Contents lists available at ScienceDirect

Sustainable Production and Consumption

journal homepage: www.elsevier.com/locate/spc

Prioritizing the responses to manage risks in green supply chain: An Indian plastic manufacturer perspective

Sachin K. Mangla[a,*], *Pradeep Kumar*[a], *Mukesh Kumar Barua*[b]

[a] *Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee, India*
[b] *Department of Management Studies, Indian Institute of Technology, Roorkee, India*

ABSTRACT

Green Supply Chain Management (GSCM) has become a very useful initiative for industries to improve their environmental capabilities in terms of, reducing resources consumption and ensuring sustainable production in business. However, the effectiveness of Green Supply Chain (GSC) is comparatively low, as there has been a substantial amount of risk involved in managing GSC efficiently. In this contribution, therefore, we aim to identify and prioritize/rank the responses of risks in a GSC context. It would be useful for industries to focus on highly ranked responses and formulate strategies to practice them in accordance with their priority for managing the consequences of risks in GSC. The present research seeks to propose a model by using the fuzzy Analytic Hierarchy Process (AHP) and fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methods to prioritize the responses in GSC to manage its risks under the fuzzy environment. The fuzzy AHP is useful in deciding the importance weights of the related GSC risks. While, by using the fuzzy TOPSIS, the priority/ranking of the responses in a successful accomplishment of green initiatives is determined. To illustrate the effectiveness of the proposed model, the GSCM real-world case of an Indian poly-plastic manufacturing company is presented. The model proposed would offer a scientific analytic means to the managers/business professionals/practitioners for systematic implementation of the responses of risks relevant to adoption and effective implementation of green initiatives in business. A sensitivity analysis test has also been performed that monitors the robustness of the proposed network model.

Keywords: Sustainable production; Green supply chain management; Resources consumption; Risk responses; Fuzzy AHP; Fuzzy TOPSIS

1. Introductory background

Supply Chain Management (SCM) has been observed as one of the key success areas to improve the effectiveness of business. In recent years, a significant need of natural and non-renewable resources has been identified all over the world across industries in their supply chain scenario (Mangla et al., 2012; Muduli et al., 2013). Having said that, it requires more than eighty tons of natural resources, including minerals per person yearly globally—really a matter of great concern among nations (ICMM report, 2012). In this sense, it has been stated that the adoption and implementation of green in supply chain, i.e., green supply chain (GSC) helps industries to conserve resources, which in turn enhances their ecological and economic performances (EPA, 2000; Srivastava, 2007; Zhu et al., 2008b; Paulraj, 2009; Hu and Hsu, 2010; Sundarakani

* *Corresponding author. Tel.:* +91 9416824761.
E-mail addresses: sachinmangl@gmail.com (S.K. Mangla), kumarfme@iitr.ernet.in (P. Kumar), baruafdm@iitr.ac.in (M.K. Barua).
Received 19 March 2015; Received in revised form 11 May 2015; Accepted 20 May 2015; Published online 28 May 2015.

http://dx.doi.org/10.1016/j.spc.2015.05.002

et al., 2010; Madaan and Mangla, 2015). GSC not only incorporates the ecological thinking in the business, but also ensures the sustainable development of industries (Beamon, 1999; Jung, 2011; Muduli and Barve, 2013; Mangla et al., 2014b; Luthra et al., 2014a,b). In this line of getting maximum competitive and sustainable advantages, many other industries have either initiated or thinking to initiate the green trend in their business activities (Zhang et al., 2009; Mohanty and Prakash, 2013).

However, the successful adoption of the green initiatives/trends/different GSC business activities (From here onwards the word initiatives is used throughout the paper.) is not so easy at industrial perspective (Ma et al., 2012). Different production and business activities in GSC engages several different types of risks (Mangla et al., 2014c). These risks and their sources can create problems in smooth functioning of GSC, and reduce the efficiency of a structure GSC (Wang et al., 2012). Therefore, it is important to manage and reduce the convolution of risks in GSC. Hence, to help industries, it is needed to concentrate on devolving some appropriate responses and concrete strategies helpful in effective adoption and implementation of GSCM.

1.1. *Motivation and need for this research*

Adding of 'green' initiatives in the supply chain includes dealing with interactions between supply chain management and the environment (Sarkis, 2003). However, still, it is not easy to the point of view of industries to adopt the green initiatives in their supply chain planning (Mathiyazhagan et al., 2013; Govindan et al., 2014a). There is an incomplete understanding of what is responsible for green adoption to fail in the supply chain (Mangla et al., 2014c). It is due to the reason as the initiatives of green at various aspects of business involve several complexities (Ma et al., 2012). Due to which, there arises different risks and risk factors in implementing different GSC initiatives in business, which would certainly affect the overall performance (Dan-Li et al., 2011; Wang et al., 2012). Therefore, for effectively managing the different business processes and activities linked to GSC, the risks associated with the green supply chain necessarily need to be known, and understood (Ma et al., 2012). The risks in GSC context can be recognized through literature resource and from the expert's inputs. Moreover, it should be noted that different industries may face different GSC risks and problems for greening their respective supply chain (Mangla et al., 2015). The same risk may not be equally important to the individual industry with regards to its priorities, capabilities, resource, etc. Considering this, Mangla et al. (2015) analyzed the risks for an effective understanding and successful management of implementation of different GSC initiatives with the help of a case example of multiple plastic manufacturing industries in Indian perspective. This study has identified and prioritized the common risks, as agreed upon by all the industries, in the implementation aspects of GSC initiatives using fuzzy AHP technique. Besides, it has also been mentioned in their study that in order to manage and reduce the consequences of the risks in GSC, the appropriate response measures need to be proposed in future research by using technique for order performance by similarity to ideal solution (TOPSIS). Further, literature also reveals that the area of risk analysis and management in the context of GSC is comparatively uncharted (Ma et al., 2012; Mangla et al., 2014c, 2015). Hence, it is considered as an evident gap of research in GSC dimension. Thereby, in order to improve the performance of adoption and implementation of green in the supply chain, a set of reasonable and viable response measures need to be proposed and prioritized or ranked to manage the GSC risks in a systematic way.

1.2. *Research objectives*

This paper aims in achieving two objectives, mentioned as: (1) to propose and or identify the responses to manage the risks associated with the GSC; (2) to prioritize the responses to diminish the effect of the risks in managing the GSC efficiently.

In this research, an effort has been made to prioritize the responses to manage the risks and their implementation in GSC. The prioritization of the responses of the risks in GSC is a multi-criteria decision making (MCDM) problem. However, due to the presence of fuzziness and unclearness in the data, there exist difficulties in prioritizing the responses of risks. To ease the process and for removing the inherent ambiguity, it is proposed to use the theory of fuzzy sets (Zadeh, 1965) for the above purpose. The present research proposes to utilize the fuzzy analytic hierarchy process (AHP) and fuzzy TOPSIS methods to prioritize the responses of risks in GSC. The fuzzy AHP method (Saaty, 1980) determines the importance weights of the related GSC risks. While, the fuzzy TOPSIS method (Hwang and Yoon, 1981) was used to analyze the identified appropriate responses of the risks to obtain their performance rating by using triangular fuzzy number (TFN). To demonstrate the real-life application of the proposed model, the GSCM case example of an Indian polyplastic manufacturing company is discussed. The chosen case example company seeks to know, understand, and prioritize the responses of the risks in effective GSCM adoption and implementation.

The rest of this paper is structured in a manner: Section 2, explores the literature relevant to this study. The details on the proposed research methods are given (Section 3). The description of the proposed model is illustrated in Section 4. The real-life application of the proposed model is shown in Section 5. The results of the study and sensitivity analysis of the proposed model are discussed in Section 6. Section 7, covers the research conclusions, limitations, and scope for next work.

2. Literature review

This section presents the literature on the GSC and GSCM, the risks in GSC, and the multi criteria decision analysis techniques used in GSC and GSCM.

2.1. *Exploring recent in the context of GSC and GSCM*

It has been recognized that literature is growing on the GSCM and Sustainability over the past two decades as mentioned in a study conducted by Fahimnia et al. (0000). This study undertook 884 research articles related to GSCM, published during a period of 21 years, from 1992 to December 31, 2013. Their work presented a progression of the influential GSC and sustainability research articles and further aimed to contribute to the subject via mapping the relationships amongst the higher impact contributions. In line with this, Min and Kim (2012) presented an extensive review of literature on GSCM and