Pricing Strategies for Different Periods During Subsequent Selling Season for Seasonal Products

JUNFENG DONG¹,², BEILEI RAO¹,², YU LIU¹,², LI JIANG³, WENXING LU¹,², AND QIANG GUO³

¹School of Management, Hefei University of Technology, Hefei 230009, China
²Key Laboratory of Process Optimization and Intelligent Decision-making, Ministry of Education, Hefei 230009, China
³School of Tourism, Hainan University, Haikou 570100, China

Corresponding author: Li Jiang (jianglix316@126.com)

This work was supported in part by the Fundamental Research Funds for the Central Universities under Grant PA2019GDQT0005, in part by the Ministry of Chinese Education, Humanities and Social Sciences under Grant 17YJA630037, in part by the National Science and Technology Support Program of China under Grant 71502047, Grant 71502047, Grant 71502047, Grant 71502047, Grant 71502047, and Grant 71502047, in part by the Project of Graduate Teaching Quality in Hefei University of Technology under Grant 110-4116000050, and in part by the Natural Science Foundation of Anhui Province in China under Grant 1808085QG229.

ABSTRACT This study applies a two-period pricing model to investigate the optimal pricing strategy for different periods during the subsequent selling season for seasonal products. The model assumes that the market is populated by two types of consumers, namely, myopic and strategic, and analyzes three optimal pricing strategies: one price (OP), preannounced slash price (PSP), and preannounced small price reduction (PSPR). Several propositions are derived by comparing these three strategies. Results show that the PSP strategy is superior to PSPR and OP strategies only when certain conditions are satisfied. Otherwise, the OP or the PSPR is consistently superior to the PSP. When retailers adopt a markdown price, they should reduce the price early to ensure a long second period. Finally, this study provides several numerical examples to illustrate the propositions derived from the theoretical analysis.

INDEX TERMS Pricing strategies, seasonal products, length of sales season, consumer type.

I. INTRODUCTION

The rapid development of technology has substantially decreased the life cycle of products in recent years, and several goods have been characterized as seasonal products. Seasonal products originally covered numerous industries, such as electronic items, food, and clothing. This coverage has expanded smoothly and continuously, and research regarding seasonal products has increased in value. Specifically, retailers can adopt an optimal pricing strategy as an important means to gain profits. After all, profit is the eternal goal among retailers in business competition. Simultaneously, new technologies also affect a wide range of commercial behaviors of the consumers, from the way people evaluate products and services to the way people pay for purchases [1]. Consumer demands exhibit increased individuality and variety, which make the study of optimal pricing strategies for retailers complex.

With this background, retailers usually sell a seasonal product at two different prices over two sales periods, namely, the regular and the reduction periods [2]. For instance, numerous seasonal products decrease in value in a single selling season, such as electronics and fashion apparel [3]. Specifically, fast fashion apparel brands, such as Zara and UNIQLO, usually slash the price of old clothes when new collections are released. Nevertheless, some brands adopt a small price reduction even when fresh apparel appears on the market, whereas the prices of other clothes are seldom reduced unless their style goes out of fashion. Which pricing strategy is the optimal choice for different retailers? Solving the following issues has become increasingly important:

1. How should the retailer set the price during the regular and reduction periods of the selling season?
2. Should the retailer reduce prices? If so, under what conditions?
3. When the retailer adopts price reduction, should it choose a small price reduction or a preannounced slash price?

To investigate these issues, we develop a two-period pricing model and introduce three pricing strategies for seasonal products, namely, one price (OP) strategy, preannounced slash price (PSP) strategy, and preannounced small price reduction (PSPR) strategy. The retailer sells products with
the same price over the whole selling season if it takes on the OP strategy. Under the PSP strategy, the retailer sells products with the regular price \( p_1 \) in the first period and with a preannounced slash price \( p_2 \) in the second period. When the retailer adopts the PSPR strategy, it sells products with the regular price \( p_1 \) in the first period but with a small price reduction \( p_2 \) in the second period. In order to distinguish PSP strategy and PSPR strategy, we introduce a discount factor \( \lambda (0 < \lambda < 1) \), which means discount rate of consumers in the utility of the outdated product caused by the appearance of a new product. When \( p_1/p_2 \geq 1/\lambda \) is satisfied, the PSP strategy is reflected. Otherwise, we call it PSPR strategy. With the two-period pricing model, we derive the optimal prices for the retailers and the length of reduction period of the selling season under the three pricing strategies. Comparing the optimal profits among these three strategies, we obtained the conditions required for the adoption of each strategy.

Different from previous studies, we incorporate the length of reduction period of the selling season in our model and attempt to analyze its impacts on the pricing choice of retailers. In addition, our discussion on the optimal pricing strategy is based on the different purchasing behaviors of two types of customers. Uncertainty of valuation may arise in consumer goods in different ways [4]. We assume that the market is populated by myopic and strategic consumers, and each consumer has his/her own valuation \( v \) on the product (also called psychological expectatons). Whether each consumer purchases the product depends on their surplus. If a product provides utility over a finite season, then the total utility from consumption will depend on the time of purchase within the season [5]. Therefore, the length of the selling season has an important effect on the pricing of seasonal products. Specifically, our study focuses on when the reduction period of the selling season should begin, whether the retailer should reduce the price during the reduction period, and the extent of the price reduction if the retailer chooses to do so.

A preannounced dynamic pricing strategy affects consumers in each period, and price reduction during the reduction period of the selling season has a negative influence on the sales of the product. Thus, we assume that the valuation on the product by consumers will be reduced from \( v \) to \( \beta v (0 < \beta \leq 1) \) in the first period, but the valuation on the product will be reduced from \( v \) to \( \beta \lambda v (0 < \lambda < 1) \) in the second period. In addition, we introduce a discount factor \( \delta (0 \leq \delta \leq 1) \) to distinguish between strategic and myopic consumers. Myopic consumers will purchase the product if and only if their surplus is non-negative regardless of the period of the selling season. Strategic consumers will choose the best time to buy, wait for sales, and purchase at certain times. Thus, we consider consumer demand and purchasing time. Then, we assume that demand time \( t \) refers to the time when the consumer desires to buy, and purchasing time is the time at which the consumer generates buying behavior. With these assumptions, the retailer’s quantity of sales over the two periods is derived. Based on these sales quantities, we obtain the profit functions of the retailers. Then, we analyze the optimal strategy and the main factors that affect the choices of retailers.

Our results show that the optimal pricing strategy of the retailer is mainly determined by the length of the second period over the selling season. For example, (1) if the second period is sufficiently short compared with the first period, then the profitability of the OP strategy is better than the markdown pricing strategies. (2) If the second period is sufficiently long compared with the first period and a certain condition is met, then the PSPR strategy is better than the two other strategies. (3) If the length of second period is close to the first period and a certain condition is met, then the PSP strategy is better than the two other strategies.

The rest of this paper is organized as follows. Related literature and concurrent research are reviewed in Section 2. Section 3 introduces the model. The optimal pricing decision of the retailers is derived under the three pricing strategies in Section 4. The three strategies are compared in Section 5, and the numerical analysis and its results are presented. Four numerical examples are provided in Section 6 to prove that the results are correct and effective. The conclusions and managerial implications for future research are discussed in Section 7.

II. LITERATURE REVIEW

Profit relates to several factors, which primarily depend on pricing strategies and consumer behaviors. Previous studies have proven the effects of pricing strategies and consumer behaviors on revenue. This study is mainly related to three streams of literatures, namely, (i) two-period model, (ii) the different types of consumers, and (iii) pricing strategies for seasonal products.

A. TWO-PERIOD MODEL

As a dynamic model, the two-period model has been widely used to determine the impacts of disruptions on demand on pricing decisions, where the demand is unknown in the first period but can be resolved in the second period [6]. Several scholars use the two-period model to study pricing problems. Hazledine [7] proposed a “market power model”, and to test both it and the law of one price against some cross-sectional data on difference between Canadian and US prices in 33 manufacturing industries. Yang and Pan [8] have studied the two-period pricing model considering the reference prices of customers. Dong and Wu [3] have examined the impact of strategic customer behavior in two-period pricing and inventory decisions in a quick response system. Chai et al. [9] have applied a two-period dual-channel model for mixed bundling of retailers or pricing strategies for reserved products in response to encroachment of suppliers. Li et al. [10] introduced a two-period, pricing policy, the firms adjust prices to maximize profits and determine optimal pricing policies, choosing from dynamic pricing, fixed-ratio pricing, and elastic pricing policies. Firms should make dynamic pricing and ordering decisions based on market demand forecast to obtain the maximum cumulative profit.
over the life cycle of the product [11]. In this study, we focus on a two-period dynamic pricing problem in which the retailer has a single opportunity to reduce the price of a product at a predetermined time during the season [12]. Given that our product is seasonal (i.e., clothes with a short life cycle), we construct a two-period model to discuss pricing problems for the retailer with uncertainty in demand in a declining price environment. Hence, we assume that the retailer sells the product in two periods (first and second), which is similar to Mersereau and Zhang [13] and Correa et al. [14], who have assumed that the selling season consists of two periods, namely, the first (regular) and the second (clearance).

B. THE DIFFERENT TYPES OF CONSUMERS

Consumers may strategically choose the best time to buy, wait for sales, and purchase at certain times. The purchase behavior of consumers, which is closely related to the operational strategies of sellers, can affect the benefits gained by the sellers from sales [2]. When making a purchase decision, strategic consumers consider their expectations of future prices and either immediately choose to buy or delay their purchase [3]. The literature has concentrated on the study of strategic consumers. Levin et al. [15] have focused on dynamic pricing in relation to strategic consumers. Cachon and Swinney [16] have studied purchasing, pricing, and quick response in relation to strategic consumers. Cui et al. [17] have considered the pricing of conditional upgrades in relation to strategic consumers. Numerous studies have also examined strategic (forward-looking) and non-strategic (myopic) customers [12], [14], [18]–[23]. Besanko and Winston [24] have compared the effects of myopic consumers on price with those of rational (strategic) consumers; they found that when a monopolist implements the optimal pricing policy for myopic consumers, profits may be lower than when it adopts the equilibrium pricing policy for rational consumers.

In this study, we refer to strategic or forward-looking consumers as those who maximize long-term utility by strategically timing their purchases to obtain reduced prices. We also refer to myopic or nonstrategic consumers as those who immediately make a purchase decision without strategizing over the timing of the purchase [25]. When a product with uncertain quality is introduced, consumers may opt to postpone their purchasing decisions strategically to evaluate the product against other products [19]. Consumers can choose to purchase the product as early as possible before learning its value or postpone the purchase decision until the uncertainty in valuation is resolved [4]. However, strategic customers purchase a product only when their surpluses exceed a threshold [26]. Based on this review, our study assumes that the sales quantity of retailers in the first and second periods is based on myopic and strategic consumers, respectively. We assume that consumers have a valuation of the product.

C. PRICING STRATEGIES FOR SEASONAL PRODUCTS

Studies that have regarded consumers as strategic usually assume that firms adopt one of two classes of dynamic pricing strategies—either preannounced or responsive [19]. Dynamic pricing is effective for increasing revenue in response to uncertain market conditions. Industries with highly uncertain demand, such as fashion retail, hotels, airlines, and consumer electronics, frequently utilize dynamic pricing [27]. Liu et al. [28] have developed a dynamic game framework to explore the optimal pricing strategy when the firm sequentially introduces a new generation of products to a market populated by strategic consumers. Bitran and Mondshein [29] presented a continuous time model to study intertemporal pricing policies when selling seasonal products in retail stores. Early research has focused on the importance of each of the two classes of dynamic pricing strategies. For example, Stokey [30] and Landsberger and Mellijson [31] have investigated preannounced pricing, and Besanko and Winston [24] have examined responsive pricing. Several studies have found that social learning has a substantial influence on the behavior of strategic consumers, and the preannounced pricing strategy is generally not beneficial for firms [19]. However, most studies have emphasized the considerable influence of preannounced pricing strategies on the behavior of strategic consumers (e.g., [18], [21]). The assumption of preannounced pricing is common in literature, and it dates back to the groundbreaking paper of Stokey [30]. Hence, we assume that the retailer announces the price before the selling season but does not announce a specific pricing strategy.

Market demand is sensitive to retail price [32]. Before the selling season, the market size must be studied first, which is a pivotal step in deciding initial production opportunities. Product quantity also depends on the inventory level of a firm. Dasu and Tong [26] have discovered that when customers are strategic, dynamic pricing is valuable only if customers perceive that stockouts are possible. Faced with a market that consists of strategic and myopic customers, the firm may not reduce its inventory level because numerous myopic customers become strategic [33]. We consider the retailer’s inventory level and pricing decisions according to the market size before the selling season. Fu et al. [34] addressed the joint determination of pricing and ordering decisions in a newsvendor setting, where a retailer (newsvendor) sells the seasonal products and faces demand risk due to weather uncertainty. An industry response to the high or low inventory cost is quick response (QR), a strategy that focuses on providing short lead times to allow orders close to the beginning of the selling season [35]. Hence, we assume the sequence of events under QR.

Through years of predictable late-season deep discounts, a retailer is likely to find that a growing number of consumers are reluctant to purchase at full price, and these consumers become accustomed to waiting for heavy discounts [27]. Firms offer periodic discounts even in commodity markets with numerous competitors; they target buyers with different search costs to acquire a high profit [36]. Therefore, we consider a retailer that dynamically sets the price of a product to maximize the expected revenues from sales. Still, a retailer
can also adopt the OP strategy over the whole selling season. Here, we analyze dynamic pricing strategies and the OP strategy to determine which strategy is the optimal decision for the retailer.

III. DESCRIPTION OF THE MODEL
In our model, the retailer sells a product over two sequential periods. The retailer’s decisions consist of a regular price $p_1$ in Period 1 and a markdown price $p_2$ in Period 2, which are usually announced before the selling season. Consumers and the retailer participate in a game where the consumers decide whether and when to buy the product, and the retailer decides which pricing strategy to use and at what price over the two periods. The model is shown in Figure 3.

A. NOTATIONS
The following notations are used in the present study.

**T** Length of the selling season

**$T_M$** Start point of Period 2

**$p_i$** Price in period $i$ ($i = 1, 2$)

**$v$** Valuation of consumers on the product before the selling season

**$\beta$** Discount rate of consumers in utility caused by preannounced dynamic pricing strategy

**$\lambda$** Discount rate of consumers in utility of the outdated product caused by the appearance of a new product

**$r$** Percentage of myopic consumers among all consumers

**$t$** Demand time

**$D$** Sales quantity of retailer

**$\pi$** Total profit of the retailer over two periods

**$\delta$** Waiting cost of customers

**$c$** Production cost per unit product

**$T^\wedge$** Length of Period 1

B. BASE MODEL
Wu and Lai [37] have assumed that the firms enter the market at time 0 and sell their first-generation products in the first stage within time period $[0, T_{ab}]$; then, the firms sell their next-generation products in the second stage within time period $[T_{ab}, T]$. Similar to this assumption, we examine a retailer who sells a product over a finite selling season $[0, T]$, which is divided into two periods: the first period $[0, T_M]$ and second period $[T_M, T]$. The retailer preannounces the two prices ($p_1$ and $p_2$) before the selling season [23]. The consumer has a significant effect on the two prices. We assume that each consumer has their own valuation $v$ on the product when they are initially launched, and such valuation will not change without a new product appearing in the market. Given the heterogeneity of consumers in their valuation $v$, $v$ is uniformly distributed from 0 to 1 [6]. When the retailer utilizes a regular price $p_1$ in Period 1, the valuation of a consumer on the product will be reduced from $v$ to $\beta v (0 < \beta < 1)$, where $\beta$ is the discount rate of the consumers in the utility of the outdated product caused by the appearance of a new product.

Production during the selling season is not postponed, and the market size is unknown, which are different from the assumptions of Swinney [4].

To economize on notations, the total number of consumers is normalized to one [38]. To a large extent, the type of consumers will determine their buying behaviors. Considering the characteristics of seasonal products, we assume that consumers are either myopic (Kind-M, a fraction $r$ of all consumers) or strategic (Kind-S, a fraction $1 - r$ of all consumers) in this study. We also assess the consumers’ demand and purchasing time. Demand time $t$ refers to the time when the consumer has the desire to buy, and purchasing time is the time at which the consumer generates buying behavior. We assume that $t$ follows distribution function $G(t) = 1/r, G(t) \in (0, T)$.

A Kind-M customer will purchase the product if their surplus is non-negative and the products are in stock, i.e., $\beta v - p_1 \geq 0$ (i.e., $v \geq p_1/\beta$) in Period 1 and $\beta \lambda v - p_2 \geq 0$ (i.e., $v \geq p_2/\beta \lambda$) in Period 2. Let $p_1 = p_1/\beta$ and $p_2 = p_2/\beta \lambda$, and the sales quantity of the retailer in the first period from Kind-M consumers is

$$D_{1M} = \int_{v} \left[ v \geq p_1 \right] \int_{0}^{T_M} rdG(t)dF(v). \tag{1}$$

The sales quantity of the retailer in the second period from Kind-M consumers is

$$D_{2M} = \int_{v} \left[ v \geq p_2 \right] \int_{T_M}^{T} rdG(t)dF(v). \tag{2}$$

We introduce a discount factor (or a waiting cost), which is denoted by $\delta(0 \leq \delta \leq 1)$, to model strategic and myopic customers simultaneously [25]. That is, when consumers compare the surplus of purchasing in Period 1 and the waiting time to purchase in the future, they discount the future surplus by $\delta$. Hence, $\delta$ can be interpreted as the level of consumers’ strategy; a high $\delta$ implies that consumers are strategic. If $\delta = 0$, then consumers purchase the product as long as its surplus is positive because the surplus of future purchases in Period 2 is zero. By contrast, if $\delta = 1$, then they anticipate the lack of discounts in future purchases.

A Kind-S consumer can buy products at their demand time or delay purchasing from the first to the second period if the products arrive in the first period. Their surpluses are $\beta v - p_1$ and $\delta (\beta \lambda v - p_2)$. Thus, when $v \geq p_1/\beta$ and $\beta v - p_1 \geq \delta (\beta \lambda v - p_2)$ (i.e., $v \geq p_1 - \delta p_2/\beta \lambda$) are satisfied, The sales quantity of the retailer in the second period is consumers buy the products at their demand time. Let $\rho_3 = p_1 - \delta p_2/\beta \lambda$.

$$D_{1S} = \int_{v} \left[ v \geq p_1, v \geq \rho_3 \right] \int_{0}^{T_M} (1 - r) dG(t) dF(v). \tag{3}$$

When $v \geq p_2/\beta \lambda$ and $\beta v - p_1 \leq \delta (\beta \lambda v - p_2)$ (i.e., $v \leq p_1 - \delta p_2/\beta \lambda$) are satisfied, consumers choose to delay their
purchase.
\[ D_{2S1} = \int_{v \geq p_2, v \leq p_1}^{T_M} (1 - r)dG(t)dF(v). \]  
(4)

If the consumers arrived in the second period, then they choose to buy the products if and only if \( v \geq p_2/\beta \lambda \).

\[ D_{2S2} = \int_{v \geq p_2} \int_{T_M} (1 - r)dG(t)dF(v). \]  
(5)

Therefore, the sales quantity of the retailer in the first period is

\[ D_1 = D_{1M} + D_{1S}. \]  
(6)

The sales quantity of the retailer in the second period is

\[ D_2 = D_{2M} + D_{2S1} + D_{2S2}. \]  
(7)

To ensure non-negative profits for the retailer, we assume \( c < 1 \). With the demand functions shown in Equations (6) and (7), we obtain the total profit of the retailer over the two periods.

\[ \pi = (p_1 - c)D_1 + (p_2 - c)D_2. \]  
(8)

### IV. THREE PRICING STRATEGIES

The retailer can use various pricing strategies when selling a product, and they must adopt effective pricing strategies to sell their products in a competitive marketplace to gain profit. In addition, they need to consider a range of factors, such as prices offered by competitors, costs for production and distribution, positioning of product image in the minds of consumers, and the demographics of potential buyers. Different from previous literature, the present study posits that the retailer has three different pricing strategies to utilize, i.e., PSP, PSPR, and OP strategies. Our main objective is to determine which of the three pricing strategies is the best choice under certain conditions and reveal the optimal price under the three strategies.

Under the OP strategy, the retailer sells products with the same price over the whole selling season, and we can obtain the following relationships:

The sales quantity of the retailer in the first period is

\[ D_1 = \frac{T_M}{T} (1 - p). \]  
(9)

\[ D_2 = \left(1 - \frac{T_M}{T}\right) (\lambda - p). \]  
(10)

The total profit of the retailer in this period is

\[ \pi = (p - c)(D_1 + D_2). \]  
(11)

By maximizing the total profit given in Equation (11), that is, Equation (11) must satisfy the necessary conditions \( \partial \pi/\partial p = 0 \), we derive the optimal price for the retailer as

\[ p^*_0 = \frac{cT + T_M + T\lambda - T_M\lambda}{2T}. \]  
(12)

The total profit of the retailer is

\[ \pi^*_0 = \frac{(cT - T\lambda - T_M + T_M\lambda)^2}{4T^2}. \]  
(13)

Under the two markdown pricing strategies, the retailer preannounces prices \( p_1 \) and \( p_2 \) at the beginning of the selling season, where \( p_1 \geq p_2 \). With the uniform distribution assumptions of \( t \) and \( v \), we find that:

When \( \rho_1 \leq \rho_2 \) (i.e., \( p_1/p_2 \geq 1/\lambda \)) is satisfied, the PSP strategy is reflected. A Kind-M customer will buy the products in Period 1 if and only if their surplus is non-negative, i.e., \( \beta v - p_1 \geq 0 \) (i.e., \( v \geq p_1/\beta = \rho_1 \)). By contrast, Kind-S consumer will buy the products at their demand time if and only if their surplus in Period 1 is superior to their surplus in Period 2 when they arrive in Period 1. Thus, the sales quantity over the first period is

\[ D_1 = D_{1M} + D_{1S} \]
\[ = \frac{T_M}{T} (1 - p_1) + (1 - r) \frac{T_M}{T} (1 - p_1 - \frac{p_2}{\beta}). \]  
(14)

Otherwise, the sales quantity over the second period is

\[ D_2 = D_{2M} + D_{2S1} + D_{2S2} \]
\[ = r \frac{T_M}{T} (1 - \frac{p_2}{\beta}) + (1 - r) \frac{T_M}{T}. \]

Under the OP strategy, the retailer chooses to buy the products if and only if

\[ \pi = \frac{cT + T_M + T\lambda - T_M\lambda}{2T}. \]  
(11)
where schemes under different circumstances. The analysis of these quantity over the normal sale period as superior to their surplus in Period 2. We can obtain the sales

\[ \delta \]

without discount of future purchases or all consumers are it the PSPR strategy. If and only if all strategic consumers do without discount of future purchases or all consumers are myopic (\( \delta = 0 \) or \( r = 1 \)), then their surplus in Period 1 is superior to their surplus in Period 2. We can obtain the sales quantity over the normal sale period as

\[ D_1 = D_{1M} + D_{1S} = \frac{T_M}{T} (1 - \frac{p_1}{\beta}). \] (16)

Otherwise, the sales quantity over the discount sale period is

\[ D_2 = D_{2M} + D_{2S1} + D_{2S2} = (1 - \frac{T_M}{T}) (1 - \frac{p_2}{\beta}). \] (17)

By substituting these quantity functions into Equation (8), we obtain the profit function of the retailer. By maximizing this profit, we obtain the optimal prices for retailers under the markdown pricing strategy shown in the following propositions.

When the retailer utilizes the markdown pricing strategy, it preannounces prices \( p_1 \) in the first period and \( p_2 \) in the second period. Decision makers choose different pricing schemes under different circumstances. The analysis of these two markdown pricing strategies (i.e., PSP and PSPR) is performed as follows.

Under the PSP strategy, quantity functions indicate that Kind-M and Kind-S consumers’ surplus on products is positive in one period and is superior to their surplus in the other period. Thus, \( r, \beta, \lambda \) and \( \delta \) have substantial influence on the quantity functions over the two periods. We consider the relationship among these four notations and the length of the first period \( t^\Delta \) (i.e., \( t^\Delta = \frac{T_T}{T} \) and \( 0 < t^\Delta < 1 \)) and obtain the following propositions.

Proposition 1: Under the PSP strategy, we have the following:

(i) PSP - 1: If \( \alpha \leq t^\Delta \leq 1 \), then the optimal prices for the retailer are (18) and (19), as shown at the bottom of this page.

The total profit of the retailer over the two periods is (20), as shown at the bottom of this page.

(ii) PSP - 2: If \( 0 \leq t^\Delta < \alpha \), then the optimal prices for retailers are

\[ p_1^* = \frac{1}{2} \beta \left( \frac{T_c}{T_M (1 - \lambda) + T \beta \lambda} \right), \] (21)

\[ p_2^* = \frac{1}{2} \beta \lambda \left( \frac{T_c}{T_M (1 - \lambda) + T \beta \lambda} \right), \] (22)

\[ \pi^*_\text{PSP-2} = \frac{(T_c (c - \beta \lambda) - T_M (\beta - \beta \lambda))^2}{4 T (1 - \beta \lambda) (1 - \lambda)}. \] (23)

The proof of Proposition 1 is presented in the Appendix.

Proposition 1 illustrates that if the retailer utilizes the PSP strategy, then its optimal prices are dependent on the length of the second period. If the second period is longer than the first period under a certain condition (\( \alpha \leq t^\Delta \leq 1 \)), then the optimal choice is PSP-1. If the second period is short enough compared with the first period and \( 0 \leq t^\Delta < \alpha \) holds, then the optimal decision is PSP-2.
By comparing the optimal prices for retailers under PSP-1 and PSP-2, we determine that \( r, \delta, \) and \( \alpha \) have considerable influence on the set of optimal prices. By analyzing the value of \( r \) and \( \delta \), we establish the following propositions.

**Proposition 2:** Under the PSP strategy, if all strategic consumers do without discount of future purchases or all consumers are myopic, then the optimal choice for the retailer is PSP-2.

Proof of Proposition 2: When \( r = 1 \) or \( \delta = 1 \) holds by substituting it into \( \alpha \), \( t^\Delta < \alpha = 1 \) is always satisfied.

This result illustrates that if and only if all strategic consumers do not perform future purchases or all consumers are myopic should PSP-2 be utilized. Otherwise, the retailer should utilize PSP-1. Generally, the occurrence probability of this specific condition is low. Hence, the general condition is worthy of additional study.

**Proposition 3:** Under the PSP strategy, if no myopic consumers exist and all strategic consumers think that future earnings will be zero, we obtain the following results by substituting \( r = 0 \) and \( \delta = 0 \) into \( \alpha \), Equations (18), (19), and (20).

(i) PSP-1: If \( t^\Delta > \frac{(1-\lambda) - \beta^2}{4(\beta - \lambda)} \), then the optimal decisions of the retailer are (24)–(26), as shown at the bottom of this page.

(ii) PSP-2: Otherwise, the choice of the retailer is as follows:

\[
p_1^* = \frac{1}{2} \beta \left( 1 + \frac{Tc}{T_M(\beta - \beta \lambda) + T \beta \lambda} \right),
\]
\[
p_2^* = \frac{1}{2} \beta \lambda \left( 1 + \frac{Tc}{T_M(\beta - \beta \lambda) + T \beta \lambda} \right),
\]
\[
\pi^* = \frac{(T - c - \beta \lambda - T_M(\beta - \beta \lambda))^2}{4T(T_M(\beta - \beta \lambda) + T \beta \lambda)}.
\]

By combining the results of Propositions 2 and 3, we find that different types of consumers have different future purchases, and they have a considerable effect on the retailer’s choice of future pricing strategy. The results prove that \( r \) and \( \delta \) have an important influence on the set of optimal prices.

**Proposition 4:** Similar to the PSP strategy, the optimal prices for the retailer in the PSPR strategy are

\[
p_1^* = \frac{c + \beta}{2},
\]
\[
p_2^* = \frac{c + \beta \lambda}{2}.
\]

The total profit of the retailer over the two periods (32), as shown at the bottom of this page.

The proof of Proposition 4 is presented in the Appendix.

The results show that the optimal prices under the PSPR strategy are always dependent on the values of \( c, \beta, \) and \( \lambda \). However, several factors, such as \( r \) and \( \delta \), have no influence on the optimal choice under the PSPR strategy unlike in the PSP strategy.

We have analyzed the three pricing strategies. The retailer’s decision process and the profits from each possible decision are depicted in Figure 2. We use “R” to denote selecting the markdown pricing and PSPR strategies. We use “M” to indicate adopting the PSP strategy and selecting PSP-1. We use “N” to signify adopting the PSP strategy and selecting PSP-2, and we use “O” to represent selecting the OP strategy. The retailer chooses from “R,” “M,” “N,” and “O.”

V. COMPARISON AND DISCUSSION

Dynamic pricing incentivizes strategic customers to postpone purchases and wait for reduced prices in the future. To prevent strategic waiting behavior, retailers charge a single price over the entire selling season. Zara, a Spanish fashion retailer, often promotes affordable full prices. Zara informs their customers that products are ineligible to future discounts. However, the price depends on specific circumstances instead of being generalized. In this study, we have analyzed three pricing strategies. Although we have derived the optimal prices for retailers under the three pricing strategies, we have not obtained the conditions under which one strategy dominates over the others. By comparing the three strategies, we achieve the optimal decision for retailers.

**Definition 1:** Assuming that the OP strategy is consistently superior to the PSPR strategy, i.e., \( \pi_0^0 - \pi_0^* > 0 \), we obtain \( x (r^\Delta)^2 + y r^\Delta + z > 0 \), where \( x = \beta \lambda (1 - \lambda)^2, y = -2c \beta \lambda + 2c \beta \lambda^2 + 2c \beta \lambda^2 - 2 \beta \lambda^2 + c^2 - 2c \lambda - \beta \lambda^2 + \beta^2 \lambda^2, z = \lambda (c - \lambda)^2 \beta \lambda - (c - \beta \lambda)^2 \).

In accordance with \( 0 < \beta < 1, 0 < \lambda < 1, 0 < c < 1, T = 1 \), we find that \( x > 0 \) when \( \Delta = y^2 - 4xz < 0 \), and \( \frac{y}{z} > 0 \) always satisfies the equation without a solution. When \( \Delta = y^2 - 4xz > 0 \), if \( r^\Delta = 0, z < 0 \) is always satisfied. For \( \frac{y}{z} > 0 \) or \( \frac{y}{z} < 0 \), a solution always exists on the positive of axis \( r^\Delta \).

When \( \Delta = y^2 - 4xz > 0 \), the equation \( \pi_0^0 - \pi_0^* = 0 \) always comprises two different solutions (i.e., \( r^\Delta_1 < 0 \) and \( r^\Delta_2 > 0 \)).
\[ t_1 > 0. \] Hence, we choose \( t_1 \) as the solution of the equation to be practical. We then obtain the following lemma.

**Lemma 1:** When \( t^\Delta < t_1^* \) or \( t^\Delta > t_1 \) holds, \( \pi_0^* - \pi_2^* > 0 \); when \( t_1^* > t^\Delta \leq t_1 \), \( \pi_0^* - \pi_2^* \leq 0 \).

With the result of Lemma 1, when \( 0 < t^\Delta < 1 \), we determine if the PSPR and OP strategies dominate each other when \( 0 < t^\Delta < t_1 \) and \( t_1 < t^\Delta < 1 \) are satisfied. Through analysis, we obtain the following proposition.

**Proposition 5:** When \( 0 < t^\Delta < t_1 \) is satisfied, the PSPR strategy is superior to the OP strategy. When \( t_1 < t^\Delta < 1 \) is satisfied, the OP strategy is superior to the PSPR strategy. When \( t_1 > 1 \) is satisfied, the optimal strategy is PSPR.

The proof of this proposition is simple and presented in the Appendix. Given that we have already identified which strategy dominates when comparing the PSPR and OP strategies under certain conditions, we must compare the PSPR and PSP strategies and analyze the OP and PSP strategies to determine which strategy is optimal.

**Definition 2:** Assuming that the PSPR strategy is consistently superior to the PSP-2 strategy, i.e., \( \pi_2^* - \pi_{PSP-2}^* > 0 \), we determine that \( 1 - t^\Delta > 0 \).

In accordance with \( 0 < T_M < T \), \( 1 - t^\Delta > 0 \) is always satisfied. Hence, the PSPR strategy is consistently superior to the PSP-2 strategy when \( t^\Delta < \alpha \) is satisfied. If and only if \( T_M = T \) holds, then the PSPR strategy is equal to the PSP-2 strategy, and the solution is \( t_2^* = 0 \) or \( t_2 = 1 \).

Assuming that the OP strategy is consistently superior to the PSP-2 strategy, i.e., \( \pi_0^* - \pi_{PSP-2}^* > 0 \), we determine that \( x (t^\Delta)^3 + y (t^\Delta)^2 + z t^\Delta + w > 0 \), where \( x = -b (1 + \lambda)^3 \), \( y = 4c\beta\lambda^2 - 2c\beta - 6b\lambda^3 + 3b\lambda - 2cb\lambda^2 + 3b\lambda^3 - \beta^2 - 2\beta^2 + 2\lambda^2 \), \( z = 2c\beta - 6c\lambda - 2\beta^2 + 2\lambda^2 + 2c\beta^2 + 3b\lambda^2 - c^2 - 3b\lambda + 4c\lambda^2 \), \( w = -c^2 - 2\beta^2 + 2b\lambda - c\beta^2 - \beta^2 - 3\lambda^3 + 2c\beta^2 + 3b\lambda^2 - 2c\lambda^2 + 2c\lambda^2 \). This variable cubic equation is about \( t \). In accordance with \( 0 < \beta < 1, 0 < \lambda < 1, 0 < c < 1 \) and by utilizing the multiple root discriminant formula of Sheng Jin to solve the equation \( \pi_0^* = \pi_{PSP-2}^* \), we find that \( \Delta = B^2 - 4AC > 0 \), where \( A = y^2 - 3xz, B = yz - 9xw, C = z^2 - 3yw \). Hence, this equation has one real root (i.e., \( t_3^* \)) and two conjugate complex roots (i.e., \( t_3^* \) and \( t_3^* \)). In addition, \( x < 0 \) is always satisfied when \( \frac{d^2}{dt^2} < 0 \), \( \pi_0^* - \pi_{PSP-2}^* < 0 \) is always satisfied. Hence, we choose \( t_3 \) as the solution of the equation to be practical. In general, we have the following lemma.

**Lemma 2:** When \( 0 < t^\Delta \) is satisfied, \( \pi_2^* - \pi_{PSP-2}^* > 0 \); when \( t^\Delta < t_2^* \) or \( t^\Delta > t_2 \) holds, \( \pi_2^* - \pi_{PSP-2}^* < 0 \). When \( t^\Delta < t_3 \) holds, \( \pi_0^* - \pi_{PSP-2}^* < 0 \); when \( t^\Delta \geq t_3 \), \( \pi_0^* - \pi_{PSP-2}^* \geq 0 \).

We know that the PSPR strategy dominates over the PSP strategy when \( 0 \leq t^\Delta \leq 1 \) is satisfied. Then we must identify whether the OP strategy or the PSP strategies dominates when \( 0 < t^\Delta < t_3 \) and \( t_3 < t^\Delta < 1 \) are satisfied. Through analysis, we obtain the following propositions.

**Proposition 6:** When \( t^\Delta \rightarrow 1 \), the profit of the PSPR strategy is consistently higher than that of the PSP strategy. Therefore, the PSPR strategy is consistently superior to the PSP strategy.

When \( TM \rightarrow T \), \( \pi_{PSP-2}^* < \pi_2^* \) is always satisfied. The proof of this proposition is presented in the Appendix. This proposition illustrates that the PSPR strategy always dominates over the PSP strategy.

**Proposition 7:** When \( t^\Delta < 1 \) is satisfied, the OP strategy is consistently superior to the PSP strategy. Otherwise, the PSP strategy dominates over the OP strategy.

The proof of this proposition is presented in the Appendix. We have obtained the superior decision between two different strategies under several conditions from these propositions. Next, we analyze the three strategies to determine the optimal decision. Through comparison, we obtain the following proposition.

**Proposition 8:** Based on Propositions 6 and 7, if \( \alpha \geq 1, t^\Delta < \alpha \) is always satisfied. When \( 0 < t^\Delta < t_1 \) is satisfied, then the optimal decision is the PSPR strategy. When \( t_1 < t^\Delta < 1 \) is satisfied, the optimal decision is the OP strategy. We also find that when \( t_1 > 1 \) or \( t_3 > 1 \) is satisfied, the optimal decision is the PSPR strategy. The proof of Proposition 8 is presented in the Appendix.
Hence, if $t^\Delta < \alpha$, the retailer should not consider the PSP strategy. We have obtained the optimal decision among these three strategies under necessary conditions when $t^\Delta < \alpha$ is satisfied. Next, we need to analyze which strategy is the optimal decision when $t^\Delta \geq \alpha$ is satisfied.

Definition 3. Similar to the analysis for Definition 2, when $t^\Delta \geq \alpha$ holds, we determine that $\pi_0^* = \pi_{(PSP-1)}^*$ has two different solutions (i.e., $t_3^\Delta = 0$ and $t_4 > 0$). We choose $t_4$ as the solution of the equation to be practical.

Moreover, $\pi_0^* = \pi_{(PSP-1)}^*$ has one real root (i.e., $t_5$) and two conjugate complex roots (i.e., $t_3^\Delta$ and $t_4^\Delta$). Additionally, $x < 0$ is always satisfied. Hence, we choose $t_4$ as the solution of the equation to be practical.

Lemma 3: When $0 \leq t^\Delta \leq t_4$, $\pi_0^* - \pi_{(PSP-1)}^* \geq 0$; when $t^\Delta < t_4$ or $t^\Delta > t_4$, $\pi_0^* - \pi_{(PSP-1)}^* < 0$.

When $0 \leq t^\Delta \leq t_5$, $\pi_0^* - \pi_{(PSP-1)}^* \leq 0$; when $t^\Delta > t_5$, $\pi_0^* - \pi_{(PSP-2)}^* > 0$.

We determine whether the PSPR strategy or the PSP strategy dominates when $0 < t^\Delta < t_4$ and $t_4 < t^\Delta < 1$ are satisfied and which strategy between the OP and the PSP strategies dominates when $0 < t^\Delta < t_5$ and $t_5 < t^\Delta < 1$ are satisfied. Through analysis, we obtain the following propositions.

Proposition 9: When $0 < t^\Delta < t_4$ is satisfied, the PSPR strategy is superior to the PSP strategy. Otherwise, the PSP strategy dominates over the PSPR strategy. When $0 < t^\Delta < t_5$ is satisfied, the PSP strategy is superior to the OP strategy. Otherwise, the OP strategy dominates over the PSP strategy.

The proof of this proposition is presented in the Appendix.

We have obtained the superior decision between two different strategies under certain conditions. Next, we combine Proposition 5 with Proposition 9. By comparing the three strategies, we obtain the following proposition.

Proposition 10: If $\alpha < 0$, $t^\Delta \geq \alpha$ is always satisfied. When $0 < t^\Delta < t_4$ is satisfied, the optimal decision is the PSP strategy. When $t_4 < t^\Delta < t_5$ where $t_4 < t_1$ is always satisfied, the optimal decision is the OP strategy. When $t_5 < t^\Delta < 1$ is satisfied, the OP strategy is the optimal decision. The proof of Proposition 10 is presented in the Appendix.

Another condition which we must analyze exists when $0 < \alpha < 1$ is satisfied. Through analysis, we obtain the following proposition.

Proposition 11: If $0 < \alpha < 1$, the optimal decision is the PSPR strategy when $0 < t^\Delta < t_1$ for any $t^\Delta < \alpha$ or $t^\Delta \geq \alpha$ is satisfied. When $t_1 < t^\Delta < 1$ is satisfied, the optimal decision is the OP strategy. When $t_1 > 1$ is satisfied, the optimal strategy is the PSPR.

From the results of Proposition 11, we can find that PSP is the worst strategy. When $0 < \alpha \leq 1$ is satisfied, the retailer should not consider the PSP strategy.

We have derived the optimal strategy for all the cases. For clarity, the optimal pricing strategy of retailers is given in Table 1.

**TABLE 1. Optimal decision of retailers on the three pricing strategies.**

| Value of $\alpha$ | Condition | Optimal strategy |
|-------------------|-----------|-----------------|
| $\alpha \leq 0$   | $t_4 < t^\Delta < t_1$ & $t_4 > t_1$ | ✓ |
| $0 < \alpha < 1$  | $0 < t^\Delta < t_1$ & $t_4 > t_1$ | ✓ |
| $t_5 < t^\Delta < 1$ | ✓ |
| $\alpha \geq 1$   | $t_1 < t^\Delta < 1$ | ✓ |

**VI. NUMERICAL EXAMPLES**

To prove that the results of the comparison and discussion are correct and effective, we provide four numerical examples.

Example 1: When a consumer's valuation $v$ of the product before the selling season is $[0, 1]$ and $c = 0.5$, $T_M = 0.9$, $T = 1$, $\beta = 0.9$, $\lambda = 0.7$, $r = 1$, $\delta = 0.5$, the profit of the retailer is distributed in $[0, 0.05]$. Through calculation, we obtain $\alpha = 1$, $t_1 = 0.172$, $t_2 = 1$, $t_3 = -0.562$, thereby satisfying Proposition 6.

Figure 3 shows that the PSPR strategy is superior to the PSP strategy. Under the OP strategy, the optimal pricing is 0.735, and the profit is 0.055. This example also satisfies Proposition 8 and proves that the OP strategy is the optimal decision among the three (i.e., □). If $0 < t^\Delta < t_1$, then PSPR is the optimal strategy among the three (i.e., ◯).

Example 2: When a consumer's valuation $v$ of the product before the selling season is $[0, 1]$ and $c = 0.2$, $T_M = 0.8$, $T = 1$, $\beta = 0.9$, $\lambda = 0.7$, $r = 0.5$, $\delta = 1$, the retailer’s profit is distributed in $[0, 0.15]$. Through calculation, we obtain $\alpha = 4.333$, $t_1 = 0.474$, $t_2 = 1$, $t_3 = 0.461$, thereby satisfying Proposition 8.
FIGURE 4. The result of matching condition ③.

FIGURE 5. The result of matching condition ②.

FIGURE 6. The result of matching condition ⑧.

Figure 4 shows that the PSPR strategy is consistently superior to the PSP strategy. This example satisfies \( t_1 < t^A < 1 \). Under the OP strategy, the optimal pricing is 0.57, and the profit is 0.137. Hence, OP is the optimal strategy among the three (i.e., ②). If \( 0 < t^A < t_1 \), then PSPR is the optimal strategy among the three (i.e., ⑥).

Example 3: When a consumer’s valuation \( v \) of the product before the selling season is \([0, 1]\) and \( c = 0.1, T_M = 0.6, T = 1, \beta = 0.9, \lambda = 0.7, r = 0.5, \delta = 0.5 \), the profit of the retailer is distributed in \([0, 0.2] \). Through calculation, we obtain \( \alpha = -0.648, t_1 = 0.583, t_1 < t_5 < 0.61, t_4 = 0.007 \), thereby satisfying Proposition 9.

Figure 5 shows that the PSP strategy is consistently superior to the PSPR strategy. This example satisfies \( t_4 < t^A < t_5 \) and \( t_4 < t_1 \). Under the OP strategy, the optimal pricing is 0.49, and the profit is 0.1521. Hence, the PSP strategy is the optimal decision under this situation (i.e., ②). If \( 0 < t^A < t_4 \), PSPR is the optimal strategy among the three (i.e., ③). If \( t_5 < t^A < 1 \), the OP strategy is optimal (i.e., ③).

Example 4: When a consumer’s valuation \( v \) of the product before the selling season is \([0, 1]\) and \( c = 0.2, T_M = 0.8, T = 1, \beta = 0.9, \lambda = 0.6, r = 0.5, \delta = 0.5 \), the retailer’s profit is distributed in \([0, 0.15]\). Through calculation, we obtain \( \alpha = 0.773, t_1 = 0.615 \), which satisfies Proposition 11.

Figure 6 shows that the PSPR strategy is consistently superior to the PSP strategy. Under the OP strategy, the optimal pricing is 0.56, and the profit is 0.1296. This example proves Proposition 11, and the OP strategy is the optimal decision under this situation (i.e., ③). If \( 0 < t^A < t_1 \), then PSPR is the optimal strategy among the three (i.e., ④).

VII. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

We explore an equilibrium solution between the retailer and customers in which the consumers decide whether and when to buy the product and the retailer decides which pricing strategy to use and at what price over two sale periods.

To achieve this purpose, we develop a two-period pricing model to analyze the OP strategy and two markdown pricing strategies. Through comparison, we derive the optimal pricing decisions of retailers under the three strategies and which strategy dominates.

Different from previous studies, our model is the calculation of the sales quantity of retailers by introducing demand time and valuation of consumers on products and the analysis of the effect of three different pricing strategies on sales quantity. Thus, we can obtain the total profits. Moreover, this study analyses the influence of the length of the second period on pricing strategies based on the two-period model. The results show that the values of percentage of myopic consumers among all consumers and the waiting cost of customers have an important influence on the PSP strategy, but have no effect on the PSPR and OP strategies. However, when the necessary conditions are satisfied, the PSPR and OP strategies are consistently superior to the PSP strategy, and the retailer should not consider the PSP strategy under this situation. If the PSP strategy is the optimal decision, then this study find that only several conditions must be met.

The length of the second period also has an important influence on the profits of the three strategies. When the length of the second period is sufficiently short compared with the first period, the optimal decision is the OP strategy under any condition. If the second period is sufficiently long compared with the first period, a certain condition is met, then a small price reduction strategy is better than the two other strategies. If the length of second period is close to the first period, when a certain condition is met, a slash price strategy is better than the two other strategies. UNIQLO decides prices...
based on product life cycle, the headquarters expects to sell 1W of a piece of clothing, sold out within one month, and the employee decides the price reduction in accordance with the weekly sales volume. Therefore, when a piece of clothing is popular with customers, UNIQLO will not cut price and the length of selling season is sufficiently short. Still, when the sales volume of a piece of clothing is unideal, UNIQLO will consider to adopt small price reduction at first, if the situation has not improved, UNIQLO will choose slash price to stimulate sales to minimize inventory.

Future research can consider this study’s limitations as research directions. First, how to choose a dynamic pricing strategy in the presence of two or more retailers to gain competitive advantages is worthy of additional study. Second, in the assumption of this study, we do not consider the safe stock of retailers, whether the retailer faces stock-out over two periods, its effect on the purchase behaviors of consumers and opportunity cost of retailers, and its effect on earnings.

REFERENCES

[1] A. Smith and M. Anderson. (2016). Online Shopping and e-Commerce. [Online]. Available: http://www.pewinternet.org/2016/12/19/online-shopping-and-e-commerce/

[2] B. Yan and C. Ke, “Two strategies for dynamic perishable product pricing to consider in strategic consumer behavior,” Int. J. Prod. Res., vol. 56, no. 5, pp. 1577–1722, 2018.

[3] J. Dong and D. D. Wu, “Two-period pricing and quick response with strategic customers,” Int. J. Prod. Econ., vol. 215, pp. 165–173, Sep. 2019.

[4] R. Swinney, “Selling to strategic consumers when product value is uncertain: The value of matching supply and demand,” Manage. Sci., vol. 57, no. 10, pp. 1737–1750, Oct. 2011.

[5] G. P. Soysal, The Dynamics of Demand in Seasonal Goods Industries: An Empirical Analysis. Evanston, IL, USA: Northwestern Univ., 2008.

[6] E. Zhou, J. Zhang, Q. Gou, and L. Liang, “A two period pricing model for new fashion style launching strategy,” Int. J. Prod. Econ., vol. 160, pp. 144–156, Feb. 2015.

[7] T. Hazledine, “Testing two models of pricing and protection with Canada/United states data,” J. Ind. Econ., vol. 29, no. 2, pp. 145–154, Dec. 1980.

[8] H. Yang and Q. Pan, “A two-period pricing model with customers’ reference prices,” in Proc. IEEE Int. Conf. Softw. Eng. Service Sci., Jun. 2012, pp. 620–623.

[9] J. Chai, Z. Qian, E. M. Ampaw, and H. Chen, “To have your cake and eat it? A two-period model for retailers’ mixed bundling or reserved product pricing strategies in response to supplier encroachment,” IEEE Access, vol. 7, pp. 9173–91744, 2019.

[10] H. Li, X. Yang, Y. Tu, and T. Peng, “Two-period dynamic versus fixed-ratio pricing policies under duopoly competition,” Math. Problems Eng., vol. 2019, no. 1, Mar. 2019, Art. no. 6567952.

[11] K. Pan, K. K. Lai, L. Liang, and S. C. H. Leung, “Two-period pricing and ordering policy for the dominant retailer in a two-echelon supply chain with demand uncertainty,” Omega, vol. 37, no. 4, pp. 919–929, Aug. 2009.

[12] Y. Aviv and A. Pazgal, “Optimal pricing of seasonal products in the presence of forward-looking consumers,” Manuf. Service Oper. Manage., vol. 10, no. 3, pp. 339–359, Jul. 2008.

[13] A. J. Mersereau and D. Zhang, “Markdown pricing with unknown fraction of strategic customers,” Manage. Service Oper. Manage., vol. 14, no. 3, pp. 355–484, May 2012.

[14] J. Correa, R. Montoya, and C. Thraves, “Contingent preannounced pricing policies with strategic consumers,” Opt. Res. vol. 64, no. 1, pp. 251–272, Jan. 2016.

[15] Y. Levin, J. McGill, and M. Nediak, “Dynamic pricing in the presence of seasonal consumers and oligopolistic competition,” Manage. Sci., vol. 55, no. 1, pp. 32–46, Jan. 2009.

[16] G. P. Cachon and R. Swinney, “Purchasing, pricing, and quick response in the presence of strategic consumers,” Manage. Sci., vol. 55, no. 3, pp. 497–51, Mar. 2009.

JUNFENG DONG received the bachelor’s degree in information management and the Ph.D. degree in management science and engineering degree from the University of Science and Technology of China, China, in 2004 and 2009, respectively. From 2011 to 2012, he was a Lecturer with the School of Management, Hefei University of Technology, where he has been an Associate Professor, since 2013. His research interests include operations research, supply chain, and game theory.
BEILEI RAO was born Luan, Anhui, China, in 1994. She received the bachelor’s degree in management from the Anhui University of Science and Technology, in 2017. From 2017 to 2019, she was a Research Assistant, under the supervision of Prof. Dong. Her research interests include logistics and supply chain management, and game theory.

YU LIU was born Fuyang, Anhui, China, in 1990. She received the bachelor’s degree in information management from the Bengbu Medical College, in 2017. From 2017 to 2019, she was a Graduate Student, under the supervision of Prof. Dong. Her research interests include logistics and supply chain management, and engineering management.

LI JIANG was born in Yibin, Sichuan, China, in 1983. She received the B.S. degree in engineering management from the Southwest University of Science and Technology, in 2006, and the Ph.D. degree in management science and engineering from the University of Science and Technology of China, in 2011. From 2011 to 2013, she was a Lecturer of management information systems with the Hefei University of Technology, where she has been an Assistant Professor, since 2014. She is the author of more than 20 articles and more than four inventions. Her research interests include distribution disruption recovery management, optimization management of the last mile delivery, engineering management, and health and medical.

WENXING LU was born in Changzhou, Jiangsu, China, in 1971. He received the M.S. degrees in computer application and the Ph.D. degree in management science and engineering from the Hefei University of Technology, in 2004 and 2015, respectively. He is currently an Associate Professor with the Hefei University of Technology. His research interests include operations research, supply chain, and engineering management.

QIANG GUO was born in Hefei, Anhui, China, in 1984. He received the Ph.D. degree in management from the School of Management Science and Engineering, China University of Science and Technology, in 2003. He is currently the Vice Dean of the Tourism College, Hainan University, where he is also a Supervisor of postgraduate students. He is the Standing Committee of the Youth Federation of Hainan Province and also the Vice President of the Research Institute of Management Modernization of Hainan Province. His research interests include pricing and supply chain management, and tourism supply chain management.