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Channel leadership, performance and coordination in closed loop supply chains

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ABSTRACT

The business values of product remanufacturing have been well-recognized in the literature. Companies have also increasingly realized the importance of coordinating the closed-loop supply chains (CLSCs) with both manufacturing and re-manufacturing processes. In this paper, we investigate a CLSC which consists of a retailer, a collector, and a manufacturer, and examine the performance of different CLSC under different channel leadership. Through a systematic comparison, we find that the retailer-led model gives the most effective CLSC. Moreover, we analytically reveal that the remanufacturing system's efficiency is highly related to a supply chain agent's proximity to the market. Counter-intuitively, we show that the collector-led model is not the most effective model for collecting the used-product. We finally illustrate how both the serial and parallel CLSCs can be coordinated by using different kinds of practical contracts.

1. Introduction

Closed-loop supply chain (CLSC) management focuses on collecting the products from downstream members and reusing them to create additional values (Huang et al., 2013). CLSCs are present in virtually all kinds of industries because of its substantial economic values. For instance, it is well-known that large retailers such as Home Depot have over 10% of sales being returned (Guide and Van Wassenhove, 2009). On the other hand, under the pressure of regulations on environmental sustainability and take-back laws in nations all around the world (Toffel, 2003), many corporations have proactively taken measures in anticipation of all kinds of evolving environmental performance requirements and this also gives rise to the popularity of CLSCs. For example, a garment manufacturer Sun Hing Ltd. has been investing heavily in its own factory town in China with its own environmental-friendly measures on recycling scraps. Also, many manufacturers, such as IBM, Ford, Caterpillar, Muji, Timberland, all have established economically viable remanufacturing systems either by themselves or via outsourcing to a third party (c.f., Ferguson and Toktay, 2006; Karakayali et al., 2007).

In a simple CLSC, there will be three main types of channel participants: the retailer, the manufacturer/remanufacturer, and the third-party collector (Savaskan et al., 2004). In fact, industry provides ample examples of different channel leaderships. For instance, traditionally, it is common to see in the industry that the manufacturer acts as the channel leader which will offer supply contracts to the retailer (see Cachon, 2003); supply chains with those giant OEMs such as GM and Toyota belong to this model (e.g., Womack et al., 1990). Meanwhile, retailing giants such as Wal-Mart, Gome, A&P, ToysRus, Tesco and Hudson's Bay have great market power and it is widely observed that in the respective supply chains, many measures are driven by these retailers and the manufacturers become followers (Chiu et al., 2011). Moreover, recent years have also seen a significant increase in the power of collectors (c.f., Karakayali et al., 2007), such as SIMS Metal Management, IBM's Global Asset Recovery Services, and AER Worldwide, etc. These collecting parties are known to be taking a leadership role in the corresponding CLSCs and coordinate the operations in reverse logistics.

Interestingly, to a great extent, different channel leaderships will have a substantial effect on the acquisition efficiency and even on the performance of the whole CLSC. As Majumder and Srinivasan (2008) addressed: *Such large supply chains are common in the auto and apparel industries…. Typically one particular firm acts as the leader of the supply chain, in the sense that its decisions have the largest effect on the products of the supply chain, as well as on the quantity output of the chain….* From a single firm perspective, most firms would arguably want to become the channel leaders, and get a lion share of the supply chain profit. With this argument, intuitively, if the retailer is the channel leader (R-led),

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it may have incentive to reduce selling price so as to enhance market demand and hence its own profit (c.f., Ertek and Griffin, 2002); in conjunction, the collector will also need to invest more on used-product collection. However, if the manufacturer has dominant bargaining power and acts as the leader in the supply chain (M-led), it may charge a higher wholesale price, which would potentially lead to a higher retail price (by retailer) and a lower collection effort (by collector). If the collector acts as the channel leader (C-led), it is believed that the collector has incentive to increase the collection effort (Karakayali et al., 2007). In addition, from an environmental and societal welfare perspective, for all the cases we considered, which leadership model is the most effective one is also a critical question which we would like to answer in this paper.

Thus, motivated by the importance of CLSC management in practice and the open questions on different channel leadership in CLSCs, we explore in this paper a CLSC where there is a retailer, a collector and a manufacturer. *With the above models, we aim at addressing the following open research questions:*

(1) *How do different channel leaderships of CLSCs influence the retail price, the transfer price, the effort of "take-back" and the channel performance?*
(2) *Among the three types of leadership (M-led, R-led, C-led), which one is the best from the total CLSC's perspective?*
(3) *What incentive alignment mechanisms can be designed to coordinate the CLSCs under different channel leaderships?*

Addressing the above important open questions highlight the research objectives and contributions of this paper. To the best of our knowledge, this is the first paper which specifically addresses these channel leadership related issues in a CLSC with a price-dependent demand.

The remainder of the paper is organized as follows. In Section 2, we provide a literature review. In Section 3, we introduce the research problem, and related model assumptions. In Section 4, we provide a proposed multi-tier reverse logistics channel model, and derive the optimal policies. Following the development of the model, the analytical results for the optimal CLSC structures are presented in Section 5. Section 6 examines channel coordination mechanisms with used product collection. We conclude and outline the limitations of this work and possible directions for future research in Section 7. To simplify our exposition: (i) we use the subscripts *C*, *M* and *R* to represent the collector, manufacturer and the retailer, respectively throughout the paper, (ii) all proofs are provided in Appendix A.

2. Literature review

First, this paper is most closely related to game theoritical analysis of the CLSC system. Under this category of research, some studies only focus on the competitive behaviors with respect to remanufacturing activity, but not the new product manufacturing part (Bakal and Akcali, 2006; Liang et al., 2009; Karakayali et al., 2007). While in general, both the manufacturing and remanufacturing parts should be considered and this gives rise to some other interesting papers. For instance, Majumder and Groenevelt (2001) pioneer a study on a two-stage competitive model between an OEM and a remanufacturer. They consider the scenario where in the first period, only the new product is offered by the OEM, and in the second period, the OEM competes with the remanufacturer in a Nash game. Important insights for the equilibrium decisions under competition are generated. Later on, Ferrer and Swaminathan (2006) expand the above model and characterize the optimal strategies (production quantities and prices) in both monopoly and duopoly environments for two-period, multi-period and infinite-horizon settings. Almost the same time, Ferguson and Toktay (2006) also formulate a two-period model to examine the recovery strategy of the OEM in light of a competitive threat from the remanufactured product market. Most recently, Ferrer and Swaminathan (2010) extend the above model to a situation where the remanufactured product is differentiated from the new one and derive several influential new insights.

While the above studies mainly focus on the competitive behaviors between the new product and remanufactured one, either within one OEM, or between an OEM and a remanufacturer, none of these studies examine closely on the incentive of collecting used products under different reverse channel structures. Moreover, little research examines the interaction between pricing decisions in the forward channel of the CLSC. We refer readers to Savaskan et al. (2004) for the reverse channel structure for collecting used products: manufacturer collecting, retailer collecting and the third party collecting. Further extended competing-retailer collection problem is studied in Savaskan and Van Wassenhove (2006).

To the best of our knowledge, all the above studies are built on the same assumption that the manufacturer acts as a channel leader. Our work differs from the papers in this stream of literature in that we consider different channel leaderships in reverse logistics structures, encompassing retailer-led, collector-led and manufacturer-led models. Thus, the CSLC model in our paper not only embraces the traditional manufacturer leadership research question, but also opens up a new leadership issue in CLSC. Moreover, rather than on collection option, we focus on providing such a comparison among different channel leaderships. Besides, we consider the CLSC with a price-dependent demand which is by itself a challenging problem even for simple supply chains (Chiu et al., 2011).

Second, supply chain channel leadership is an interesting and emerging topic. In the past, the supply chain coordination literature commonly assumed that the supplier (manufacturer) is a leader and the retailer is a follower (c.f., Jeuland and Shugan, 1983; McGuire and Staelin 1983, 1986; Savaskan et al., 2004). Nowadays, with the downstream power shifting in a supply chain, the retailer-led supply chains become a popular topic (Messinger and Narasimhan 1995; Cachon and Zipkin 1999; Ertek and Griffin, 2002). For example, Dong et al. (2007) study the efficient replenishment (ER) business process that involves the reduction of order costs. They establish the conditions under which the manufacturer and the retailer gain more from adopting ER and show that the incremental channel profit is greater in a retailer-led channel than in a manufacturer-led channel. Majumder and Srinivasan (2008) consider the contract leadership in the supply chain network, and derive the optimal location for the channel leader. Most recently, Cakanyildirim et al. (2010) consider a retailer-led supply chain which sells a newsvendor product with asymmetric production cost information and demonstrate the issue of channel leadership on supply chain performance. Almehdawe and Matin (2010) consider a supply chain with a single manufacturer and multiple retailers. They compare the supply chain efficiency between the manufacturer-led and the retailer-led cases. They find that retailer leadership decreases the wholesale price. From the above reviews, there is no doubt that channel leadership is an important topic and it has been explored from different perspectives. However, the existing literature only focuses on exploring the "forward supply chains" and ignores the related issues in CLSCs (with an exception of Karakayali et al. (2007) which analyzes remanufacturer-driven and collector-driven decentralized collection and processing operations for the end-of-life products in the durable goods industry. However, different from our work, Karakayali et al. only