopt green supply chain. All materials not very eco-friendly.	Perron (2005).
Knowledge		
16. Lack of awareness about reverse logistics adoption	Industries generally unaware of reverse logistics practices.	Ravi and Shankar (2005), Meade et al. (2007) and Mudgal et al. (2010).
17. Disbelief about environmental benefits	Industries lack belief in environmental benefits for implementing green concept.	Revell and Rutherfoord (2003) and Walker et al. (2008).
18. Perception of "out-of-responsibility" zone	Perception of organizations that taking steps for environmental good-will is not their responsibility.	Shen and Tam (2002).
19. Difficulty in identifying environmental opportunities	Industries inefficient to identify environmental opportunities.	Theyel (2000).
20. Lack of Eco-literacy amongst supply chain members	Supply chain members lack knowledge about Eco-literacy.	Theyel (2000), Ravi and Shankar (2005), Mudgal et al. (2010) and Revell and Rutherfoord (2003).
21. Lack of Environmental Knowledge	Lack of awareness of environmental legislations and ignorant of environmental impact on the organization's activities and benefits of adopting green supply chain.	Shen and Tam (2002).
22. Lack of green system exposure to professionals	SMEs known to lack human resources both in quantity and quality to pursue environmental management.	Yu Lin and Hui Ho (2008).
23. Complexity in identifying third parties to recollect used products	Identifying third parties to recollect used products not easy for industries.	Our contributed barrier
24. No specific environmental goals	Industries lack well set environmental goals.	Theyel. (2000).
25. Difficulty in obtaining information on potential environmental improvements	Industries struggle to get information on potential environmental improvements/inability to get correct feedback.	Perron (2005).
26. Hesitation/fear to convert to new systems	Industries fear adopting new systems.	Revell and Rutherfoord (2003).
FINANCIAL		
27. High investments and less return-on-Investments	High investment-low returns in implementing green concept.	Our contributed barrier
28. Expenditure in collecting used products	Collection of used products expensive.	Our contributed barrier
29. Cost of environment friendly packaging	High cost of eco-friendly packaging.	Walker et al. (2008).
30. Non-availability of bank loans to encourage green products/ processes	Industries struggle to get bank loans for environment related initiatives.	Our contributed barrier
31. Risk in hazardous material inventory	Maintaining hazardous materials inventory involves high probability of financial loss.	Our contributed barrier
32. Financial constraints	Finance plays major role in green supply chain management implementation; has many constraints.	Ravi and Shankar (2005), Hervani et al. (2005) and AlKhidir and Zailani (2009).
33. Need for extra human resources		Our contributed barrier

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Table 1 (*continued*)

Barriers	Description	Sources
	More human resource needed to adopt/maintain GSCM in environmental systems.	
34. High cost of hazardous waste disposal	Disposal of hazardous costly due to threats involved.	Our contributed barrier
35. Cost of switching to new system	Adoption of new system costly.	Mudgal et al. (2010).
Involvement and support		
36. Lack of training courses/ consultancy/institutions to train, monitor/mentor progress specific to each industry	Industry professionals need training to adopt GSCM in their units and to monitor progress from consultancy or institutions.	Carter and Dresner (2001).
37. Lack of customer awareness and pressure about GSCM	Low demand from customers for eco-friendly products due to lack of GSCM awareness.	Chen et al. (2006) and Mudgal et al. (2010).
38. Lack of Corporate Social Responsibility	Corporate social responsibility suggests firms are willing to go beyond simple compliance. Willing to consider public consequences of organizational actions but industries fail to adopt it.	Mudgal et al. (2010).
39. Not much involvement in environmental related programs/meetings	Lack of participation in conferences/seminars related to green supply chain conducted by government/organizations which successfully adopted this concept. Hence, less exposure to top management.	Perron (2005).
40. Restrictive company policies towards product/process stewardship	Lack of importance attached to product and process stewardship and management's inattention detrimental to GSCM.	Beamon (1999), Revell and Rutherfoord (2003) and AlKhidir and Zailani (2009).
41. Poor supplier commitment/ unwilling to exchange information	Suppliers unwilling to exchange environment related information with industries, fearing end product being affected.	Sarkis (2003), Hong et al. (2009).
42. Lack of Inter-departmental co-operation in communication	Restriction in information flow across organization hierarchy makes GSCM implementation unfeasible.	Ravi and Shankar (2005).
43. Lack of involvement of top management in adopting green supply chain management	Resistance of top management to change existing investments, information systems and habits make switchover to a new supply chain system challenging.	Ghobadian et al. (1998), Hillary (2004), Yu Lin and Hui Ho (2008), Ravi and Shankar (2005), Zhu et al. (2007)
44. Lack of awareness of the environmental impacts on business	Top management lacks awareness of environmental impacts on their business.	Mudgal et al. (2010).
45. Inadequate management capacity	Management capacity is poor/unstable.	Beamon (1999).
46. Market competition and uncertainty	Implementation of GSCM is time consuming and affects staid industries.	Mudgal et al. (2010).
47. Lack of support and guidance from regulatory authorities	Regulatory authorities fail to extend proper support to maintain a green environment.	Perron (2005).

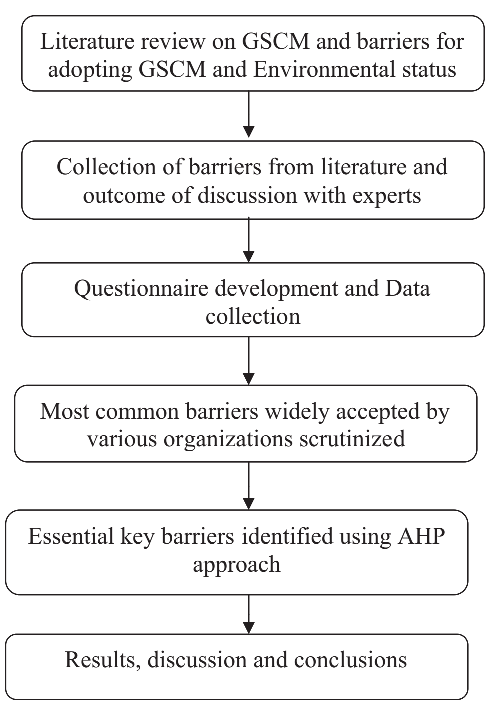

Fig. 1. Flowchart of research.

category level. An improved nine-point scale was used to assign relative weights to pair-wise comparisons between categories and specific barriers as shown in Table 3.

6.2. *Data collection*

This study targeted managers in the middle or higher management levels from various industries in Tamilnadu, South India. (For a detailed respondent profile, please see Table 2). Before starting this work, the objective of the survey, together with the GSCM concepts, were introduced to target respondents by proper documents to ensure that they fully understood various items in the survey questionnaire, its overall goals and objectives of the research, and how the data would be used.

6.2.1. *Phase 1: initial survey to identify the common barriers*

From the 47 recommended barriers, the respondents were asked to identify the important barriers (given the choice of 'Yes' or 'No' for each barrier) for GSCM implementation in their industry. Questionnaires were mailed to 373 companies in July, 2011 and pursued periodically to ensure a quick and proper response. The duration for this initial survey was fixed as three months. Of 138 respondents, 22 questionnaires were incomplete and 13 were returned empty. Hence, the valid overall response rate was 27.61%. Malhotra and Grover (1998) suggested that a response rate of 20% was enough for a positive assessment of the survey. From this initial survey we observed that Indian industries are aware of the environmental impact on their business but are still at the initial stages of GSCM implementation.

6.2.2. *Phase 2: identification of essential barriers*

In this section, the identification of essential barriers for GSCM implementation was done using the AHP approach. After the

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initial survey, 26 common barriers were identified and raised to a priority level of concern. The 26 barriers used in this phase are provided in Table 4. This phase is categorized into four hierarchy decision process levels and the same is shown in Fig. 2. The four level hierarchy processes are described as below

Level-I: The objective/overall **goal.**
Level-II: This level represents the **barrier category**.
Level-III: This level of the hierarchy contains **specific barriers.**
Level-IV: **Priorities of essential barriers** are found at this level.

The 26 barriers identified from Phase 1 were sent to relevant experts of the corresponding 87 companies. The remaining 16 industries expressed less interested in the second phase and hence were omitted. Participating companies were requested to give the pair-wise comparison weight from Saaty's method of nine point scale values (1–9) as shown in Table 3. The duration for the survey was one month. At the end of this period, 27 responses were received. The response rate is 31.03% and acceptable for analysis (Malhotra and Grover, 1998). The pair-wise comparison matrix for the main barrier category is shown in Table 5, and the detailed AHP weights for barrier categories are depicted in Table 6.

Vector: 0.2345, 0.3566, 0.1482, 0.1762, 0.0846
Max. Eigenvalue (λ_{Max}) = 5.424399, CI = 0.1061
RI = 1.12, Consistency ratio CR = 0.094732

Table 2
Profile of the responding Indian companies.

Industry type	Total	Percentage
Paper	10	9.70
Chemical	5	4.85
Food	10	9.70
Plastic	6	5.82
Textiles and Apparel	8	7.76
Iron & Steel	7	6.79
Electrical/electronics	24	23.3
Auto components	21	20.38
Power plant	12	11.65
Total	103	100
Size (Employees)		
> 3000 (Enterprises)	07	6.79
2001–3000 (Large)	19	18.44
701–2000 (Medium)	27	26.21
501–700 (Small)	50	48.54
Total	103	100
Ownership		
Private	69	67
Foreign Direct Investment or Joint Venture	34	33
Total	103	100
Turnover/annum (Rs- Crores)		
> 201 (Enterprises)	12	11.65
176–200 (Large)	08	7.76
101–175 (Medium)	35	34.02
50–100 (Small)	48	46.60
Total	103	100

Table 4
Criteria and sub-criteria for barrier identification.

Barrier category	Specific barrier
Outsourcing (O)	Lack of government support to adopt Environmental friendly policies **(O1)**
	Complexity of measuring/monitoring environmental practices of suppliers **(O2)**
	Problems in maintaining environmental suppliers **(O3)**
Technology (T)	Lack of new technology, materials and processes **(T1)**
	Complexity to design, reuse/recycle products **(T2)**
	Lack of technical expertise **(T3)**
	Lack of Human resource **(T4)**
	Lack of effective environmental measures **(T5)**
	Fear of failure **(T6)**
Knowledge (K)	Lack of professionals exposed to green systems **(K1)**
	Lack of Environmental Knowledge **(K2)**
	Perception of “out-of-responsibility” zone **(K3)**
	Disbelief about environmental benefits **(K4)**
	Lack of awareness about reverse logistics **(K5)**
Financial (F)	High cost for hazardous waste disposal **(F1)**
	Financial constraints **(F2)**
	Non-availability of bank loans to encourage green products/ processes **(F3)**
	High investments and less Return-on-Investments **(F4)**
Involvement and support (IS)	Lack of training courses/ consultancy/ institutions to train, monitor and mentor progress specific to each industry **(IS1)**
	Lack of customer awareness and pressure about GSCM **(IS2)**
	Lack of Corporate Social Responsibility **(IS3)**
	Lack of top management involvement in adopting green supply chain management **(IS4)**
	Restrictive company policies towards product/process stewardship **(IS5)**
	Poor supplier commitment, unwilling to exchange information **(IS6)**
	Lack of Inter-departments co-operation in communication **(IS7)**
	Less involvement in environmental related programs and meetings **(IS8)**

Table 3
Scale of preference between two elements (Saaty, 1980).

Preference weights/level of importance	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective.
3	Moderately	Experience and judgment slightly favor one activity over another 0).
5	Strongly	Experience and judgment strongly or essentially favor one activity over another.
7	Very strongly	An activity is strongly favored over another and its dominance demonstrated in practice.
9	Extremely	The evidence favoring one activity over another is of the highest degree possible for affirmation.
2,4,6,8	Intermediate values	Used to represent a compromise between preferences listed above.
Reciprocals	Reciprocals for inverse comparison	

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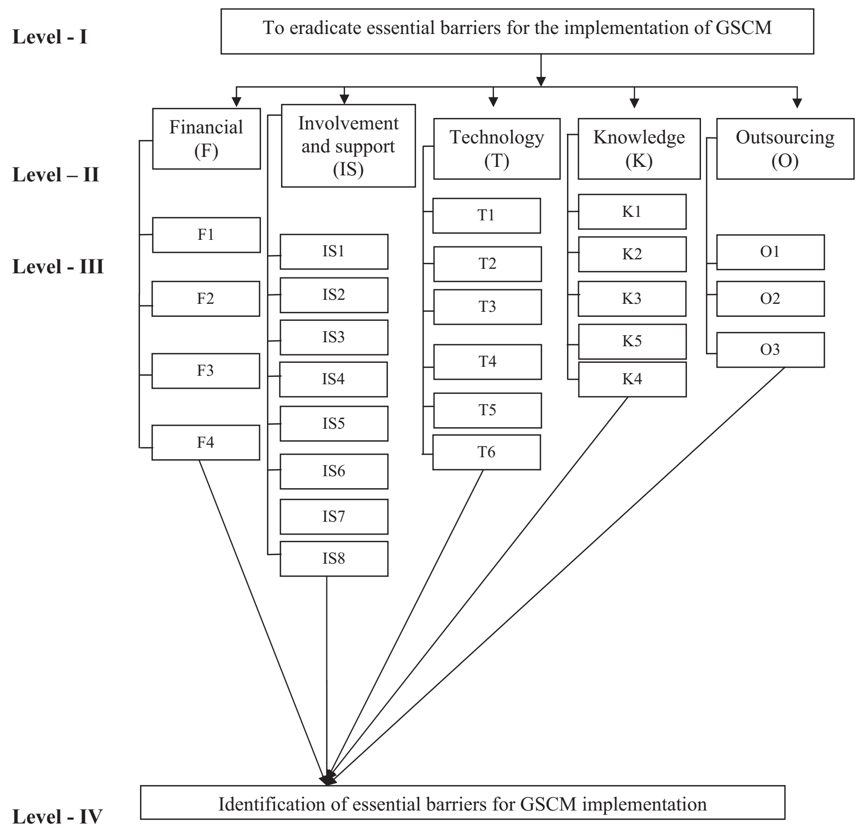

Fig. 2. AHP framework for identifying essential barriers of GSCM implementation.

Table 5
Pair-wise comparison matrix for barrier category.

	O	T	K	F	IS
O	1	0.78	2.73	0.66	2.48
T	1.281	1	2.89	3.7	2.89
K	0.3663	0.346	1	1.66	1.98
F	1.5152	0.2703	0.6024	1	2.6
IS	0.4032	0.346	0.5051	0.3846	1

Table 6
AHP weights for barrier category.

Barrier category	Sorted weight value
T	0.3566
O	0.2345
F	0.1762
K	0.1482
IS	0.0846

7. Result and discussions

7.1. Barrier category

We infer from Table 6 that the technology barrier is the first priority among the barrier categories. Technology change is an expensive and crucial barrier for GSCM implementation (Calleja et al., 2004; Ninlawan et al., 2010). The outsourcing barrier category receives the next highest weight. Green purchasing was explored to determine the key factors affecting the buying firms' choice of suppliers, including major barriers and obstacles (Rao, 2007; Min and Galle, 2001). The financial barrier category obtained less than half of the weight of the technology barrier category, thereby showing that industries commonly need more finances to extend their environmental management systems. Economy is critical in implementing GSCM (Ninlawan et al., 2010; Calleja et al., 2004; Hervani et al., 2005; Lee, 2008). The knowledge barrier category ranks fourth. Björklund et al. (2012) has found that there is a lack of knowledge in measuring environmental performance in supply chain management, which reveals that the involvement and support barrier category is not essential for comparison with other barrier categories.

7.2. Barrier ranking for GSCM implementation in Indian industries

The ranking of specific barriers is shown in Table 7 revealing that overall ranking is based on the global weight values of the AHP approach. Global weights are obtained by multiplying the relative weight of barrier category values with the relative weights of each specific barrier. The result of each barrier, based on barrier categories, is discussed in the following sections.

7.2.1. Technology

Industries need to develop and update themselves on new trends and technologies when implementing GSCM (Mudgal et al., 2010). In the technology barrier category, a lack of new technology, materials and processes (T1) barrier ranks first. SMEs are usually slow to respond to the challenge of improving environmental performance as they lack new technical resources (Massoud et al., 2010; Hitchens et al., 2003; Zhu and Geng, 2010). In India, the lack of sufficient educational programs at schools and colleges, and the

Table 7
Local and global weights of all barrier categories and specific barriers for the implementation of GSCM.

Barrier category	Relative weights using AHP	Barriers	Relative weights using AHP	Global weights using AHP	Rank
O	0.2345	O1	0.2618	0.0614	4
		O2	0.6265	0.1469	1
		O3	0.1117	0.0262	15
T	0.3565	T1	0.3663	0.1306	2
		T2	0.1213	0.0432	8
		T3	0.112	0.0399	11
		T4	0.1141	0.0407	10
		T5	0.2385	0.0850	3
		T6	0.0496	0.0177	17
K	0.1482	K1	0.3025	0.0448	7
		K2	0.1972	0.0292	14
		K3	0.2329	0.0345	13
		K4	0.1072	0.0159	18
		K5	0.1603	0.0238	16
F	0.1762	F1	0.2339	0.0412	9
		F2	0.2952	0.0520	5
		F3	0.2589	0.0456	6
		F4	0.212	0.0374	12
IS	0.0846	IS1	0.1758	0.0149	20
		IS2	0.16	0.0135	21
		IS3	0.1805	0.0153	19
		IS4	0.0754	0.0064	26
		IS5	0.1114	0.0094	23
		IS6	0.0855	0.0072	24
		IS7	0.1335	0.0113	22
		IS8	0.078	0.0066	25

lack of research and development to promote green supply chain were identified as major obstacles (Arif Khan et al., 2009). Lack of effective environmental measures (T5) barrier is next to T1 barrier. Saadany et al. (2011) confirmed from their results that conventional cost accounting methods lack flexibility to consider qualitative environmental measures. Complexity of design to reuse/recycle the product (T2) barrier comes third. It shows that Indian industries have started to design and incorporate recycling and reusing properties for products to be reused in the future. Lack of human resource (T4) barrier's weight is slightly less than T2 barrier's weight. SMEs are known for lacking human resources in quantity and in technical knowledge to pursue environmental management (Hillary, 2004). It is clear that the Lack of human resource barrier (T4) is followed by the Lack of technical expertise barrier (T3). SMEs have low environmental expertise (Environment Canada, 2003; Perron, 2005). Low priority was assigned to Fear of failure (T6). Calleja et al. (2004) state that some feared that simplification of administrative and legislative burdens for SMEs could lead to lower environmental standards with a continuing fear of overlapping and contradictory legislation.

7.2.2. Outsourcing

In this category, of the three barriers, O2 (Complexity to measure/monitor environmental practice of suppliers) is the most essential barrier. The normalized global weight of O2 shows that most Indian industries do not have proper monitoring/measuring systems for their suppliers' environmental practices. Due to lack of direction and legislation on environmental management, industries do not know what they should measure and how to measure what should be measured (Shaw et al. 2010). Mathiyazhagan et al. (In press) found that monitoring/measuring suppliers' environmental performance is a difficult process. Next is the lack of government support to adopt environment friendly policies (O1) barrier. Massoud et al. (2010) have confirmed that "lack of government support and incentive" is a significant barrier to acquiring an environmental certificate. In this category, the last barrier is the problem in maintaining environmental suppliers (O3). Calleja et al. (2004) mentioned that outsourcing new knowledge through collaboration with suppliers is problematic in situations of technology privacy. The O3 barrier's weight and rank demonstrates that industries have been forced to focus on new technology trends that help the environment.

7.2.3. Financial

In GSCM implementation, the lack of financial support is usually considered as the most important constraint to environmental actions (Zhang. et al., 2009). In this barrier category, financial constraints (F2) are a dominant barrier. It reveals that Indian industries are unable to fulfill their economic needs and hence do not spend much for GSCM implementation. Lack of finances can hinder GSCM applications (Hussain, 2011). The non-availability of bank loans to encourage green products/processes (F3) barrier acts is next to F2 barrier based on its weight. Compared to developed countries, India has a long loan sanctioning process, one that requires more time and extensive documents. Thus, the initiative to start industries and to adopt environmental initiatives may involve a lengthier process. In this financial barrier category, the high hazardous waste disposal cost (F1) barrier ranks third. A significant financial barrier to environmental technology improvement is the effect of collection and treatment costs and prices to dispose of hazardous materials (Mudgal et al., 2010). The lowest priority in the financial category goes to High investments and less Return-on-Investments (F4) barrier, which comes in as less effective than barrier F2. From survey results it is seen that industries will not risk profits, but they are ready to initiate environmental management systems if they can do so without violating profits.

7.2.4. Knowledge

The Knowledge barrier category is comprised of five barriers. Lack of green system exposure professionals (K1) barrier comes first in this category. The survey results show that professionals in industries are less exposed to green systems. The succeeding barrier is the perception of "out-of-responsibility" zone (K3) barrier. Industries are reluctant to take responsibility to adopt and update environmental issues (Shen and Tam, 2002). Lack of Environmental Knowledge (K2) barrier is placed in third. Mudgal et al. (2010) show that there is "lack of preparedness owing to the low level of uptake of environmental management systems due to ignorance and lack of awareness of benefits which in turn becomes a significant barrier." Another important barrier under technology is disbelief about environmental benefits (K4). Disbelief about benefits of environmental initiatives is an internal attitude and perception barrier (Perron, 2005). Finally, low priority is obtained for Lack of awareness about reverse logistics (K5) barrier. It proved to be a big obstacle to minimize waste and improve profits. A chief barrier of reverse logistics, seen in the Indian automobile industry supply chain, is the lack of awareness about the benefits of reverse logistics (Ravi and Shankar, 2005; Mudgal et al., 2010).

7.2.5. Involvement and support

In implementing any system, involvement and support of management is important especially in issues such as GSCM adoption (Mudgal et al., 2010). GSCM did not evolve alone. There are many corporate and industrial environmental philosophies and practices closely linked to and in support of green supply chain management (Sarkis, 2012). This survey revealed that involvement and support barrier category and specific barriers obtained the lowest weights. Under this category, Lack of Corporate Social Responsibility (IS3) barrier comes first. Walker et al. (2008) and Mudgal et al. (2010) have stated that corporate environmental awareness is most important to adopt GSCM. Lack of training courses/consultancy and institutions to train, monitor, and mentor industry specific progress (IS1) barrier is next to IS3. The participation of company professionals in environmental seminars, training courses, and mentorship programs is poor. The lack of customer awareness and pressure about GSCM (IS2) barrier is in third place, following the IS1 barrier. The consumer's environmental consciousness is a significant driving force for companies to engage in environmental management (Chen et al. 2006). Lack of Inter-departmental co-operation in communication (IS7) barrier is ranked next to the IS2 barrier. EIP's structure and composition often leads to difficulties in information dissemination and communication, and this limitation is primarily related to incomplete/imperfect information (Zhu and Cote, 2004; Tudor et al., 2007). Restrictive company policies towards product/process stewardship (IS5) weights are of greatly less value than the IS7 barrier. Product stewardship is management code to ensure safe handling and use of products throughout their life cycle (Mudgal et al., 2010). Poor supplier commitment and lack of willingness to exchange information (IS6) is the next barrier. Industries are often unwilling to exchange information on green supply chain management, fearing exposure of an inherent weaknesses or giving other companies a competitive advantage (Walker et al., 2008). Less involvement in environmental related programs and meetings (IS8) barrier comes next. This weight reveals that most industries have awareness to develop environmental management. Lack of top management involvement in adopting green supply chain management (IS4) barrier received the lowest weight and ranks last among the 26 barriers. Presently most industries are involved in adopting GSCM and are aware of GSCM benefits, but more commitment is certainly required for 100% progress. Green business practices require radical changes in both mindset and practice. Many authors have discussed the role of top management to determine a firm's level of environmental commitment (Ghobadian et al., 1998; Mudgal et al., 2010).

This paper discusses identification of essential barriers from an organizational point of view. AHP is used to provide a simple approach and helps decision-makers to identify essential barriers. Using the AHP framework ensures that qualitative judgment is quantified to provide a highly precise comparison and to reduce or to eliminate any unbalanced scale of judgments, uncertainty, and imprecision among the pair-wise comparisons (Borade et al., 2013). Both the identification of barriers and the insights on GSCM provided contribute to the importance of this survey.

8. Sensitivity analysis

Table 6 reveals that technology barrier category has more weight and thereby influences the other barrier categories. Chang et al. (2007) and Kannan et al. (2013) mentioned that small changes in relative weights would provide major changes in the final ranking. Such weights are usually based on highly individual judgments and therefore, ranking stability under varying barrier category weights should be tested. Sensitivity analysis can be performed for this method of validation. Here, the technology category barrier is selected with its value varying from 0.1 to 0.9 with 0.1 as increment. This change is reflected in the other category barriers with the outsourcing barrier category showing maximum variation. The changes in other barrier category values are tabulated in Table 8. Hence, specific barrier weights and rank also change accordingly. At 0.1 of technology category barrier, barrier O2 holds first rank and barrier T6 the last rank. Barrier O2 retains first rank till the normal value of 0.3565. From 0.4 to 0.9 T1 holds first rank, and the ranks of other barriers vary. Priority (rank) changes are illustrated in a chart in Fig. 3. It shows that changes in

Table 8
Barrier category values after increasing technological category barrier.

Barriers	**Barrier category values**									
O	**0.2345**	0.32797	0.29153	0.25508	0.21864	0.18220	0.14576	0.10932	0.07288	0.03644
T	**0.3565**	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
K	**0.1482**	0.20727	0.18424	0.16121	0.13818	0.11515	0.09212	0.06909	0.04606	0.02303
F	**0.1762**	0.24643	0.21905	0.19167	0.16428	0.13690	0.10952	0.08214	0.05476	0.02738
IS	**0.0846**	0.11832	0.10517	0.09202	0.07888	0.06573	0.05258	0.03944	0.02629	0.01314
Total	**1**	1	1	1	1	1	1	1	1	1

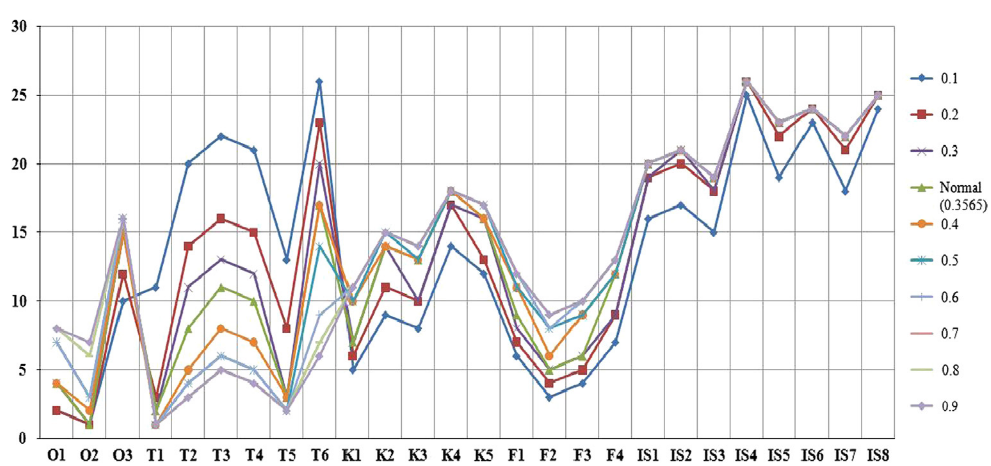

Fig. 3. Ranking for barriers when increasing technological barrier category value by sensitivity analysis.

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Table 9
Ranking for barriers when increasing technological barrier category value from 0.1 to 0.9 by sensitivity analysis.

Barriers	Technological barrier category values in sensitivity analysis									
	0.1	0.2	0.3	Normal (0.3565)	0.4	0.5	0.6	0.7	0.8	0.9
O1	2	2	4	4	4	7	7	8	8	8
O2	1	1	1	1	2	3	3	6	6	7
O3	10	12	15	15	15	16	16	16	16	16
T1	11	3	2	2	1	1	1	1	1	1
T2	20	14	11	8	5	4	4	3	3	3
T3	22	16	13	11	8	6	6	5	5	5
T4	21	15	12	10	7	5	5	4	4	4
T5	13	8	3	3	3	2	2	2	2	2
T6	26	23	20	17	17	14	9	7	7	6
K1	5	6	7	7	10	10	11	11	11	11
K2	9	11	14	14	14	15	15	15	15	15
K3	8	10	10	13	13	13	14	14	14	14
K4	14	17	17	18	18	18	18	18	18	18
K5	12	13	16	16	16	17	17	17	17	17
F1	6	7	8	9	11	11	12	12	12	12
F2	3	4	5	5	6	8	8	9	9	9
F3	4	5	6	6	9	9	10	10	10	10
F4	7	9	9	12	12	12	13	13	13	13
IS1	16	19	19	20	20	20	20	20	20	20
IS2	17	20	21	21	21	21	21	21	21	21
IS3	15	18	18	19	19	19	19	19	19	19
IS4	25	26	26	26	26	26	26	26	26	26
IS5	19	22	23	23	23	23	23	23	23	23
IS6	23	24	24	24	24	24	24	24	24	24
IS7	18	21	22	22	22	22	22	22	22	22
IS8	24	25	25	25	25	25	25	25	25	25

priority (rank) vary according to change in the technology category barrier. Changes of specific barrier ranks are tabulated in Table 9. It is inferred that technology category barrier has more impact on the GSCM implementation and so this category demands greater attention. If the technology category barrier is eliminated, there is a high possibility of eliminating the remaining category barriers, so the. elimination procedure for specific barriers is also easier. By following this, industries can implement GSCM without difficulty.

9. Conclusions

Regarding the results obtained from data analysis, we present the following conclusions. GSCM implementation in industries is crucial (Zhu et al., 2010; Walker et al., 2008; Zhang. et al., 2009) and requires coordination from all level of the workforce, from bottom-line employee to top management. Identification of essential barriers for GSCM implementation is tricky due to its numerous characteristics. This paper has attempted to present a benchmarking framework to ease these complicated elements and to trim down barrier identification difficulties to make managers' efforts towards environmental improvement a little easier. A literature review reveals the existence of more studies identifying barriers for GSCM adoption within industries. In our explorative research, we were able to determine the barriers to be eradicated and those which are essential for GSCM adoption. 47 initial barriers, under five barrier categories, from literature and industrial discussion were examined. Twenty-six common barriers are identified from 47 barriers through the initial survey. During GSCM adoption, it is not possible to eradicate all these barriers initially and so industries must identify which barrier – of the 26 choices – is a major obstacle for GSCM implementation. The proposed AHP approach is used to give rank (priorities) to these twenty-six barriers based upon judgments of industrial experts. The AHP results clearly show that the technology barrier category is the leading barrier category. Lack of technology is the most important obstacle during GSCM adoption (Zhu et al., 2005). Outsourcing, financial concerns, and knowledge barrier categories are the next priorities. But because the involvement and support barrier category ranks last, that ranking reveals that industries, although involved in motivating their systems for GSCM adoption, still face a considerable gap. Compared to the technology barrier category, the involvement and support barrier category is not essential in the industrial expert's point of view. Similarly, specific barriers are also ranked based on the AHP global weights. Complexity to measure and monitor environmental practices of suppliers (O2) barrier acts as an essential barrier when compared to the other 25 barriers. The result has shown clearly that measuring/monitoring environmental practice and performance is a critical process requiring more focus (Shaw et al. 2010; Sarkis, 2012; Walker et al., 2008). Note that the involvement and support category barriers received less weight than other barrier categories. It is clear that all involvement and support barriers are less essential than the other barriers and they can be eradicated without trouble. Sensitivity analysis was performed to analyze the changes of the influential technology barrier category values (0.1–0.9). It gives the changes of rank of specific barriers when the technology barrier category values change. Barrier category values are increased from 0.1 to 0.3 with respect to an increase in the technology category values, and they decrease when technology category values increase from 0.4 to 0.9. This analysis shows that the technology barrier category influences and impacts other barrier categories.

This research has identified essential barriers requiring elimination during GSCM implementation. This work has successfully given priorities (rank) to barrier categories and specific barriers based on experts' judgments by AHP. It is not possible to remove all obstacles when starting GSCM implementation in industries. This paper has provided industries with extensive solutions for identification of essential barriers, and it provides a benchmark that may assist them during their GSCM implementation.

The study revealed that Indian industries still struggle to prioritize environmental performance improvements over economic performance. Similarly, most industries struggle for financial support for new environmental adoptions. Indian industries also

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have low awareness on sharing of environmental knowledge and updating environmental technologies. However, they are interested in improving environmental performance.

10. Managerial implication and limitations

It is evident from the results that identification of essential barriers in industries during GSCM adoption is helpful to ensure a pollution-free environment. The most important Level 2 and specific Level 3 barrier categories are considered. The technology barrier category is important during GSCM adoption and industries need to concentrate more on technological development. The outcome of this research helps to adopt GSCM easily in industries in the Indian scenario. This work can be extremely useful to industries that need to convert their traditional supply chain management to GSCM. However, industries cannot eradicate all barriers simultaneously and hence should be ready to afford time to eradicate them one after another. As established above, this is the first research to identify/analyze the essential barriers that underscore environmental initiatives.

In this research, 47 barriers, under five barrier categories relevant to GSCM implementation were considered, with the help of literature and experts discussion. Of the 47 barriers, only 26 barriers were considered to isolate essential barriers. Further studies can address more barrier categories and barriers. Various sectors in industry could also be considered for exhaustive investigation leading to further improved ways for GSCM implementation.

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Appendix A

GENERAL INDUSTRY INFORMATION
Please answer the appropriate elements furnished below.

Industry name	
Type of industry	Paper Chemical Food Plastic Textiles and apparel Iron and Steel Electrical/ electronics Auto components
Member of Confederation of Indian Industry (CII)	Yes No
EMS Certified	Yes No

Phase 1: Initial survey to identify the common barriers

The following is a questionnaire on the barriers that could have hindered your company in the implementation of Green Supply Chain Management. Please respond to the questionnaire with a "YES" or "NO." Please give your response on a nine point scale.

Preference weights/level of importance	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective.
3	Moderately	Experience and judgment slightly favor one activity over another.
5	Strongly	Experience and judgment strongly or essentially favor one activity over another.
7	Very strongly	An activity is strongly favored over another and its dominance demonstrated in practice.
9	Extremely	The evidence favoring one activity over another is of the highest degree possible of affirmation.
2,4,6,8	Intermediate values	Used to represent/ compromise between preferences listed above.
Reciprocals	Reciprocals for inverse comparison	

Questionnaire

Sl. no.	Barriers	Response Yes/No
Outsourcing		
1	Products potentially conflicting laws	
2	Environmental partnership with suppliers	
3	Lack of government support to adopt environmental friendly policies	
4	Complexities in measuring/ monitoring environmental practice of suppliers	
5	Problem in maintaining the environmental suppliers	
6	No proper training and reward system for suppliers	
Technology		
7	Lack of new technology, materials and processes	
8	Complexity in design to reuse or recycle the product	

9	Current practice lacks flexibility to switch over to new system
10	Complexity in design to reduce the consumption of resource and energy
11	Lack of technical expertise
12	Lack of human resources
13	Difficulty in transforming positive environmental attitudes into action
14	Lack of effective environmental measures
15	Fear of failure
KNOWLEDGE	
16	Lack of professionals with green system exposure
17	Problems in identifying third parties to recollect used products
18	Lack of Environmental Knowledge
19	Hesitation/fear to convert to new systems
20	Difficulty obtaining information on potential environmental improvements
21	Lacking specific environmental goal
22	Perception of "out-of-responsibility" zone
23	Difficulty identifying environmental opportunities
24	Disbelief about the environmental benefits
25	Lack of awareness about reverse logistics
26	Lack of Eco-literacy amongst supply chain partners
Financial	
27	Cost of environmentally friendly packaging
28	Risk in hazardous material inventory
29	High hazardous waste disposal cost
30	Financial constraints
31	Non-availability of bank loans to encourage green products/processes
32	Recruitment of extra human resources
33	Expenditure in collecting used products
34	High investments and low return-on-investments
35	Cost for switching to the new system
INVOLVEMENT AND SUPPORT	
36	Lack of training courses/consultancy/institutions to train, monitor, and mentor industry specific progress
37	Lack of awareness of environmental impact of business
38	Inadequate management capacity
39	Lack of customer awareness and pressure about GSCM
40	Market competition and uncertainty
41	Lack of Corporate Social Responsibility
42	Lack of support and guidance from regulatory authorities
43	Restrictive company policies towards product/process stewardship
44	Poor supplier commitment/lack of willingness to exchange information
45	Lack of inter-departmental cooperation in communication
46	Low involvement in environmental related programs and meetings

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47	Lack of top management involvement in adopting green supply chain management

Phase 2: Identification of essential barriers (AHP)

The following is a questionnaire on the barriers that could have hindered your company in the implementation of Green Supply Chain Management. Please respond to the questionnaire, giving your response on a nine point scale.

Preference weights/Level of importance	Definition	Explanation
1	Equally preferred	Two activities contribute equally to the objective.
3	Moderately	Experience and judgment slightly favor one activity over another.
5	Strongly	Experience and judgment strongly or essentially favor one activity over another.
7	Very strongly	An activity is strongly favored over another and its dominance is demonstrated in practice.
9	Extremely	The evidence favoring one activity over another is of the highest degree possible of affirmation.
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above.
Reciprocals	Reciprocals for inverse comparison	

Barrier category

	O	T	K	F	IS
O	1				
T		1			
K			1		
F				1	
IS					1

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