Two-period pricing and decision strategies in a two-echelon supply chain under price-dependent demand

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ABSTRACT

This paper presents a two-period supply chain model which is comprised of one manufacturer and one retailer who are involved in trading a single product. The demand rate in each period is dependent on the selling prices of the current period and the previous period. We assume that the manufacturer acts as the Stackelberg leader and declares wholesale price(s) to the retailer who follows the manufacturer’s decision and sets his selling prices for two consecutive periods. The manufacturer adopts one of the two pricing options: (1) setting the same wholesale price to both the selling periods (2) setting different wholesale prices to two different selling periods. Based on these pricing options, we develop four decision strategies of the manufacturer and the retailer and compare them. For a numerical example, we study the effects of these decision strategies on the optimal results of the supply chain. Further, we graphically analyze under what circumstances a particular decision strategy plays a dominant role.

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1. Introduction

In this era of rapidly changing technology, short life-cycle products such as PCs, digital cameras, mobile phones, etc., have become a fact of life in the business world. These products are characterized by high demand uncertainties and limited number of decision-making opportunities. The newsvendor framework is often adopted to analyze operational issues related to such products in the literature. The newsvendor framework is a single period of sales, along with a single replenishment and pricing opportunities for retailers. In reality, however, the selling period (product life-cycle) might be long enough to allow multiple production/buying opportunities for firms. If more than one period is considered, the parties involved can exhibit flexibility in terms of supply and production quantities that may arise due to changes in demand. Furthermore, demand characteristics and operating costs can change during the course of the selling season as the product progresses in its life-cycle. As a result, multi-period pricing models are often used for these products. Carryover inventory becomes one of the key issues when more than one period is considered in a supply contract. Two or multiple periods supply chain is common in the fashion and textile industries. The demand of most fashion and textile products varies over time due to the regular developments of fashion. In the two-period setting, for most seasonal products such as fashion clothes, vogue handbags, style cell phones etc., have a tendency to reduce retail prices during the selling seasons [1–4]. While the price reduction may occur for various reasons, the retailer could benefit from two important effects by utilizing such a price

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skimming strategy, i.e. the skimming effect and the reference price effect. Reference price evolves as a function of past observed price [5–10].

In this paper, we consider a retailer who sells a new product to a fixed population of consumer over two periods. The dynamic pricing policy may be employed in two different ways. The firm may either (a) announce the full price path from the beginning of the selling horizon (pre-announced pricing) or (b) announce only the first-period price, and delay the second-period’s price announcement until the beginning of the second period (responsive pricing). We develop a two-echelon supply chain model with price-sensitive deterministic demand. The demand linearly decreases with the current period’s selling price and linearly increases with previous period’s selling price. We assume that the manufacturer acts as the Stackelberg leader and he can offer two types of wholesale price: (1) the same wholesale price for both the periods2 (2) different wholesale prices for the two periods3. Then the retailer (who acts as the follower) decides his decision strategies. For the unique wholesale price situation, the retailer may take two actions: (1) optimize both periods’ profits together and set the selling prices p1 and p2 for periods 1 and 2, respectively (strategy I), (2) set the selling price p1 by optimizing the profit portion of the first period only and then optimize the profit portion of the second period and set selling price p2 (strategy II). Again, for different wholesale prices option, the retailer may also take two actions: (1) optimize both periods’ profits together and set the selling prices p1 and p2 for periods 1 and 2, respectively (strategy III), (2) after the declaration of the first period’s wholesale price w1 by the manufacturer, the retailer sets the selling price for the first period by optimizing the profit portion of the first period only; the manufacturer then declares the wholesale price w2 for the second period and the retailer follows this declaration and sets selling price p2 by optimizing the profit portion of the second period (strategy IV). A number of studies have been reported in the literature with regard to various pricing decisions set by the manufacturer or the retailer [11–16]. However, to the best of our knowledge, no attempt has been made with the types of decision strategy adopted in this paper in dealing with a two-period supply chain model. Some interesting research questions linked to this matter include the following:

(1) What is the best time for the manufacturer to declare his wholesale price(s)?
(2) When the manufacturer should adopt the unique wholesale price and when different wholesale prices?
(3) For each strategy mentioned above, which one is the firm’s optimal decision strategy?

To find answers to the above questions and provide insights with regard to the influence of manufacturer’s pricing strategy with dynamic retail price on supply chain decisions and performance, we develop a two-period supply chain model with a manufacturer and a retailer under price-dependent demand. In this model, we illustrate the above mentioned four strategies and compare the optimal decisions with these four strategies. The rest of the paper is organized as follows. In the next section, a brief review of the relevant literature is given. Notations and assumptions are provided in Section 3. The proposed model is formulated in Section 4. Section 5 deals with the manufacturer-led decentralized policy. Section 6 analyzes optimal results of different decision strategies. Optimal results and sensitivity analysis for a numerical example are presented in Section 7. Section 8 concludes and provides some directions of future research activity.

2. Literature review

In the literature, a significant amount of works have been carried out on dynamic pricing. Mainly two types of dynamic pricing policy are considered: (i) pre-announced pricing (Stokey [17] and Landsberger and Meiljon [18]) and (ii) responsive pricing (Besanko and Winston [19]). Later, Chen and Chen [20] dealt with the joint decisions on pricing and replenishment schedule for a periodic review inventory system. In their model, a replenishment order is placed at the beginning of some or all of the periods. Yin et al. [21] and Whang [22] described the effect in markdown pricing with strategic customers to study the implications of alternative inventory display formats and demand learning, respectively. Cachon and Swinney [23] examined the firm’s quantity and salvage pricing decisions under responsive pricing. Dasu and Tong [24] provided an analysis of pre-announced and dynamic pricing schemes in the multi-period fixed-quantity setting. Sato and Sawaki [25] considered a continuous time dynamic pricing problem when the competitor adopts a static pricing policy. In a closed-form optimal pricing policy, they compared the competitive case with the monopoly case and showed how dynamic pricing affects the firm’s revenue. The treatment of dynamic pricing is attempted by several researchers e.g., Ahmadi and Shavandi [26], Lee [27], etc. Our primary objective is to execute these dynamic settings in a two-period supply chain framework. In real life, many customers would like to purchase in several periods, so that demand in a period becomes a function of several periods’ prices. Our model explicitly considers these inter- temporal demand–price interactions so that realized demand in each period is dependent on realized demands in previous periods as well as past and current prices. In our model, we first consider the price interaction in two periods and then extend it to a multi-period case.

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1 The airline industry modifies the price of its seats based on the type of seat, the number of seats remaining, and the amount of time before the flight departs. Therefore, many different prices may be charged for seats along a single flight. Another example relates to the hotel business. The hotel industry alters its prices depending on the size and configuration of its rooms, as well as the time of year. Thus, some resorts increase their room rates over the Christmas holidays, while some inns increase their prices during the fall season, and some resorts reduce their prices during the hurricane season.

2 Food, grocery and ornaments industries are not much dependent on the rapid technological changes in production and therefore they set the same wholesale price for the whole selling season.

3 Cars, computers, smart-phones industries are dependent on rapid technological changes in production and therefore they change their wholesale prices on a regular basis.
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