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Flexible decision modeling of reverse logistics system: A value adding MCDM approach for alternative selection

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Abstract

The most favorable reverse manufacturing alternative arriving to collection centers has always been a key strategic consideration of any product recovery system. The nature of these decisions usually is considered to be multidimensional, interdisciplinary, complex, and unstructured due to lack of certainty in environment and information regarding time, quantity and quality of returns, etc. Fuzzy decision methodology provides an alternative framework to handle these reverse logistics system (RLS) complexities and to determine the decision strategies for best alternative selection for reprocessing. Designing a decision-making model for the same requires quantitative and qualitative evaluation based on criteria such as cost/time, legislative factors, environmental impact, quality, market, etc. Performance must be considered on the basis of these criteria to determine a suitable reverse manufacturing option depending on the expert opinion in this domain. In this paper, we propose a multiple criteria decision-making (MCDM) model based on fuzzy-set theory. The proposed model can help in designing effective and efficient flexible return policy depending on the various criteria. Further, companies can use this analysis as a strategic decision-making tool to develop fresh reprocessing facilities or efficiently use the already exiting facility. Finally, an example has been illustrated to highlight the procedural implementation of the proposed model. Further, this paper also makes an attempt to bring fuzzy-based flexible MCDM and reverse logistics together as a well-suited group decision support tool for alternative selections.

Keywords: Fuzzy; Alternative selection; Supply chain management; Flexible recovery

1. Introduction

In general, reverse logistics (RL) can be defined as the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal [1]. Moving goods from their point of origin towards their final destination has been the focus of logistics systems. A RL system (RLS) incorporates a supply chain that has been redesigned to manage the flow of products or parts destined for remanufacturing, repairing, or disposal and to effectively use the resources [2]. Today product return has become endemic for almost all product categories, with rates as high as 20% in some sectors. Therefore, developing a comprehensive and cost-effective decision system for product return handling is a daunting challenge that reaches well beyond the operational level. Thus, a well-developed reverse logistics and management plan can be a vital strategic asset [3,4]. According to a past survey conducted by the Reverse Logistics Executive Council (RLEC) [5], the average returns rate is 8.46%, with individual expected return shown in Table 1. Looking across the entire manufacturing value chain, one finds return rates are as high as 20–30% or more in the year 2005–06, and these rates are expected to increase in the near future.

To cater the need for this emerging field with inter-disciplinary, multi-criteria decision-making complexity, designing a framework has always been a challenging issue. Specially, when there are a number of reprocessing alternatives available (remanufacturing, repair, resell, refurbishing cannibalization, etc.). With a high variability

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Table 1
Expected rate of return (survey by RLEC)

Product category	Return % in year 2004
White goods	8%
House hold appliances	7%
TVs	8%
Computers and accessories	20%
Brown goods	6%

in evaluation of these alternatives with respect to other alternatives (either tangible or intangible), no crisp data are available. A flexible decision system is required that can choose the required alternative option based on some multiple criteria given by experts. No matter how, when, and in what condition products are returned, the primary problem in designing an effective logistics system is the high degree of quantity, timing, and quality variability inherent in a recoverable product environment [6]. The presence of multiple criteria (both managerial and technical (time/cost, market, legislative factor, quality, and environment impact)) and the involvement of multiple decision-makers will expand decisions from one to many dimensions, thus increasing the complexity of the alternative selection process. It seems obvious that we cannot solve the selection problem simply by grinding through a mathematical model or algorithm. We need new approaches, which could handle multi-criteria decision-making problems of choice and prioritization, to support these types of complex and unstructured selection problems. These selection decisions regarding the reprocessing alternative selection can help companies to prioritize and develop reverse manufacturing facilities accordingly. This paper makes an attempt to bring fuzzy decision-making method and reverse logistics (RL) once again together by making the reverse manufacturing alternative selection decision structure flexible and by quantifying preferences based on the decision structure. This formal decision analysis allows decision-makers in setting to rank order the alternatives based on the results of the analysis.

2. Review of literature

Although products have been returned since the early days of commerce, RL has only attracted academic attention since the early 1990s. RL commonly refers to the backward movement of materials in the supply chain [7]. This does not imply that materials are necessarily ending up at their original manufacturers, but refers to the collection of product returns, disassembly, and disposal aspects of RL, regardless of their final destination [8]. While some authors limit RL to the sum of those activities that ensure a sustainable or environment-friendly recovery of products and materials [9,10], broader definitions extend this to the handling of all kinds of product returns, including the take-back of unwanted products, recalls, and warranty returns [1,11,12]. In addition, Bloemhof-Ruwaard et al. [13] deal with interactions of issues between operational research and environmental management, and discuss recycling through value-chain collaboration. Lippmann [14] discusses combined location-routing problems and elements for success in environmental focus supply chains. Sufficient literature also exists in the related areas of environmental issues in purchasing, industrial ecology, and industrial ecosystems [15–18].

Earlier works and reviews have a limited focus and narrow perspective. They do not cover adequately all the aspects and facets of RL [19]. Much of the work is empirical and does not adequately focus on complexity of decision modeling and network design-related issues and practices.

Our objective is to present a comprehensive integrated view of the RL as an enterprise system and on the improving decision aspects, taking a "RES focus" so as to facilitate further study, practice, and research.

Here, we can use the broader definition of RL as a reverse enterprise system in the sense that we include products flowing backwards for all kinds of reasons [4]. Furthermore, the terms "product-returns" and "reverse logistics" have been used interchangeably in this paper. Thierry et al. [20] proposed the term product recovery management (PRM) to recover as much of the economic (and ecological) value as reasonably possible, thereby reducing the quantities of waste.

A lot of previous research on product returns has concentrated on technical issues such as network design [21], shop floor control [22], and inventory control [23] realized the hidden value in RL and starts to focus in this area. Mollenkopf and Closs [24] demonstrated the need to understand the financial impact of RL decision strategies. Srivastava and Srivastava [25] developed a hierarchical decision-making framework to find the feasibility of profit-driven RL networks. They developed an analytical model showing RL activities profitable for their selected category of products. Nowadays, information and communication technologies (ICT) and real-time decision making are likely to play a key role in the co-ordination and integration of product recovery activities [26,27]. Issues related to the integration of RL activities within an enterprise have been dealt by Chouinard et al. [28], while Daugherty et al. [29] find that coordination decision to information technology and call for a flexible model that can lead to superior RL performance.

Therefore, the present literature shows the advances in analytical modeling from an operational decision-making perspective to be more advanced than analytical models to support strategic decision making. We propose a strategic model that links with operational characteristics, in the selection of the most favorable reverse manufacturing alternative. By focusing on various recovery options, five different alternatives can be found: cannibalization, remanufacturing, refurbishing, repair, and reselling, listed in