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Joint-advertising for collection of returned products in a closed-loop supply chain under uncertain environment

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ABSTRACT

Advertising plays an important role in contributing to the supply of returned items and market expansion. In this paper, advertising is considered as a means to entice consumers to return used-items in a remanufacturing environment. We investigate the impact of sharing or of not sharing advertisement cost on the total profit gained and the quantity of used-items acquired under the uncertain demand of remanufactured/new products and uncertain returns. For analysis, we develop mathematical models for the following closed-loop supply chain configurations: (i) advertising by manufacturer with cost-sharing, (ii) advertising by retailer with cost-sharing, (iii) individual advertising with cost-sharing, (iv) centralized advertising, and finally, (v) advertising without cost-sharing. These models have been illustrated through a numerical study, and the results reveal that the closed-loop supply chain model with "centralized advertising configuration" performs better over other models, and also, that advertising provides positive economic and environmental benefits.

1. Introduction

Traditionally, the products, which are manufactured using raw materials extracted from the nature, are disposed of in landfills or via incineration at the end of their useful life. However, this practice is environmentally unsustainable. Therefore, it is important to find ways to mitigate the adverse impacts of these practices on the environment as well as on the quality of human life. Consequently, the study of closed-loop supply chains (CLSC) has received considerable attention both from the academia and industrial communities. A CLSC combines forward and reverse activities of supply chains into a unified system that targets to improve economic, environmental, and social performance (Bottani, Montanari, Rinaldi, & Vignali, 2015; Guide & Van Wassenhove, 2009). In the CLSC, a manufacturer may decide to handle the return process separately. Guide (2000) has mentioned that 82% of the firms collect used-products directly from the customers. However, with the retailers being the closest players to the market, they can influence the customers by creating knowledge and awareness about environmental and social concerns and thereby, encouraging them to return used-items (De Giovanni, 2014; Hong & Yeh, 2012).

Remanufacturing of used-products is an important sustainable activity, and it has a significantly positive environmental impact (Atasu, Toktay, & Van Wassenhove, 2013; Sheu, 2011). Remanufacturing extends the useful life of a product and it may reduce demand for new products, and thereby, decrease burden on the environment (Jena & Sarmah, 2014). For instance, Fuji Xerox (Australia) remanufactured more than 230,000 equipment parts, equating to $6 million cost savings compared with sourcing of new parts (Bulmus, Zhu, & Teunter, 2014). It is a common practice for manufacturers to use advertising in order to increase sales. Advertising has become a crucial tool for demand creation and market expansion (Liu, Cai, & Tsay, 2013). Almost every company keeps a significant portion of their total budget for advertising. According to He, Krishnamoorthy, Prasad, and Sethi (2011), manufacturers spent more than $25 billion on advertising in 2007, compared with $5 billion in 2000 and $900 million in 1970. However, merely selling of good-quality products is not enough in the present competitive business environment. The collection of returned items is equally important in today's environmentally-sensitive society. For example, the aim of conducting advertisement by an automobile company is to make public aware of product usage, product quality, return of used-items, etc. If the advertisement for automobiles includes reverse logistics information, it can improve consumers' awareness for recycling automobiles and their parts (Jian & Xianjia, 2013). Besides, some consumers are also willing to return used-products directly to the manufacturer at specific drop-off locations. For instance, Samsung has undertaken a collection program (called Samsung Takeback and

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Recycling Program) by which consumers can return used toner cartridges (De Giovanni, Reddy, & Zaccour, 2016; Samsung, 2014). Samsung has invested in an advertisement program to encourage return of used-products, which is measured by return rate.

Jena and Sarmah (2015) in their study have found that advertising plays an important role in influencing the consumer's perception for returning their used-products. In fact, advertising has a significant impact on product pricing, reverse channel performance and profit earned. Johnson (2013) has mentioned that the consumers' become aware of the product or business only as a result of an advertisement. The consumers' can take more interest in returning their used-product after getting information through advertisement. If one member of the channel uses advertisement, it does not necessarily imply that they should bear the entire cost alone (Liu et al., 2013). For instance, in 2002, manufacturers gave approximately $60–65 billion in promotional assistance to their retailer partners (Arnold, 2003). Cost-sharing has often been implemented in the form of cooperative advertising (Berger, 1972; He, Prasad, & Sethi, 2009; Xie & Neyret, 2009; Hong, Xu, Du, & Wang, 2015). Advertising by the manufacturer and the retailer, as well as cooperative advertising in a CLSC, have been acknowledged in the literature (see De Giovanni et al., 2016; Hong et al., 2015; Jian & Xianjia, 2013; Savaskan, Shantanu, & Van Wassenhove, 2004; Savaskan & Van Wassenhove, 2006). The manufacturing firms face a significant challenge due to variation in the supply of used-products and their uncertain demands. To address this situation, the retailer collects used-products from the market with a fixed acquisition price and sells them to the manufacturer with a transfer price, which is higher than the acquisition price (Atasu et al., 2013; Savaskan et al., 2004). Hence, offering a lower incentive enhances the company's unit profit gained from the returns, whereas it diminishes the consumers' willingness to return used-products (Aras, Aksen, & Tanugur, 2008). Again, the retailer sells the manufactured products to the market with a higher than wholesale price. As a result, the retailer generates more revenue from collection of used-products and selling of manufactured products. In the literature, it is observed that the retailer and the manufacturer collect more used-products by increasing investment on advertisement (Hong et al., 2015; Xie, Liang, Liu, & Ieromonachou, 2017). Hence, it behooves the retailer to take interest in sharing a proportion of advertising expenses with the manufacturer. As also observed by Hong et al. (2015) and Xie et al. (2017), advertising with cost-sharing as such has not been studied adequately in the CLSC literature. Therefore, in this paper, we assume that both members of the CLSC (manufacturer and retailer) share advertising cost. In addition, to the best of our knowledge, a comprehensive examination of advertising strategies in the face of uncertain market demand and return of used-products has not been undertaken in the literature.

We address the following research questions:

(RQ1) Who are the responsible members for sharing advertising expenses in a CLSC?
(RQ2) How is the total profit of the CLSC impacted by different modes of advertisement?
(RQ3) How the advertising expenditure should be treated: cost-sharing or no cost-sharing?
(RQ4) How are the environment and economic benefits affected by advertisement over no advertisement?

We address these questions as follows. First, a mathematical model is developed that comprises uncertainty in demand of products and uncertainty in return of used-items in the presence of advertisement cost sharing. Second, an investigation is carried out on acquisition price, selling price and total chain profit as well as on advertising expenditure considering uncertain returns and demands. Third, the total CLSC profit (earned) under different modes of advertisement is compared. Fourth, the impact of advertisement on economic and environmental performance is analyzed by comparing the case of advertising with that of without advertising. Finally, a bargaining model is developed to determine optimal sharing of extra joint profit.

The paper is organized as follows. A brief background of literature is provided in Section 2. Section 3 provides a model overview, and our model is presented in Section 4. Section 5 is the subject of comparative analysis. A numerical example is used in Section 6 to illustrate the working of our models. In Section 7, we address the bargaining problem. Sensitivity analysis and the managerial insights drawn from our study are presented in Section 8. Section 9 is devoted to a comparison of the CLSC with and without advertising. Finally, concluding remarks and scope for future work are presented in Section 10.

2. Background literature

Some of the earlier works in the CLSC have addressed the problem of maximizing the total chain profit by determining optimal brand name investment, local advertising effort, and participation rate. Keeping in view of our work, we have broadly categorized the review of literature into two sections: (i) Literature related to uncertainty in demand and returned items and (ii) literature related to advertisement.

2.1. Literature related to uncertainty in demand and returned items

The demand for products and their return are the two main sources of uncertainty in a CLSC because of market volatility. Variability in the quality and quantity of returned products has been well documented in the literature (Bloemhof-Ruwaard, Van Wassenhove, Gabel, & Weaver, 1996; Guide & Jayaraman, 2000; Keyvanshokooh, Fattahi, Seyed-Hosseini, & Tavakkoli-Moghaddam, 2013). Inderfurth (2004) proposed a single-period model with stochastic return of used-items, and stochastic demand of serviceable products, and developed a mathematical model to coordinate the manufacturing and remanufacturing decisions in order to maximize the total expected profit. In addition, Inderfurth (2005) addressed a CLSC network design considering uncertain demand, return and quality by using stochastic programming. They developed a model to analyze the impact of making cost-effective decisions on the product recovery behavior in the face of uncertain demand, and yield, etc. Ketzenberg, Van der Laan, and Teunter (2006) extended this work and studied the value of information in the context of a firm remanufacturing under uncertain demand, product return, and product remanufacturing yield. They assumed a single-period scenario with normally distributed demand and returns, and they restricted the presence of uncertainty for up to two entities. This study is extended by Ketzenberg (2009) to a capacitated recovery system with disposal options for returned items. Guo and Xu (2008) examined a two-level CLSC network design where the retailer is engaged in the promotion and collection of used-products from the market under uncertain demand. They developed a game-theoretical profit model to analyze decisions pertaining to order quantity and collection price for both the retailer and the manufacturer. Lee and Dong (2009) employed a stochastic programming approach for a dynamic reverse network design considering uncertain demand and return of used-products. They developed a two-stage mathematical model considering simulated annealing-based heuristics algorithms under uncertainty. Pishvaee and Torabi (2010) studied a multi-period model with uncertain demand, returns, costs, and capacities, for determining the collection of used-items, recovery, and the number of distribution and recycling centers in each period. They formulated a mixed integer linear programming model to minimize the total cost and delivery tardiness. Saman and Zhang (2013) proposed a model to select the best suppliers, remanufacturing subcontractors, and refurbishing sites based on quantitative and qualitative criteria in an uncertain demand environment. However, none of these studies has considered cost sharing for the collection of used-items.

Xiong and Li (2013) studied a single class of cores with random price-dependent returns and uncertain demand for the remanufactured product considering backlogs. They proposed a dynamic pricing policy