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Managing channel profits of different cooperative models in closed-loop supply chains ☆

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ABSTRACT

The importance of closed-loop supply chains has been widely recognized in literature and in practice. The paper investigates interactions among the different parties in a three-echelon closed-loop supply chain consisting of a single manufacturer, a single retailer and two recyclers and focuses on how cooperative strategies affect closed-loop supply chain decision-making. Various cooperative models are considered by observing recent research and current cases, and the optimal decisions and supply chain profits of these models are discussed. By comparing various coalition structures, we discover that cooperative strategies can lead to win–win outcomes and increase an alliance's profit and can be effective ways of achieving greater efficiency from the point of view of the overall supply chain. Finally, the paper presents a detailed comparative analysis of these models and provides insights into the management of closed-loop supply chains.

1. Introduction

Closed-loop supply chains (CLSCs) focus on taking back products from customers and recovering added value by reusing the entire product and/or certain of its modules, components, and parts. Over the past 20 years, CLSCs have gained considerable attention in industry and academia [1,2]. To achieve high supply chain efficiency, some channel members in CLSCs may choose to cooperate with other channel members to form an alliance; such cooperation can bring great benefits or competitive advantages [3]. This paper focuses on developing a detailed comprehension of the implications that interactions among the different parties in a CLSC have for optimal decisions and supply chain profits and on how cooperative strategies affect the CLSC decision.

In current practice, we find various coalition structures in CLSCs. In some cases, manufacturers establish strategic alliances with recyclers or invest in their own collection channel for collecting used products. For instance, the “big three” auto manufacturers (i.e., GM, Ford, Chrysler) have made large investments in remanufacturing programs and have established a long-term cooperative partnership with recyclers in the United States [4]. Nike has created a strategic alliance with an eco-non-profit organization, the “National Recycling Coalition”, to collect used tennis shoes [5]. Some companies, such as IBM [6] and Dell [7], have designed their own reverse supply chain and formed a department or subsidiary to take part in collecting used products [8], a similar approach to a coalition consisting of a manufacturer and a recycler forming to produce products and recycle used products.

In real life, many manufacturers cooperate with retailers not only in the selling market but also in the collecting market. For example, Haier and Changhong not only set up their own subsidiaries that primarily engage in collecting and handling used products but also established a coalition with large retailers (e.g., Suning, Gome) in China [9,10]. Xerox and Eastman Kodak Company also established cooperative relationships with retailers, in which the coalition not only produces and sells products but also participates in collecting and handling used products [11,12]. These alliances function as coalitions including manufacturer, retailer and recycler, all taking part in the operations of a CLSC.

In other cases, independent and non-overlapping recyclers are utilized for collecting and handling used products. For instance, there are two large, independent and non-overlapping Industry Alliances (IA) that manage their own recovery, reuse and recycling of used products in Japan [13]. Hewlett Packard Corporation also built two independent factories to collect and handle its own used computers in the US [14].

Based on observations of current practice and the literature, it is necessary to conduct a deeper study of how cooperative strategies affect the equilibrium profits and optimal decisions of

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all channel members in CLSCs. In this paper, we consider four cooperative formats in a three-echelon closed-loop supply chain consisting of a single manufacturer (M), a single retailer (R) and two recyclers (C): (1) The manufacturer cooperates with one of the recyclers (M–C coalition structure). (2) The manufacturer builds a coalition with the retailer (M–R coalition structure). (3) The manufacturer builds a coalition with two recyclers (M–C–C coalition structure). (4) The manufacturer, the recycler and the retailer build alliances with one another (M–C–R coalition structure). We analyze the results of the cooperative models by contrasting them with a completely centralized structure (all channel members enter into an alliance with one another and act as a single entity) and a completely decentralized structure (all channel members independently make their own decisions) to illustrate potential sources of efficiencies in CLSCs.

More specifically, we address the following research questions: (1) Should channel members cooperate with one another and, if so, how should they cooperate with one another? (2) How do coalition structures affect the equilibrium profits and optimal decisions of the members in CLSCs?

Some of the key results of this paper demonstrate that the cooperation between the manufacturer and the retailer would increase each profits and return rates. By approaching the selling market together, they can jointly optimize the final price of the product and efficiently reflect unit net savings from manufacturing and remanufacturing. Additionally, return rates are sensitive to changes in demand. When a manufacturer establishes a coalition with recycler/recyclers, the coalition structure may improve the return rates, the alliance's profit and the retailers' profit. From economies of scale and by being closer to the final demand, they jointly optimize return rates and net savings by remanufacturing directly and efficiently controlling the wholesale price. The manufacturer has a dual role because it produces products by using either new materials or remanufactured materials in CLSCs. Although the manufacturer creates an alliance with both the retailer and the recycler/recyclers, this coalition structure is the most-preferred option because of direct proximity to the selling market and the recycling market, and of jointly optimizing the retail price and the return rate. By comparing various coalition structures, we find that cooperative strategies can lead to win–win outcomes and increase the alliance's profit. Additionally, more members entering into an alliance increase return rates.

On a broader level, this paper contributes to our understanding about interactions among the different parties in a CLSC and the effects of cooperative strategies on the CLSC decision.

The rest of the paper is organized as follows. A comprehensive literature review is exhibited in Section 2. The notations and assumptions of models are described in Section 3. Various cooperative models are considered, and optimal decisions and supply chain profits are analyzed in Section 4. A detailed comparative analysis of these models is made and some interesting propositions are presented about the relationships of various coalition structures in Section 5. Research contributions are summarized, and future research directions are outlined in Section 6.

2. Literature review

A broader collection and comprehensive review of reverse supply chains and CLSCs can be found in review articles [15,16]. From a survey of the literature, reverse channel management of CLSCs is one of the most important topics. Savaskan et al. introduced and compared three different reverse channels (i.e., the manufacturer collecting channel, the retailer collecting channel and the third-party collecting channel) and summarized some results from the three channels [1]. Savaskan and Wassenhove studied a two-stage CLSC consisting of a single manufacturer and two retailers and primarily discussed the manufacturer collecting model and the retailer collecting model [17]. Wei and Zhao considered a CLSC with one manufacturer and two competitive retailers and extended the manufacturer collecting model with fuzzy demand [18]. Hong and Yeh proposed a retailer collecting model, in which the retailer collected used products and the manufacturer cooperated with a third-party recycler to handle used products [19]. They demonstrated that the manufacturer might cooperate with a recycler without considering the cooperation of other members in CLSC. Huang et al. considered three decentralized third-party collecting models and represented a CLSC consisting of a recycler, a manufacturer and a retailer, in which the retailer, the recycler and the manufacturer act as the channel leader (Stackelberg leader), respectively [20]. The above studies largely focus on different reverse channel structures. However, due to economies of scale and the fixed investment, the collecting and handling cost paid by the third-party recycler is usually lower than that paid by the manufacturer or the retailer [21,22], and the third-party collecting model is common in current practical activities. Therefore, in this paper, we focus on the third-party collecting model, in which the manufacturer produces the product, the retailer sells the product and the recycler collects the used product. Moreover, the literature did not study interactions among the different parties in a CLSC. In contrast, we will investigate various cooperative models in a CLSC with a third-party collecting channel. Specifically, we examine the effect of these cooperation models on optimal decisions and supply chain profits.

Cooperative interactions in a supply chain have been comprehensively researched in the past. Cachon investigated several types of supply chain contracts to promote cooperation between a manufacturer and a retailer [23]. Li et al. [9], Huang and Li [24], and Zhang et al. [25] discussed cooperative advertising models in a manufacturer-retailer supply chain and investigated the effect of cooperation on investment effort levels. Gurnani et al. analyzed the effect of supply chain co-opetition on product prices and investment decisions [26,27]. Leng and Parlar analyzed how the cooperative effect would influence cost savings from a supply chain with a manufacturer, a distributor and a retailer [28]. The above studies aim at the issues of cooperation in forward supply chains. In contrast, in this paper, we specifically investigate cooperative interactions among members in CLSCs.

Next, we present our modeling assumptions and the four cooperative models in CLSCs.

3. Model assumptions and notations

We consider a three-echelon CLSC consisting of a single manufacturer, a single retailer and two recyclers. The manufacturer can manufacture a new product directly from raw materials, or remanufacture part or all of a returned unit into a new product. We consider product categories in which there is no distinction between a remanufactured product and a manufactured product [17]. The manufacturer sets the wholesale price paid to the retailer per unit of product and the transfer price paid to the recycler for per unit used product. The retailer sets the selling price and sells the product to consumers. The recyclers collect used products and sell them to the manufacturer, who also determines the return rate affecting the investment in the collection of used products.

The primary goal of this paper is to understand the implications of different cooperative strategies in CLSCs for optimal decisions and supply chain profits. Hence, we extend the models of Savaskan et al. [1] and Jena et al. [29] to a single period model with a three-echelon CLSC consisting of a single manufacturer (M), a single retailer (R) and two recyclers (C). We specifically consider four