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Optimal pricing and order policies with B2B product returns for fashion products

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ABSTRACT

We study optimal pricing and order policies in supply chain management of fashion products (e.g., a fashion apparel category) with consideration of product returns between supply chain partners (B2B). In order to study channel performance and optimal policies, two stochastic models for centralized channel and decentralized channel are, respectively, developed to handle new fashion and off-season product sales. In the centralized channel, closed-form solutions for optimal order and pricing decisions are proposed for new fashion products. Further, in a decentralized channel, the Stackelberg game model is proposed to derive the optimal Stackelberg equilibrium solution, and then a buy-back contract is designed to coordinate the channel. We also perform parameter analysis on performance of the two channel models. Numerical analysis is finally presented to validate our theoretical results and compare channel performances.

1. Introduction

In recent years, product returns management is receiving growing attention. Manufacturers have started to integrate reverse logistics into their enterprises' logistics management. In product reverse flow, products may be returned by consumers or other companies in the distribution chain. Retailers may return products for a variety of reasons, including damage in transit, expired date code, product discontinuation or replacement, product off-season, retailer's inventory too high, etc. (Tibben-Lembke, 2002). Especially for fashion products, an appropriate quantity of product returns from retailers/distributors to manufacturers has been a popular means of improving coordination in forward supply chains (Savaskan and Corbett, 2001). For example, in catalog sales of clothes, the total return rate of fashion apparel is up by 35% (Dowling, 1999). Some manufacturers, for example, the Guangzhou DiDi Apparel Trade Co., Ltd, provide drop shipping service for their retailers to deal with the headaches of handling goods, warehouse space, shipping and product returns. Compared with traditional product returns from consumers, the main characteristic of B2B returns is that the returns time is fixed, the returns quantity is much large, and the returns quality is generally the same as that of new products except that the returns are off-season.

Generally, when the manufacturer receives returns, they may mark these products down and resell them to reduce the loss of profit. However, the manufacturer needs to consider how to sell new and returned products simultaneously, and which channel to use to dispose of off-season products. In this paper, we will study the supply chain channel with the returns of fashion products, where optimal pricing of the new and off-season products and order quantity decision for the new product will be discussed in different logistics channels that are made up of forward and reverse logistics.

Our study is motivated by the clothing industry, which is designed by season and fashion (Johansen and Riis, 1995). Clothing manufacturers are now suffering from high inventory levels (Warburton et al., 2003; Lowson, 2003) and high channel return rate (up to 35% (Dowling, 1999)). There are many reasons that lead to this type of situation, two of which demand more attention: (1) the clothing manufacturer is overly concerned with distribution and marketing, but not concerned enough with the product returns problem in the clothing channel and (2) the price, quality and marketing factors are all interrelated with the channel factor, so the channel factor is the most important among the four factors. In the clothing industry, channel return is pervasive, and the decisions in different channel modes are different.

Therefore, it is significant to study how to sell new and off-season products coordinately in different supply chain channels after B2B product returns of fashion products, such as clothing.

Based on the above situation, we will consider supply chain channel management problems with fashion products based on clothing industrial practice, where product returns occur among

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supply chain partners, i.e., B2B returns. The optimal joint pricing-order decision of new products will be discussed with consideration of simultaneous discount sales of off-season products. We will study the centralized channel and decentralized channel modes with product returns, respectively. In practice, both modes often deal with returns through using traditional distribution channels and selling off-season and new products in the same market.

We develop two models with respect to the above channel modes. The first one is a centralized model, for which we prove the existence and uniqueness of optimal pricing and order polices through a two-step optimization method, and then derive closed-form formulation of the optimal solution. It is a basic model to be used as a benchmark in numerical analysis. For the decentralized model, the Stackelberg game model is proposed and then the optimal Stackelberg equilibrium solution is derived. In order to conduct further analysis of the models, numerical examples are provided to show the correlation between some key parameters.

The remainder of this paper is organized as follows. In Section 2, we briefly overview related literature and point out the difference between our work and other studies. The basic assumptions and definitions of the model formulation are given in Section 3. Then the model formulation and solution approach are proposed in Section 4 and the model analysis can be found in Section 5. Numerical analysis is presented in Section 6. Finally, conclusions and future research directions are addressed in Section 7.

2. Literature review

In what follows, we will provide a brief discussion on related literature regarding the four important dimensions of studies in this area: (1) product return; (2) periodic pricing; (3) discount pricing; and (4) joint pricing and order (production) problems.

On product returns: We first refer readers to the book with the title of *Product return handling*: *decision-making and quantitive support*, by de Brito and de Koster (2003) for a comprehensive overview. From a marketing perspective, their research examines how returns policies affect channel performance or return rates. Taylor (2001) examines supply chain coordination policies in declining environments by presenting three policies: price protection, midlife returns and end-of-life returns policies. Lee and Rhee (2007) examine returns policies in the newsboy framework and propose three coordination contracts to coordinate the supply chain when both the supplier and retailer have limited and stochastic salvage capacities. Ferguson et al. (2006) address the problem of reducing false failure returns via supply chain coordination methods by proposing a target rebate contract of Pareto improvement. Östlin et al. (2008) identify seven different types of closed-loop relationships for gathering cores for remanufacturing. The relationships identified are ownership-based, service-contract, direct-order, deposit-based, credit-based, buy-back and voluntary-based relationships. Building theory around these different types of relationships, several disadvantages and advantages are described in the paper. The above studies mainly focus on the study of return polices, i.e., how to coordinate members in the supply chain effectively. However, the costs related to and the effects of product return on the system are not discussed.

Some studies also consider the sale of new and remanufactured products in the same market, such as Ferrer and Swaminathan (2006), Vorasayan and Ryan (2006), etc., which mainly focus on the market competition between the new and remanufactured products. And Yalabik et al. (2005) provide an integrated framework for designing a product returns system by combining a responsive refund policy, and then investigate the influence of optimal refund policy on one seller and one time selling market. All of the papers reviewed above study return policies and channel design when the market of new and returned products is competitive. In our study, however, we consider the optimal pricing and production policies with a centralized target where the markets of new and returned products are to be cooperated, not in competition.

Periodic pricing: Generally, the study of the periodic pricing problem in literature is mainly on optimal dynamic pricing for the sale of perishable, short-life-cycle or fashion products by a retailer, e.g., Bitran and Mondschein (1997), Chatwin (2000), Aviv and Pazgal (2002), and Monahan et al. (2004). All studies in this field focus on the pricing decision of the product at the beginning of every period to seek revenue maximization. In contrast with the setting of our problem, no product returns or sales of off-season products are taken into consideration.

Some research has also been carried out on the periodic pricing problem with product returns. A two-period model is proposed to study the market competition between new and remanufactured products to find optimal equilibrium sale prices, e.g., Ferguson and Toktay (2006) and Ferrer and Swaminathan (2006). Competition from manufacturing and remanufacturing processes has also been investigated, e.g., Toktay and Wei (2006), Vorasayan and Ryan (2006), and Webster and Mitra (2007), etc. Different from the above studies, new and remanufactured (off-season) products are all owned by the central planner, and no competitions exist in our problem.

Discount pricing: In general discount pricing studies, researchers are mainly concerned with how to find an optimal discount policy to maximize the revenue for the value-drop product. Rajan et al. (1992) propose a continuous model to decide varying price and inventory cycle when the demand is deterministic. Wang (2005) considers discount pricing policies as coordination mechanisms of a two-echelon distribution system. Ding et al. (2006) consider the use of dynamic price discount to encourage backlogging of demand for customer classes who do not need immediate service. Aviv and Pazgal (2008) study the optimal pricing of a finite quantity of seasonal products during two periods, in which the retailer has a chance to discount seasonal products. Elmaghraby et al. (2008) analyze the optimal design of markdown pricing with preannounced prices. As seen in the above reviews, these studies are mainly to seek optimal discount pricing policies to attract customers for profit increase. Generally, the discount policy, as a decision, is made by the retailer. Karakul (2008) focuses on joint pricing and procurement of fashion products in the case of the existence of clearance markets, where excess inventory at the end of period is sold at a known discounted price in a clearance market. However, in our paper, we assume that the discount rate is exogenous, and we mainly focus on optimal ordering (production) and pricing policies of new products at the beginning of the sale season.

Joint pricing and production: Existing studies are mainly concerned with optimal pricing and production decisions in a centralized or decentralized supply chain situation. An earlier literature review can be found in Yano and Gilbert (2004), and other recent related papers include (Bernstein and Federgruen, 2003; Deng and Yano, 2006; Wang, 2006; Li and Zheng, 2006). Studies on the production and pricing decision of fashion product have also been carried out, cf., Gallego and van Ryzin (1994) and Webster and Weng (2008), etc., where no discount sale is considered. Khouja (2000) extends the single-period newsboy's problem through considering price discount to sell excess products. However, this study does not consider the relationship and coordination between supply chain members. As far as we know, all existing studies do not consider production and pricing decision simultaneously in a supply chain with product returns,