



Coordinating manufacturer's innovation and retailer's promotion and replenishment using a compensation-based wholesale price contract



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ABSTRACT

In this paper, coordination of a manufacturer-retailer chain is investigated where the manufacturer innovates in manufacturing process and the retailer applies promotional efforts. The market demand is assumed to be stochastic dependent on the retailer's promotional and the manufacturer's innovation efforts. The retailer uses a periodic review inventory system for replenishing items and decides on order-up-to level, review period and promotional efforts level. On the other hand, it is possible for the manufacturer to boost the market demand by innovation in manufacturing process. The retailer's promotional and manufacturer's innovation efforts not only affect their profits, but also impress their mutual profits and the supply chain performance in an indirect manner. Firstly, we develop the decentralized and centralized decision-making models along with solution procedures and concavity analysis to solve the models. Although the centralized model improves the profitability of the whole supply chain, it may reduce the profitability of either the retailer or the manufacturer. Therefore, we propose a new compensation-based wholesale price contract for encouraging actors to take part in the joint decision-making scheme. Moreover, a profit sharing strategy based on the bargaining power of members is proposed for distributing the surplus profit between members. Finally, the results of the decentralized, centralized and coordination models are compared using test problems and some sensitivity analyses are presented.

1. Introduction

A supply chain (SC) consists of various members who are involved in satisfying consumers' needs by flowing products from suppliers to consumers. In such a process, each SC member has to make some important decisions on how to perform its functional activities. In practice, most decisions made by a SC actor not only influence its own performance but also impact on the performance of the other SC actors. For instance, an innovation in product development made by the manufacturer would increase demand of the product, which in turn all SC members would enjoy a greater market share. However, to introduce newly launched products, designing strategies to support the promotion of innovation is of high importance. Promotional efforts made by the retailer, who acts as a touch point between the manufacturer and consumers, could boost sales of the product for both the retailer and manufacturer. Despite such positive impacts that SC members could have on each other, there are cases that the inappropriate decisions made by an independent SC member reduce performance of other SC members. For instance, the

retailer's mismanagement of its replenishment system could raise the risk of product shortage and lost sales, which in turn reduce the sale of the manufacturer, especially in a competitive limited market. In traditional business environments, SC actors focus on optimizing their own performance. Due to such interactions between the manufacturer and retailer, it is of high importance to coordinate decisions regarding *innovation*, *promotional* and *replenishment* activities in the SC system.

The research field of SC coordination proposes practical mechanisms for aligning various decisions made in a decentralized SC in such a manner that not only improves the whole SC performance but also provides enough incentives for SC members to participate. Coordination contracts such as quantity discount (Goyal and Gupta, 1989), buyback (Emmons and Gilbert, 1998), revenue sharing (Giannoccaro and Pontrandolfo, 2004), collaborative model (Nematollahi et al., 2017a), and delay in payments contract (Jaber and Osman, 2006) have been proposed for coordinating various decisions. Applying coordination mechanisms is of high importance where a decision made by an individual SC member impacts on the other SC members.

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The *innovation* and *promotional* efforts are two important decisions in the SC systems. The innovations made by the manufacturers increase the customer perceived value of the final product, which in turn boost the market demand at a given price (Gilbert and Cvsa, 2003). Advertising is one of the promotional efforts which is used by several corporations to well inform customers about their new products and services (Giri and Sharma, 2014). It is evident that advertising and promotional efforts have a significant impact on enhancing market demand of the product (Wang et al., 2013). There are some studies in the literature on coordination of innovation and promotional efforts' decisions. Krishnan et al. (2004) investigated coordination of a SC with retailer's promotional efforts and showed that buyback contract alone could not be able to achieve coordination and there must be additional incentives such as cost sharing or unilateral cut-rates, etc. Xie and Wei (2009) considered cooperative advertising in a manufacturer-retailer chain and showed that the cooperative model produces higher profits for the channel than non-cooperative game. Chen (2011) used channel rebate to coordinate advertising expenditures and order quantity in a two-level chain. Zhang et al. (2013) considered cooperative advertising and its effect on reference price and proposed a two-way subsidy contract for coordinating purposes. Ma et al. (2013) designed a new contract based on two-part tariff contract along with both quality improvement and marketing efforts cost sharing to achieve channel coordination. Wang and Shin (2015) considered supplier innovations in a supplier-manufacturer chain and investigated a wholesale price contract dependent on quality and a revenue-sharing contract. Bai et al. (2015) coordinated sales price and promotional efforts in a two-echelon SC, by using revenue sharing contract and its developed form contract, i.e., revenue and cost sharing contract. Karray and Surti (2016) compared quantity discount contract with cooperative advertising by solving four non-cooperative game models. Chen et al. (2017) examined different decision making structures and the equilibrium solutions for them and used a two-part tariff contract for coordinating the SC. Bai et al. (2017) showed that in a SC with retailer's promotional and manufacturer's sustainable efforts, both two-part tariff contract and revenue-and-promotional cost sharing contract could coordinate SC. Yenipazarli (2016) studied the results of collaboration between two members for upstream innovation by investigating cost sharing agreement and revenue sharing contract. Basiri and Heydari (2017) applied a collaborative scenario based on mathematical programming to increase profit of the whole SC and to provide a win-win outcome for the members.

The *replenishment* decisions of the retailer can impact on the performance of other SC members and therefore should be coordinated. Inappropriate management of inventory system increases the risk of product shortage in the retailer site and consequently all upstream members incur losses due to the SC's lost sales. Due to high number of items, most grocery stores, supermarkets and pharmacies use periodic review inventory system for replenishing items. The main drawback to periodic review policy is that the necessary safety stock to satisfy a given service level and protect against stock-out is larger compared to other inventory systems (Tagaras and Vlachos, 2001). However, stocking higher level of safety stock imposes cost to the retailer. Most of the previous studies in the research field of SC coordination focused on coordinating economic order quantity and continues review inventory systems. However, periodic review systems are one of the widely used policies in practice that need to be coordinated. Most studies in the literature on inventory management have investigated multi-echelon periodic review inventory systems in integrated SCs (Cachon, 2001; Kanchanasuntorn and Techanitisawad, 2006; Chiang, 2008, 2013; Wang, 2013; Mallidis et al., 2014). However, few researches have studied coordination of replenishment decisions under periodic review inventory systems in decentralized SCs. For the first time, Nematollahi et al. (2017b) studied coordination of a two-echelon decentralized SC under periodic review inventory system using a collaborative decision-making approach. Afterwards, Johari et al. (2017) studied coordination of a manufacturer-retailer chain under periodic review replenishment policy by using quantity discounts. Recently,

Nematollahi et al. (2017c) have investigated coordination of a two-level decentralized supply chain under periodic review inventory system, through a multi-objective collaborative model. Ebrahimi et al. (2017) proposed a delay in payment contract to coordinate a two-echelon period review inventory system under a stochastic promotional effort sensitive demand.

Based on the literature review conducted above, it seems that there is no study in which three important decisions: (1) manufacturer's innovation efforts, (2) retailer's promotional activities and, (3) retailer's periodic review replenishment policy, are coordinated simultaneously. Therefore, to come close to real world situations, a new coordination method is proposed in the current study to coordinate those decisions when the stochastic market demand depends on both manufacturer's innovation and retailer's promotional efforts.

In real-world industrial environments, there are many cases that motivate the current study. Collaboration on innovation and promotional efforts can be extensively observed among SC partners. For instance, Intel established a lab to help original equipment manufacturers (OEMs) in the development of e-business applications and encourage innovation among its SC actors (Gilbert and Cvsa, 2003). Due to the high investment required in innovation and promotional efforts of new drugs, most pharmaceutical firms turn to each other and often collaborate with other SC partners to develop new compounds. In the United States, pharmaceutical companies invest five times more in research and development, with respect to their sales, than the average U.S. producing companies (Austin, 2006). As noted by Bhaskaran and Krishnan (2009), two pharmaceutical firms in the United States (Alpha Labs and Mega Pharmaceuticals) made a contract on the development investment of a new innovative category of diabetes medicines. Under the terms of the contract, Alpha took the responsibility of the drug development and Mega invested on the commercialization and distribution of the newly launched drug. Under such a situation, both members should coordinate their decisions in such a way that profitability of both members increases by implementing the coordination plan.

Motivated by the above practical challenges and research gaps, we analytically analyze simultaneous coordination of manufacturer's innovation, retailer's promotion as well as retailer's replenishment decisions in a periodic review inventory model, which are closely related decisions. Our contribution to the literature is several fold.

- In the supply chain coordination literature, it is shown that the wholesale price contract generally does not coordinate the supply chain (Cachon, 2003). In this study, we propose a modified version of the wholesale price contract named compensation-based wholesale price contract and show that the proposed contract is capable of coordinating the supply chain.
- To the best of our knowledge, this is the first paper which proposes a method for simultaneous coordination of manufacturer's innovation, retailer's promotion as well as retailer's replenishment decisions in a periodic review inventory model, which are closely related decisions and are important factors in today's market.
- The previous coordination models have been applied where only one supply chain member's decisions impact on the other members. Taking a different perspective, we coordinate the supply chain where not only the manufacturer's decisions impact on the retailer's performance but also the retailer's decisions simultaneously influence on the manufacturer's performance.

The main aim of the current paper is to firstly determine the optimal decisions from the whole SC viewpoint and then to design a novel coordination mechanism for persuading both members to participate in the coordination plan. To this end, we model the investigated SC under three decision-making structures: (1) decentralized, (2) centralized, and (3) coordinated decision-making models. In the decentralized model, each member individually optimizes its own profit function and therefore independent self-interested decisions will be obtained. In the centralized

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