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Pricing and return product collection decisions in a closed-loop supply chain with dual-channel in both forward and reverse logistics

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ABSTRACT

This paper deals a closed-loop supply chain with two dual channels – forward dual-channel where a manufacturer sells a product to customers through traditional retail channel and e-tail (internet) channel, and reverse dual-channel where the used items are collected for remanufacturing through the traditional third party logistics and e-tail channel. We derive analytically the pricing and return product collection decisions for the supply chain under five different scenarios viz. centralized, decentralized (Nash game), and manufacturer-led, retailer-led and third party-led decentralized scenarios. We also demonstrate the proposed model through a series of data sets. It is observed from the numerical study that the retailer-led decentralized scenario provides more profit than other decentralized scenarios.

1. Introduction

The rapid development of Information Technology (IT) helps many manufacturers/suppliers to sell their products in the direct channel along with the traditional retail channel. Many companies such as IBM, Panasonic, Kodak, Apple, Dell, Sony, Hewlett Packard, Lenovo, Pioneer Electronics, Cisco System, Estee Lauder, and Nike sell their products through direct channel today. A direct channel offers the manufacturer to create its own market, and attracts customers to form loyalty avoiding domination by the retailer. Direct marketing is often used to provide information to support sales in the traditional channel. Selling over Internet attracts many manufacturers to avoid middlemen. The current revolution of materials delivery by third party also influences Internet sales growth. Even though the dual-channel assures to take over as the prevalent supply chain design for all kinds of business, it is difficult to manage the expected competition between traditional retail channel and the e-tail channel. To use the dual-channel system, the manufacturer has to redefine his/her relationship with the downstream retailer. In the age of e-tail, success of dual-channel is influenced by the management of channel conflict [1–5]. Channel conflict between channel members tends to be a very negative force which may lower profits for all parties. To the benefit of both the manufacturer and the retailer, it is, therefore, required to decrease channel conflict and improve channel coordination [6]. This paper aims to address how e-tail channel entry affects the manufacturer's and the retailer's payoffs, who benefits from the e-tail channel entry, and how the profits of different entities are affected by the e-tail channel entry when different members led the systems.

Due to resource shortage and environment degradation, manufacturing enterprisers are facing the challenge of coordinated development of production and environment. These enterprisers are required to make the integrated optimization for the forward logistics of new products and reverse logistics of waste products. The closed-loop supply chain (CLSC) concerns the integration of material flows, financial flows, and information flows throughout both forward and reverse chains. It assists companies in recognizing potential benefits and overcoming challenges associated with its operations and strategies. The CLSC, especially the reverse logistics system with the third party reverse logistics provider, is very important for materials recycling, resources saving, and environment protecting activities. Several companies in many countries have started recognizing the strategic value of integrating environmental principles into business policies and have developed innovative product recovery programs to recover and reuse their end-of-life products. Remanufacturing is usually considered as a recovery process in which a returned (recovered) item is transformed through several operations including disassembly, cleaning, testing, part replacement/repair, and reassembly to a "like new" one which is equivalent to the original manufactured product. Examples of such remanufactured products include mostly high-value industrial products such as aircraft or automobile engines,

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aviation equipment, railroad locomotives equipment, medical equipment, machine tools, copiers, electrical and electronic equipment, toner cartridges, cellular telephones, single-use cameras, etc.

In CLSC, manufacturers may collect the used products directly from consumers. Xerox Corporation, Hewlett Packard Corporation, Eastman Kodak and many other companies receive used products directly from consumers. Third parties (e.g. GENCO Distribution System) are preferred by some consumer goods manufacturers for their experience in collection of used products. Also, the internet has provided consumers a new way to interact with manufacturers/retailers. It appears that dual-channel in reverse flow can be effective like dual-channel in forward logistics. In this paper, we develop a CLSC model which consists of a forward dual-channel and a reverse dual-channel. The forward dual-channel consists of one traditional retail channel and the manufacturer's direct e-tail channel. The reverse dual-channel is operated by the traditional third party and the manufacturer itself (for direct collection of used items via e-tail channel).

It is common to see in industry that the manufacturer acts as the channel leader who offers supply contracts to the retailer. In some cases, third party logistics providers (e.g. SIMS Metal Management, IBM's Global Asset Recovery Services, and AER Worldwide, etc.) take a leadership role in the corresponding CLSCs and coordinate the operations in reverse logistics [7–9]. We investigate the proposed CLSC model under centralized (cooperative) and decentralized (non-cooperative) or Nash game policies along with three Stackelberg games led by the manufacturer, retailer and third party logistic service provider. Within the framework of Game Theory, a cooperative game helps to design a supply chain by selecting an optimal coalition of partners. A non-cooperative game approach is certainly more appropriate to determine the set of equilibrium points that can be reached in trade conditions. A case of particular interest is when there exist decisional states from which no player has interest to depart. Such cases are called Nash equilibria. Existence of Nash equilibrium points reduces the negotiation process to a one-shot exchange of information. In many real situations, the equilibrium is not unique, and the first player imposes the outcome of the game. The particular equilibrium reached in such an asymmetric game is called 'Stackelberg equilibrium'. With the help of these game theoretic approaches, in our investigation, we will try to find the answers of the following questions:

1. In the forward dual-channel, which channel and under which decentralized policy would provide the lowest selling price?
2. In the reverse dual-channel, which channel and under whose leadership would provide the maximum return product?
3. What happens if the manufacturer would not use the e-tail channel for the recycling process?

The rest of the paper is put in order as follows. Next section describes a brief literature review on the topic discussed above. Section 3 presents notations and assumptions of the model under consideration. In Section 4, the closed-loop supply chain model is formulated under different scenarios, and relevant analytical results are derived. Numerical outcomes and sensitivity analysis are presented in Section 5. The paper is concluded in Section 6.

2. Literature review

With the emergence of the Internet as a viable channel of distribution, study of dual-channel or multi-channel competition has acquired much importance. Balasubramanian [10] reported competition between direct marketers and conventional retailers. Levary and Mathieu [11] found that a dual-channel distribution holds the most promise for increasing profit. Geyskens et al. [12] found that powerful companies with a few direct channels achieve better financial performance than less-powerful companies with broader direct market offerings. Using game theory, several researchers studied the price competition between a manufacturer's direct channel and its traditional retail channel [2–5]. They observed that the vertically integrated direct channel allows a manufacturer to constrain the partner retailer's pricing behavior. This may not always be detrimental to the retailer because the constraints on pricing may be accompanied by wholesale price reduction.

A few researchers studied dual-channel addressing the strategic importance of retail services in the direct versus retail competition [2,13,14]. They found that the direct channel could not always be detrimental to the retailer because of improved retail services. A number of researchers considered the effect of channel conflict, which may arise between a manufacturer and its retail channel partner when the manufacturer initiates a direct sales channel. Channel conflict in a dual-channel supply chain arises from a rather unique competitive situation: a manufacturer and its retailer are engaged simultaneously in both vertical and horizontal competition. Vertical competition particularly occurs when the manufacturer sells to a mediator at a wholesale price above its marginal cost and induces his retailer to set a retail price above what it would be if it faced the true marginal cost of the channel. Several studies on channel conflict reported that multiple channels increase the difficulty for a firm to recover its costs [1,15–17].

Game theoretical aspect is one of the main features of dual-channel [1,18]. Tsay and Agrawal [1] studied the channel conflict and coordination between the manufacturer and the retailer in a dual-channel supply chain and proposed policies that could coordinate the actions of channel members. Most of the studies assume that the manufacturer has more bargain power than the other players [5,19]. Lu and Liu [20] used two types of Stackelberg pricing game and one type of Nash pricing game in dual-channel distribution system and analyzed the effects of several key factors such as the supplier's pricing mode, game schemes, and efficiency of e-channel. Pei and Yan [21] developed a game-theoretical model to show that opening an online channel with the added national advertising effectively alleviates the channel conflict and thus helps improving the whole channel's and each channel member's performances. Several studies have been conducted on dual-channel under various issues such as pricing strategy [22–24], service competition [25], add value product [26], lead time effect [5,27], branding differentiation or substitutable product [28] and disruption [29]. Recently, Gan et al. [30] proposed a CLSC model where he implemented separate sales channels and differentiated prices for new and remanufacturing products on dual-channel in forward logistics.

For improving economic and environmental performances, development of forward and reverse channels together i.e. CLSC is very much essential. Savaskan et al. [31] analyzed the problem of choosing the appropriate reverse channel structure for collecting used products from customers in a CLSC. Several researchers have focused on channel management of CLSC with the presence of competition [32–36]. Their models are more practical due to the consideration of retail competition in the forward supply chain. Hong and Yeh [37] showed that the retailer collection model's performance is superior to the non-retailer collection model under some conditions in a CLSC in electronics industry. Choi et al. [9] examined the performance of different CLSCs under different channel leaderships. They showed that the supply chain performance is the worst when the most upstream member acts as the supply chain leader. De Giovanni and Zaccour [38] developed