



Science

AN ERA OF CHANGING THE ENVIRONMENTAL CONDITION BY GREEN SUPPLY CHAIN MANAGEMENT

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Abstract

Green supply chain management is defined as the process of using environmentally friendly inputs and transforming these inputs into outputs that can be reclaimed and re-used at the end of their life cycle thus, creating a sustainable supply chain. GSCM is one of the recent innovations for the enhancement of capabilities of Supply Chain Management. The purpose of this paper is to carry out a theoretical review of Green supply chain management (GSCM). The assessment involved 144 research articles published in 48 selected journals between 1998 and 2013. The methodology of empirical research involved selection and classification of 144 research articles in GSCM. A systematic classification and a critical analysis is carried out so as to identify research gaps in content of GSCM, as well as to recommend directions for future research. It is concluded from the analysis of the results that research in GSCM is increasing at a faster rate than ever; with theory building more in focus than verification. Furthermore, a new taxonomy was proposed on the basis of content and research methodology utilised. Based on this taxonomy, significant trends were observed and some unique inferences were drawn, apart from identifying the directions for future research. There have been a couple of literature reviews in GSCM but none of them focused exclusively on research methodology in GSCM. Also the sample size with respect to the number of papers (144 papers), as well as number of journals (48 journals), is larger than ever considered for literature review in GSCM. The papers spans a longer time period of 16 years (1998-2013).

Keywords: Green Supply Chain Management; Empirical Research; Literature Review.

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1. Introduction

The cross-disciplinary field of green supply chain management (GSCM) has been growing in recent years with an interest from both academia and industry. The growing importance of GSCM is driven mainly by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profits. (Srivastava S.K. 2007) Hence, the scope of GSCM ranges from reactive monitoring of the general environment management programs to more proactive practices implemented through various Rs (Reduce, Re-use, Rework, Refurbish, Reclaim, Recycle, Remanufacture, Reverse logistics, etc.).

Green Supply-Chain Management Defined

Green supply-chain management has its roots in both environment management and supply chain management literature. Adding the 'green' component to supply-chain management involves addressing the influence and relationships between supply-chain management and the natural environment. Similar to the concept of supply-chain management, the boundary of GSCM is dependent on the goal of the investigator.

The definition and scope of GSCM in the literature has ranged from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer (Zhu and Sarkis 2004). For the purpose of this paper, GSCM is defined as 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'. We specifically focus on RL and mathematical modeling aspects in order to facilitate further study and research.

The objective of the paper is to provide a critical analysis of empirical research content in GSCM. This paper can also serve as a useful reference for researchers in GSCM or other operations fields to advance organizational theory building and applications. The paper is organised as follows: Section 2 discusses literature reviews in GSCM and section 3 deals with methodology chosen for carrying out a structured review on GSCM. The proposed taxonomy and its associated structural attributes are explained in detail in this section. Section 4 provides a discussion on the results based on such taxonomy, while Section 5 ends with conclusions.

The literature in GSCM has been growing as organizations and researchers begin to realize that the management of environmental programs and operations do not end at the boundaries of the organization. Overall, research in corporate environmental management and its operations relationships have been growing in recent years with a number of papers outlining these

relationships (Sarkis, 2001), including the identification of a need to investigate GSCM. GSCM's definition has ranged from green purchasing to integrated supply chains flowing from supplier, to manufacturer, to customer and reverse logistics, which is "closing the loop" as defined by supply chain management literature (Zhu and Sarkis, 2004). Similar to the concept of supply chain management, the boundary of GSCM is dependent on the goal of the investigator. The research in GSCM addresses a variety of issues ranging from organizational research and practice in GSCM (Hall, 2001) to prescriptive models for evaluation of GSCM practices and technology (Sarkis, 2003).

2. Methodology

This section of paper elaborates the methodology adopted for the purpose of providing a comprehensive and critical literature review of GSCM. The issues of time horizon of review, journal selection, article selection, article classification and analysis of articles will be discussed under literature review methodology.

Step 1: The assessment period of articles is between 1998 and 2013, a 16-year time horizon. The year 1998 is considered as the starting point of data collection because term "Green Supply Chain Management" first appeared in 1998 (McIntyre et al. 1998).

Step 2: The articles were collected from five major management science publishers viz. Science Direct, Emerald Online, Sage, T&F and JSTOR as majority of well-referred journals of industrial management are found in these databases.

Step 3: Exact phrase "supply chain and green" was searched in abstract, title and keyword of all four databases. To reduce the repetition and to enhance the acceptability of the source from where the papers are collected, it was decided to consider only those research papers that are published in peer-reviewed journals.

Table shows the details of articles searched in terms of distribution of articles with respect to each of the search items.

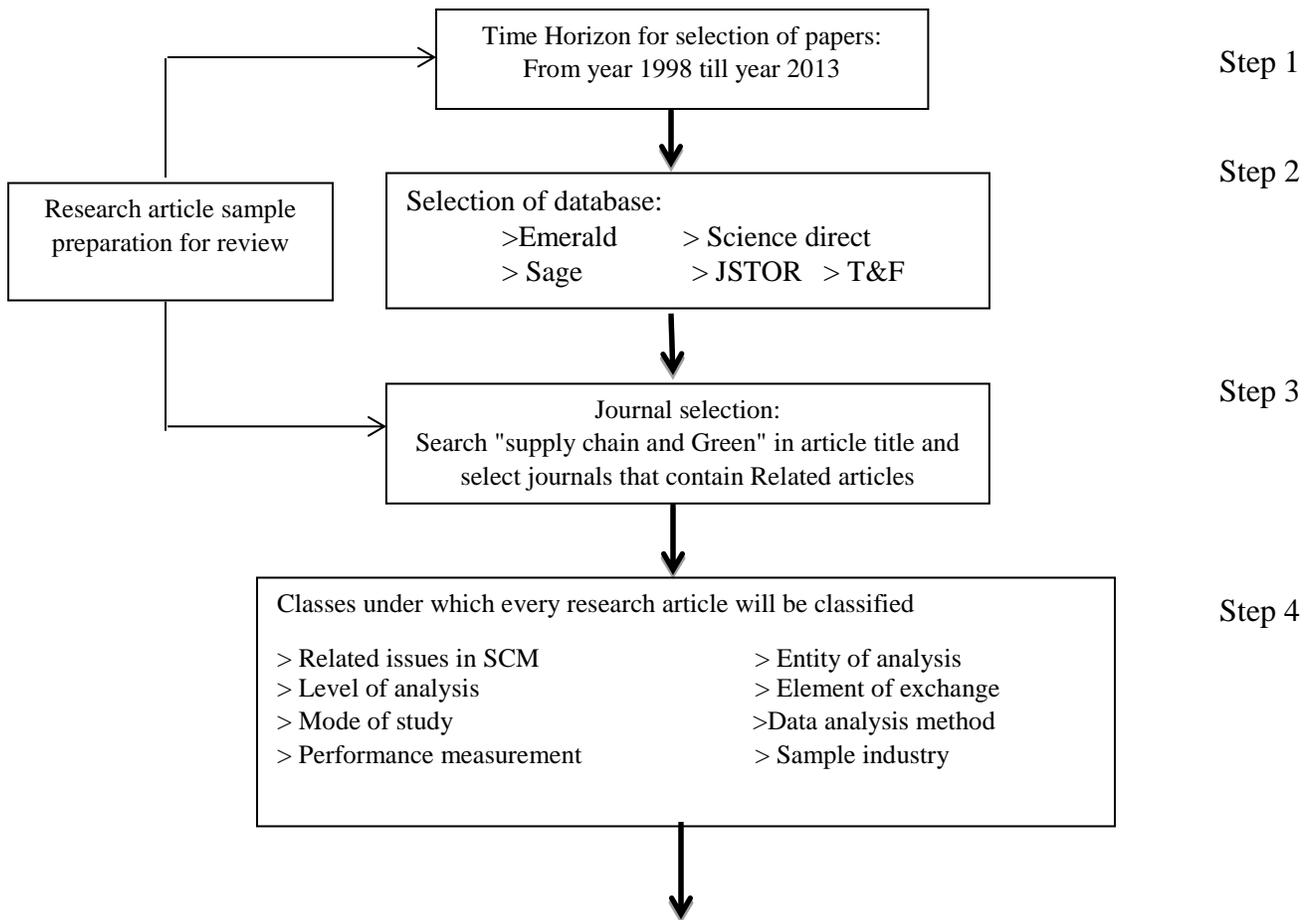
Step 4: All the selected research articles are classified under following eight classes:

Related issues in GSCM: It represents the issue covered in an article. For example implementation, integration of GSCM etc.

- *Entity of analysis:* It represents the focal entity under analysis in a given article. For example, supplier, manufacturer, distributor, retailer, 3PL, etc. The term "supplier" here means an entity that exists on inbound side of supply chain and supplies raw material or semi-finished product to "manufacturer". While "manufacturer" is final finished product supplier to any one of "distributor", "retailer", "third-party logistics (3PL)", "fourth-party logistic (4PL) provider" or "consumer". All entities including "distributor", "retailer", "3PL" or "4PL" lie on outbound side of supply chain and are involved in distribution of final finished product.
- *Level of analysis:* This class is adopted from an analytical framework for critical literature review given by Croom et al. (2000). Although Croom et al. (2000) suggested

only three levels, i.e. dyadic, chain and network, Halldórsson and Arlbjörn (2005) have addressed the fourth level, also denoted by “firm”.

- *Element of exchange*: this class is about “what” is exchanged in the supply chain (material assets, financial assets, human resource assets, technological assets, information and knowledge) and “how” relationships between actors are conducted and managed.
- *Mode of study*: It tells about whether the analysis of any paper is done on empirical basis or on Desk basis.
- *Data analysis method*: It tells about the tool or method used for analysis,
- *Performance measurement*: A performance measurement system plays an important role in managing a business as it provides the information necessary for decision making and actions.
- *Sample industry*: GSCM research is not restricted to any particular industry. It is thus important to find out the range of industries from which data are collected. This classification criterion will thus help in identifying possible sectors of GSCM research as well as highlight sectors that received inadequate attention of researchers.



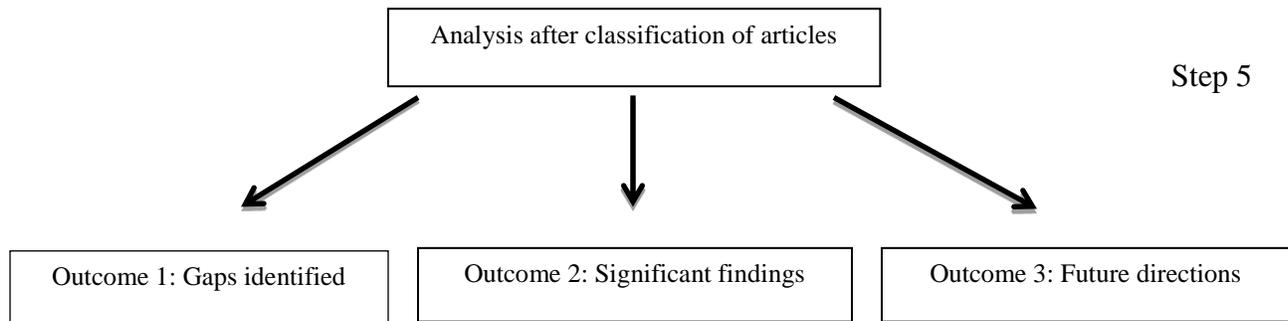


Figure 1:

Step 5: In this step, all the efforts are directed towards critically analysing the classified articles so as to identify research gaps in content of SCM in empirical research as well as to present significant findings from the existing literature.

The obtained papers were classified based on the following two major schemes as defined in (Soni and Kodali, 2011; Soni and Kodali, 2012):

- a) Content based
- b) Research based

These classifications have been described in detail in the following sections.

Content based classification

The content based classification is carried out by considering the following attributes and the description of the same are presented here.

- i. **Entity of analysis:** A GSC consists of various entities such as the manufacturer, supplier, retailer, distributor and the customer. Entity of analysis represents the focal entity under analysis in a given research article. These entities might be either from inbound side or outbound side of SC or as a whole. The entity of analysis can be identified based on the general theme of the article apart from a cursory reading of the title, abstract, keywords and full text/body of the paper. By doing this exercise the practical aspect of the research can be recorded.

For example, the article by Hu & Hsu (2010) focuses on Critical factors for implementing GSCM practice in a case of electrical and electronics manufacturing industries in Taiwan. Hence, it can be easily inferred that the entity considered is the manufacturer – i.e., the electrical and electronics company. However, if there are papers, which address GSCM aspects in general irrespective of any such entities, then they are classified under “combination”. Especially, those articles that deal with survey based approach, might have involved organizations that constitute different entities of SC for getting the responses and hence may not have such differentiation. For example, Cheng et al. (2008) studied the knowledge sharing among supply chain through a survey based approach in which the responses for their questionnaire are obtained from different manufacturing organizations

falling under the different entity of analysis. Hence, it is classified under the category of “combination”.

- ii. **Level of analysis:** The SC can be analyzed at different levels. One may study the interactions between any two or more of the several entities in a SC. This classification is adopted from Croom et al. (2000), who suggested only three levels, i.e. dyadic, chain and network. A fourth level, “firm” is used by Halldorsson and Arlbjörn (2005). Hence, in this review a hybrid classification scheme suggested by Soni and Kodali (2011), which is obtained by integrating the classification schemes of Gubi et al. (2003) and Croom et al., (2000) to create four levels of analysis, is used for classification.

In an article, the author(s) would have attempted to focus on a single organization to describe a particular situation or enumerate evidence to bolster their research findings. Under such situation, the level of analysis is just carried out on a single firm. Hence such papers are categorized under a classification scheme named as “Firm”. For instance, Lee T. Ru (Jiun-Shen), Le T. P. N., Genovese A. and Koh L.S.C.(2012) discussed criteria selection of green suppliers in a hand tool industry. In this paper, the focus is merely on a single organization, whose SC was changed. Hence it is classified under “firm”. On the other hand, some of the papers would discuss the interaction between any two entities of the chain and such papers would fall under “Dyad”. For example, Vachon S. and Klassen R. D.(2006) discussed about the supplier customer integration in environmental monitoring. In this case, the focus of analysis is on both the supplier and customer – i.e., the interactions happening between two levels of the SC. Hence, it is classified under “Dyad”. Similarly, further levels in the supply chain are “Chain” (where three or more parties are involved in the interactions) and “Network” (representing real-life supply chains that have more than one member at the same level of the chain). Hence, papers dealing with interaction between several members in different stages of the SC were classified accordingly.

- iii. **Element of exchange:** Croom et al. (2000) also explained that the interaction between the GSC members can be based on various factors such as exchange of asset, information, inventory, knowledge, relationship, etc. These factors are called as the element of exchange. Hence, one can also establish the taxonomy based on the element of exchange that happen between different entities under various stages of the GSC.

- iv. **Performance measurement:** A research becomes more valuable when it reports about enhanced performance of the organization or any of the entity(s) of GSC. The importance of performance measurement is justified by Kaplan (1990).

For example, Hervani A. A., Helms M. M., and Sarkis J. (2005) find performance measures for green supply chain. This paper provides an integrative framework for study of green supply chain performance tools.

- v. **Areas of research / SCM issues:** As mentioned earlier, the papers in the realm of GSCM deal with variety of issues. This includes strategy, logistics, performance measurement etc. which gives an idea about the focal/decision areas of GSCM. Hence, the reviewed papers were also classified according to the decision/research area.

For example, Zhu Q., Geng Y., Fujita T. and Hashimoto S.(2010) addressed the issue of “Green Supply Chain Management Implementation” by studying the case of nine large Japanese manufacturers. Hence, it is classified under the issue of “GSCM implementation” which is gaining importance in recent times in the field of SCM.

Research based classification

This classification studies the details of the research process employed. The following are the various structural attributes under this scheme.

- i. **Research outlets:** This gives the details of the journals, which published articles related to GSCM practices. This would help in understanding the effort of researchers and practitioners from various disciplines apart from examining the spectrum of journals that publishes papers related to GSC issues from the Indian context.
- ii. **Year:** This gives the year in which the paper was published in the journal. The purpose of this classification is to understand growth and importance of GSCM over the years. Figure 1 shows the trend of GSCM literature that addresses the issues of GSCM for the last 16 years. It is obtained by counting the papers that are published in different journals during a given year.

Take in Figure 1

It is evident from Figure 1 that in recent times, there is an increasing interest among the researchers and practitioners in addressing the various issues of GSCM.

- iii. **Research design:** This refers to the research instrument and methodologies used in the study (Flynn et al., 1990). One can use different methodologies such as
 - Empirical
 - Case study
 - Survey
 - Focus group
 - Action research
 - Desk based
 - Literature review
 - Mathematical modeling
 - Simulation
 - Experiment

The reviewed articles are organised based on the above classification mechanism. A brief about the same is presented below:

- a) **Methodologies used:** It can be found that empirical research is highly preferred in addressing the various issue of GSC. Many papers such as Lee S.Y. (2008), Qing-hua Z. and Yi-jie D. (2007), etc. have utilised the empirical research methods such as surveys, focus groups, etc. On the other hand, the article by Chung C.J. and Weeb H.M. (2011) used a mathematical model by combining Taylor series to investigate green product designs and remanufacturing efforts. This is a perfect example of a desk based research, which involve mathematical modeling.
- b) **Research design:** It can be seen that all forms of research design have been used in the papers reviewed. The survey method relies on self-reports of factual data, as well as opinion. One approach is to administer a survey to a group which is homogeneous with respect to at least one characteristic, such as industry or use of a common technology. For

example, Shukla et al. (2009) conducted a survey to understand about the environmentally responsive supply chain within the Indian auto sector. They attempted to understand the practices and performance measures that can capture the environmental impact due to the GSC activities of the Indian auto sector. On the other hand, the case study documents in detail, the operations of a single plant/chain/network. This may be used in conjunction with survey research, or some other type of comprehensive data gathering effort, to develop explanations for some of the findings on a more comprehensive basis. Apart from this, there is significant number of literature reviews in the field of GSCM. Similarly, other papers that are conceptual in nature are classified accordingly.

- iv. **Sample industry:** Supply chain research is not restricted to any particular industry. This classification is based on Burgess et al. (2006) and this criterion helps us in identifying possible sectors of GSCM research as well as highlight sectors that received inadequate attention among researchers and practitioners (Soni and Kodali, 2012).

Some papers which were based on literature review and mathematical models did not mention any particular industry. Hence, such papers are classified under a separate category called 'Not available'. For instance, the article by Ahi P. and Searcy C. (2013) reviewed the literature on definition of green and sustainable SCM and hence did not mention about any of the industries. Hence, this article is classified under the category of "Not available". On the other hand, those papers which dealt with survey collected information from multiple companies and hence they were grouped under another category called 'multiple'. Zhu Q. and Sarkis J. (2006) attempted to understand the sectoral differences in the practices of GSCM by conducting a survey, which involved companies from different industrial sectors. Hence, this paper is grouped accordingly.

3. Results and Discussions

Although the GSCM literature has evolved a lot in the past few decades; there are certain trends which are clearly visible. Identifying such trends and findings answers for such behaviour is referred as "synthesis" - the fourth step in the systematic approach proposed by Rousseau et al. (2008). Based on the organisation of different papers under various categories, meaningful results are synthesised. The results are presented in the same order as per the taxonomy discussed in the previous section for ease of understanding.

Content based classification

- i. **Entity of analysis:** It can be found that there are total seven different entities. About 47% of the articles (68 out of 144) have considered combination of entities for analyzing. This shows that most of the studies too have attempted to study GSCM as a whole, rather than viewing it as individual entities. However, about 24% of the articles attempted to analyze an individual entity – namely, the manufacturer. Since, the manufacturer always play a central role in a SC, by having linkages at both upstream and downstream end, it is natural that manufacturer deserves special attention in comparison to other individual entities such as retailer (only 3 papers), supplier (only 29 papers), logistics service provider (2 papers), etc. Furthermore, the entities in downstream side of SC are not given adequate importance.

- ii. **Level of analysis:** Almost equal number of papers (about 39%) are focusing at both “firm” (52 papers) as well as “chain” (57 papers), while the analysis at “dyad” level (i.e., between two stages) is least preferred – only 1 papers were found under this category. The importance towards the analysis at network and firm level may probably be due to various factors such as globalization, opening up of economy, political factors, etc. as this would affect both the individual and a network of firms. For example the case of Tata Motors is a perfect example of both firm level and network level analysis of SC. Due to political issues, the company as an individual entity was forced to shift its manufacturing location, which in turn also affected their strategic suppliers and the entire network of suppliers too moved along with Tata Motors to the new location. This example also substantiates the importance of analysis at both firm and network level.
- iii. **Element of exchange:** It can be inferred that asset and inventory as element of exchange is less discussed in GSCM, however about 129 articles (i.e. 89%) of articles are dealing with information exchange only. This is in line with the general theory of GSCM that information plays a vital role as an essential driver of the GSC and consequently, the “information distortion” creates major havoc within any SC. Hence, most of the researchers and practitioners too have given adequate importance to “information” as the element of exchange than inventory, assets, skills, etc.
- iv. **Performance measurement:** It is evident that most of the articles (about 87 percent) did not focus on the performance measurement. However, this result should be inferred with adequate caution because some of the topics/issues that are addressed by the contributors may not warrant the performance measures to be studied.
- v. **Area of research (SCM issue):** It can be found that the theme of “GSCM implementation” was frequently addressed in most of these papers. This category included articles on diverse issues such as GSCM practices, Green strategy, logistics, performance measurement, etc. These papers were classified under this category based on factors such as type of decisions addressed, profile of respondents to the survey questionnaires, time taken for implementation, etc.

Research based classification

- i. **Research outlets:** It is evident that most of the journals are either from operations management (OM) or from SCM. It is quite natural that authors would like to publish issues related to SC and SCM in relevant/related journals. Some of the articles surveyed got published in some journals that were not exactly related to OM/SCM but in journals related to specialised areas such as food, information technology, etc. This is primarily due to the fact, the contributors would have considered the theme of the article to be more related to other fields rather than having a direct relevance to SCM. This shows that the level of “inter-disciplinary” research is still less.
- ii. **Year:** Based on Figure 1, it can be found that there is an increase in the number of articles over the years. However, another observation is that the trend is neither linear nor exponential and hence, it can be inferred that this growth may not be only due to the increase in number of publications every year.
- iii. **Research design:** This categorization deals with the different types of research methods that are used by the contributors in carrying out their research.

- a) **Methodologies used:** About 65% of the reviewed papers utilized empirical research, while the remaining papers contributed to the desk based research. It is natural to see such importance to empirical research because the research hypotheses for various GSC issues require collecting data from multiple entities of the SC at different stages to substantiate the claims and validate them. On the other hand, if the study is carried out with respect to a single entity, using either a mathematical technique or explaining a unique situation or best practices in a case company, then desk based research could have been employed.
 - b) **Research design:** Various analysis techniques were used in the reviewed papers. Some techniques were used more than others. Generally, survey is considered to be the most commonly used research design in GSCM or management research. However, in this case, the data shows that case study still remains the most preferred choice of researchers. But a close analysis of the papers dealing with case studies revealed that usage of this method to deal at the network level is sparsely reported. Since case studies can include multiple organizations, it is surprising to note that this methodology is not being used to identify the GSCM issues in them. However, the usage of survey methods cannot be ignored as significant number of papers have also utilised this methodology. Another interesting observation is that the contributions in the form of structure or concepts are very less.
- iv. **Industry:** The result revealed that GSC issues of diverse spectrum industries are addressed. However, as expected, most of the GSC issues are studied with respect to the manufacturing industry. About 29% of the paper dealt with manufacturing sector. It is also heartening to see that GSC issues of other sectors such as apparel, fashion and perishable food industries are also studied; the number of such studies is less than 10% of the total studies reviewed. Similarly, this also reveals that such sectors of industries are not given adequate importance in the last 15 years, as the number of publications per year is minuscule. On a positive note, this shows that these industrial segments have high potential to be researched for various SC issues.

Directions for future research

Based on this review, some directions for future research are also suggested, which are as follows:

- 1) It is clear that not much importance is given to understanding the interface between two or multiple stages/nodes of SC. Similarly, future research efforts should be directed towards understanding the downstream side of SC and in particular the interface between distributors and retailers, manufacturers and distributors, etc. Similarly, more studies should be directed towards understanding the role of “knowledge”, “asset”, “technology”, etc. as an element of exchange within the GSC.
- 2) Another observation is that the number of papers addressing issues of Information Technology (IT) within the SCM is lesser. Hence, research focusing on such segment should be addressed in the future, as these industries in developing countries play a crucial role in shaping up the economy.

4. Conclusion

This paper made an earnest attempt to provide a review of literature on GSCM. Multiple taxonomies are established to understand the contributions and efforts of the academia, researchers and practitioners and unique results and inference were made, which were detailed in the previous section. It can be concluded that with the increase in number of papers in recent years, it can be predicted that environmental issues will get more attention in the future and naturally the number of articles addressing GSC issues would also increase as the field of GSCM is evolving very fast with the changes in technology, economy and the business paradigms as a whole. One of the limitations of the existing study is that all the papers relating to this theme in the given time frame considered may not have been reviewed. This can be attributed to our selection criteria which are constrained by the limiting boundaries established as part of the systematic review process adopted. Especially, those researches that are published by Inderscience publishers, manuscripts under Open Source collections, papers published in, renowned conferences and other Indian journals are not included in the present study. Nevertheless, it is believed that this review would have provided an introductory picture towards this important research issue and our future research might delve further into this area to resolve the missing link identified in the research gap.

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