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Evaluating suppliers to include green supplier development programs via fuzzy c-means and VIKOR methods

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ABSTRACT

Green supplier development has became necessity as organizations increasingly compete on environmental supply chain capabilities. This paper aims to determine green/environmental performance of supplier, and define which suppliers need to improve their conditions about environmental issues, and identify which suppliers should be included to green supplier development programs to enhance their environmental performance. Therefore, primarily, performance criteria and green supplier evaluation criteria were determined via a survey, then factor analysis was conducted to evaluate validity of factors. Then two step clustering was performed by using c-means clustering method. In the first step of clustering, all suppliers of a firm performing in automobile industry were clustered according to criteria-delivery, quality, cost and service. Thus best performing suppliers were determined. In the second step of clustering, best performing suppliers determined in the first step of clustering were evaluated with environmental/green criteria. As a result of clustering, best performing suppliers were splitted to three groups according to green criteria-good, medium, poor. Lastly, suppliers within the poor group were sequenced by using VIKOR method in order to include green supplier development programs.

1. Introduction

In last two decades, because studies about the protection of the environment have been increasingly gain importance in the world, the increase in the number of legal regulations on this issue and increasing public pressure are forcing companies to give particular attention to the environment (Lee, Kang, Hsu, & Hung, 2009). Specifically, with new environmental legislations such as WEEE (Waste from Electronic and Electrical Equipment), RoHS (Restriction on the Use of Hazardous Substances), and EuP (Ecodesign Requirement for Energy-using Product) in European Union, companies have faced with the pressure to make their manufacturing and their supply chains environmentally friendly (Tsai & Hung, 2009). Therefore, there is an increasing interest to green supply chain, and environmental issues have been more critical in supply chain management (SCM) (Kuo, Wang, & Tien, 2010). To decrease hazardous environmental effects, companies have been forced to develop environmental issues such as decreasing hazardous effects of products, production and logistics processes (Noci, 1997).

Manufacturers work with suppliers at each operational stage. For example, supplied green material/components are identified as critical for the development and manufacturing of green products (Kermani, Malaei, & Nasiri, 2011). Hazardous/harmful substances in the raw materials provided by suppliers can cause serious environmental impacts in the supply chain (Lee et al., 2009). For this reason, working with suitable green suppliers is a very critical issue and integrating environmental matters into supplier development activities has become a necessity for the long-term competitiveness and processes of focal companies and their supply chains (Bai & Sarkis, 2010a,b; Fu, Zhu, & Sarkis, 2012; Tang & Zhou, 2012).

Environmental performance of a company's supply chain can be measured by the company's own environmental efforts and the environmental performance of its suppliers. In this context, cooperative relationship with suppliers regarded environmental issues allows companies to improve their environmental performance. For green manufacturing and its related processes, companies need to make their supply chains "green" and to work with suppliers which have green capabilities (Lee, 2008). Therefore companies demand their suppliers to take the required environmental certifications and to define green applications. But all suppliers cannot be in a good condition about environment, and also are not green at the beginning. Suppliers cannot effectively improve their environmental performance by themselves, and they need aid of focal company to improve their environmental performances (Fu et al.,

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2012). Therefore, in order to develop their environmental/green capabilities, companies should make cooperative, close and integrated relationships with their suppliers, evaluate green performance of their suppliers, and aid suppliers about green issues. In order to aid suppliers for green issues, focal companies can implement supplier development programs. In order to determine needs of suppliers for greening and make a plan for green supplier development programs, focal companies require for a green performance evaluation system. Thus focal companies can have a greener supply chain via green supplier development programs.

Although the increasing popularity of including green criteria to supplier selection and evaluation, developing a green supplier segmentation tool has received little attention in literature. In supply chain literature various studies have been performed to explain the inter-relationships between green supply chain management and supplier performance. Much of this performance can be achieved by only working with green suppliers and involving suppliers in green supplier development programs (Tang & Zhou, 2012). But, studies in the literature focusing on green supplier development programs (GSDPs) and supplier involvement in GDSPs are very limited. When studies about GSDPs performed up to now in the literature are investigated, it can be seen that they research effects of GSDPs on various factors (Bai & Sarkis, 2010b; Blome, Hollos, & Paulraj, 2014) or effects of various factors on green supplier development or evaluation of effectiveness of green supplier development programs (Dou, Zhu, & Sarkis, 2014; Fu et al., 2012). None of the studies about GSDPs in the literature are related with the involvement of suppliers into GSDPs. This is a gap in the literature. The main objective of the paper is to fill this gap by proposing a methodology using segmentation and evaluation approaches together by means of fuzzy c-means and VIKOR methods in order to determine which suppliers should be included to GSDPs and to help manager to prepare plans for GSDPs.

The paper is structured as following. Firstly, a literature survey is performed about green supply chain and supplier development, green supplier segmentation, green supplier evaluation and green evaluation criteria. Then the proposed methodology and methods in the methodology are explained. Then a case study is operated in an automobile manufacturing company. In the case study, firstly reliability and validity of the criteria are evaluated via confirmatory factor analysis. Secondly, two step clustering is performed via fuzzy c-means (FCM) clustering method. In the first step of clustering, all suppliers are clustered via performance evaluation criteria, suppliers are divided into three groups – good performer, medium performer and poor performer. In the second step of clustering, good performer suppliers are clustered via green criteria by means of FCM. Three clusters for good performer are defined – good, medium and poor. Lastly, suppliers in poor condition about green performance are evaluated and prioritized by VIKOR method. The paper was ended with conclusions.

2. Literature review

2.1. Green supply chain and supplier development

Recently, companies have integrated other members of supply chain to environmental management processes. This condition is called as green supply chain (GSC). GSC is a new management approach incorporating product development and environmentally-friendly product/service strategies (Büyüközkan & Vardaloğlu, 2008). Green supply chain management (GSCM) is generally defined as monitoring suppliers based on their environmental performance and making collaboration only with green suppliers that satisfy environmental standards (Hsu & Hu, 2009).

GSCM reduces negativities, strengthens control mechanisms, allows for recycling, and enables resource utilization. While GSCM create value in the supply chain of the company, it also explains the importance of the environment (Büyüközkan & Vardaloğlu, 2008). Srivastava (2007) defines GSCM as "integrating environmental thinking into supply chain management, including product design, material procurement and selection, manufacturing processes, delivery of the final product to the consumers and end-of-life management of the product after useful life of the product." According to Hervani, Helms, and Sarkis (2005), GSCM is a management process which is involvement suppliers in environmental management process. GSCM contain activities such as waste management, recycling, reuse and substitution of materials. In addition, it also contains green procurement, green production and material management, green distribution and marketing, and reverse logistics (Linton, Klassen, & Jayaraman, 2007). Common element in the base of these definitions is "environment". GSCM is integration of environmental issues to supply chain (Olugu, Wong, & Shaharoun, 2011).

According to Vachon and Klassen (2008), suppliers, manufacturers and customer should make collaboration in order to decrease hazardous effects of products and their manufacturing processes. There are several studies about this issue such as green supplier selection, including supplier's input to greening of organizational applications, expanding product life cycle assessment analysis to suppliers' processes, aiding suppliers about development and implementation of environmental management system, etc. (Sarkis, 2006).

Superior supplier performance is a necessity for excellent supply chain. It is important that targeted supplier development initiatives can cause to superior supplier performance (Handfield, Walton, Sroufe, & Melnyk, 2002). Supplier development is a broad concept aimed at strengthening the performance of suppliers not only allowing them to evolve the skills and competences required by the main contracting company but also assisting them in improving their performances (Crombrugghe & Cog, 2003). Supplier development is the process of working with certain suppliers on a one-to-one basis to improve their performance for the advantage of the main company (CIPS, 2013). Supplier development focuses on improving the efficiency of supplier operations, therefore it has direct impacts on performance-related benefits such as reduced costs, more reliable delivery, greater quality and flexibility, better service, and short product development cycle times (Krause, Handfield, & Tyler, 2007). Supplier development activities include training to suppliers, offering technical and quality expertise and advice, site visits or personnel exchanges between the supplier's and the focal company's facilities, and information sharing, etc. (Blonska, Storey, Rozemeijer, Wetzels, & de Ruyter, 2013).

In recent years, companies have implemented several supplier development programs to ensure that suppliers can supply materials and services with high quality and also dedicated to environmental standards (Awasthi, Chauhan, & Goyal, 2010; Kuo et al., 2010). Similar to organizations which support their suppliers about developing job and competitive performance such as cost, quality, delivery, companies can also help to their supplier how they develop their green performance (Fu et al., 2012). Supplier development for GSC in an important factor for expanding and spreading GSCM applications to suppliers and to supply chain by focusing on aspects of green supplier management, and this issue has been protected its importance (Bai & Sarkis, 2010b; Lee et al., 2009).

Some activities performed in the context of supplier development or common works with suppliers about environmental issues can be given as following (Simpson, Power, & Samson, 2007); GSDPs that reduce or eliminate materials used in production processes or products, GSDPs focused on environmental compliance status and applications of supplier operations, GSDPs for developing new materials and processes together with suppliers or other solutions in environmental issues.