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Two-echelon pharmaceutical reverse supply chain coordination with customers incentives

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ABSTRACT

In the pharmaceutical industry, leftover medications that have not been properly disposed not only damage the environment but also might turn into a peril to people's health if being redistributed illegally in undeveloped countries. In contrary, if they are returned to the pharmaceutical producer before their expiry dates, they can be sold at subsidized prices or donated in such countries. In this research, we explore the role of providing incentives to customers in order to facilitate leftover returns and improve the sustainability for a real pharmaceutical reverse supply chain (RSC). Moreover, this research investigates the effect of having a proper coordination method between a producer of medications and third-party logistics (3PL) companies, responsible for collecting unwanted medications from customer zones. Finally, a technique is also proposed to share the RSC's saving among the producer and the 3PL companies. The experimental results on a real case study indicate that introducing incentives to customers could decrease the amount of uncollected medications from 18% up to 6.5%. Furthermore, having a proper coordination with 3PL companies could guarantee a full medication recovery.

1. Introduction

The pharmaceutical industry has witnessed significant changes in recent years. New regulations have been imposed by governments for tackling the recovery of unwanted/expired medications at different customer zones (Kumar et al., 2009). Hospitals and pharmacies, as the main consumers of medications, are faced with uncertain and fluctuating demand. Since the shortage of certain medications might lead to severe consequences for patients, customers might adopt a conservative inventory control policy through keeping large quantities of drugs in stock. Given the perishable nature of medications, such a strategy would lead to the expiration of excess inventory in the absence of patients demand. In contrary, if unwanted medications are returned to the producer prior to the end of their shelf-lives, they can be either sold in subsidiary markets or donated in developing and undeveloped countries. This humanitarian aid could improve the quality of health care in such communities. Accordingly, improving the reverse supply chain (RSC) is one way to gain and maintain strategic advantages in this industry.

Medications recovery process is complex in the sense that information about available amounts of leftovers, the willingness of customers to return medications, and the cost associated with the collection and disposal processes are not always known by the producer (Sbihi and Eglese, 2007). The paucity of such information could be indeed the result of the lack of trust and coordination between producers, customers, and 3PL companies. Moreover, the direct and leakage effects of information sharing discourage companies from collaboration (Li, 2002). Hence an efficient decision-making process in such RSCs is bound to fail unless a coherent coordination mechanism is utilized (Lin and Ho, 2014).

While many studies have investigated the impact of coordination on forward supply chain networks (Kanda et al., 2008; Oliveira et al., 2013), the literature is scant on the benefits of coordination in RSC networks. The available literature is limited to the profitable RSCs, such as the electronics recovery networks (Walther et al., 2008; Govindan and Popiuc, 2014). This is due to the possibility of reusing the precious metals in such networks. On the other hand, knowing the complexity of the pharmaceutical RSC, little attention has been addressed for the coordination of this specific value chain. The negligible salvage value of the expired medications has also encumbered the investment in this RSC.

In this research, we investigate the use of coordination methods to ensure full medication recovery while sharing the savings fairly between members of a pharmaceutical RSC. The current structure of this pharmaceutical RSC involves the producer, the 3PL companies, and the RSC customers. We can observe that hospitals and pharmacies, as the RSC customers, keep medications to expire at their sites; then, they inform the producer about the

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quantity of the expired medications. Because it is a non-profitable activity, the producer is not motivated to collect the expired medications by herself. Instead, she contracts with one or more 3PL companies to collect the expired items at customer zones by offering non-negotiable collecting fees. Thereafter, 3PL companies collect the medications and ship them to one of the governmental safe disposal sites. Consequently, the producer pays disposal fees to the government for those shipped items.

It is worth mentioning that depending on the collecting fees offered by the producer, 3PL companies might only collect a percentage of the available leftovers according to their own profit margins. If we look at the archival data of the pharmaceutical producer under investigation, we can notice that the collecting fees that are paid currently to 3PL companies are insufficient. In other words, about 20–40% of the available unwanted medications remain uncollected. Leaving expired medications at customer zones and disposing them improperly (e.g., thrown away in water resources) lead to penalties that must be paid by the producer to the government. Furthermore, this puts company's reputation in the market in peril due to the negative environmental footprint of her products. Therefore, new strategies have to be implemented to ensure the RSC effectiveness and to reduce the negative environmental impacts.

Against the current reactive approach in collecting unwanted medications, in this paper, we propose a proactive approach. It involves offering incentives to customers to encourage them to return those medications that have high stock levels and less demand before their expiry date. By involving customers in the recovery process, medications could be collected in a sufficient time to expiry date. Hence, they could be donated or sold in subsidiary markets. The idea is to have more efficient and sustainable RSC by involving customers in the recovery process (Sarkis, 2003). In other words, these alternative reduces the risk of medical traces in groundwater by decreasing the quantity of medications that are landfilled while ensuring humanitarian aid. Besides, producers can earn revenue by selling the unexpired medications in subsidiary markets and benefit from tax deductions after donating them to developing countries.

To achieve this, we propose two coordination schemes between the pharmaceutical producer, the 3PL companies, and the customers. They have been modeled by the aid of nonlinear mathematical programming to reflect the decision-making process of the pharmaceutical RSC under study. While the first model is mainly focused on producer–customer coordination, the second one incorporates a negotiation mechanism to the first model in order to motivate 3PL companies to collect the total amount of leftover medications at customer zones. Finally, in order to reward the 3PL coordination efforts, we propose a procedure for sharing the expected savings in the enhanced RSC. To the best of our knowledge, this study is the first contribution to the literature that develops a coordination mechanism among all entities of RSC (i.e., customer, producer, and 3PL companies) in the pharmaceutical industry.

Our experimental results on a real case study reveal the importance of ensuring customers' coordination in increasing the return volume up to 6.5% while creating extra revenue/tax deduction for the producer. Furthermore, by implementing the proposed negotiation mechanism with 3PL companies, all leftovers can be collected at customer zones, hence no more penalties will be paid to the government. The cost of such coordination for the company would incorporate the incentive paid to customers, increased collection fees, as well as a portion of the savings that would have to be paid to 3PL companies. In return, adopting sustainable practices, such as the safe disposal of expired medications and regulated redistribution of unexpired ones to developing countries, is expected to improve the company's image in the market. Furthermore, the proposed producer–customer coordination has financial benefits for the producer as opposed to the current practice where the disposal of expired medications has no cash return.

This paper is structured as follows. A brief summary of the literature related to RSC coordination is given in Section 2. In Section 3, the description of the case study context and two different coordination models are proposed. Numerical results for each model are presented in 4. Finally, concluding remarks and future recommendations are provided in Section 5.

2. Literature review

With the imposed environmental regulations, a stream of research has been focused on involving the recovery process in supply chain practices (Blackburn et al., 2004). For example, detailed reviews on RSC models can be found in Akcali et al. (2009) and Aras et al. (2010). Knowing that supply chains inherently involve multiple independent decision-makers, profitable solutions for every member are complicated and seldom to be obtained unless a proper coordination mechanism is utilized. A coordination mechanism can be used to conquer the anti-trust problems, the loss of control, the uncertainty about local policies, the variability of a returned product quality, etc. (Bahinipati et al., 2009). Supply chain coordination problem was tackled by many researchers, such as Modak et al. (2014, 2015a,b) and Sana (2014).

Furthermore, many definitions have been proposed over the years to describe coordination and its role in supply chains. According to Arshinder et al. (2011), supply chain coordination can be defined as the process of managing dependencies between supply chain entities in order to achieve mutually defined goals. Another similar definition was given by Li and Wang (2007) as “an operational plan to coordinate the operations of individual supply chain members and improve system profit”.

Camarinha-Matos et al. (2009) reviewed the key concepts, classifications, and some applications related to supply chain coordination. By reviewing the literature prior to 2011, Arshinder et al. (2011) highlighted the coordination mechanisms for managing supply chains uncertainty. The authors concluded that in order to coordinate a supply chain, the aggregation of the impact of all coordination mechanisms on the performance of supply chain is required. According to another holistic literature review by Kanda et al. (2008), coordination mechanisms for supply chains can be achieved through (1) supply chain contracts, (2) information technology, (3) information sharing, or (4) joint decision making.

Many papers in the available literature on coordination mechanisms deal with forward supply chains and focus on coordinative contracts, such as revenue-sharing (Cachon and Lariviere, 2005; Giannoccaro and Pontrandolfo, 2004; Xu et al., 2012), buy-back contracts (Liu et al., 2014), and quantity discounts (Cachon, 2003). In particular, if we look at the revenue-sharing techniques investigated, Cachon and Lariviere (2005) studied the effect of revenue-sharing on the supply chain performance. They highlighted the limitations of revenue-sharing contract, such as the administrative burden it imposes on supply chain entities. Cao et al. (2013) implemented a revenue-sharing contract to coordinate a decentralized supply chain for one manufacturer and multiple retailers. Giannoccaro and Pontrandolfo (2004) proposed another revenue-sharing contract to coordinate a three-stage model. By tuning the contract parameters, they could achieve supply chain's efficiency and improve the profits of all the entities. Recently, Du et al. (2013) studied a two-echelon supply chain coordinated by a credit payment and a wholesale price discount offer. Their results lead to the determination of the retail price and