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Pricing and effort decisions in a closed-loop supply chain under different channel power structures

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ABSTRACT

This paper aims to explore the influence of different channel power structures on the optimal decisions and performance of a closed-loop supply chain (CLSC) with price and effort dependent demand, to identify the most profitable channel power structure and to propose coordination strategy for the decentralized CLSC. Considering the demand expansion effectiveness of collection effort and sales effort, centralized and decentralized game theoretic models of a CLSC with one manufacturer and one retailer are built, to investigate optimal decisions of collection effort, sales effort and pricing under different channel power structures, namely manufacturer Stackelberg, vertical Nash and retailer Stackelberg. Through a systematic comparison and numerical analysis, the results show that with dominant power shifting from the manufacturer to the retailer, the retailer's profit always increases and the manufacturer may also benefit when the demand expansion effectiveness of collection effort is large enough. The symmetric channel power structure is the most favorable for both the CLSC and consumers when the demand expansion effectiveness of collection effort is relatively low; otherwise, the CLSC with dominant retailer is the most profitable. Moreover, the proposed low price promotion strategy can effectively enhance the performance of decentralized CLSC.

1. Introduction

The intensifying pressure of environmental deterioration and natural resource shortages highlights the importance of closed-loop supply chain (CLSC) management. Government legislations, oversight from non-governmental organizations, consumer environmental awareness and corporate social responsibility are important drivers for enterprises to participate in CLSC, while the economic benefits may be the key factor that attracts enterprises to incorporate reverse logistics in their supply chain (Chen and Chang, 2013; Shi et al., 2011; Wu, 2012; Wu and Pagell, 2011; Zhu et al., 2008). In many industries, such as automobiles, copiers and computers, CLSC management has been successfully practiced, with the establishment of economically viable production and collection systems that enable remanufacturing of used products in parallel with the manufacturing of new units (Savaskan et al., 2004). Motivated by the significance of CLSC management in practice and open questions in channel decision-making, CLSC has also been a critical research topic in the academic area. The objective of this paper is to present a comprehensive discussion on the influence of channel power structure on optimal channel strategies and profitability of CLSC with the price and effort dependent demand, analyze which channel power structure is the most favorable one for the CLSC and consumers, and coordinate the decentralized CLSC.

Manufacturers have realized that CLSC management can be used to gain competitive advantage and achieve sustainable development. In a common form of a CLSC, a manufacturer collects used products and appropriates the benefits (De Giovanni and Zaccour, 2014). For example, Xerox has been a leader in reusing their high-value, end-of-lease copiers in the manufacturing of new copiers. Similar activities are undertaken by Hewlett Packard Corporation with their used computers and peripherals (Savaskan and Van Wassenhove, 2006). To facilitate collecting, the manufacturer usually exerts collection effort such as product design and process modification towards recycle, advertising and communication campaigns about the recycling policies, reverse logistics services, monetary and symbolic incentives, and employees-training programs. These activities reflect firm's environmentally responsible features and enhance the firm's reputation, satisfy the consumers'

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environmental concerns and simplify their disposal process (Hong and Yeh, 2012). With economic and environmental benefits, in practice, it is noted that the investment in collection effort can not only positively influence the return rate but also enhance the market demand. Despite of this, most previous studies merely pay attention to the effectiveness of collection effort on the return. Thus this paper investigates the optimal effort-input and pricing decisions, considering the demand expansion effectiveness of collection effort.

On the other hand, the retailer's sales effort is crucial for winning the market share. For instance, the retailer can stimulate demand by advertising the products' features, providing attractive shelf space, and point-of-sale demonstrations by salespeople. Since the sales effort also incurs significant investment, it is vital for the retailer to make the optimal sales effort decision and retail margin decision in the channel. Based on this, the collection effort and sales effort are simultaneously taken into account in this paper when exploring the optimal strategies and profitability of CLSC, and proposing coordination mechanism.

Moreover, channel power structure, which depends on the member's ability to control the decision making process in the channel, will have a substantial effect on the channel performance. 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 (Choi et al., 2013). Traditionally, many manufacturers enjoy sufficient power to be the channel leader who will anticipate the retailer's response and make decisions at first. However, the increasing power of some retailers such as Wal-Mart and Tesco leads to the symmetric channel power structure or even the retailer-dominated power structure. Therefore, a more thorough understanding of the impact of channel power structure on optimal pricing, effort decisions and profitability is necessary and interesting. Furthermore, companies have also increasingly realized the importance of coordinating the supply chain to achieve higher performance. It hence raises the question that how to coordinate the CLSC with price and effort dependent demand.

This paper explores a CLSC with one manufacturer and one retailer, where the market demand is sensitive to retail price, collection effort and sales effort. The manufacturer decides the collection effort and wholesale price, while the retailer chooses the sales effort and retail margin. Game theoretic models of centralized CLSC and decentralized CLSC under three channel power structures, i.e., manufacturer Stackelberg (MS), vertical Nash (VN) and retailer Stackelberg (RS), are established to answer the following questions:

What are the optimal pricing, effort-input decisions and profits in different models?
What is the influence of channel power structure and demand expansion effectiveness on channel strategies and profits?
Which channel power structure is the best, from the view of the CLSC and consumers, respectively?
What role does low price promotion strategy play in enhancing the performance of decentralized CLSC?

Therefore, the contributions of this paper to literature are in the following aspects. First, the impact of channel power structure on optimal CLSC decisions and profits is examined when the demand expansion effectiveness of collection effort and sales effort are considered simultaneously. Second, the best channel power structure is analyzed from the perspective of the CLSC and consumers. Third, a strategy is proposed to coordinate the decentralized CLSC with price and effort dependent demand. The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 gives model description and presents different CLSC models with equilibrium results. Section 4 discusses optimal results with the impact of power structure and demand expansion effectiveness. Section 5 presents the low price promotion strategy to coordinate the CLSC. Section 6 provides the numerical examples to examine the propositions and shed more implications. Section 7 concludes the study and outlines the future research directions.

2. Relevant literature

Over the past decades, many researchers have shown interest in decision-making and coordination of the CLSC. A detailed review of earlier efforts on CLSC research can be found in Guide and Van Wassenhove (2009). An overview of the literature on coordination contract can be found in Govindan et al. (2013). Govindan et al. (2015) presents a systematic classified analysis of recent papers on reverse logistics and CLSC to spot future avenues.

In recent years, Wei et al. (2010) explore the optimal pricing decisions for the CLSC with retail competing by the use of game theory and fuzzy theory, considering the collecting price, wholesale price and retail prices as triangular fuzzy numbers. Shi et al. (2011) analyze the optimal decisions of production quantities, selling price and acquisition price for a closed loop system with uncertain demand and return, where the manufacturer can manufacture brand-new products and remanufacture returns into as-new products. Wei and Zhao (2011) focus on the decision-making process of the wholesale price, retail prices and remanufacturing rate in a fuzzy CLSC with retail competition. Wei et al. (2012) study the pricing problem for a CLSC consisting of a manufacturer and a retailer in a fuzzy environment and show the effect of bargaining power on the results by establishing the MS game and VN game. Wu (2012) identifies the equilibrium characteristics with respect to the remanufacturer's effort and price and service decisions for all members of the supply chain, and investigates the profits of chain members by considering different interactions of prices and service competition between the manufacturer and the remanufacturer.

Choi et al. (2013) examine the implications of different channel leaderships on the performance of CLSC with a manufacturer, a retailer and a collector, given the price-dependent demand, and present the two-part tariff and novel revenue-cost sharing contract to coordinate the CLSC. De Giovanni and Zaccour (2014) investigate the pricing, collection effort decisions and members' profitability to compare several CLSC configurations of collection process. Tseng et al. (2014) evaluate the close-loop and open hierarchical structures in the multi-criteria decision making analysis of green supply chain management using hybrid fuzzy set theory and analytical network process techniques, and find that the close-loop hierarchical structure more closely resembles the real situation. Maiti and Giri (2014) investigate the effect of channel power structures on the quality of manufactured and remanufactured products, the pricing strategy, the collection rate, and the profits of the CLSC, finding that the centralized policy is always the best and the retailer-led decentralized policy is more acceptable among the decentralized policies. Wei et al. (2015) study the optimal wholesale price, retail price, collection rate decisions and member's bargaining powers by examining a CLSC under symmetric and asymmetric information conditions.

Most of the above papers focus on the pricing, collection effort or collection rate decisions of CLSC under certain channel power structure. In particular, despite the fact that the collection effort can not only facilitate the collection of used products but also exert positive influence on the market demand, little research has been done. Wu (2012) incorporates the impact of service on demand; however, the study draws attention to the competition between the manufacturer and the remanufacturer rather than the influence of channel power structure. Choi et al. (2013) provides a comparison