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Reprint of "Green decision-making model in reverse logistics using FUZZY-VIKOR method"☆

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ABSTRACT

Due to the increasing global environmental consciousness and sustainability concerns, different industries that deal with Reverse Logistics (RL) are seeking methods to measure and analyze the impacts of their RL activities on the environment. However, making the greenest decision in the vague and complex area of RL makes this process somewhat difficult. Hence, to address these issues and provide a more meticulous and closer approach to the real world situations, a FUZZY-VIKOR method using interval-valued trapezoidal fuzzy numbers is proposed in the current research. As the further discussions explain, first, the significant factors in environmental sound practices together with the main processes and recovery options in RL are identified. Second, the influences of each green environmental factor on each RL recovery option are analyzed and ranked. To obtain concise results, the elicitation of experts is sought from among academicians and industry. The final results illustrate that, intriguingly, disposing of the returns has the lowest negative impact on the environment; thereby the best recovery option, while reselling of the returns was perceived as the worst recovery option. This research also suggests new directions for future research. From the managerial point of view, it would be interesting to study a sustainable reverse logistics through the proposed model. We only considered the impacts of environmental factors on RL, while the final decision will be more exact if the economic and societal aspects of RL are also analyzed. In addition, to reflect the technical views of all the stakeholders in RL towards the best recovery option and also take into account their concerns, we suggest designing a group decision making model across the RL using the Fuzzy-MADM methods.

1. Introduction

In recent years, the increasing awareness of environmental dilemmas in reverse logistics (RL) has attracted the attention of manufacturers and encouraged them to redesign their RL processes and networks according to green concepts. A number of efforts are being made to minimize the destructive effects of RL on the environment. In this respect, the environmental considerations, legal regulations, and the related economic advantages have also prompted several companies, such as General Motors, Kodak and Xerox, to consider RL and associated recovery processes (Meade et al., 2007; Üster et al., 2007). Since the main discussions about RL and its environmental matters were initiated by the works carried out by Rogers and Tibben-Lembek over the last decade, companies with RL processes have embarked on taking "green" and sustainability into account. In order to reduce the impacts of pollution on the environment, reverse logistics have been analyzed (Byrne and Deeb, 1993; Carte and Ellram, 1998; Wu and Dunn, 1995).

In this context, the Malaysian government has launched several progressive policies to support its national agenda on reverse logistics activities. For example, the Tenth Malaysia Plan (2011–2015) put forward by the government is based on the fundamental issue of

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sustainable production activities that could balance economic growth and environmental degradation. Moreover, many companies announced in their websites that they have reverse logistics programs. HP declared that it has two basic programs for reverse logistics; HP trade-in and HP buy-back. The HP Trade-In program offers HP customers cash payments for their old equipment when new HP products are purchased. In HP buy-back, HP collects, tests and evaluates the equipment. If the equipment has market value it will be refurbished, resold to the secondhand market. If the equipment has no value, it will be disposed of in accordance to HP's strict global recycling standards (HP, 2007). Nokia designed a program for product take-back that aims at collecting products at the end of its service life with a view to recovering its material and energy content as well as ensuring safe treatment of substances that may cause harm to people or the environment (Nokia, 2002). Dell apply industry leading recycling program that enable customers to recycle or donate their PCs for free (Dell, 2007).

With respect to environmental matters, the role of reverse logistics and the associated influences on developing the concept of sustainability and environmental protection have been explained (Brito et al., 2003; Fernández, 2004; Krikke et al., 1998). Rogers and Tibben-Lembek (1998) discussed the negative impacts of recovery options on the environment, such as disposing, landfilling, and incineration of returns. In order to improve the recovery process within RL, an environmental study considering the life cycle analysis in the battery sector was carried out (Tsoulfas et al., 2002). The increase in CO_2 emissions and greenhouse gases (GHG) due to unnecessary processes in RL, such as extra transportation, would be minimized if the green and RL processes could be integrated in a holistic and unique approach.

In addition, legislative policies with respect to environmental regulations and sustainability have enforced manufacturers to accept the responsibility of taking back their returns. Nonetheless, many companies are not capable of applying the current techniques and models to satisfy these requirements. One of the main obstacles in this regard is to measure the environmental contribution of certain activities in RL; especially, when the impacts of a group of environmental factors should be ranged and interpreted for a group of RL recovery options. Therefore, the need for a comprehensive technique that is able to cope with all these issues appears necessary.

In order to solve the ambiguous part of this problem, which is interpreting the impacts of environmental elements on RL recovery options, first, the linguistic terms and weights are defined in a reasonable range. This possibility facilitates the process of impact analysis for the experts during the interview sessions. Second, the equalization of qualitative terms into quantitative values by using interval-valued trapezoidal fuzzy numbers is performed. Ultimately, the FUZZY-VIKOR is applied to acquire the final ranking. The rest of this article is organized as follows: The following section briefly reviews the background literature. The third section describes the research methodology for testing the method of VIKOR, and the fifth section discusses the results of the data analyses. The article concludes with a delineation of the significance of the findings, managerial implications, and future research directions.

2. Literature review

2.1. Reverse logistics (RL) vs. green logistics (GL)

Rogers and Tibben-Lembek (1998) defined RL as: "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal". According to the definition of Dowlatshahi (2000), RL is "a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, remanufacturing or disposal". He considered the strategic and operational factors for implementing efficient reverse logistics in the company. Based on his approach, in the process of implementing holistic reverse logistics, the strategic factors, such as cost, quality, customer service, environmental effects, and regulations, are more critical than the operational factors like cost benefit analysis, transportation, warehousing, supply management, remanufacturing, recycling, and packaging.

On the other hand, Fleischmann et al. (2001) described RL as: "a process of planning, implementing and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal". Reverse logistics requires supply chain members to coordinate and integrate environmental management with the traditional logistics functions of transportation, packaging, labeling and warehousing. Pohlen and Theodore Farris (1992) find that the requirements for reverse logistics vary noticeably across firms and have important environmental and economic implications. The environmental aspects focus on resource reduction, materials substitutions and waste reduction, whereby companies become more environmentally efficient and help finding solutions for environmental problems. The economic aspects emphasize recapturing value from the returned products, such as retrieving integrated circuit boards from electronic products, or recovering valuable materials from the product through the recycling process.

While, "Green Logistics (GL) is a form of logistics which is calculated to be environmentally and often socially friendly in addition to economically functional (Smith, 2012)". The MGC Institute of Logistics in Vietnam (2010) described green logistics as "The management of the logistics and supply chain process including the incorporation of environmentally sustainable strategies that assist in minimizing the effects of pollution, particulate emissions and the management of processes to overcome climate change". Carter and Rogers (2008) stated that "Green logistics consists of all activities related to the eco-efficient management of the forward and reverse flows of products and information between the point of origin and the point of consumption whose purpose is to meet or exceed customer demand". Rogers and Tibben-Lembek (1998) considered that "Green logistics, or ecological logistics, refers to understanding and minimizing the ecological impact of logistics. Green logistics activities include measuring the environmental impact of particular modes of transport, ISO 14000 certification, reducing energy usage of logistics activities, and reducing usage of materials".

Both definitions as above, however, have led some authors to suggest that reverse logistics is imperative to the green logistics (Autry et al., 2001; Knemeyer et al., 2002), green marketing (Wu and Dunn, 1995; Carter and Rogers, 2008) and sustainability (Markley and Davis, 2007; Carter and Easton, 2011). By transforming the returns into products with value in the market, reverse logistics allow the supply chain to be in circulation so that the waste can be minimized through the process (Andiç et al., 2012). Hence, the best approach by companies to achieve the environmental protection is by introducing the reverse flow of supply chain that can maximize the value of the product returns (Kumar and Malegeant, 2006). The reverse logistics therefore, have been widely recognized in the literature as the major component that