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A hybrid decision model to evaluate critical factors for successful adoption of GSCM practices under fuzzy environment

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A B S T R A C T

Due to environmental issues, social concerns, increased pollution and enforced regulations; organizations are focusing to include green practices in their supply chain. This can be accomplished by adoption of green supply chain management (GSCM) practices. Therefore, GSCM is now a proactive approach for firms to increase their ecological performance, corporate image, achieve competitive advantages and sustainable business practices. This study identifies, evaluate and analyze the critical factors (CFs) for successful implementation of GSCM practices. The proposed study uses hybrid Fuzzy DEMATEL model to prioritize the identified critical success factors (CSFs) for GSCM adoption. Fuzzy approach is integrated with DEMATEL to deal with uncertainty arises in decision making process. To demonstrate the application of the proposed approach a case study from electronic industry is considered. This approach investigates the cause and effect relationships among the CFs for successful adoption of GSCM practices in Indian electronic organizations.

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1. Introduction

Integration of green and environmental consideration with supply chain activities has gained momentum among researchers and practitioners. Additionally, ecological concern in supply chain management practices in industries is getting popularity due to resource scarcity, increased pollution and waste disposal issues (Praksh & Barua, 2015a). Green supply chain management (GSCM) practices have been considered as a part of sustainable development (Govindan et al., 2015). Industries can reduce negative impacts from environment and society by adopting green practices in their supply chain process (Diabat et al., 2013). Governments are also putting pressures on industries to adopt and incorporate green and ethical practices in their supply chain (Mathiyazhagan et al., 2013, Prakash & Barua; 2016a). An environmental/green supply chain primarily encompasses activities that affect the environment (Simpson & Power, 2007) into traditional supply chain. These activities comprise efforts to minimize emission, improvements in packaging, use of renewable energy in production, adoption of reverse logistics and waste minimization process, less input materials used in manufacturing and green

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initiatives and efforts in sourcing, production, and logistics, transportation, marketing and distribution activities. Adoption of green practices can improve organizational social image and provide competitive advantage (Li, 2011). Green practices are already prevalent in developed world but these are relatively new concept in developing countries like India (Prakash et al., 2014). Indian industries are facing challenges to integrate supply chain activities with environmental thinking. On the other hand, continuous pressures from government, regulatory bodies, society, stakeholders, customers and competitors are also enforcing industries to implement GSCM practices. Hence industries have to identify and rank these critical factors in order to implement green practices in their supply chain on the priority basis, successfully.

1.1 Research goals

- To identify, finalize and evaluate critical factors for successful adoption of GSCM practices,
- To analyze the cause and effect relationship of the critical factors.

There are many critical success factors (CSFs) identified through relevant literature review with experts' consents to adopt GSCM practices. These identified CSFs are evaluated using Fuzzy DEMATEL model. Fuzzy concept is helpful in decision making process when multiple conflicting factors are involved and the evaluation is complex under uncertain environment. The proposed hybrid model prioritizes the identified CFs for successful adoption of GSCM practices on priority basis.

To show the application of the proposed framework, a real world case of Indian electronic industry has been taken. Electronic industry of India is huge; urban and semi-urban market are growing more than 40% compound annual growth rate (CAGR). However overall market is growing more than 30% CAGR. Additionally, rising e-waste in India is also major concerns for policy makers to implement green practices in supply chain and adopt reverse logistics practices. Hence this inspired us to deal with green practices in order to ensure green trends and sustainability in Indian electronic industries.
The rest of the paper is planned as follows. Section 2 concisely reviews the literature on the identification of CFs for successful adoption of GSCM practices. Problem definition is given in part 3. The Fuzzy DEMATEL approach is discussed with results analysis in Part 4. Discussions and managerial implications are presented in Part 5. Finally, part 6 represents conclusions of the study.

2. Literature review

Indian industries are trying to focus on manufacturing activities to make presence in world's market (Hu & Hsu, 2010). That would create enormous opportunities; but it will also generate environmental liability and social issues (Prakash & Barua; 2016b). Moreover decreasing natural resources, stresses industries should follow sustainable business practices throughout the supply chain. Therefore, industries need to implement green practices into their supply chain. Many firms have also recognized effective implementations of green practices, which could provide a good environmental performances, competitive advantage, economic benefits and improvement in corporate image (Prakash & Barua, 2016a; Govindan et al., 2015). Many authors have suggested various critical factors of successful implementation of GSCM practices (Govindan et al., 2015; Al Zaabi et al., 2013; Luthra et al., 2014; Haleem et al., 2012). Critical Success Factors (CSFs) are key parameters; which are helpful in the achievement of organizational success. Therefore organizations have to identify, evaluate and rank the CFs for successful adoption of GSCM practices. Prakash and Barua (2015b) suggested government regulations are effective drivers/factors for implementing GSCM practices; but not welcomed by organizations. Hence, regulatory bodies such as ministry of environmental & forest, India; pressurizing electronic firms to understand sustainability issues and implement orderly green practices into their supply chains. Many researchers have identified top management commitment and support is necessary to produce green products and strategic management concern also influence other stakeholders of supply chain (Luthra et al., 2014; Govindan et al.; 2013). Tseng et al. (2012) identified organizational support, policies, strategies and efforts, which are required to attain the goal of green practices. Firms must understand green practices in supply chain are long term goals; Initially green strategies and efforts would have high cost but in long term beneficial and economies of scale can be achieved (Giunipero et al., 2012). Luthra et al. (2014) proposed green design, procurement and packaging are also critical factors. Buyukozkan and Cifci (2012) suggested that environmental impact of the products can be reduced if product design would be integrated with green concerns in the product development phase. Green products have less effects on the environment during their life cycle (Zhu et al., 2007). Procurement of green materials have high cost but provides economic benefits in disposition activities and environmental protection (Azevedo et al., 2011). Implementation of green practices needs cleaner technology development and advancement (Chan et al., 2012). Luthra et al. (2014) identified organizations may attain low cost and environment-friendly manufacturing system by adopting cleaner production technology. Implementation of cleaner technology also reduces waste and pollution and support in green production system (Andic et al., 2012). Kannan et al. (2014) suggested firms should also develop and upgrade their suppliers and motivate them to adopt green practices. Organizations had to work closely with suppliers to achieve green practices into supply chain (Muduli et al., 2013). Praksh and Barua (2015c) found that; adoption of reverse logistics practices & proper waste disposal measures considerably assists organizations to implement environmental supply chain practices. Prakash et al. (2015b) identified that electronic industry can reduce negative impact from environment and society by adopting reverse logistics practices in their supply chain process. Overall success of green supply chain depends on customers' acceptance and encouragement (Zhu et al., 2008). Ageron et al. (2012) recognized that economic, social and environmental aspects in supply chain activities help to attract new as well as existing customers and improve corporate image of the organization.

3. Problem Definition

Since green practices are only available options with the organizations in order to curb environmental related concern, societal and pollution issues, there is a need to adopt GSCM practices to reduce negative ecological impact. To accomplish this; critical factors are needed to identify for successful adoption of GSCM practices. Identification of CSFs is performed by a team of decision makers who have expertise in this area and team members have more than 15 years of experience in the electronic industry. Various CSFs were identified by a team of experts in this area and available literature. This team has members from industry, supply chain managers, senior managers and industry associates, etc. Identified CFs should be contextualized according to the need of the industry. Due to the dynamic nature of the electronic industry within the India and based on CFs, factors are identified from the literature and with the validation of the industrial experts summarized in Table.1. This paper proposes a model on prioritization and cause and effect relationships of CFs for successful adoption of GSCM practices which is supposed to be multi-criteria decision making problem.

Table 1
Identified critical factors for successful adoption of GSCM practices

	Critical factors	Code	References
1	Government regulations	CF1	Prakash & Barua, 2016a; Zhu & Sarkis, 2006; Zhu et al., 2012
2	Top management commitment	CF2	Prakash & Barua, 2016b; Govindan et al., 2013; Luthra et al., 2014
3	Waste minimization & reverse logistics adoption	CF3	Prakash & Barua, 2015a, b; Luthra et al., 2014; Gopalakrishnan et al. 2012
4	Green procurement, designing & packaging	CF4	Kumar & Garg, 2016; Luthra et al., 2014; Eltayeb et al., 2011; Ageron et al., 2012
5	Cleaner technology development & advancement	CF5	Prakash & Barua, 2015c; Chan et al., 2012; Luthra et al., 2014
6	Green supplier development and certification	CF6	Luthra et al. 2014; Agarwal and Vijayvargy, 2012; Kannan et al., 2014
7	Organizational support for GSCM	CF7	Tseng et al., 2012; Muduli et al., 2013; Toppinen and Korhonen-Kurki, 2013
8	Support & motivation from customers	CF8	Zhu et al., 2008; Luthra et al., 2014; Ageron et al., 2012

4. Research methodology

The motive behind selection of methodology is the identification, evaluation and prioritization of identified critical factors. The decision makers include experts (Domain specialist, Supply chain managers, and senior executive) from north central region of India. In this research 8 CFs of GSCM adoption comprising qualitative and quantitative are recognized through literature and discussion (See Table 1). This study utilizes Fuzzy DEMATEL to rank and evaluate the identified CFs for successful adoption of green practices in supply chain. In this methodology, fuzzy set theory is mixed with the DEMATEL method. The concepts of fuzzy logic are useful in capturing the vagueness and human bias in the process of ranking CFs. While, for capturing the direct and indirect influences among CFs and building their causal relationships, this study uses DEMATEL method. The other details are given as below:

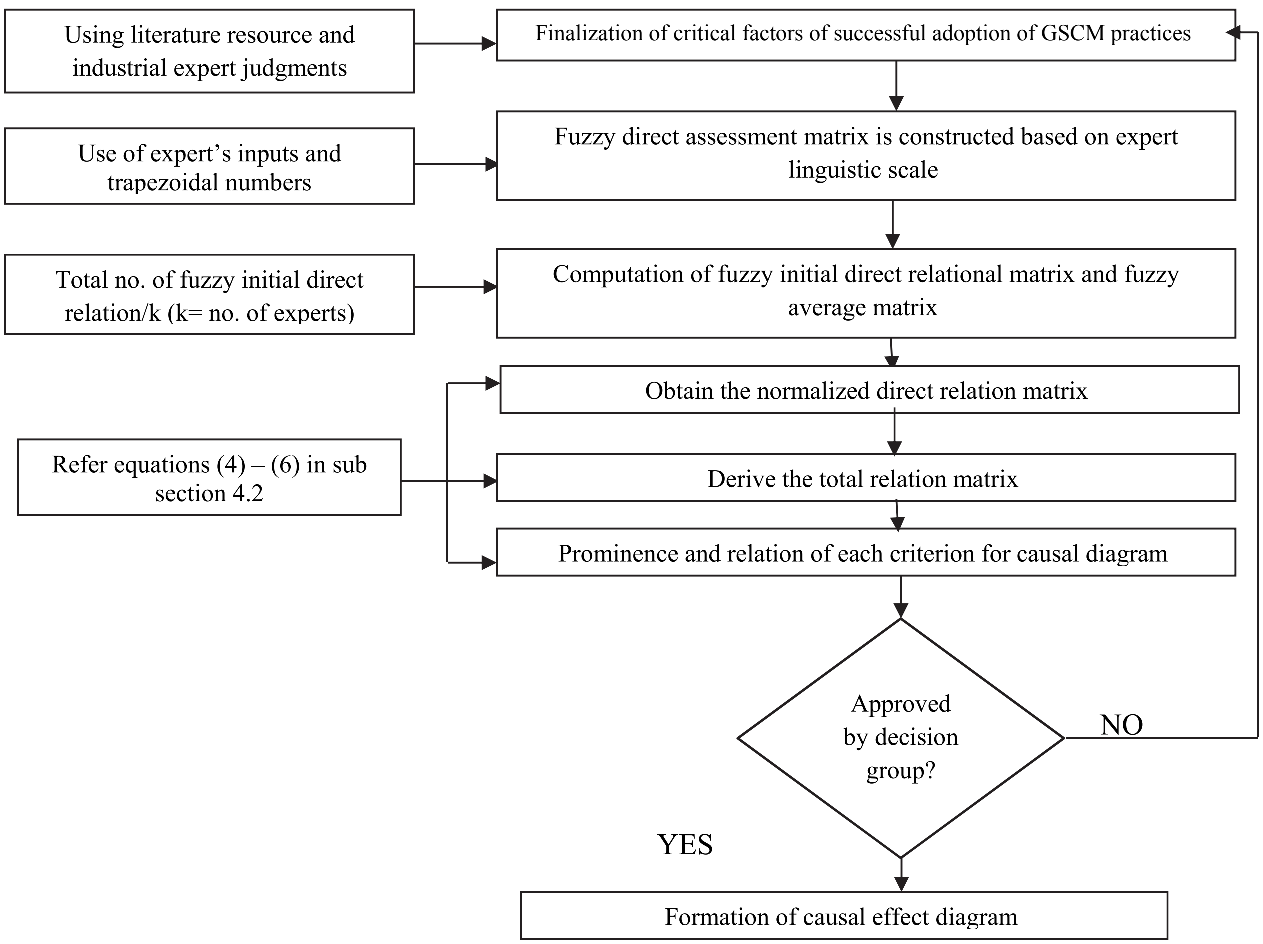

Fig. 1. Proposed Fuzzy DEMATEL methodology for GSCM adoption success factors

4.1 Utilization of fuzzy set

Fuzzy stands for uncertainty, and is utilized to explore evidence and/or information that usually vagueness and impreciseness in nature. Zadeh (1965) suggested the utility of fuzzy set in the diverse decision-making area with uncertain information. Group decision making is commonly a method employed by organizations to solve different problems, which often inadequately described. Human judgments generally include qualitative criteria, and mainly expressed in linguistic statements. To reduce such problems fuzzy theory is appropriate tool which can easily include human subjectivity in decision making (Garg; 2016; Prakash et al., 2015a; Prakash & Barua, 2016c; Vishwakarma et al., 2015a, 2015b; Vishwakarma et al., 2016). In this fuzzy theory, each value lies between 0 and 1; which shows fractional accuracy of that set, although crisp values denote the binary representation [0, 1]. Additionally, if a set of elements is denoted by A, and the element of A is symbolized by a, at that time, a fuzzy set X for A is given as $\{(a, \mu X(a)) \mid a \in A\}$, and its associated membership function is represented by Zimmerman (1996). Trapezoidal fuzzy number (TrFN) is a special kind of fuzzy numbers and utilized in this study. The trapezoidal membership function for a fuzzy number $A = (a_1, a_2, a_3, a_4)$ can be expressed mathematically by using the Eq. (1), where $a_1 \le a_2 \le a_3 \le a_4$. If $A = (a_1, a_2, a_3, a_4)$ and $B = (b_1, b_2, b_3, b_4)$ are two TrFN, then it can be equal if and only if $a_1 = b_1, a_2 = b_2, a_3 = b_3, a_4 = b_4$. The algebraic operations for these two TrFNs are given as: $A + B = (a_1, a_2, a_3, a_4) + (b_1, b_2, b_3, b_4) = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4)$; $A - B = (a_1, a_2, a_3, a_4) - (b_1, b_2, b_3, b_4) = (a_1 - b_1, a_2 - b_2, a_3 - b_3, a_4 - b_4)$; $A \times B = (a_1, a_2, a_3, a_4) \times (b_1, b_2, b_3, b_4) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3, a_4 \times b_4)$; $A \div B = (a_1, a_2, a_3, a_4) \div (b_1, b_2, b_3, b_4) = (a_1 \div b_1, a_2 \div b_2, a_3 \div b_3, a_4 \div b_4)$.

4.2 Fuzzy DEMATEL method

DEMATEL (Fontela & Gabus, 1976) is a well-known approach in multi-criteria decision making based on graph theory and helpful in analyzing complex problems related to real life (Zhou et al., 2011). It portrays a basic concept of contextual relations among the elements of the system. These relations generally expressed by crisp values (Chen et al., 2011). There are limited crisp values in practical situations due to human interference and fuzziness in data (Shieh et al., 2013).

The fuzzy DEMATEL is an appropriate method for evaluating the decision making system under such fuzzy surroundings (Lin, 2013). Additionally, the fuzzy DEMATEL method can transform the interaction between the causes and effects of criteria into an intelligible structural model of the system. The procedural steps of fuzzy DEMATEL methodology (Gupta et al., 2016) with the objective of adoption and effective implementation of GSCM practices in Indian electronic industry are given as following:

Step 1. Define decision group and evaluation criteria: In this step, a critical review of literature is required to explore and gather relevant data. The expert's judgment is crucial that is why a decision group of experts is necessary to form for discussion on the issue to achieve the objective. The factors for successful implementation of GSCM practices as evaluation criteria are based on the information gathered and expert opinion.

Step 2. Obtain fuzzy direct assessment matrix: After identifying the evaluation criteria, it needs to develop their pair wise comparisons. For this, a five-point fuzzy linguistic scale (1 = no influence, 2 = low influence, 3= high influence, 4 = very high influence) is designed to help experts evaluate the interrelationships among different criteria. Based on this scale, experts are asked to make their linguistic judgment to develop a direct assessment/relation matrix of evaluation criteria. For evaluation corresponding TrFN is used given in Table 2.

Table 2
TrFN scale

Description of linguistic variable	Preference in terms of score	Equivalent TrFN
No influence	0	(0, 0, 0.1, 0.2)
Very low influence	1	(0.1, 0.2, 0.3, 0.4)
Low influence	2	(0.3, 0.4, 0.5, 0.6)
High influence	3	(0.5, 0.6, 0.7, 0.8)
Very high influence	4	(0.7, 0.8, 0.9, 1)

Step 3 Fuzzy initial direct relation matrix: Since the form of fuzzy numbers is not suitable for matrix operations. Therefore, for converting fuzzy numbers to a crisp number, de-fuzzification process is required. Based on the bisection of the area (method), we de-fuzzify the fuzzy assessment matrix by

using Eq. (1); the fuzzy average matrix (M) is set up by calculating the average of *k* fuzzy initial direct relation matrix (*A*) of $n \times n$ for all experts' opinions, *k* is no. of experts.

$$\mathrm{M} = \frac{1}{4}\,(a_1 + a_2 + a_3 + a_4) \tag{1}$$

Step 4 Obtain the normalized direct relation matrix: The normalized direct relation matrix (N) is obtained by using Eqs. (2-3):

$$\mathrm{L} = \mathrm{Min}\left[\frac{1}{Max\sum_{j=1}^{n} a_{ij}}, \frac{1}{Max\sum_{i=1}^{n} a_{ij}}\right] \tag{2}$$

$$\mathrm{N} = \mathrm{L} \times \mathrm{M} \tag{3}$$

Step 5 Construct the total-relation matrix. The normalized direct relation matrix (*D*) is transformed to the total relation matrix (*T*) in accordance with the Eq. (4) as given below:

$$\mathrm{T} = \mathrm{N}(\mathrm{I} - \mathrm{N})^{-1} \tag{4}$$

Step 7: Obtain causal parameters

R denotes the sum of rows and D denotes the sum of columns. This should be calculated through Eqs. (5-6):

$$R = \left[\sum_{i=1}^{n} a_{ij}\right]_{n\times 1} \tag{5}$$

$$D = \left[\sum_{j=1}^{n} a_{ij}\right]_{1\times n} \tag{6}$$

Step 8: Set up diagram

A causal and effect diagram is obtained here by means of the dataset consisting of (*R+D, R-D*)

4.3 Results Analysis

Fuzzy DEMATEL methodology is applied to evaluate the GSCM adoption success factors for Indian electronic industry. The details have been discussed below:

a) A decision group of four experts is formed consisting of people both from industry and academia. From the literature survey and experts' opinion, eight success factors of GSCM implementation were identified. After discussion with the decision group, these factors are finalized as the evaluation criteria (please see Table 1).
b) The experts are interviewed and inquired to evaluate the causal relations among eight implementation factors based on the fuzzy linguistic scale as shown in Table 2. Thus, the expert's linguistic assessments are obtained (see Table 3). These linguistic assessments are then replaced with corresponding TrFN (see Table 4). After this, the linguistic assessments are aggregated to crisp values by using Eq. (1). The crisp values represent the extent to which evaluation GSCM adoption success factor have direct impacts on each other. Based on this, the fuzzy initial direct-relation matrix (*A*) is derived as shown in Table 5.
c) By taking an average of ten fuzzy initial direct-relation matrices of the experts, the fuzzy average matrix (*M*) is derived.
d) The normalized initial direct relation matrix (*N*) is derived using Eqs. (2–3).
e) The normalized initial direct relation matrix is transformed into a total-relation matrix (T) through Eq. (4) (see Table 6).
f) The prominence and relation for each risk is calculated by using Eqs. (5-6) (see Table 7).

Table 3
Direct relation matrix

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8
CF1	-	0	3	0	0	1	0	1
CF2	1	-	0	0	1	0	1	3
CF3	0	1	-	0	1	1	1	1
CF4	0	0	2	-	0	2	0	2
CF5	0	0	1	1	-	3	0	1
CF6	0	1	1	1	1	-	1	3
CF7	0	1	1	1	1	1	-	2
CF8	1	1	1	1	1	3	1	-

Table 4
Fuzzy direct assessment matrix

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8
CF1	-	(0, 0, 0.1, 0.2)	(0.5, 0.6, 0.7, 0.8)	(0, 0, 0.1, 0.2)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)
CF2	(0.1, 0.2, 0.3, 0.4)	-	(0, 0, 0.1, 0.2)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0.5, 0.6, 0.7, 0.8)
CF3	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	-	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)
CF4	(0, 0, 0.1, 0.2)	(0, 0, 0.1, 0.2)	(0.3, 0.4, 0.5, 0.6)	-	(0, 0, 0.1, 0.2)	(0.3, 0.4, 0.5, 0.6)	(0, 0, 0.1, 0.2)	(0.3, 0.4, 0.5, 0.6)
CF5	(0, 0, 0.1, 0.2)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	-	(0.5, 0.6, 0.7, 0.8)	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)
CF6	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	-	(0.1, 0.2, 0.3, 0.4)	(0.5, 0.6, 0.7, 0.8)
CF7	(0, 0, 0.1, 0.2)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	-	(0.3, 0.4, 0.5, 0.6)
CF8	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.1, 0.2, 0.3, 0.4)	(0.5, 0.6, 0.7, 0.8)	(0.1, 0.2, 0.3, 0.4)	-

Table 5
Fuzzy initial-direct relation matrix F

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8
CF1	-	0.075	0.65	0.075	0.075	0.25	0.075	0.25
CF2	0.25	-	0.075	0.075	0.25	0.075	0.25	0.65
CF3	0.075	0.25	-	0.075	0.25	0.25	0.25	0.25
CF4	0.075	0.075	0.45	-	0.075	0.45	0.075	0.45
CF5	0.075	0.075	0.25	0.25	-	0.65	0.075	0.25
CF6	0.075	0.25	0.25	0.25	0.25	-	0.25	0.65
CF7	0.075	0.25	0.25	0.25	0.25	0.25	-	0.45
CF8	0.25	0.25	0.25	0.25	0.25	0.45	0.25	-

Table 6
Total direct relation matrix T

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8
CF1	0.0631	0.1298	0.4058	0.1132	0.1379	0.2419	0.1298	0.2561
CF2	0.1603	0.1010	0.1774	0.1286	0.1957	0.2093	0.1843	0.3942
CF3	0.1075	0.2097	0.3645	0.1389	0.2226	0.2842	0.2097	0.3072
CF4	0.1015	0.1438	0.3510	0.1050	0.1528	0.3320	0.1438	0.3477
CF5	0.0961	0.1374	0.2746	0.1897	0.1194	0.3923	0.1374	0.2857
CF6	0.1084	0.2004	0.2840	0.1960	0.2129	0.2013	0.2004	0.3639
CF7	0.1084	0.2004	0.2840	0.1960	0.2129	0.2846	0.1171	0.3639
CF8	0.1666	0.2075	0.3062	0.2022	0.2204	0.3552	0.2075	0.2372

Table 7
The prominence and relation for causal effect

	R	D	R+D	R-D
CF1	1.4776	0.9121	2.3897	0.5656
CF2	1.5508	1.3301	2.8809	0.2207
CF3	1.8443	2.4476	4.2919	-0.6033
CF4	1.6777	1.2698	2.9475	0.4079
CF5	1.6326	1.4745	3.1071	0.1582
CF6	1.7674	2.3008	4.0682	-0.5334
CF7	1.7674	1.3301	3.0975	0.4373
CF8	1.9029	2.5558	4.4587	-0.6529

After approval by decision group, next, a causal diagram is formed (see Fig. 2). Prominence (i.e. $R + D$), depicts the importance of success factors and is represented as horizontal axis vector. Similarly, the relation (i.e. $R - D$), depicts the categorization of cause and effect group and is represented as vertical axis vector. The causal effect diagram provides valuable insight for analyzing the critical factors of successful adoption of GSCM practices. With respect to different success factors, their positions and the relative importance in the system, experts can distinguish the success factors that help in implementation of GSCM practices in Indian electronic industry, and thus, improvements can be made accordingly.

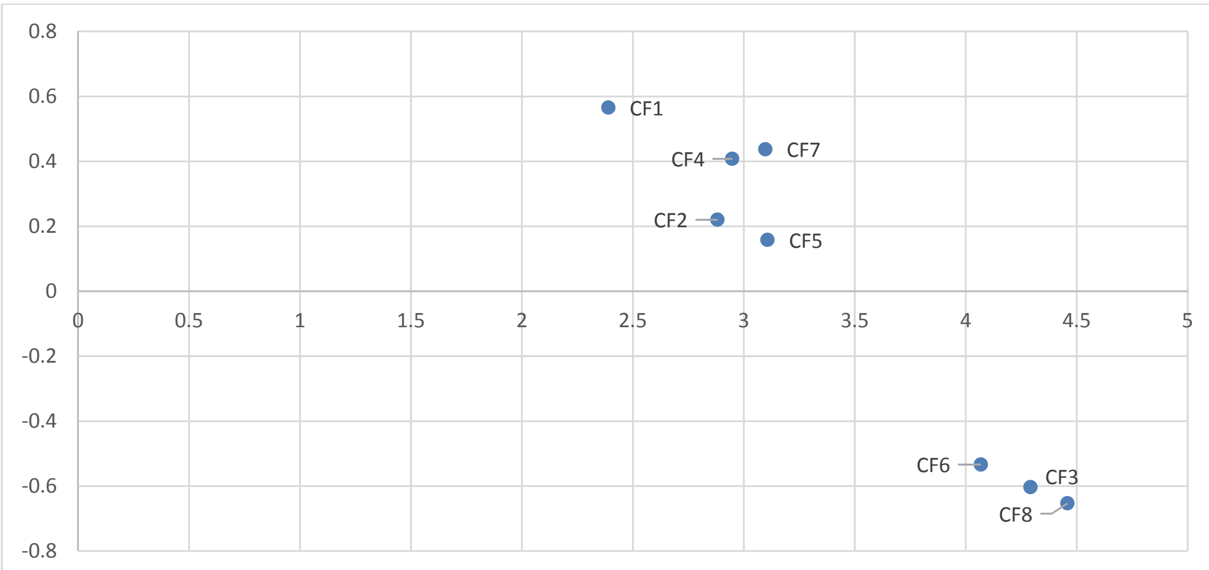

Fig. 2. The results of DEMATEL

5. Discussions and managerial implications

The ranking of the critical factors has been performed by observing in non-decreasing order of (R+D) score, which shows CF1>CF2>CF4>CF7>CF5>CF6>CF3>CF8 (Please see Table 7). According to the results, CF1 i.e. Government regulations received the first rank as critical success factor with the weightage value (2.3897), CF2 i.e. Top management commitment is the second with weightage value (2.8809) and CF4 i.e. Green procurement, designing & packaging attained the third position with weight value (2.9475). Last rank is obtained by CF8 i.e. Support & motivation from customers with weightage value (4.4587). Other CFs rating can be seen through Table 7. Additionally, findings of this study show that Government regulations (CF1) was the most influential factors among other factors. Hence, owing to legal obligations, organizations are incorporating green practices in their supply chains in various industries including electronic in developing countries (Prakash & Barua, 2016; Abdulrahman et al., 2014). Government is enforcing organizations to implement green practices therefore strategic group people are concentrating on adoption of green practices and this supports our findings that top management commitment (CF2) is focusing on green practices (Prakash & Barua, 2016). Adoption of green practices in supply chain management requires initiation and commitment from top management as it involves physical, technical and financial resources for green initiatives, strategy, concepts and ideas development (Bai & Sarkis, 2013). The third rank is obtained by green design, green purchasing and packaging (CF4) factor. Green design not only reduces environmental impact of the products but also it is able to restore resources (Lin, 2013). Green procurement is costly but it provides good corporate image, environmental protection, resource recovery options and less cost in disposition of the products (Azevedo et al., 2011). Therefore, organizations are looking to adopt green practices have to implement green procurement, designing & packaging (CF4) strategies into their supply chain. Next rank is acquired by organizational support for GSCM (CF7) factor. It is prerequisites in greening the supply chain; organizations' help, support and care are required to reach the objectives of GSCM practices. Organizational support & assistance is necessary for successful adoption of GSCM practices (Carter et al., 1998). The fifth rank is registered by cleaner technology development & advancement (CF5) factor. It includes green or environment-friendly technology, ecological innovations, modification and upgradation or advancement of production technology. Firms may attain low cost and environment-friendly manufacturing system by adopting cleaner production technology (Luthra et al., 2015). Adoption of cleaner technology also reduces waste and pollution and support in green production system. Sixth rank is acquired by green supplier development and certification (CF6) factor. It means focal firms have to encourage, motivate and involve their suppliers/vendors for green practices adoption and certification. Firms may influence suppliers to participate in green certification programs and guide and promote them towards cleaner technology and environmental concerns. Moreover, firms may work closely with them to achieve green practices in supply chain (Muduli et al., 2013). Seventh rank is achieved by waste minimization & reverse logistics adoption (CF3) factor. It suggests implementation of reverse logistics practices into supply chain process. Industries can reduce negative impact from environment and society by adopting reverse logistics practices in their supply chain process and efficient reverse logistics program can support companies to make effective utilization of resources and retain equilibrium between environment and economy (Diabat et al., 2013; Prakash & Barua, 2016b; Prakash & Barua, 2015a; Meng; 2008). The last rank is obtained by support & motivation from customers (CF8) factor. It means products and services are not only able to meet customers' expectations and requirements but also have environment-friendly properties. Customer would support and attract towards green products. It may help firms acquire new customers, attain sustainable business practices and get competitive advantage and good corporate image (Ageron et al., 2012).

By using this approach decision makers can identify and assess which critical factors are important in adoption of GSCM practices. Further, the results show that, Government regulations (CF1), Organizational support for GSCM (CF7), Green procurement, designing & packaging (CF4), Top management commitment (CF2) and Cleaner technology development & advancement (CF5) are categorized under cause set factors, i.e. the causer group factors based on descending order values of (R-D), on the other hand Green supplier development and certification (CF6), Waste minimization & reverse logistics adoption (CF3) and Support & motivation from customers (CF8) are classified as effect set factors i.e. the receiver group factors based on descending (R – D) score (please see Fig. 2).

6. Conclusions

Due to ecological issues, resource scarcity and increasing pollution; Indian electronic organizations are facing pressure from government and other agencies to adopt and implement GSCM practices. This study makes an attempt to identify critical factors for successful implementation of GSCM practices. This has been executed through the identification of critical success factors of GSCM adoption based on relevant studies in this area and industrial experts and then linguistic ratings were assigned by decision making team. Fuzzy DEMATEL has been applied next to get final rank and cause and effect relationships among factors which shows that government regulations was very important factor for successful adoption of GSCM practices followed by top management commitment towards these practices and green procurement, designing & packaging is the third important factor. Similarly other factors are organizational support for GSCM, cleaner technology development & advancement, green supplier development and certification, waste minimization & reverse logistics adoption and finally support & motivation from customers. Further cause and effect diagram is plotted to determine various cause elements, which shows that government regulations, organizational support for GSCM, green procurement, designing & packaging, top management commitment and cleaner technology development & advancement are cause group factors. The effect factors are green supplier development and certification, waste minimization & reverse logistics adoption and support & motivation from customers. This method considered uncertainty of expert opinions, which makes this approach intelligent support tool in decision making process.

Limitations and future scope of the study

Eight critical factors for successful adoption of GSCM practices were identified in this study. The other factors have not been identified and categorized. The proposed fuzzy DEMATEL-based analysis model may also be extended to different industry sectors in improving their organizational performance. However, the experts' opinions regarding factor evaluation may vary according to industry type, priorities, etc. Several extensions of this study may be possible for more number of quantitative and qualitative drivers/factors and various approaches such as MAUT, TOPSIS and VIKOR can be utilized to evaluate the factors.

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