



Service supply chain environmental performance evaluation using grey based hybrid MCDM approach



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ABSTRACT

Contribution of service supply chains to economic growth is significant and recent climate change issues expect services to be greener. The entire supply chain will be green if their suppliers adopt the requirements of the focal company and customers. Hence, it is essential that every organization constantly analyses and monitors the green performance of different members of the supply chains. Furthermore comprehensive studies have been carried out to identify criteria to evaluate green performance of manufacturing supply chain. However there is lack of studies to identify criteria and evaluate the performance of service supply chain. Service supply chain green performance evaluation necessitates methods to consider both qualitative and quantitative factors. Many conventional multi-criteria decision making (MCDM) methods have drawbacks such as inability to capture realistic fuzziness in decision making (human judgment), inadaptability to different levels of measurement, complexity in calculation and requirement of intricate details, which render them unsuitable for the task of environmental performance evaluation of service supply chains. In this paper, a grey based hybrid framework for evaluating the environmental performance of service supply chains is proposed by integrating grey based method with ELECTRE and VIKOR approaches. Two case studies were carried out to understand the effectiveness of criteria and method to evaluate environmental performance of service supply chains in a developing country context.

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1. Introduction

Green supply chain management (GSCM) is an emerging organizational philosophy to achieve economic sustainability by reducing environmental risks and impacts with improved ecological efficiency of the focal companies and their partners (Diabat et al., 2013). Based on the study of Basu and Wright (2008), we define GSCM as a supply chain which adapts set of environmental practices to overcome regulatory issues and interventions from various stakeholders in order to minimize overall environmental disruptions. Firms worldwide are more concerned with environment due to severe pressures from regulatory authorities, customers and competitors (Georgiadis and Besiou, 2010). These pressures are due to climate change, diminishing raw material

resources, overflowing waste sites, and increasing pollution levels. In recent years, GSCM initiatives are popular and widely used by firms to protect environment and to enhance their green image (Bose and Pal, 2012; Lin, 2013). Institutional pressure is an important motivator for the green adoption of advanced environmental management practices. Focal companies do not act alone but are interconnected which mandates all the members to adopt green practices (Seuring et al., 2008). Through GSCM, firms can select a wide variety of suppliers and leverage resources throughout the firm to eliminate the environmental impacts of supply chain activities (Tseng, 2010).

It is interesting to note that all organizations do not face the same pressure for GSCM adoption (Zhu and Sarkis, 2006). Different industry sectors in different parts of the world face various pressures. Xiao (2006) suggests five environmental pressures from the stakeholder point of view: (a) government as regulatory stakeholder, (b) media, (c) local resident as a community group, (d) contractors and clients, and (e) other stakeholders including related organization which can affect the company financially.

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Realizing that sustainability can drive the improvement of the company's bottom line through cost savings, improved market share, and stronger brand images, a growing number of firms have begun to take greening initiatives as their strategic weapons (Min and Kim, 2012).

The traditional end of the pipe approach only transforms pollutants from one form to another and does not eliminate them (Eltayeb et al., 2011). Unlike the traditional environmental management approach, however, the GSCM concept supposes complete responsibility of an organization towards its products and services from the extraction of raw materials up to final use and disposal. It represents the application of sound environmental management principles to all stages of a product's life cycle, including design, procurement, manufacturing, assembly, packaging, logistics, distribution, usage and final recycling to enhance an organization's competitive advantage (Handfield et al., 1997; Eltayeb et al., 2011). To improve their environmental performance, individual firms have implemented various kinds of environmental practices such as ISO14000 certification, cleaner production, environmental management systems and ecodesign. Recent studies suggests six GSCM dimensions such as green manufacturing and packaging, environmental participation, green marketing, green suppliers selection, green stock, and green eco design as potential ways to compete against rivals (Shang et al., 2010).

The successful and efficient functioning of an organization is greatly influenced by the degree of efficiency of performance of the supply chains the organization is employing in general and in particular the green performance of the members of the supply chains can have significant impact on the overall green performance of organizations. Hence it is absolutely essential that every organization constantly evaluates and monitors the environmental performance of the different member firms of the supply chains the organization is making use of. During recent years many researchers have investigated GSCM practices and performances in manufacturing sector (Zhu et al., 2007a, 2007b; De Brito et al., 2008; Zhu et al., 2008a, 2008b; Jain et al., 2009; Bhattacharya et al., 2010; Georgiadis and Besiou, 2010; Diabat and Govindan, 2011; Kumaraswamy et al., 2011; Tseng, 2011; Tseng and Huang, 2011; Zarandi et al., 2011; Gimenez et al., 2012; Hassini et al., 2012; Pirraglia and Saloni, 2012; Lin, 2013; Tseng and Chiu, 2013; Bhattacharya et al., 2014; Karsak and Dursun, 2014; Rezaei et al., 2014; Yu and Wong, 2014).

Few popular criteria used to evaluate green performance of suppliers are environment management system, GSCM capabilities, level of commitment to environment, degree of green supplier assessment, degree of green supplier collaboration and pollution control and prevention (Lee et al., 2009; Grisi et al., 2010; Large and Thomsen, 2011; Govindan et al., 2013). From the above studies it is obvious that criteria used to evaluate manufacturing sector have been discussed well in the literature. However, the criteria suitable to evaluate service supply chains are not well known.

In terms of methods, early studies proposed hybrid methods but most of them are related to fuzzy based method. Few of them are Noci (1997), Zhang et al. (2003) and Awasthi et al. (2010). However few other studies used other methods such as DEA (Kumar and Jain, 2010; Wen and Chi, 2010; Kuo and Lin, 2011; Mirhedayatian et al., 2014). In terms of developing country context, few attempts were made to identify the status quo of environmental aspects such as awareness, sharing environment knowledge and recognizing the importance of environmental performance over economic performances of supply chains (Govindan et al., 2014; Min and Kim, 2012). It is clear from the recent review article by Min and Kim (2012) that very few attempts have been made to understand the GSCM nature in the developing countries context.

In addition to the above, service sector is becoming the lifeline for the social and economic growth of any country. It is well known that the contribution of the service sector to nation's progress is substantial. Services contribute twice the economic output compared

with manufacturing (Rosenblum et al., 2000). Until today, only few studies have attempted to evaluate the performance of member firms of service supply chains. In particular, the environmental performance of member firms of service supply chains in a specific industry with respect to developing country context remains an unexplored area.

In addition to identification of suitable criteria for environmental performance evaluation through literature review and case studies, this paper proposes a grey based hybrid framework for evaluating the environmental performance of service supply chain members. The evaluation criteria are vague with most of them capturing intangible aspects. Since human judgments including preferences are often vague and cannot be expressed by exact numerical values, the application of the grey system theory for performance evaluation is an appropriate option. The grey approach has the ability to capture, process and integrate uncertainty in the decision making process. Since grey approach uses original data, the results are more relevant to practice (Golmohammadi and Mellat-Parast, 2012). Furthermore we found ELECTRE (ELimination and Choice Expressing the Reality) and VIKOR (the Serbian name: ViseKriterijumska Optimizacija I Kompromisno Resenje) approaches have most desirable properties such as insensitive to variation, capable to capture holistic aspects, suitability to accommodate different levels of measurements, simple to use and easy to implement which make these two approaches very much suitable for the task of evaluation. The framework proposed comprises of two hybrid approaches, the first developed by the integration of grey system theory and ELECTRE and the second developed by the integration of grey system theory and VIKOR. The framework proposed was applied to a case study available in the literature and the feasibility and practicability of the framework is validated. Two case studies were carried out to understand the evaluation criteria and effectiveness of the proposed framework with the member firms of service supply chains in a developing country context.

The remaining paper is organized as follows: review of the supply chain environmental performance evaluation criteria is presented in Section 2. In Section 3, the fundamentals of the grey system theory, the ELECTRE and the VIKOR approaches are discussed and the detailed procedural steps of the proposed framework for environmental performance evaluation are explained. In Section 4, two case studies on service supply chains were explained. Section 5 discusses the environmental performance evaluation with respect to the industry context. Section 6 validates the proposed framework with a published method and finally Section 7 summaries major findings and highlights the future research directions.

2. Environmental performance evaluation criteria for supply chains

Identification of appropriate criteria based on which the environmental performance evaluation of supply chains can be carried out is an important step in the whole exercise. Many authors have come up with a variety of environmental evaluation criteria for carrying out environmental performance evaluation of supply chains. The dynamic change of environmental criteria adds additional complexities for both practitioners and researchers. Environmental performance evaluation criteria suggested by various authors have been summarized based on the literature in Table 1. The most widely considered criterion is environmental management system. This major criterion is followed by green image, environmental performance, environmental competencies, design for environment, green competencies, corporate and social responsibilities, environmental efficiency, environmental authentication, environmental improvement cost, green logistic dimension, green organization activities, environmental certification, suppliers' green image, use of environmentally friendly material, use of environmentally

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