Analysis of the barriers in implementing green supply chain management (GSCM) practices: a hybrid approach

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Abstract. Green supply chain management (GSCM) is being felt as the need of the day in many industries. This is because of the mounting evidence in favour of global warming and climate change due to human activities. The government is being pressurized by the people and the government in turn pressurizes the industries to adopt green practices. Apart from this there is moral responsibility for the managers of a company to reduce their ecological footprint. Due to these reasons there is a need to implement GSCM practices. As with anything we can observe that there are a lot of barriers that hinder the implementation of green supply chain (GSC) practices. To understand the nature of these barriers a literature survey was conducted on the barriers that affect small and medium scale industries. Fifteen barriers were recognised and literature survey was conducted on the analysis that had previously been done on these barriers. To address these barriers, they have been evaluated using MCDM approaches that are suited for the unique nature of these barriers (i.e., the barriers interact with each other). The effectiveness of removal of each barrier should be considered and should be integrated with a structural model to achieve the goal. For, this purpose SAW, TOPSIS, AHP and ISM have been used.

1. Introduction:

In today’s world, companies are concerned about the environmental problems such as global warming, toxic substance change, and decreasing non-renewable resources. Due to the increase in recent changes in climate and increasing global temperatures, awareness of a need for environmental protection worldwide has increased. Due to this, the green trends aimed towards the economicalisation of the Earth’s resources and shielding of the environment against the global warming caveat is overwhelming (Koh et al., 2012). Awareness among consumers about environmental compliance of products has increased substantially. As result companies are dedicating resources to make their supply chains greener. Supply chain management (SCM) is the administration of the finances, information, and materials as they move from supplier to manufacturer to wholesaler to retailer and finally to the consumer. The GSC is the integration of environment into SCM which sprawls into material tracking, product design, manufacturing process and delivery of the final product to the customers for the use and return of the used products to the manufacturers in some cases. In a vast logical overlook a SC is composed of two or more legally separable organisations, being associated by material, information and financial flows (Sivakumar et al., 2012). And these problems can be a plethora of items including a level of uncertainty regarding market position, stakeholders, concerns, and change. Going green refers to affecting the environment in a minimal way without pollution or waste from the industries,
transportation, Storage, etc. Minimizing the waste reduces the cost of purchasing and disposal which saves the money for the industries.

The GSC has advantages both on the environment as well on the industries. The green supply chain improves operations by employing an environmental solution. GSCM increases agility, it leads to the innovation and increases the speed of the innovations and also mitigate risk. It also helps for continuous improvement, increases adaptability. It also helps in the development of business processes and principles like negotiating policies with the suppliers and customers.

The green supply chain can be implemented in designing of products: design of products in an eco-friendly way, proper use of computational fluid dynamics tools, minimum operations and less material usage can be used to reduce the emissions present in the exhaust at design level itself. It can also be implemented in material purchase department, technical support to vendors, guidelines for use of less hazardous materials, and implementing green purchase policies to reduce the emissions. In production department, the green supply chain can be used in achieving fuel efficient tools, machines, lean manufacturing approach and selecting less carbon emitting energy sources. By implementing in packaging department, the process can be made mercury free, non-toxic, recyclability, hazardous waste concerns, robustness and reusability, and energy efficient. In logistics, it can be used in optimizing the truckloads, routing of distribution, direct shipment to the customer, and reverse logistics. Information and Communication Technology’s implementation in SCM increases workflow, collaboration and decision-making which leads to improved operational efficiency, cost savings and inventory visibility (Nair & Anbuudayasankar, 2016) and thereby dramatically improve the supply chain performance (Nair et al., 2017).

GSCM is still not implemented in many industries because of barriers like lack of government support, lack of bank credits to encourage green product, Lack of Top management commitment in adopting GSCM and many other similar barriers (Jayant & Azhar, 2014; Walker et al., 2008). The following observations were made when looking for reasons to implement green supply chains. There are increasing environmental constraints due to global warming, need for corporate social responsibility, benefits acquired by the organization, need for an increase in eco-friendly nature of products, increasing environmental awareness in stakeholders, evolving consumer and client demand.

2. Barriers to implementing green supply chain management

As there is an increase in environmental problems, industries are very particular about the waste they produce and resources they use. Though many industries are trying to adopt GSCM, but there are some barriers which stop them or delay them from doing so. Some of the barriers in implementing GSCM in Indian industry were identified through literature review and expert opinions.

| S.no | Barriers | Reference |
|------|----------|-----------|
| B1   | Cost Implication | (Jayant & Azhar, 2014; Mohammadjafari et al., 2014) |
| B2   | Lack of IT applications | (Jayant & Azhar, 2014) |
| B3   | Poor company culture in adopting GSCM | (Mohammadjafari et al., 2014) |
| B4   | Lack of commitment by top management in adopting GSCM | (Walker et al., 2008) |
| B5   | Resistance to advance technology adoption | (Jayant & Azhar, 2014) |
| B6   | Lack of support by government to adopt | (Jayant & Azhar, 2014) |
| B7   | Lack of awareness about green practice | (Mohammadjafari et al., 2014) |
| B8   | Lack of Technical expertise | (Govinda et al., 2014) |
| B9   | Market competition | (Walker et al., 2008) |
Lack of customer involvement in greening the supply chain (Walker et al., 2008)
Lack of environmental awareness to the supplier (Mohammadjafari et al., 2014)
Fear of failure (Govindan et al., 2014)
Pollution/Wastage in industries (Jayant & Azhar, 2014; Walker et al., 2008)
Lack of bank credits to encourage green product (Jayant & Azhar, 2014; Mohammadjafari et al., 2014)
Lack of training courses about implementing GSC (Jayant & Azhar, 2014)

3. Multi-criteria decision making:

In the daily lives of people, weigh for multiple criteria are considered implicitly and people are generally found to be comfortable with the consequences of such decisions that are made based on only intuition. MCDM comes into picture when there is more than one criterion to select. There can be more than one solution since there is more than one decision. A non-dominated solution has the property that has to be sacrificed at least on a criterion. Therefore, it makes decision maker to choose from a non-dominated set of solutions. However, the solutions to a set of non-dominated criterions are too large to be evaluated by the decision makers to conclude to a solution. Hence, different variety of tools are required to address the issue of MCDM problems.

The barriers are analysed in three different ways. These are their individual effects on implementation of GSCM, their effects on implementation of GSCM relative to each other, interdependencies between the barriers. This is done by using TOPSIS, AHP and ISM methodologies respectively. By combining the data from these three methods the reliability of the results obtained will greatly improve.

4. Literature survey:

MCDM is used to make the decision of the identified problems. These methods can handle both quantitative as well as qualitative criteria and analyse conflict in criteria and decision makers. Problems addressed, case study, tools used and conclusion were taken and documented from the literature. Though the above-mentioned tools can be used in the same way, like an evaluation of the alternatives etc., they have their own limitations and also the advantages of doing so. There are a lot of problems till date which were dealt with these conventional tools individually. Some of the works were reported by combining papers on TOPSIS and AHP (Freeman & Chen, 2015; Karim et al., 2016; Yurdakul et al., 2005; Harwinder & Raman, 2013); AHP and ISM (Chan, n.d.; Khaksar et al., 2015; Ravikumar et al., 2015; Sharma & Singh, 2012; Taylor et al., 2013; Taylor et al., 2007) and TOPSIS and ISM (Ravi, 2012; Jain & Raj, 2015). So, this inspires us to go for the hybrid approach of these methods.

5. Problem methodology

The barriers to implementing the GSCM using multi-criteria decision-making approach (MCDM) are analysed for the purpose of solving the above-given problem. The tools that are used in analysing the barriers are AHP, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and interpretive structural modelling (ISM). Three MCDM methods were used to analyse the barrier and find the relationship among them and the methodology is depicted in fig. 1.
**Figure 1. Hybrid Methodology**
5.1. TOPSIS:
TOPSIS is used to get the ranking of barriers using their individual properties without looking at the inter-relationships between these barriers. In TOPSIS an ideal solution and a negative ideal solution is found. The solution that is the least distant from the ideal solution and the highest distance from the negative ideal solution is selected.

Ideal solution = \{3.052626, 2.511031, 2.816066, 3.039592\}

Negative ideal solution = \{0.763157, 0.87678, 0.648827, 0.759898\}

Table 3. Ranking of barriers using TOPSIS.

| REF. NO. | BARRIERS                                           | Total weight | Rank |
|---------|---------------------------------------------------|--------------|------|
| B06     | Lack of support by government to adopt            | 0.999849     | 1    |
| B14     | Lack of bank credits to encourage green product   | 0.776565     | 2    |
| B09     | Market competition                                | 0.678686     | 3    |
| B04     | Lack of commitment by top management in adopting GSCM | 0.579267  | 4    |
| B08     | Lack of technical expertise                       | 0.416549     | 5    |
| B01     | Cost implication                                  | 0.381417     | 6    |
| B13     | Pollution/ wastage in industries                  | 0.311189     | 7    |
| B07     | Lack of awareness about green practice            | 0.25456      | 8    |
| B05     | Resistance to advance technology adoption         | 0.215783     | 9    |
| B12     | Fear of failure                                   | 0.178866     | 10   |
| B15     | Lack of training courses about implementing GSC    | 0.090079     | 11   |
| B10     | Less awareness of customers about GSCM            | 0.070712     | 12   |
| B02     | Lack of IT applications                           | 0.051508     | 13   |
| B03     | Poor company culture in adopting GSCM             | 0.051508     | 14   |
| B11     | Lack of environmental awareness to the supplier    | 1.54E-06     | 15   |

The low weight obtained (Table 4) by the lack of environmental awareness compared to the others can be explained by considering the fact that an industry depends on the demand and thus the barrier will be removed when any of the other barrier is removed. It is also seen that the top five barriers obtained is the same as the one obtained using AHP analysis.

5.2. AHP
In 1970’s, a structured technique called AHP was developed by Dr. Thomas L Saaty to make decisions in an organized way. AHP is the most used MCDM process (Saaty, 1980). A pairwise comparison is done by the decision maker by comparing two criteria at a time. This gives a clear idea to the decision maker and the evaluator about the understanding of the problem. AHP takes and gives quantitative inputs and outputs.

To get the pair-wise comparison matrix, a value ‘I’, which gives the importance of each barrier, is assigned to the barriers. This importance (I) is obtained from the judges. These values are compared with results of TOPSIS to validate the importance (I) assigned. Next, the relative importance between barriers were found to fill up the pair-wise comparison matrix. The relative importance for each pair of barriers is found by finding the difference between the importance (I) assigned for them. This data is then used to fill the pair-wise comparison matrix.

Table 2. Ranking of the barriers using AHP.

| REF. NO. | BARRIERS                                           | Total  | Rank |
|---------|---------------------------------------------------|--------|------|
| B14     | Lack of bank credits to encourage green product   | 0.103  | 1    |
B06  Lack of support by government to adopt  0.094  2
B09  Market competition  0.092  3
B04  Lack of commitment by top management in adopting GSCM  0.083  4
B08  Lack of technical expertise  0.078  5
B13  Pollution/Wastage in industries  0.071  6
B01  Cost Implication  0.07  7
B07  Lack of awareness about green practice  0.066  8
B15  Lack of training courses about implementing GSC  0.065  9
B12  Fear of failure  0.062  10
B05  Resistance to advance technology adoption  0.058  11
B10  Less awareness of customer about GSCM  0.045  12
B03  Poor company culture in adopting GSCM  0.043  13
B02  Lack of IT applications  0.038  14
B11  Lack of environmental awareness to supplier  0.034  15

Thus, we acquire the priorities of addressing the different barriers (Table 3). Lack of bank credits plays a major role. The next two barriers can be seen to cause the first barrier. Thus, Lack of bank credits is an important barrier while lack of government support and high market competition cause it.

5.3. Interpretive Structural Modelling (ISM)
ISM is a widely used methodology for establishing a relationship among particular items that define a problem or an issue. Here, ISM is used for developing a graphical representation of system composition and structure among the barriers.

5.3.1. Structural self-interaction matrix. Structural self-interaction matrix is formed with the help of variables P, Q, S, R which defines some relationship among the factors or barriers. They establish the contextual relationship between ‘I’ and ‘j’. ‘I’ being the barrier represented in the corresponding row and ‘j’ being the barrier represented in the corresponding column.
Four different variables to denote the relation between any two factors are defined below (i&j):

(1) P - ‘i’ influences ‘j’   (2) Q - ‘j’ influences ‘i’
(3) R - ‘i’ and ‘j’ influence each other   (4) S - ‘i’ and ‘j’ are unrelated

|    | B1  | B2  | B3  | B4  | B5  | B6  | B7  | B8  | B9  | B10 | B11 | B12 | B13 | B14 | B15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| B1 | R   | P   | S   | S   | S   | Q   | S   | P   | R   | S   | S   | S   | Q   | S   | Q   | P   |
| B2 | Q   | R   | Q   | Q   | Q   | Q   | S   | R   | R   | S   | S   | Q   | S   | Q   | P   |
| B3 | S   | P   | P   | R   | P   | S   | R   | S   | P   | R   | S   | S   | P   | S   | Q   |
| B4 | S   | P   | P   | R   | P   | Q   | P   | R   | S   | P   | R   | P   | Q   | P   | P   |
| B5 | P   | P   | P   | S   | P   | R   | Q   | P   | R   | P   | P   | R   | S   | P   | S   |
| B6 | P   | P   | S   | P   | S   | R   | Q   | P   | R   | P   | P   | R   | P   | P   |
| B7 | S   | S   | R   | Q   | P   | P   | R   | Q   | R   | R   | R   | S   | P   | S   | R   |
| B8 | Q   | R   | S   | Q   | P   | Q   | P   | R   | R   | S   | S   | S   | P   | S   | R   |
| B9 | R   | R   | Q   | R   | Q   | R   | R   | Q   | R   | Q   | R   | R   | P   | R   |
| B10| S   | S   | R   | S   | P   | Q   | R   | S   | P   | R   | R   | S   | P   | S   | S   |
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The driving power and dependence of each barrier for the implementation of GSCM are calculated. The driving power is plotted against the dependence power. The driving power is the number of barrier that it affects, while the dependence power is the number of barriers that affect this single barrier. The
observation of the points presents in the graph points to three different clusters of the barriers to implementation of GSCM. The clusters are then categorized and their properties are noted down based on their position on the graph. The categories are named as independent variables, linkage variables, and dependent variables. Independent barriers have low dependence power and high driving power relative to others. Linkage barriers have high driving power and dependence power. Dependent barriers have high driving power and low dependence.

![MICMAC analysis](image)

**Figure 2.** MICMAC analysis

Barriers B3, B6, B10 and B11 have been identified as independent variables. This is because their deriving power is very high than their dependence power. Barriers B1, B2, B5, B13 and B14 have been identified as dependent variables. This is because their dependence power is higher than their driving power. The other barriers are classified as linkage variables as there driving power is same as their dependence power.

7. Results and Discussion:

With the increase in the need for greater implementation of green supply chains, the factors that prove as a barricade for the implementation of GSCM should be reduced. The ranking in TOPSIS is obtained by using the priorities given by the experts. In AHP the relative importance of the barriers with respect to each other is taken. While these two are sufficient for obtaining a ranking of the barriers, the effects that the removal of one has on another barrier can only be taken into account by doing an ISM analysis. For this reason an ISM analysis was done to take this into account. After evaluating the barriers using ISM a MICMAC analysis was done using the results and the driving power of each variable was found out. The driving power from MICMAC analysis was then normalized based on the values present in the closeness obtained from AHP analysis. These two values were then added to obtain the final ranking.

Thus after a comprehensive analysis of the factors involved, the order in which the detraction of these factors will prove most beneficial, was figured out. The factors that are ranked higher should be first reduced for attaining effective benefits for the implementation of GSCM. Future works on the theory for removal each of these barriers can be done and these pose as future opportunities.
8. Conclusion:

GSC practices are needed to be implemented by many industries to reduce the impacts of their products on the environment. At the present time it is seen that implementation of GSC is faced with many barriers. A list of these barriers is made by doing a literature survey on the barriers to implementing GSC practices. These barriers have to be ranked based on the impact that their removal will produce on the implementation of GSC practices. The procedure that has been used for this purpose is summed up below.

To sum it up, TOPSIS analysis is done using values obtained from questioning the experts. This was done to find the different weights of the barriers for the implementation of GSCs. This data from TOPSIS was used to find the data about the relative effect of rectifying each barrier, on the implementation of the green supply chain. This data is then used to form a ranking using AHP. Next, the barriers are modelled based on their effect on the other barriers to their removal. This is done by using ISM approach. A subsequent MICMAC analysis on the data gives us the driving power and dependence of the barriers. This is done for the reason that any barrier that which upon removal, removes a large number of barriers, will give more result even if its ranking obtained from the AHP is low. So, the results from ISM is used to make sure that such barriers are not excluded from the final selection. This is done by normalizing and adding the driving power obtained in MICMAC analysis with the results from AHP. This provided a new ranking that accounts for the raw effect of removing them and the indirect effects the removal of a barrier might have on its removal on the other barriers.

The final results obtained by combining information about the individual effectiveness of removal of a barrier and the relationships between various barriers was obtained. The Lack of support by government to adopt GSCM, Market competition, lack of bank credits to encourage green product, Lack of commitment by top management in adopting GSCM and Lack of technical expertise have been identified as the barriers that will contribute the most upon removal to achieve more effective implementation of GSCM. Indian small and medium scale industries shall look after these five barriers for making their organisation greener.

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