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Evaluation of key enablers of green supply chain management in Indian manufacturing industries: a fuzzy approach

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Abstract: Manufacturing industries are an indispensable source for a nation's financial development; however, those industries are also a major source of increasing environmental issues. The situation is no different in India. Recently, green supply chain management (GSCM) is emerging as a key strategy that can reduce the negative impact on the environment. Indian manufacturing industries lag in implementing GSCM. This research highlights the different key factors that affect the execution of GSCM in the Indian manufacturing sector. Further, the fuzzy DEMATEL framework is established to prioritise the key factors and to establish a cause and effect relationship among the factors. The results of this study uncover that 'Environmental regulation and support factor' gains the dominant position among the main factors. Moreover, sub-factors like 'green innovation motivation', 'consumers' awareness about the environment', 'market competition', and 'reverse logistic adoption cost' create the highest impact on the execution of GSCM practices in Indian manufacturing firms.

Keywords: green supply chain management; GSCM; key factors; fuzzy DEMATEL; India; manufacturing.

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1 Introduction

Industries play an important role in the financial development of any nation. However; revolutions in the industrial sectors and a faulty supply chain could affect the environment badly (Muduli et al., 2013; Luthra et al., 2015). Due to immense population growth, the world has witnessed the growing insufficiency for daily needs within people. To overcome these problems mankind has started overuse of non-renewable resources which is leading to the depletion of those resources. The pollutants released from the industries not only increase the carbon footprint but also harm public health (Shahzad et al., 2020). Lack of proper planning for the disposal of hazardous wastes has made the industrial pollution issue a severe one (Kusi-Sarpong et al., 2016; Kaur et al., 2017). To overcome these environmental issues, developed nations like the the USA, China, Japan, the UK, have figured out the proper implementation of the green supply chain into their industrial processes. In 2012, a historical earth summit was organised in Rio de Janeiro, Brazil. At this summit, which focused on 'sustainable economic development', organisations, as well as government officials from across the world, agreed to take needed actions to protect the environment from damage.

Indian manufacturing industries are vital sources of the nation's financial development (Sahoo and Vijayvargy, 2020). However, those industries are also a major reason for the rising environmental issues in the country (Gandhi et al., 2016; Mangla et al., 2015a, 2015b). In the past few years, developed nations have incorporated green practices into their conventional supply chain which helped them to achieve sustainability, and increase the brand value of their organisations (Wang et al., 2016). As indicated by an ongoing survey, the cleaner production market will reach $1.6 trillion by 2020, up from $670 billion in 2010. The World Resources Institute estimated that individuals at the base of the income pyramid whose income is under $3,000 per year, epitomise a worldwide market of more than $5 trillion.

Around the world, enthusiasm for environmental safety and people's attraction towards green products is gaining popularity. Nowadays, not only the customers but also the regulatory bodies are more concerned about nature and safety (Fang and Zhang, 2018). Green supply chain management (GSCM) is the process of incorporating eco-friendly activities into supply chain management. It comprises of 'sourcing and choice of environment-friendly materials', 'green product configuration', 'eco-friendly manufacturing procedures', 'delivery of the end product to the customers without making any harm to the environment', and at last the 'end-life management of the product' after its valuable life (Srivastava, 2007). With the assistance of GSCM, firms can alleviate risk, accelerate their innovations in eco-friendly product design, and improve operational efficiency. Eco-friendly production and green distribution packaging help businesspersons to gain economic benefits (Çankaya and Sezen, 2019). GSCM has a strong and positive impact on both environmental impact and environmental cost-saving (Al-Sheyadi et al., 2019). GSCM establishes collaboration among the supplier communities which makes the circulation of environmentally friendly products easy (Govindan et al., 2014). The idea of every supply chain must be eco-friendly so that it could help organisations in accomplishing their ecological goals.

The planning and execution of GSCM may include different factors. For example, 'knowledge factors', 'regulatory factors', 'economic factors', 'environmental factors', etc. How these factors affect GSCM is addressed further in the 'research methodology' part of this study. These factors could help an organisation to convert its conventional supply chain to a green supply chain. Currently, firms need to recognise those key factors for the effective execution of GSCM. This study recognises the essential factors which could help the organisations to implement green ideas into their supply chain scenario. Several research articles have been referred by the authors to explore enablers, key factors, and barriers related to GSCM in different types of industries. For example, mining, automobile, paper, cement, rubber, food packaging, etc.

From an extensive literature review, authors have gathered a handful of information about (Zhu and Sarkis, 2007) the influential factors of GSCM. Those identified factors are needed to be prioritised according to their influential strength on industries. Those studies from the literature review have also uncovered that over the last few years, researchers used different mathematical modelling and tools to prioritise their identified factors. Luthra et al. (2015), Zhu and Sarkis (2007) and Tong et al. (2012) proposed the regression model for analysing the influential factors of GSCM in Chinese manufacturing firms. Mavi et al. (2013) proposed a fuzzy DEMATEL for ranking the logistic factors of GSCM in Asian manufacturing industries. Irajpour et al. (2012) applied the fuzzy DEMATEL model to rank the key factors of GSCM considering the automobile industries of Iran. Kusi-Sarpong et al. (2016) proposed a fuzzy DEMATEL and ANP method to analyse the GSCM factors considering the mining industries of Ghana. Kaur et al. (2017) proposed a DEMATEL model to rank the challenges of GSCM in Canadian manufacturing industries. Holt and Ghobadian (2009) conducted an empirical study in GSCM among UK manufacturing industries using a hypothesis analysis and questioner-based survey. Lin (2013) and Lin et al. (2018) selected the fuzzy-based DEMATEL and proposed a model for raking the influential factors in the electrical and electronic industries of Taiwan. In India, Muduli et al. (2013) proposed a graph theory and matrix approach and categorised the behavioural factors of GSCM in the Indian mining industries. Gandhi et al. (2016) developed a structural model using DEMATEL for ranking the influential factors of GSCM in Indian manufacturing industries. Gandhi et al. (2016) and Mangla et al. (2015a) carried out their research in Indian manufacturing industries and proposed an AHP-based DEMATEL for establishing the relationship between the influential factors of GSCM. Majumdar and Sinha (2018) proposed an ISM model to analyse the barriers of GSCM in textile industries in the South-east Asia region.

An extensive literature survey confirmed that in India though researchers have conducted some studies to identify the influential factors of GSCM, still those findings are not sufficient enough to describe the influential strength of the factors effectively. Previously, researchers have considered fewer key-factors for their study. This study widens the research field by considering more key-factors. It is very difficult to develop a causal relationship among the influential-factors and to know the impact of one factor over the other. As a result, this study proposes to use the fuzzy DEMATEL model for the prioritisation of key factors and the establishment of causal relationships among them. Specifically, the objectives of this study are:

a Identification and finalisation of key factors of GSCM in Indian manufacturing industries.

b Prioritisation and establishment of a relationship among the identified key factors.

To fulfil the objective of this study, the authors have conducted an intense literature survey regarding influential factors of GSCM. Further, a questionnaire survey has been conducted by the authors. Based on the survey result and expert inputs authors have finalised the key factors of GSCM. A total of 29 factors are finalised and grouped under five main categories. As previously in this study a fuzzy DEMATEL model has been chosen for prioritisation of the key factors, the authors would like to proceed with the same approach. The causal diagrams would help the readers to understand the cause and effect relationship among the factors. Fuzzy DEMATEL is a robust method that has been used by various analysts for examining and surveying the incomprehensible problems in different fields (Deng and Jiang, 2019). Lin (2013) used this methodology to establish a proper green production network, and Mangla et al. (2018) employed it for developing the framework of risk management in green supply chain.

A section-wise discussion is presented further in this study where Section 1 shows the objective of the present work. Section 2 describes the literature review related to GSCM from the perspective of foreign countries and Indian manufacturing industries. The end part of Section 2 illustrates the research gaps. Section 3 describes the selection of key factors with the help of expert opinion. Thereafter, this section describes the fuzzy DEMATEL model step by step. Then Table 2 demonstrates the list of 29 finalised key factors under five main key factors. Section 4 holds the outcome of this study. Here, the mathematical model is used to analyse and prioritise the influence of the key factors on GSCM in Indian manufacturing industries. Section 5 delivers the conclusion of our study and future research guideline. This paper mostly consists of recent activities and explorations which makes it eye-catching and noteworthy for both industries and academia to gain a genuine unmitigated idea about GSCM.

2 Literature review

GSCM has turned into the most genuine and complex issue over the previous decades. The implementation of GSCM factors in an industrial field varies over different circumstances. The factors that influence the green supply chain in a developed country may not be the same as in a developing country. Apart from that social and cultural backgrounds, geological factors also possess a great impact on the GSCM factors. Countries all over the world are taking needed actions by formulating strict policies to alleviate environmental pollution. Such policies are applied to all enterprises which include manufacturing sectors and services sectors. Excess carbon emission from manufacturing industries higher the risk of environmental damage. In this study, the authors considered common factors that influence GSCM practices in Indian manufacturing industries. These factors have both positive and negative effects on GSCM implementation. This section shows a comparative study between the status of GSCM in foreign countries and India.

2.1 Literature review related to GSCM in foreign countries

Hu and Hsu (2006) performed a questionnaire survey and recognised the key success factors of GSCM in the electrical and electronics industry and then finalised that product recycling, supplier management, organisational participation, and life cycle management are the most influential valid factors. Hsu et al. (2013) performed an empirical study in the electronics industries of Taiwan and proposed a DEMATEL model. Lin (2013) conducted his study in the electrical and electronic industries of Taiwan. He established a cause and effect relationship between the GSCM factors with the help of a fuzzy DEMATEL model. His study uncovered that 'supplier-customer collaboration', 'reuse of products, and government regulation' fall under the cause group. 'Economic performance', 'green design', and 'stakeholders' pressure' fall under the effect group. Tsai et al. (2015) conducted their study in the printed circuit board industries of Taiwan and used a fuzzy DEMATEL model to rank the key-factors. The results of their study uncovered that 'green design' and 'eco-friendly material procurement' acted as important factors to create a good green supply chain.

Liu et al. (2012) conducted a questionnaire survey and measured the overall GSCM practices in Chinese manufacturing companies. In his study, he considered 165 valid respondents and finally concluded that the sustainability issue of a firm could be solved by frequent internal training of employees. Wang et al. (2016) distinguished the key barriers of GSCM in a packaging business and proposed a DEMATEL model. their study exhibited that 'absence of satisfactory training and progress observing', 'poor customer mindfulness', and 'absence of pressure for GSCM adoption' possessed negative impact to the execution of GSCM. Mavi et al. (2013) proposed a fuzzy DEMATEL model and ranked the logistic factors of GSCM in Asian manufacturing industries. Their study uncovered that environment-friendly packaging of products acts as a crucial factor for GSCM implementation. Rostamzadeh et al. (2015) performed their research in the laptop industries of Malaysia and proposed a fuzzy VIKOR model to rank their factors.

Irajpour et al. (2012) proposed a fuzzy DEMATEL model and ranked GSCM factors in the automobile industries of Iran. Their study uncovered that factors like 'cleaner production', 'effective communication', 'environmental agreement', 'government eco-friendly policies', 'green brand image' highly influence GSCM practices. Kazancoglu et al. (2018) proposed a fuzzy DEMATEL model for ranking the criteria of GSCM in the cement industries of Iran. Ghafourian and Shirouyehzad (2019) conducted their study in the manufacturing industries of Iran. They identified the essential critical success factors of a sustainable supply chain and proposed an ISM model to determine the relationship between the success factors. Kaur et al. (2018) investigated the essential barriers in GSCM in Canadian manufacturing industries and proposed a DEMATEL approach. Their study uncovered that 'knowledge-related barriers', 'commitment related barriers', and 'product design related barriers' possess a negative effect on GSCM implementation.

Zhu (2010) performed a comparative study about GSCM implementation between Chinese and Japanese large manufacturing industries and their study uncovered that Japanese industries perform green practices much effectively than Chinese industries.

Their study uncovered that 'appropriate regulation' and 'government policies' could accelerate the spread of GSCM from large manufacturing industries to small scale and medium scale industries. Zhu et al. (2013) conducted their research in 369 Chinese manufacturing industries and explored that institutional pressure has forced the manufacturers towards the adoption of GSCM practices. Their study uncovered that green supply chain practices may not possess a direct impact on economic performance but indirectly GSCM could positively affect the economy. Zhu and Sarkis (2007) performed a moderated hierarchical regression analysis. They conducted their study based on the data obtained from 341 Chinese respondents and reported that 'increasing environmental pressure', 'regulatory pressure', 'adoption of green design and green purchasing', and 'economic benefits' are the crucial factors for adoption of GSCM practices in manufacturing industries. Youn et al. (2013) performed their study in 141 Korean manufacturing industries then tested the result through a structural equation model. Walker et al. (2008) interviewed seven different private and public sector organisations and explored both of the factors that drive and/or hinder the implementation of GSCM initiatives

Tong et al. (2012) conducted their study in IT manufacturing industries in China and proposed a logistic regression analysis to rank their identified factors. They examined the green supply chain diffusion of lead-free soldering in IT industries. Nazam et al. (2015) proposed a fuzzy-TOPSIS model for green supply chain risk management in Pakistan textile industries. Sabegh et al. (2016) conducted a questionnaire-based survey in more than 180 Turkish companies to find out the influential strength of internal and external members on GSCM practices in the business field. They used a statistical method to analyse the data. Their result confirmed that the GSCM market in the industries is highly influenced by third-party logistics service providers. Said (2019) conducted a comparative study to know the effect of GSCM practices on operational performance between Shell and cooperation petroleum company in Egypt. His study found that accepting the GSCM into the operational field made the shell company the number one lubricant industry in Egypt.

Hosseini and Fallah Nezhad (2019) in their study developed a dynamic program to develop an optimal policy for order allocation and green supplier selection. they proposed a two-level supply chain model where the first part contained an AHP model to rank the suppliers and the second part ranked the other constraints. Tumpa et al. (2019) surveyed Bangladeshi textile industries to gather information about the potential barriers of GSCM. They did a hierarchical cluster analysis to rank their identified barriers. Their result uncovered that lack of government regulation and low demand from customers acted as the most significant barriers to GSCM implementation in Bangladeshi textile industries.

Tseng et al. (2019) conducted a literature survey on GSCM. In their study, they discussed the new trends and future challenges of GSCM in manufacturing firms. they covered different aspects and various areas of GSCM like the year of publication. strength of the publication, growth of the GSCM. Mumtaz et al. (2018) proposed a linear regression approach to evaluate the impact of GSCM on industrial-organisational performance in Pakistan. Their study indicates that lack of knowledge about the economic performance of GSCM hinders the use of green practices in the country. Holt and Ghobadian (2009) conducted an empirical study on GSCM among UK manufacturing industries and proposed the mathematical model to rank factors that influenced the operational activities of GSCM.

2.2 Literature review related to GSCM in Indian manufacturing industries

The manufacturing sector is considered the backbone of the Indian economy. In past years, several studies have been conducted by the researchers. The result of their study has confirmed that industries in developing countries like India are mainly focused on profit. Those industries are not much more concerned about environmental damages. The number of companies that introduced a sustainable production system into their manufacturing field is insignificant. This part of our study is mainly focused on Indian manufacturing industries and the status of GSCM in India.

Mannan et al. (2016) conducted their research in Indian manufacturing industries. They proposed an ISM with fuzzy MICMAC analysis for the establishment of the interrelationship between the key factors. The result of their study confirmed that 'government regulation' possessed higher dominating power and 'employee nature and work culture' carried strong dependence power. Luthra et al. (2015) conducted their study in 123 Indian automobile industries and examined the impact of critical success factors of GSCM on those industries. They considered a multiple regression analysis to analyse their factors. Their analysis result confirmed that 'regulatory factors' play a vital role in the promotion of green practices. Luthra et al. (2015) conducted their study in the Indian mining sectors. They proposed an ISM and MICMAC model for prioritising 26 key success factors of the green supply chain.

Raut et al. (2017) conducted their study in Indian oil and gas industries and identified 32 key success factors of GSCM. They applied ISM and MICMAC analysis for establishing a relationship between the identified factors of GSCM and end up with a conclusion that 'global climate change' and 'scarcity of natural resources' are the most influential characters. Muduli et al. (2013) categorised the behavioural factors of GSCM in the Indian mining industries and used the graph theory and matrix approach for calculating the green behavioural index of their identified factors. Their result uncovered that 'involvement from the top authority and effectiveness' influenced the success of green practices in industries. Govindan et al. (2014) identified the driving factors of GSCM and used a DEMATEL method to extract the cause and effect relationship among the factors. To rank the factors according to their influential strength they investigated the influence of those driving forces on each other and the entire system. Their study explored that 'competitiveness' and 'top management commitment' acted as the most important driving factors whereas 'employee pressure'' acted as the least one.

Malviya and Kant (2017) conducted a questionnaire-based survey and identified 35 GSCM enablers. First, they applied ISM to develop a mutual relationship among the factors and then applied fuzzy MICMAC to reveal the direct and indirect effect of factors and. The result of their study concluded that 'top management commitment and supports', 'good environment policies', and 'supplier commitment' were the factors that influenced the GSCM practices. Sharma et al. (2017) formulated a questionnaire-based survey with a collaboration with academic and industrial experts. They did the data analysis, AHP analysis, and Sensitivity analysis and found the performance indicators in GSCM. Haleem et al. (2012) used both ISM and then IRP modelling to analyse the inter-relationship among the key success factors of GSCM. Mudgal et al. (2009) performed their study in Indian manufacturing sectors and identified various success factors of GSCM processes. They proposed an ISM model to rank the factors and then did MICMAC analysis to understand the dependence and driving power of those factors.

Ali et al. (2018) conducted their study on Indian automobile industries in the Pune-Nashik area. They considered15 automobile industries to conduct their research. They proposed an ISM model to establish a relationship between their identified GSCM enablers. Amaladhasan et al. (2019) conducted their research considering the Indian automobile industries. They used an eco-balanced scorecard to evaluate the key performance indicators of GSCM. They used the fuzzy AHP to calculate the weight of the chosen evaluation indexes and applied fuzzy VIKOR and GRA to rank the GSCM performances. Kurian et al. (2018) conducted a questionnaire-based survey in the petroleum industrial sector of India to analyse the key factors influencing the implementation of GSCM practices and innovations.

2.3 Research gap

Despite being a well-known manufacturing hub, India is still in the rudimentary stage for the implementation of GSCM practices. Industries are unaware of the positive effect of GSCM and struggling to identify the necessary factors which could make their manufacturing process eco friendly. Developed countries like the USA, the UK, and Japan have already implemented the GSCM procedure into their industrial field and a review of previous literature indicates that a lot of research also has been carried out in those countries in the green supply chain. It is noticed that as compared to those countries only a few research has been conducted about the implementation of GSCM practices in India. Those research are not sufficient enough to describe the influence of factors on GSCM effectively. Previously researchers have considered a smaller number of factors. This study widens the research field by considering a greater number of factors that affect the GSCM in different ways. The literature review also addresses that the fuzzy-based DEMATEL approach is one of the most popular tools among the researchers for the ranking of factors in foreign countries. But no research has been conducted for prioritising the key factors using fuzzy DEMATEL in Indian manufacturing industries.

So far, to the best of our knowledge, the number of studies to prioritise the GSCM factors using a fuzzy-DEMATEL model in Indian manufacturing industries are keen on the ground. As a result, this study proposes to employ the fuzzy-based DEMATEL technique that not only assists us to determine the causal relationship between every factor as well as assists to define the importance of inter-relationship between each factor.

Thorough scrutinisation of the literature gap widens the pathway to determine the objective of this study. The primary objective of this study is to carry out a critical literature review and identify the key factors of GSCM in Indian manufacturing industries. Secondly, this study aims to analyse and prioritise those identified key factors with the help of a fuzzy DEMATEL model.

3 Research methodology

The authors decided to approach with a fuzzy DEMATEL method as a solution for this research work. The DEMATEL incorporated with a fuzzy environment is considered a successful approach for solving decision-making problems. This method is used to establish a causal relationship between the factors that can reduce the problem of decision making for researchers. It has been quite observed that more often researchers face problems to quantify the value of their identified factors. This happens because those identified factors possess an inter-relationship among them which makes those factors difficult to quantify. DEMATEL helps in a quantitative analysis of the factors which helps the researchers to quantify the value of their identified factors.

3.1 Data collection

At first, the authors carried out a complete literature survey and identified the key factors which might influence GSCM practices in Indian manufacturing industries. Thereafter, a questionnaire was developed to recognise the judgment of experts which further helped the authors to finalise the factors. The questionnaire with a list of key factors was sent to the experts related to the area of GSCM, reverse logistics, green designing, and sustainability development.

The questionnaire was made up of two parts.Section-1 of the questionnaire contained the queries about individual data of the respondents like the name of the person, designation, highest educational qualification, work experience, name of the organisation, and type of the organisation. Section 2 required the opinion of the experts about the impact of the key factors on GSCM practices in Indian manufacturing industries. This section represented a table that was filled with a list of key factors of GSCM which the authors had collected from their literature review. In Section 2, experts were asked to rate the key factors in a five-point Likert scale where 0 represented 'No influence'; 1 represented 'very low influence'; 2 represented 'low influence'; 3 represented 'high influence'; and 4 represented 'very high influence'. The respondents were requested to rate these factors accordingly. The Likert scale aimed to eliminate the factors which might bear inferior ratings and less influence on GSCM.

The questionnaire was sent to the 15 experts, out of these experts nine are from academia and six are industry experts. In return, the authors have received the response from five academic and three industry experts which gives a total response rate of 53.33%. Based on the response and suggestion of experts, the authors have finalised 29 key factors of GSCM. The factors taken by the authors are highly valuable and possess great influential strength on GSCM in Indian manufacturing industries, so no factors were eliminated. The identified 29 factors are grouped under five main factors. The main factors and sub-factors are listed in Table 2.

The authors have decided to use the fuzzy-DEMATEL approach. The first step in this approach is to create an initial direct relation matrix and for that expert advice is most needed. So to develop an initial direct relation matrix, the lists of key factors were sent to the experts seeking their responses. A brief discussion about the development of a direct relation matrix is presented in the next section. Five experts from academia and three experts from the industry were consulted to extract the key factors and develop the direct relation matrix. The low sample size of the respondents could have been a problem for the evaluation of the key factors but thanks to the advantage of the DEMATEL method which can be used with lower sample size.

3.2 Fuzzy DEMATEL technique

First, the DEMATEL methodology came into the concept between 1972 to 1976. This method was first developed by the Battelle Memorial Institute of Geneva (Kumar et al., 2018). This method helps to solve complex management problems efficiently. It establishes the inter-relationship between the factors and categorises them with the help of a causal diagram. Because of some major advantages of DEMATEL over ISM and AHP. This method has been popularly accepted in foreign countries and now gaining popularity among Indian researchers. DEMATEL method is flexible, accurate, and also it can prioritise the factors. It can develop an inter-relation between the factors with a limited data source. This method helps not only to establish the causal relationship between every factor but also to evaluate the importance of inter-relationship between each factor. In real-life applications, human decisions are regularly misty, and accurate numerical values are hard to find which makes it more difficult to evaluate the inter-dependency relationships among the factors (Lin et al., 2018). Thus, the idea of combining the fuzzy sets hypothesis with the DEMATEL has emerged. This methodology consists of the following steps.

3.2.1 Step 1: Development of initial direct relation matrix for each expert

Based on a fuzzy linguistic scale, experts compared the key factors in this step. The linguistic scale comprises five symbols. When factor 'i' have no influence on factor ' j', the symbol is'; When factor 'i' have a very low influence on factor 'j', the symbol is 'VL'; When factor 'i' have a low influence on factor 'j', the symbol is 'L'; When Factor 'i' have a high influence on factor 'j', the symbol is 'H'; When Factor 'i' have a very high influence on factor 'j', the symbol is 'VH'.

Authors obtained the initial direct relation fuzzy matrix $Flk = [f_{ij}^{k}]_{t^*t}$ from the k^{th} expert, where the value of k lies between 1 to 'e'. The fuzzy comparison is done by the k^{th} expert among the factors f_i and f_j based on a fuzzy linguistic scale as shown in Table 1. For $i = j$ the score is set to zero. There are a total of 't' number of identified factors and 'e' is the total number of experts.

Table 1 Fuzzy linguistic scale

Linguistic terms	*Score*	*Triangular fuzzy number*
No (N)	0	(0, 0, 0.25)
Very low (VL)	1	(0, 0.25, 0.5)
Low (L)	2	(0.25, 0.5, 0.75)
High (H)	3	(0.5, 0.75, 1)
Very high (VH)	4	(0.75, 1, 1)

Converting fuzzy numbers into crisp scores (CFCS) is incorporated for de-fuzzifying the value obtained by each expert in the fuzzy environment. The advantage of the CFCS method is that it converts a fuzzy number into a crisp score and produces better results. CFCS method consists of the following four steps.

1 Normalisation for each comparison

$$\underline{g}_{ij}^{k} = \frac{\left(g_{ij}^{k} - c\right)}{s - c} \tag{1}$$

$$\underline{h}_{ij}^{k} = \frac{\left(h_{ij}^{k} - c\right)}{s - c} \tag{2}$$

$$\underline{l}_{ij}^{k} = \frac{\left(l_{ij}^{k} - c\right)}{s - c} \tag{3}$$

where $s = \max_j l_{ij}$, $c = \min_j g_{ij}$.

2 Calculation of left and the right normalised value

$$\underline{g}_{ij}^{k,lh} = \underline{h}_{ij}^{k} \Big/ \left(1 + \underline{h}_{ij}^{k} - \underline{g}_{ij}^{k}\right) \tag{4}$$

$$\underline{l}_{ij}^{k,rh} = \underline{l}_{ij}^{k} \Big/ \left(1 + \underline{l}_{ij}^{k} - \underline{l}_{ij}^{k}\right) \tag{5}$$

3 Computation of total normalised value

$$y_{ij}^{k} = \left[\underline{g}_{ij}^{k,lh}\left(1 - \underline{g}_{ij}^{k,lh}\right) + \underline{g}_{ij}^{k,lh}\,\underline{l}_{ij}^{k,rh}\right] \Big/ \left(1 - \underline{g}_{ij}^{k,lh} + \underline{l}_{ij}^{k,rh}\right) \tag{6}$$

4 Crisp value

$$x_{ij}^{k} = \min_j g_{ij} + y_{ij}^{k}(s - c)$$

3.2.2 Step 2: Development of average direct relation matrix (A)

The average value received from the expert helped in creating an average direct relation matrix.

$$X = \left[\frac{\sum_{k=1}^{e} x_{ij}^{k}}{e}\right]_{t^*t} \tag{7}$$

3.2.3 Step 3: Development of normalised matrix (B)

The normalised matrix can be identified by dividing the matrix *X* with a scalar *p*. The calculation process for the value of *p* is shown below.

$$p = \max_i \left(\sum_{j=1}^{t} X_{ij}\right) \tag{8}$$

$$W = \left[w_{ij}\right]_{t^*t} = X / p \tag{9}$$

3.2.4 Step 4: development of total relation matrix (T)

Equation (10) shows matrix *Z* which is developed from matrix *W*. In this equation, '*I*' is an identity matrix of order t^*t.

$$Z = \left[z_{ij}\right]_{t^*t} = W * [I - W]^{-1} \tag{10}$$

3.2.5 Step 5: Development of causal relationship

As per equations (11) and (12), the values for D + R and D – R are calculated for each factor. Then authors plotted a causal diagram considering the values of D + R and D – R. The value of D + R is taken on the X-axis and the value of D – R is taken on Y-axis.

D + R reveals how much overall influence is possessed by a factor. The factor which has a higher value of D + R possesses a higher impact on the GSCM and the factor which have a lesser value of D + R possesses a low impact on GSCM. D – R tells us about the kind of relation between criteria. When D – R-value is positive the criteria belong to the cause group. When D – R-value is negative the criteria belong to the effect group that means these are affected by other criteria. Further, authors have established an interdependence among the key factors with the help of the threshold value, α. Equation (13) is used to obtain the threshold value 'α'. The values in the matrix Z which exceed α are considered for the development of causal relationships among the factors.

$$D_i = \sum_{j=1}^{t} z_{ij} \tag{11}$$

$$R_i = \sum_{i=1}^{t} z_{ij} \tag{12}$$

$$\alpha = \left(\sum_{i=1}^{t} \sum_{j=1}^{t} z_{ij} \right) \Big/ t \tag{13}$$

3.3 Key factors of GSCM

From the literature survey, it is observed that researchers have conducted several studies on the implementation of GSCM practices in developed countries. However, developing countries like India are still in the beginning phase of implementing GSCM activities into their firms. From the literature survey and expert opinion, the authors have identified 29 influential key factors of GSCM shown in Table 2.

In Table 2, 29 key factors are cited along with the respective name of the authors shown in the column to the immediate right of the respective factors. The 29 key factors are grouped under five main factors namely:

1 ecological factors (F1)
2 environmental regulation and support factors (F2)
3 commercial factors (F3)
4 social factors (F4)
5 knowledge and technical factors (F5).

3.3.1 Ecological factors (F1)

The factors related to environmental safety are the most relevant and possess a great positive impact on GSCM implementation in manufacturing industries. First of all, to create a green environment, the primary step is the construction of green infrastructure. The use of eco-friendly materials reduces the generation of hazardous waste and lowers the carbon footprint in the environment. Now people are aware of the scarcity of natural resources and started to adopt eco-friendly and green manufacturing products which encourage a firm's green existence.

Table 2 Key factors of GSCM

No.	*Key factors*	*Authors*
Ecological factors (F1)		
1	Proper disposal of waste (EF1)	Soda et al. (2016), Prakash et al. (2015), Mathiyazhagan et al. (2015), Gandhi et al. (2016), Bhool and Narwal (2013), Mangla et al. (2015a)
2	Consumer awareness about the environment (EF2)	Jia et al. (2015), Prakash et al. (2015), Mudgal et al. (2009), Mangla et al. (2015a, 2015b)
3	Diminishing natural resources (EF3)	Govindan et al. (2015), Luthra et al. (2015), Muduli et al. (2013)
4	Green infrastructure (EF4)	Govindan et al. (2014), Rehman and Srivastava (2011), Luthra et al. (2011), Rehman and Shrivastava (2011)
5	Low carbon footprint (EF5)	Gupta et al. (2015), Muduli et al. (2013), Ravi and Shankar (2015), Mangla et al. (2015b)
6	Eco-friendly materials (EF6)	Govindan et al. (2014), Balon et al. (2016)
Environmental regulation and support factors (F2)		
7	Strategic planning by top authority (ESF1)	Prakash et al. (2015), Mudgal et al. (2010), Govindan et al. (2014), Luthra et al. (2015), Diabat and Govindan (2011)
8	Supplier and management relationship (ESF2)	Govindan et al. (2014), Balon et al. (2016)
9	Environment awareness of management board (ESF3)	Govindan et al. (2014), Luthra et al. (2011), Mathiyazhagn et al. (2013), Gupta and Barua (2018)
10	Commitment from management board (ESF4)	Luthra et al. (2015, 2011), Gandhi et al. (2016, 2018), Dubey et al. (2015)
11	Government regulation and policies (ESF5)	Mathiyazhagan et al. (2013), Gupta and Barua (2018), Jayant and Azhar (2014), Balaji et al. (2014)
12	ISO 14001 certification (ESF6)	Muduli et al. (2013), Mudgal et al. (2009), Mathiyazhagan et al. (2013), Diabat and Govindan (2011), Mangla et al. (2015a, 2015b)
Commercial factors (F3)		
13	Green packaging cost (CF1)	Rehman and Srivastava (2011), Seth et al. (2018), Ravi and Shankar (2015), Rehman and Shrivastava (2011)
14	Fear of failure (CF2)	Govindan et al. (2014), Mathiyazhagn et al. (2013), Gupta and Barua (2018), Jayant and Azhar (2014)
15	The implementation cost of new technology (CF3)	Gandhi et al. (2016), Luthra et al. (2011), Balon et al. (2016), Ravi and Shankar (2015), Dubey et al. (2014)
16	Economic benefit (CF4)	Gandhi et al. (2018), Soda et al. (2016), Rehman and Srivastava (2011), Rehman and Shrivastava (2011)
17	Bank loans to encourage green products (CF5)	Mathiyazhagan et al. (2013), Govindan et al. (2014), Jayant and Azhar (2014)
18	Reverse logistic adoption cost (CF6)	Mathiyazhagn et al. (2013), Govindan et al. (2014), Gupta and Barua (2018), Jayant and Azhar (2014), Mangla et al. (2015a), Mudgal et al. (2010), Prakash and Barua (2016)

Table 2 Key factors of GSCM (continued)

No.	*Key factors*	*Authors*
Social factors (F4)		
19	Corporate social responsibilities (SF1)	Reheman and Srivastava (2011), Seth et al. (2018), Ravi and Shankar (2013)
20	Market competition (SF2)	Mudgal et al. (2009), Gandhi et al. (2018), Ravi and Shankar (2015), Mangla et al. (2015a), Rehman and Srivastava (2011)
21	Role of stakeholder and NGO and media (SF3)	Mangla et al. (2015a), Govindan et al. (2015), Gandhi et al. (2016)
22	Green brand image (SF4)	Gandhi et al. (2018, 2015), Mangla et al. (2015a, 2015b), Sharma et al. (2017), Mathiyazhagan et al. (2013), Gandhi et al. (2016), Seth et al. (2018)
Knowledge and technical factors (F5)		
23	proper training about GSCM implementation (KTF1)	Wang et al. (2016), Govindan et al. (2014), Gupta and Barua (2018), Mathiyazhagan et al. (2014), Jayant and Azhar (2014), Balaji et al. (2014), Prakash and Barua (2016)
24	Green education at the academic level (KTF2)	Shibin et al. (2016), Mangla et al. (2018)
25	Availability of advanced green technology and information (KTF3)	Govindan et al. (2013), Mathiyazhagan et al. (2013), Shibin et al. (2016)
26	Eco-friendly process design (KTF4)	Prakash et al. (2015), Mudgal et al. (2010), Govindan et al. (2014), Luthra et al. (2015), Diabat and Govindan (2011)
27	Green innovation motivation (KTF5)	Mangla et al. (2018), Wang et al. (2016), Govindan et al. (2015), Gupta et al. (2015), Mathiyazhagan et al. (2014), Jayant and Azhar (2014)
28	Research and development of a green product (KTF6)	Gupta et al. (2015), Govindan et al. (2015), Rehman and Srivastava (2011)
29	Skilled workforce (KTF7)	Govindan et al. (2014), Luthra et al. (2011), Mathiyazhagan et al. (2013), Gupta et al. (2015)

3.3.2 Environmental regulation and support factors (F2)

The factors that fall under this group are related to the regulation and law enforcement and the support factor for GSCM. A strong and obligatory commitment from the top authority of the company accelerates the GSCM implementation practices in the organisation. Strict government rules and regulations and environment-friendly certifications like ISO 14000 certification encourage the industries to approach sustainability. A good supplier and management relationship inside an organisation help to create a work-friendly environment. It also helps in the successful implementation of eco-friendly ideas. Above all, a consciousness of the top management board about environmental safety is highly essential. It creates an eco-friendly environment inside and outside the company. These valuable factors have a highly influential strength for the implementation of GSCM in the Indian context.

3.3.3 Commercial factors (F3)

Financial support is a vital need for every sector raising from small scale industries to large-scale industries. The availability of bank loans helps entrepreneurs and manufacturers to built a sustainable environment inside an organisation. Availability of good financial support, the low-cost of environment-friendly packaging of products, comparatively more profit by the implementation of new eco-friendly technologies in the industry, encourages the adoption of GSCM. Green supply chain practices may not possess a direct impact on economic performance but can increase it indirectly.

3.3.4 Social factors (F4)

The popularity of eco-friendly products among consumers have a great positive impact on GSCM implementation. Acceptance of eco-friendly products by society encourages companies to adopt GSCM practices into their firms. Corporate social responsibility helps organisations to focus on the social-economic criteria as well as the environmental criteria. Nowadays well-established industries are using the green brand image as an iconic factor to attract customers. The role of the stakeholders, campaign by the NGOs for environmental safety, and the media put a great impact on the implementation of GSCM in Indian manufacturing industries.

3.3.5 Knowledge and technical factors (F5)

Together, good knowledge of environmental sustainability and innovative product design could convert the traditional supply chain into a green supply chain. Advanced environmental-friendly technologies facilitate the research and development of green products. With the help of proper training about GSCM implementation and eco-friendly process design, a skilled workforce can easily convert any organisation to fully functional and green. And all these can be possible with the help of good education at the academic level which motivates the future generation for adopting green in their day-to-day life.

The authors have finalised 29 key factors that influence the implementation of GSCM in Indian manufacturing industries. The factors are categorised under five main criteria. i.e., 'ecological factors' (F1), 'environmental regulation and support factors' (F2), 'commercial factors' (F3), 'social factors' (F4), 'knowledge and technical factors' (F3). The factors are represented through a decision hierarchical structure as shown in Figure 1.

4 Result and discussion

Authors have used the fuzzy DEMATEL procedure briefly explained in Section 3 to formulate a ranking structure of main factors and sub-factors. A causal relationship is established among the factors to know the impact of one factor on others. Table 3 represents the average direct relation matrix for the main factors which is developed after considering and averaging the inputs of all eight experts. Table 4 represents the normalised matrix for the main factors which is obtained by dividing each element of the average matrix by a scalar 2.56. Table 5 represents the total relation matrix which is obtained by performing the matrix operations as shown in equation (10). This matrix is used to derive the prominence structure of the factors and to develop the causal relationship among the factors. A threshold value as obtained from equation (13) is employed for establishing the causal interaction among the factors.

Figure 1 Decision hierarchy structure of GSCM factors (see online version for colours)

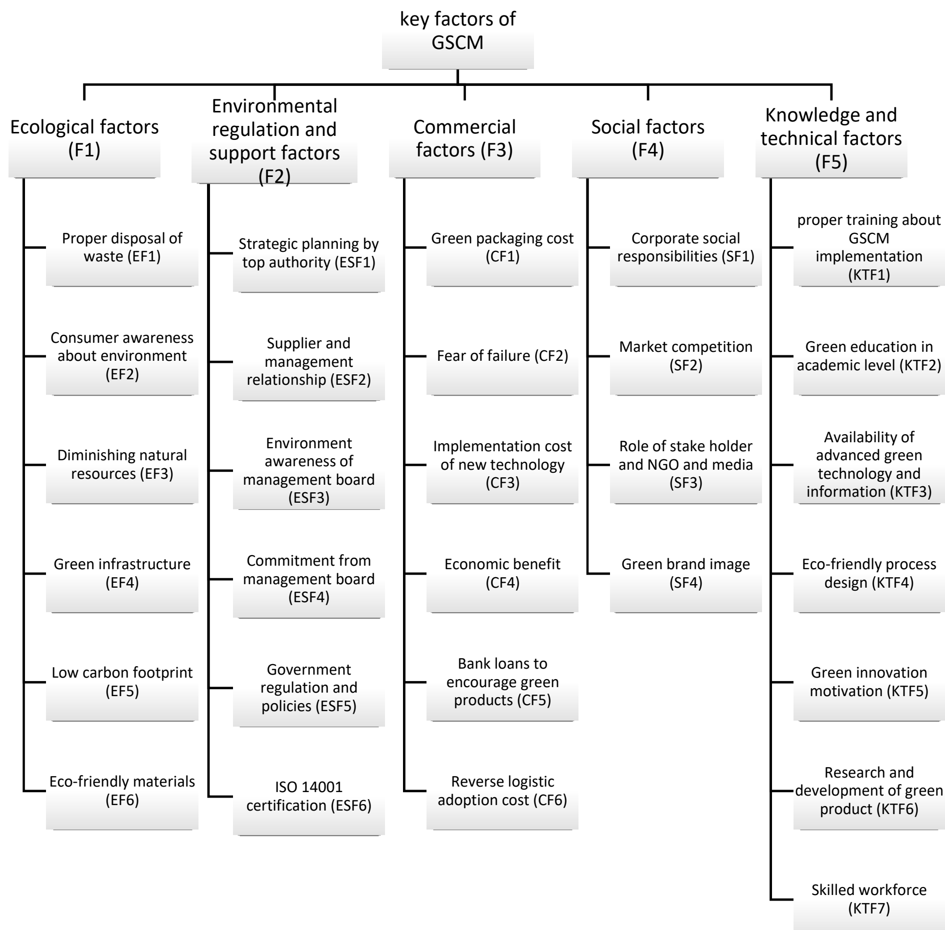


Table 3 Average initial direct relation matrix of the main factors

	F1	*F2*	*F3*	*F4*	*F5*
F1	0	0.775	0.517	0.631	0.574
F2	0.652	0	0.488	0.529	0.205
F3	0.319	0.557	0	0.266	0.414
F4	0.376	0.472	0.177	0	0.642
F5	0.507	0.753	0.823	0.395	0

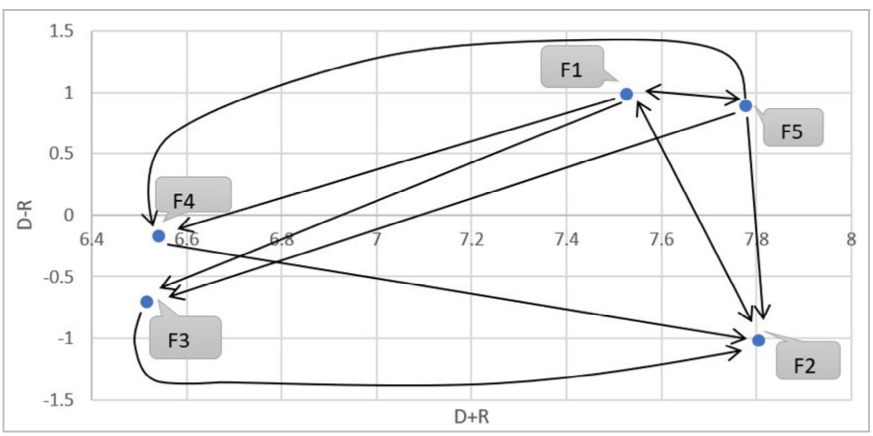
Table 4 Normalised matrix of main factors

	F1	*F2*	*F3*	*F4*	*F5*
F1	0	0.303	0.202	0.246	0.224
F2	0.254	0	0.190	0.206	0.080
F3	0.124	0.217	0	0.104	0.161
F4	0.147	0.184	0.069	0	0.251
F5	0.198	0.294	0.321	0.154	0

Table 5 Total relation matrix of main factors

	F1	*F2*	*F3*	*F4*	*F5*	*D*	*R*	*D+R*	*D-R*	*Ranking*
F1	0.679	*1.100*	*0.873*	*0.859*	*0.822*	4.335	3.441	7.776	0.894	*2*
F2	*0.733*	0.676	0.705	0.691	0.586	3.393	4.410	7.804	–1.016	*1*
F3	0.569	0.759	0.478	0.538	0.563	2.909	3.606	6.515	–0.696	*5*
F4	0.629	*0.794*	0.599	0.486	0.675	3.186	3.354	6.540	–0.167	*4*
F5	*0.829*	*1.079*	*0.949*	*0.777*	0.621	4.256	3.269	7.526	0.987	*3*

Figure 2 Causal diagram of main factors (see online version for colours)



Based on Table 5 the ‘environmental regulation and support factor’ (F2) is recognised as the most important factor that plays a significant role in the implementation of GSCM. Depending on D – R-value which is equal to –1.016 (negative), ‘environment education and support factor’ (F2) fall under the effect group (Figure 2), also the ‘environmental education and support factor’ (F2)is affected by the other factors under the main factors. The six sub-factors associated with ‘environmental education and support factor’ (F2) are symbolised as ESF1–ESF6. These sub-factors are enlisted as per their relative weight, and the order of ranking is given as government regulation and policies (ESF5) > commitment from management board (ESF4) > supplier and management relationship (ESF2) > strategic planning by top authority (ESF1) > environment awareness of management board (ESF3) > ISO 14001 certification (ESF6). The ranking of these factors is presented in (Table 8). Further, according to the (D – R) value, the subfactors (ESF1), (ESF3), (ESF5), (ESF6) belong to the cause group, and (ESF2), (ESF4) belong to the effect group. For the proper implementation of GSCM in industries, these factors are highly essential.

Table 6 Average initial direct relation matrix for 'environmental regulation and support' sub-factors

	ESF1	*ESF2*	*ESF3*	*ESF4*	*ESF5*	*ESF6*
ESF1	0	0.633	0.557	0.876	0.48	0.588
ESF2	0.736	0	0.63	0.395	0.472	0.177
ESF3	0.241	0.982	0	0.767	0.514	0.241
ESF4	0.624	0.706	0.418	0	0.945	0.191
ESF5	0.578	0.815	0.546	0.873	0	0.652
ESF6	0.891	0.873	0.357	0.657	0.557	0

Table 7 Normalised matrix for 'environmental regulation and support' sub-factors

	ESF1	*ESF2*	*ESF3*	*ESF4*	*ESF5*	*ESF6*
ESF1	0	0.157	0.138	0.218	0.119	0.146
ESF2	0.183	0	0.157	0.098	0.117	0.044
ESF3	0.060	0.244	0	0.191	0.128	0.060
ESF4	0.155	0.176	0.104	0	0.235	0.047
ESF5	0.144	0.203	0.136	0.217	0	0.162
ESF6	0.222	0.217	0.089	0.163	0.138	0

Table 8 Total relation matrix for 'environmental regulation and support' sub-factors

	ESF1	*ESF2*	*ESF3*	*ESF4*	*ESF5*	*ESF6*	*D*	*R*	*D+R*	*D-R*	*Ranking*
ESF1	0.392	*0.622*	0.456	*0.621*	*0.496*	0.369	2.958	2.908	5.867	0.049	*4*
ESF2	0.459	0.384	0.404	0.442	0.407	0.240	2.338	3.625	5.964	–1.287	*3*
ESF3	0.399	*0.623*	0.294	*0.537*	0.450	0.262	2.567	2.493	5.060	0.073	*5*
ESF4	*0.498*	*0.603*	0.412	0.414	*0.556*	0.282	2.769	3.281	6.050	–0.511	*2*
ESF5	*0.555*	*0.700*	*0.485*	*0.659*	0.422	0.404	3.227	2.861	6.089	0.366	*1*
ESF6	*0.603*	*0.691*	0.439	*0.605*	*0.528*	0.260	3.129	1.819	4.949	1.309	*6*

The second position in the priority table is occupied by the 'ecological factor' (F1). Therefore, it can also be considered as an important factor for the implementation of GSCM in the Indian context (Table 5). Considering the causal relationship mapping, the D – R value for 'ecological factor' (F1) is 0.894 (positive) so it belongs to the cause group (Figure 2). 'Ecological factor' (F1) consists of six sub-factors, and the ranking of these sub-factors are according to Table 11. The order of ranking is given as Consumer awareness about the environment (EF2) > eco-friendly materials (EF6) > GREEN infrastructure (EF4) > diminishing natural resources (EF3) > low carbon footprint (EF5) > proper disposal of waste (EF1). The sub-factors (EF2), (EF3) and (EF4) fall in the cause group, which indicates that they possess a powerful influence over the sub-factors falling in the effect group, namely (EF1), (EF5), and (EF6) (Figure 4). Government organisations must workout on some environmental-friendly policies which might inspire industrialists and specialists towards sustainability. The people engaged with GSCM exercises must be properly prepared and instructed regarding environmental protection by expert personnel. Awareness programs related to environmental safety and seminars are constructive techniques to influence the mindset of buyers who are legitimately associated with GSCM practices.

Figure 3 Causal diagram of 'environmental regulation and support' sub-factors (see online version for colours)

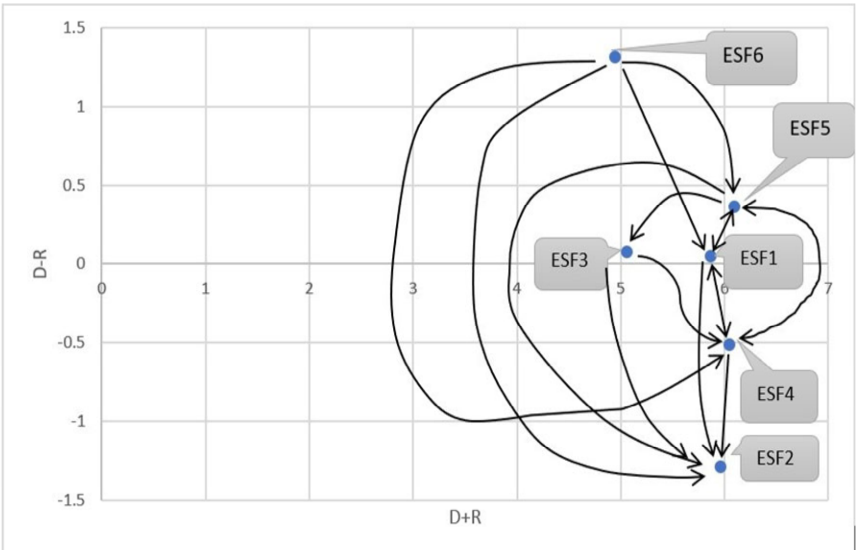


Table 9 Average initial direct relation matrix for 'ecological' sub-factors

	EF1	*EF2*	*3F3*	*EF4*	*EF5*	*EF6*
EF1	0	0.742	0.717	0.139	0.421	0.25
EF2	0.456	0	0.463	0.866	0.765	0.963
3F3	0.507	0.406	0	0.562	0.47	0.848
EF4	0.862	0.736	0.154	0	0.677	0.479
EF5	0.158	0.319	0.55	0.879	0	0.514
EF6	0.832	0.469	0.578	0.266	0.785	0

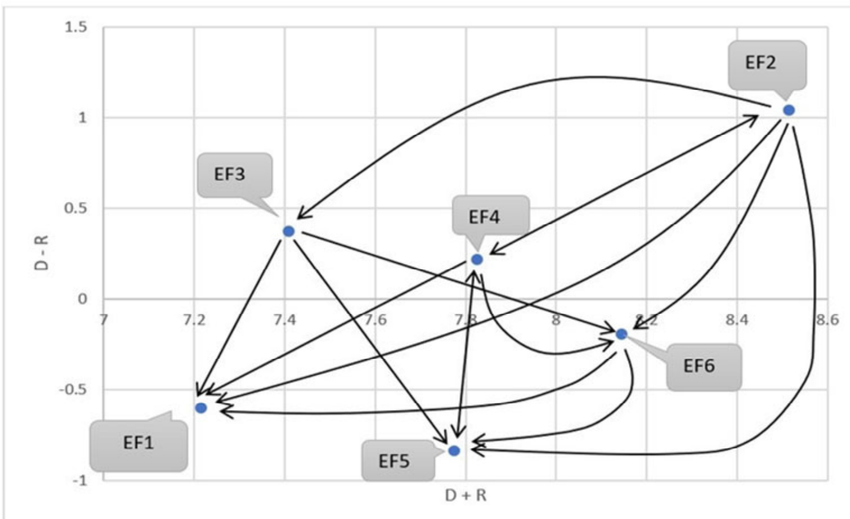
Table 10 Normalised matrix for 'ecological sub-factors'

	EF1	*EF2*	*3F3*	*EF4*	*EF5*	*EF6*
EF1	0	0.211	0.204	0.039	0.119	0.071
EF2	0.129	0	0.131	0.246	0.217	0.274
EF3	0.144	0.115	0	0.159	0.133	0.241
EF4	0.245	0.209	0.043	0	0.192	0.136
EF5	0.044	0.090	0.156	0.250	0	0.146
EF6	0.236	0.133	0.164	0.075	0.223	0

Table 11 Total relation matrix for 'ecological sub-factors'

	EF1	*EF2*	*3F3*	*EF4*	*EF5*	*EF6*	*D*	*R*	*D+R*	*D-R*	*ranking*
EF1	0.446	0.607	0.585	0.495	0.606	0.566	3.307	3.908	7.215	–0.601	*6*
EF2	*0.777*	0.627	*0.703*	*0.841*	*0.909*	*0.919*	4.778	3.737	8.515	1.041	*1*
EF3	*0.666*	0.615	0.482	0.650	*0.709*	*0.766*	3.891	3.517	7.409	0.373	*4*
EF4	*0.750*	*0.708*	0.550	0.538	*0.771*	*0.702*	4.021	3.803	7.825	0.217	*3*
EF5	0.534	0.541	0.553	*0.673*	0.528	0.635	3.468	4.305	7.773	–0.836	*5*
EF6	*0.732*	0.637	0.641	0.603	*0.781*	0.578	3.975	4.169	8.144	–0.194	*2*

Figure 4 Causal diagram of 'ecological sub-factors' (see online version for colours)



'Knowledge and the technical factor' (F5) holds the third position in the ranking list and comes under the cause group in the causal diagram as the D – R value for this factor is 0.987 (positive) (Table 5). The 'knowledge and the technical factor' (F5) consists of seven sub-factors and the prioritisation is as follows: green innovation motivation (KTF5) > research and development of green product (KTF6) > availability of advanced green technology and information (KTF3) > eco-friendly process design (KTF4) > skilled workforce (KTF7) > proper training about GSCM implementation (KTF1) > green education in academic level (KTF2). Out of these factors, green innovation motivation (KTF5) and research and development of the green product (KTF6) grab first and the second position respectively (Table 14). Sub-factors (KTF2), (KTF4) and (KTF6) fall under the cause group, and sub-factors (KTF1), (KTF3) (KTF5) and (KTF7) fall under the effect group (Figure 5). For a developing nation like India, advanced technological guidance would help in building a competent infrastructure for the implementation of GSCM practices. Dissemination of knowledge and awareness programs is essential for a successful implementation of GSCM (Kumar et al., 2018).

'Social factor' (F4) acquires the fourth rank in the ranking list (Table 5). The 'social factor' (F4) contains four sub-factors, and the priority of these sub-factors is set as market competition (SF2) > green brand image (SF4) > corporate social responsibilities (SF1) >

role of stakeholder and NGO and media (SF3). Out of these factors, market competition (SF2) and green brand image (SF4) are found to be the most influential.

Table 12 Average initial direct relation matrix for 'knowledge and the technical' sub-factors

	KTF1	*KTF2*	*KTF3*	*KTF4*	*KTF5*	*KTF6*	*KTF7*
KTF1	0	0.395	0.44	0.206	0.422	0.699	0.434
KTF2	0.633	0	0.546	0.507	0.682	0.518	0.288
KTF3	0.557	0.472	0	0.406	0.376	0.319	0.488
KTF4	0.284	0.166	0.633	0	0.854	0.54	0.784
KTF5	0.479	0.32	0.671	0.653	0	0.415	0.265
KTF6	0.591	0.239	0.658	0.738	0.751	0	0.575
KTF7	0.211	0.521	0.693	0.478	0.541	0.376	0

Table 13 Normalised matrix for 'knowledge and the technical' sub-factors

	KTF1	*KTF2*	*KTF3*	*KTF4*	*KTF5*	*KTF6*	*KTF7*
KTF1	0	0.108	0.120	0.056	0.115	0.191	0.119
KTF2	0.173	0	0.149	0.139	0.187	0.142	0.079
KTF3	0.152	0.129	0	0.111	0.103	0.087	0.134
KTF4	0.078	0.045	0.173	0	0.234	0.148	0.215
KTF5	0.131	0.087	0.184	0.179	0	0.113	0.072
KTF6	0.162	0.065	0.180	0.202	0.206	0	0.157
KTF7	0.057	0.143	0.190	0.131	0.148	0.103	0

Table 14 Total relation matrix for 'knowledge and the technical' sub-factors

	KTF1	*KTF2*	*KTF3*	*KTF4*	*KTF5*	*KTF6*	*KTF7*	*D*	*R*	*D+R*	*D-R*	*Ranking*
KTF1	0.435	0.442	*0.666*	0.528	*0.649*	0.606	0.552	3.881	4.044	7.925	–0.163	*6*
KTF2	0.664	0.404	*0.789*	*0.676*	*0.804*	*0.650*	0.602	4.592	3.215	7.808	1.376	*7*
KTF3	0.561	0.458	0.552	0.561	*0.634*	0.522	0.560	3.851	5.220	9.072	–1.369	*3*
KTF4	0.590	0.464	*0.826*	0.570	*0.851*	*0.656*	*0.721*	4.681	4.385	9.067	0.296	*4*
KTF5	0.574	0.443	*0.747*	*0.648*	0.578	0.571	0.548	4.110	5.111	9.222	–1.009	*1*
KTF6	0.698	0.510	*0.881*	*0.781*	*0.883*	0.575	*0.723*	5.053	4.144	9.197	0.909	*2*
KTF7	0.520	0.493	*0.757*	0.617	*0.710*	0.561	0.475	4.136	4.185	8.322	–0.048	*5*

'Social factor' (F4) acquires the fourth rank in the ranking list (Table 5). In the causal map, it comes under the effect group as the D – R-value is -0.167 for 'social factor' (F4) (Figure 2). The 'social factor' (F4) contains four sub-factors, and the priority of these sub-factors is set as market competition (SF2) > green brand image (SF4) > corporate social responsibilities (SF1) > role of stakeholder and NGO and media (SF3). Out of these factors, market competition (SF2) and green brand image (SF4) are found to be the most influential key factors for the GSCM implementation. Concerning these sub-factors, the factor (SF1) comes under the cause group, while factors (SF2), (SF3), and (SF4) come under the effect group (Figure 6).

Figure 5 Causal diagram of 'knowledge and the technical' sub-factors (see online version for colours)

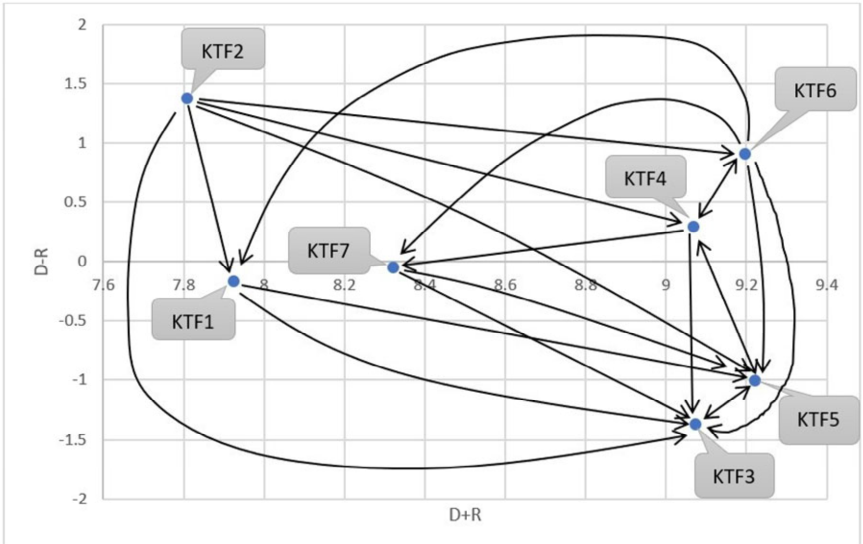


Table 15 Average initial direct relation matrix for 'Social sub-factors'

	SF1	*SF2*	*SF3*	*SF4*
SF1	0	0.767	0.812	0.63
SF2	0.652	0	0.514	0.693
SF3	0.276	0.550	0	0.643
SF4	0.624	0.699	0.546	0

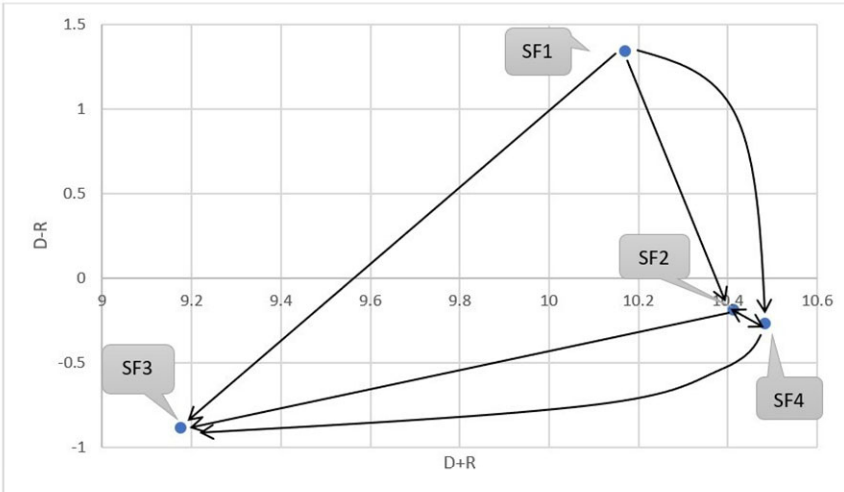
Table 16 Normalised matrix for 'Social sub-factors'

	SF1	*SF2*	*SF3*	*SF4*
SF1	0	0.347	0.367	0.285
SF2	0.295	0	0.232	0.313
SF3	0.124	0.248	0	0.291
SF4	0.282	0.316	0.247	0

Table 17 Total relation matrix for 'Social sub-factors'

	SF1	*SF2*	*SF3*	*SF4*	*D*	*R*	*D+R*	*D-R*	*Ranking*
SF1	1.096	*1.594*	*1.522*	*1.541*	5.755	4.414	10.169	1.340	*3*
SF2	1.207	1.189	*1.301*	*1.410*	5.108	5.375	10.483	–0.266	*1*
SF3	0.911	1.160	0.895	1.175	4.144	5.030	9.175	–0.886	*4*
SF4	1.199	*1.430*	*1.310*	1.172	5.112	5.299	10.412	–0.187	*2*

Figure 6 Causal diagram of 'social sub-factors' (see online version for colours)



'Commercial factor' (F3) gets the last rank in the ranking table (Table 5). The 'commercial factor' (F3) comes under the effect group in the causal diagram (Figure 2). As per the Table 20, the ranking of the commercial factors is reverse logistic adoption cost (CF6) > economic benefit (CF4) > fear of failure (CF2) > implementation cost of new technology (CF3) > green packaging cost (CF1) > bank loans to encourage green products (CF5). Out of these sub-factors, reverse logistics adoption cost (CF6) acquired the top position among all the commercial factors for GSCM implementation. Besides, the sub-factors (CF1), (CF5), and (CF7) fall under the cause group, while the sub-factors (CF2), (CF3), and (CF4) are placed in the effect group (Figure 7).

Table 18 Average initial direct relation matrix for 'commercial' sub-factors

	CF1	*CF2*	*CF3*	*CF4*	*CF5*	*CF6*
CF1	0	0.577	0.715	0.767	0.497	0.218
CF2	0.256	0	0.273	0.415	0.884	0.396
CF3	0.191	0.875	0	0.947	0.143	0.576
CF4	0.754	0.662	0.414	0	0.256	0.686
CF5	0.687	0.587	0.555	0.468	0	0.346
CF6	0.814	0.884	0.913	0.673	0.645	0

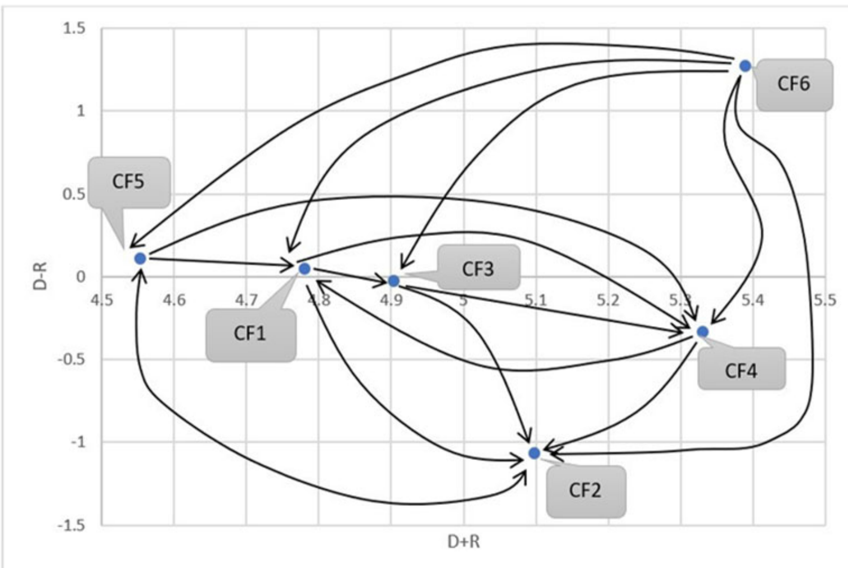
Table 19 Normalised matrix for 'commercial' sub-factors

	CF1	*CF2*	*CF3*	*CF4*	*CF5*	*CF6*
CF1	0	0.146	0.181	0.195	0.126	0.0554
CF2	0.065	0	0.069	0.105	0.224	0.109
CF3	0.048	0.222	0	0.241	0.036	0.146
CF4	0.191	0.168	0.105	0	0.065	0.174
CF5	0.174	0.149	0.141	0.119	0	0.088
CF6	0.207	0.224	0.232	0.171	0.164	0

Table 20 Total relation matrix for 'commercial' sub-factors

	CF1	*CF2*	*CF3*	*CF4*	*CF5*	*CF6*	*D*	*R*	*D+R*	*D-R*	*Ranking*
CF1	0.280	*0.497*	*0.445*	*0.507*	0.373	0.308	2.413	2.366	4.780	0.046	*5*
CF2	0.306	0.307	0.314	0.374	*0.417*	0.296	2.016	3.081	5.098	–1.064	*3*
CF3	0.338	*0.562*	0.292	*0.540*	0.315	0.387	2.437	2.466	4.903	–0.028	*4*
CF4	*0.458*	*0.528*	0.405	0.353	0.346	0.405	2.498	2.831	5.330	–0.332	*2*
CF5	*0.421*	*0.486*	0.408	0.436	0.258	0.319	2.331	2.222	4.553	0.108	*6*
CF6	*0.560*	*0.698*	0.599	0.618	0.510	0.342	3.330	2.059	5.389	1.271	*1*

Figure 7 Causal diagram of 'commercial' sub-factors (see online version for colours)



The results gathered by the use of fuzzy DEMATEL methodology highlighted that the ranking of main factors for the implementation of GSCM practices rely on their D + R values, that are found as environmental regulation and support factors (F2) > ecological factors (F1) > knowledge and technical factors (F5) > social factors (F4) > commercial factors (F3). It is observed that environmental regulation and support factors (F2) and ecological factors (F1) grab the top and next to the top place in the priority list. These factors are contemplated as important factors for GSCM execution in the Indian scenario.

The result of this study will help the practitioners not only to prioritise the GSCM factors but also to determine the inter-relationship among those factors. Currently, when the world is facing environmental problems, stringent legislation, resource scarcity, and lack of reverse logistics channel for waste management, this research work may help academicians, researchers, decision-makers, and practitioners to create a favourable circumstance for adopting GSCM practices. India is one of the largest developing nations both in the economy and industrialisation part. However, effective GSCM practices have not been actualised in India yet. Industrialists are still attempting to discover the factors that impact the GSCM factors in different ways. In this study, the authors attempted to explore the role of key factors in executing GSCM, and their significance has been depicted with the help of the fuzzy DEMATEL technique. From the empirical analysis, 'environmental regulation and support factors' (F2), 'ecological factors' (F1) are discovered as the highly influential factors in the prioritisation process. Where F1 and F5 are placed under the cause group, F2, F3, and F4 fall under the effect group. This research model may give some productive bits of knowledge and help GSCM professionals to take adaptable, long-term, and short-term decisions for the successful actualisation of GSCM practices. At last, the extracts of this proposed model might help the GSCM practitioners to incorporate appropriate resource utilisation, increase economy, and improve social responsibility towards GSCM.

5 Conclusions

GSCM has its roots in both environmental management and supply chain management practices. But, to accomplish an effective GSCM implementation, we have to understand the importance of the GSCM process and its relative significance (Kusi-Sarpong et al., 2016). Researchers should be aware of the fact that though several studies have been conducted in the field of GSCM in developed countries, the number is very small in developing countries like India. So increasingly more research is required to investigate a step-by-step improvement of GSCM execution in developing nations like India. Developed countries successfully implemented the green concept into their supply chains and gained spectacular development in the field of environmental sustainability. GSCM is one of the most noticeable and emerging concepts that need close attention particularly in developing countries like India.

In this paper, the authors have tried their best to identify the most influential key factors which might play a significant role in GSCM implementation. It has been observed that very little research has been conducted to investigate the influence of key factors in Indian manufacturing industries. This comprehensive study not only identified key factors that influence the adoption of GSCM practices but also measured the causal relationship among them. In this paper, a critical review is conducted considering a sufficient number of existing pieces of literature. This study also proved that to obtain an improved view of a problem, fuzzy DEMATEL is a robust tool.

The present research used the questionnaire survey to finalise the key factors of GSCM. From the literature review and expert opinion, 29 key factors of GSCM were finalised. Those 29 factors are grouped under five main key factors. Thereafter this study utilised the fuzzy DEMATEL methodology to prioritise the factors of GSCM. Fuzzy DEMATEL methodology helped the researchers to rank the factors by considering their (D + R) values and established a cooperative relationship among the key factors. The causal diagram characterised the factors into the cause and effect group.

The research discoveries uncovered that 'environmental regulation and support factor' (F2) holds the highest importance, which indicates that GSCM initiatives require attention from government administrations and regulatory bodies. Results exhibit that out of those 29 factors, the top 2 factors from each group are considered as the most influential factors in the adoption of GSCM such as government regulation and policies (ESF5), commitment from management board (ESF4), eco-friendly materials (EF6), consumer awareness about the environment (EF2), green innovation motivation (KTF5), research and development of the green product (KTF6), market competition (SF2), green brand image (SF4), reverse logistic adoption cost (CF6), and economic benefit(CF4).

Like every study, this paper also contains a few limitations. These limitations provide directions for future work. To begin with, this research considered a limited number of specialists from the industries. In the future, researchers may utilise more industrial experts familiar with the GSCM field. It ought to be mentioned, understanding the importance of GSCM implementation would help industrial owners to incorporate environmentally friendly practices into their companies. The proposed fuzzy DEMATEL based investigation can be stretched out to various fields like automotive sectors, construction sectors, power sectors, electronics sectors, and service sectors according to their specific GSCM practice. Nevertheless, the experts' judgement regarding the examination of factors may differ. Future research can be conducted using ANP and TOPSIS to comprehend the progressive relations among the various GSCM factors. In the future, the model can be implemented in different manufacturing industries to know the errors.

This research work may provide a piece of knowledge for comprehension of GSCM implementation persuasively. The research will help the industry managers to succeed in their future endeavours in the implementation of GSCM activities proficiently. Introducing GSCM into the process will help the organisations to accomplish success in the environmental, social, and economic fields.

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