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A robust hybrid multi-criteria decision making methodology for contractor evaluation and selection in third-party reverse logistics

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ABSTRACT

Due to green legislations, industries track the used products through reverse logistics contractors. A reverse logistics programme offers significant cost savings in procurement, transportation, disposal and inventory carrying. Since reverse logistics operations and the supply chains they support are considerably more complex than traditional manufacturing supply chains, it can be offered to third party contractors. But availability of more number of contractors make evaluating and selecting the most efficient Reverse Logistics Contractor (RLC) a challenging task and treated as a multi-criteria decision making problem. In this paper, a hybrid method using Analytical Hierarchy Process (AHP) and the Fuzzy Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) is proposed. AHP is used to obtain the initial weights and Fuzzy TOPSIS is used to get the final ranking. A case study demonstrates the application of the proposed method. Finally sensitivity analysis is carried out to confirm the robustness.

1. Introduction

Two of the most significant problems of our era are the depletion of the natural energy and resources and the pollution caused from the disposal of waste end-of-life products. An effective reverse logistics (RL) operation can help organizations make good use of nature energy and resources and take healthy balance between economy and environment (Xiangru, 2008). Online purchases, mail order and after-sales have resulted in the rise of returns in the organization. However organizations have not concentrated more on the returns. Because of changes in legislation, both for environmental protection and service reasons, number of companies now take into account reverse flows, going backwards from customers to recovery centers within their logistics system (Rogers & Tibben-Lembke, 2011). Recycling of used products is not a new concept. Waste paper recycling, soft drink bottles collection, metal scrap brokers are there in day- to day cases. The recycling of used materials requires collection, sorting and processing and the success is manipulated by the competence achieved through proper co-ordination and integration. Several forces drive reverse logistics, like competition and marketing motives, direct economic motives and concerns with the environment. Reverse logistics has an significant environmental dimensions (Ciliberti, Pontrandolfo, & Scozzi, 2008; Zhu, Sarkis, & Lai, 2008) as well as dimensions relating to value reclamation (Dat, Linh, Chou, & Yu, 2012; Ilgin & Gupta, 2010; Mutha & Pokharel, 2009).

Rate of product returns is high for magazines, photocopiers, computers, cameras, cellular phones, books, apparels, and automobile, electronic, aircraft components, chemical and medical items. Customers are demanding resolution of products that are considered to be defective. The amount of product returns can be very high with some industries at the rate of over 50% of the sales. End of life take back laws have proliferated over the past decade in the developed countries, requiring business to effectively manage the entire life of the product. Customers also pressurized the businesses to take responsibility of the disposal of their product (Prahinski & Kocabasoglu, 2006). Returned products are collected, examined and categorized by employees to the best of their knowledge. Besides, the employee regulates if the return is accepted and further measures to be taken. However the major concern is that whether the recovery of products should be more economical than the disposal of the products.

Most of the supply chain research concentrates on the forward movement and transformation of the materials from the suppliers to the end customer and on the impact that transformation has on the bullwhip effect. However the reverse flow of products from the customer to upstream business has not received much interest (Rogers & Tibben-Lembke, 2011). Managing product returns increases customer service levels and customer satisfaction. Since managing returns requires specialized arrangement and data tracking systems, reverse logistics contractors are preferred. Using

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reverse logistics contractor (RLC), the companies strengthen the core competencies with significant benefits like reducing the logistics and operating risks. While outsourcing, it is necessary to have a reliable RLC. RLC offers value added services such as repackaging and relabeling. Decision making problem for selecting the RLC has been receiving much attention recently. The presence of multiple criteria and the opinion from the decision maker will increase the complexity of the selection.

The remainder of this paper is organized as follows. Section 2 presents the literature review. Section 3 describes the problem and in Section 4, the proposed methodology is given. Application of the model to case study is given in Section 5. The result of the sensitivity analysis is given in section 6.Concluding remarks are given in Section 7.

2. Literature review

Reverse logistics is a relatively new topic and it is in the exploration. A complete supply chain should include both forward logistics and reverse logistics. Forward logistics operations also subsequently increase the reverse logistics activities and thus it plays an important role in the organization success (Govindan, Palaniappan, Zhu, & Kannan, 2012). Majority of the studies on the reverse logistics focused on facility location, resource allocation, flows, and network design. A pricing decisions model for a fuzzy closed-loop supply chain with retail competition in the marketplace was considered by Wei and Zhao (2011). Delphi method is applied to differentiate the criteria for evaluating traditional suppliers and green suppliers (Lee, Gen, & Rhee, 2009; Liu & Wang, 2009). A mathematical programming model which minimizes the total processing cost of multiple types of waste electrical and electronic products was presented by Dat et al. (2012). Efendigil, Onut, and Kongar (2008) used artificial neural network and fuzzy AHP to select the third party logistics provider in the presence of vagueness. Pochampally and Gupta (2008) used fuzzy AHP in a reverse supply chain to select the most economical product to be reprocessed and identified the potential recovery facilities. A closely related methodology, analytic network process (ANP) was used by Ravi, Shankar, and Tiwari (2005) to evaluate alternatives for end-of-life computers, connecting diverse factors including financial, non-financial factors and tangible, intangible factors.

A QFD based framework which integrated analytic network process and the goal programming models was presented by Büyüközkan and Berkol (2011). Also Büyüközkan and Cifci (2012) proposed a hybrid fuzzy multi-criteria decision making model which assisted in evaluating green suppliers. Barker and Zabinsky (2011) presented a model using AHP that establishes preferences among eight alternative network configurations, considering various flow processes. Pishvaee, Torabi, and Razmi (2012) developed a new hybrid credibility based fuzzy mathematical programming for green logistics network design. In the work done by Lee et al. (2009) genetic algorithm is used for solving a three stage reverse logistics network model for minimizing the total cost. Kannan and Murugesan (2011) used fuzzy extent analysis for selecting third-party reverse logistics provider for the battery industry. Azadi and Saen (2011) proposed a chance-constrained data envelopment analysis for selection in the presence of dual role factors. Zhi-Hong and Qiang (2009) proposed a grey comprehensive model based on AHP and grey relational analysis for the selection of RL providers. Meade and Sarkis (2002) proposed ANP model for the reverse logistics provider selection. However the number of pairwise comparison required could become cumbersome.

Based on the above literature, it is quite clear that very few studies have addressed the selection of RLC in the case of plastic recycling. Besides, sensitivity analysis was not carried out in any of the literature. Many industries have no suitable method to evaluate and select third-party reverse logistics providers. Hence, there is a necessity for a straightforward, organized and rational scientific method to direct user organizations to taking a proper decision.

3. Problem definition

Since RL takes many steps to process the returns it can be given to third party contractors to manage outbound logistics. By outsourcing reverse logistics activities, the organizations can concentrate on their core business operation. Third party reverse logistics contractor will compete with each other in specific areas like price, quality and credit. Since the third party reverse logistics contractor is using his latest technology and resource sharing advantages, uncertainty of recovery may be reduced .The majority of US industry appears to have negative experiences with outsourcing (Liou, Wang, Hsu, & Yin, 2011). This negative experience might be the result of the lack of comprehensive evaluation to discover the best candidates for outsourcing. This paper presents a case study from a company in a plastic industry which aims to show how it may choose a third party logistics contractor (RLC). Selecting the most efficient reverse logistics contractors from n number of contractors is a complicated and time consuming task which is considered as multi-criteria decision making problem. Selection process is as shown in the Fig. 1. To select the RLC, the industry should identify the criteria and the sub criteria.

The first step in the selection process is to develop a team of persons who have got knowledge and experience in logistics activities. The team should have members from all functional areas within the organization. The relevant criteria for the selection of a contractor, which are widely discussed in the literature, are presented in Table 1. The decision makers use the linguistic assessment to rate the criteria and the alternatives. Based on the literature survey and with the validation of industrial experts, possible evaluation criteria were defined and given in Table 1.

4. Proposed methodology

In this paper, a hybrid methodology based on Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) under fuzzy environment is presented. The weights of criteria are considered by applying the AHP method. The Fuzzy TOPSIS method is applied to get the final ranking. Although AHP is a decision-making methodology in itself, its ability to get exact ratio scale measurements and combine them across multiple criteria has led to AHP applications in conjunction with many other decisions support tool and methodologies. Uncertainty and imprecision is handled with linguistic values parameterized by the triangular fuzzy number. The main reason for choosing this hybrid methodology for selecting the reverse logistics contractor is due to its suitability in offering solutions in a complex

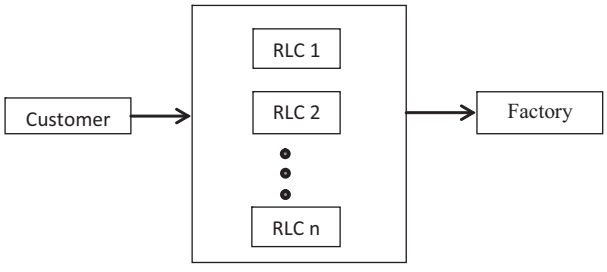

Fig. 1. RLC selection process.