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An integrated logistics operational model for green-supply chain management

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Abstract

This paper presents an optimization-based model to deal with integrated logistics operational problems of green-supply chain management (G-SCM). In the proposed methodology, a linear multi-objective programming model is formulated that systematically optimizes the operations of both integrated logistics and corresponding used-product reverse logistics in a given green-supply chain. Factors such as the used-product return ratio and corresponding subsidies from governmental organizations for reverse logistics are considered in the model formulation. Results of numerical studies indicate that using the proposed model, the chain-based aggregate net profits can be improved by 21.1%, compared to the existing operational performance in the particular case studied.

Keywords: Green-supply chain management; Integrated logistics systems; Systematic optimization; Reverse logistics

1. Introduction

With the increased environmental concerns over the past decade, there is growing recognition that issues of environmental pollution accompanying industrial development should be addressed

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simultaneously in the operational process of supply chain management, thus contributing to the initiative of green-supply chain management (G-SCM). Correspondingly, all the solutions, including logistics management, for managing the overall lifecycle of products should be integrated in a more comprehensive supply chain procedure. One striking example is that several industrial countries in Europe have enforced environmental legislation charging manufactures with the responsibility for reverse logistics flows, including used products and manufacturing-induced wastes (Robeson et al., 1992; Fleischmann et al., 2000). In addition, globalized enterprises, e.g., IBM, Hewlett–Packard, Xerox, have increasingly undertaken measures, including the integration of corresponding suppliers, distributors, and reclamation facilities in order to green their supply chains (Ashley, 1993; Bergstrom, 1993; Maxie, 1994). The above cases consider designing products which can be reused, together with the different possibilities of used product recovery. Environmental issues, e.g., used product recycling, waste disposal, and industry-induced pollution protection, therefore, can be addressed in an integrated fashion within the achievement of business operational goals.

Despite the importance of G-SCM in industrial ecology, the integration of logistics flows in a green-supply chain still remains as a critical issue in G-SCM for the following reasons. First, from an organizational strategic point of view, it is difficult to coordinate the activities of all the chain members, including the product-oriented logistics distribution channels and corresponding reverse-logistics channels. To a certain extent, this difficulty is rooted in the conflicts of operational goals among these chain members. For instance, maximizing the profits of one member in a reverse-logistics chain does not necessarily maximize the profits of a manufacturer in a given green supply chain due to the induced reverse logistics costs. Second, there is a lack of appropriate models for use as tools to manage the corresponding logistics flows associated with each chain member under the condition of system optimization in the process of G-SCM. Furthermore, the corresponding end-customer behavior, e.g., the willingness to return used products, and other external factors such as governmental policies and regulations, also influence the performance of a green-supply chain, particularly in the reverse logistics distribution channels.

Accordingly, formulation of a comprehensive framework with appropriate analytical models for systematically managing logistics flows among chain members in a green-supply chain is urgently needed. In addition, factors such as end-customer behavior and corresponding governmental policies and regulations in environmental protection must be considered in model formulation.

2. Literature review

Although the integration of logistics flows is vital for green-supply chain management (G-SCM), previous methods seem limited to specific applications for a single firm or within a limited number of chain members, rather than searching for systematic optimization across the entire green-supply chain. Correspondingly, comprehensive models involving reverse logistics strategies across green-supply chains are rare. Supportive arguments can also be found in Stock (1998). These published models can be classified into deterministic models (Schrady, 1967; Mabini and Gelders, 1991; Richter, 1996a,b) and stochastic models (Simpson, 1978; Cohen et al., 1980; Kelly and Silver, 1989; Cho and Parlar, 1991; Inderfurth, 1996, 1997; Heyman, 1997), differing mainly