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Reverse and closed loop supply chain coordination by considering government role

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ABSTRACT

Due to the increasing number of end-of-life (EOL) products and their related environmental concerns, much attention has been paid to reverse logistics. In this paper, we consider a two-echelon reverse supply chain (RSC) with one manufacturer and one retailer who try to improve sustainable consumption by increasing customers' willingness to return used products through offering a discount or a direct fee in exchange for bringing back EOL products. Afterward, the model is extended to consider a closed loop supply chain (CLSC). Quantity discounts and increasing fee contracts are proposed to coordinate supply chains. Then, government role in improving coordinated supply chains through donating different incentives (tax exemption and subsidy) to supply chain members are analyzed. Results show that total channel profit in the coordinated case is improved. Also, in the proposed models, each member has enough motives to participate in the plan. In addition, results demonstrate that government-sponsored incentives to the manufacturer are preferred to the retailer.

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1. Introduction

Over the last two decades, many companies and industries in developed countries have begun considering reverse logistics (RL) as one of the important processes in their supply chain. In the academic world, according to the special features of this backward process and its differences with forward operations, researchers have also paid special attention to it. According to [Gupta \(2013\)](#), there are several environmental and economic concerns that pertain to RL operations, including saturated landfill areas, global warming, rapid depletion of raw materials, increasing amount of customer returns, and a rise in the volume of internet marketing. The establishment of both RSC and CLSC systems becomes a critical requirement of societies in both developed and developing countries ([Govindan et al., 2015](#); [Govindan and Soleimani, 2016](#)) but the issue is highly complex and challenging ([Vahdani et al., 2013](#); [Wang et al., 2016](#)). The successful performance of a reverse logistics system depends on EOL products and customers' willingness to return their obsolete products to complete the cycle ([Shaharudin et al., 2015](#)). Level of customers' willingness to return can be mapped to a real positive number in the interval

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[0,1]; the number represents the percentage of customers who actually participate in the task of returning their obsolete products back, and are rewarded with a certain amount of incentive (Bai, 2009).

Researchers have considered RSC and CLSC from many aspects such as network design, location of distribution centers, collection centers, and disposal centers (Vahdani and Mohammadi, 2015). In many cases, reverse operations do not create enough profit for SC participants while the process is beneficial from environmental and community perspectives (e.g., see Jaber et al., 2014). In these cases, government as a facilitator can play an effective role to encourage recycling business operations and also to motivate SC participants to conduct reverse operations (Xie and Ma, 2016). Government and legislation systems that offer incentives and fees are vital for RL activities in many reverse operations (Valenzuela, 2009). Some evidence, both from theoretical models and from real cases, confirms the need for government grants or incentives to make reverse operations affordable for all supply chain players. Impact of government grants on RSC/CLSC systems has been explored by researchers in several real cases. For example, the impact of subsidies in China's auto parts industry was analyzed by K. Wang et al. (2014), Y. Wang et al. (2014). Simic and Dimitrijevic (2012) considered EU legislation and proposed a recycling model for end-of-life vehicles (ELVs). In a similar study, Wang and Chen (2013) authenticated the positive role of ELV recycling policies and regulations in China. From the theoretical perspective, using a cognition mapping process, Rahman and Subramanian (2012) found that factors such as government legislation, incentives, and customer demand are the major drivers in the case of computer recycling operations. Hammond and Beullens (2007) studied the impact of legislations on the management of products at the end of their useful life and suggested that legislations can stimulate reverse chain activities within a supply chain. Aksen et al. (2009) claimed that the company makes a higher profit in a supportive role of the government compared to the case of a legislative role of the government.

It is clear that the role of incentives in improving the reverse supply chain in government-dependent economies is much more frequently emphasized than those offered by government-independent economies. Tax credits and exemptions donated to remanufacturing processes, recovery and recycling payments provided to collectors, and various governments' subsidies for manufacturers are common legislative incentives.

The research questions that this study aims to answer are expressed as:

- (1) What is the optimal value of "customers' willingness to return EOL products" in both RSC and CLSC models?
- (2) How is it possible for a manufacturer to entice a retailer to optimize customers' willingness from the whole system viewpoint? What are the appropriate contracts between the manufacturer and retailer for this purpose?
- (3) What are the impacts of various government grants (in term of tax exemption to the manufacturer/retailer, subsidies to the manufacturer/retailer) in achieving coordination?

The main contribution of this work seeks to implement a practical coordination mechanism in the form of quantity discounts and increasing fee contracts to coordinate both reverse and closed loop supply chains. Furthermore, government role, as a supporter in the process of achieving coordination, in improving coordinated supply chains through donating various incentives (tax exemption and subsidy) is investigated. In order to illustrate the government's role in achieving channel coordination in the investigated supply chains, we develop models both with and without government interventions.

In order to answer the research questions in this paper, we consider a two-echelon reverse SC with one manufacturer and one retailer who try to increase final customers' willingness to return EOL products by offering a discount or a direct fee in exchange for returned EOL products. After inspection, valuable collected products are sent back to the manufacturer and, according to their remanufacturing value, they are recycled or disposed of. Afterward, the proposed model is extended to consider both forward and reverse operations as a closed-loop SC where remanufactured products are taken back until they again meet the demand. Since large amounts of reverse operations may not be economically justified, the effects of government interventions are modeled in four different scenarios: (1) Tax exemption donated to the manufacturer, (2) Tax exemption donated to the retailer, (3) Subsidy donated to the manufacturer, and (4) Subsidy donated to the retailer. In this regard, this study applies two different types of government interventions: subsidy and tax exemption. These two intervention types are different from various aspects and each one can be used under specific conditions. From the viewpoint that considers ease of implementation, donating subsidy logically seems to be an easier method than a tax exemption. In addition, if tax exemption amount is not adequate for the retailer's or the manufacturer's incurred cost, then applying a tax exemption cannot convince them to participate in the plan. In such cases, government has to use subsidy rather than tax exemption. However, from society's viewpoint, tax exemption may result in less payment for the consumers and, hence, a broader segment of society will benefit from this mechanism. Specific differences between tax exemption and subsidy in the proposed models will be discussed in Section 5.

The remainder of current study is organized as follows. In Section 2 we present a literature review on coordination contracts and government roles in reverse supply chains, followed by analytical models and supply chain profit functions for both reverse and closed-loop SC models provided in Section 3. Section 4 provides a numerical example and sensitivity analyses. Section 5 compares various scenarios of government intervention. Section 6 provides managerial insights and, finally, Section 7 draws conclusions and further research directions.

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