Pricing Strategy for Products with Pre-sales and Buy-back

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Abstract. The integration of a combined strategy combining pre-sale and buy-back offers significant benefits to retailers, including mitigating market demand uncertainty, enhancing retailer profits, and reducing the risk associated with consumer valuation uncertainty. This study investigates the application of a combined strategy of pre-sale and buy-back employed by retailers to maximize profits. It comprehensively examines and compares the profits generated through the adoption of a single strategy of pre-sale versus the combined strategy. Furthermore, this research presents a methodology for retailers to determine the optimal pre-sale price and buy-back price, thereby maximizing expected profits.

Keywords: pre-sales, strategic consumers, buy-back, combined strategy.

1 Introduction

The surplus value of fashion and seasonal perishable products is low, hence the surplus of those will bring great losses to retailers. Even though the pre-sale strategy allows retailers to mitigate the ambiguity surrounding future demand, the risk of inventory surplus may still exist. Hence, we adopt the combined approach of pre-sale and buy-back for these specific products. Furthermore, it is implemented out of another three reasons, 1) it assists to determine the demand with more accuracy, so that the retailer can decide the optimal order quantity; 2) it facilitates to expand the sales volume and thus to increase retailer's profit; 3)it helps to reduce the loss of the retailer and the consumers, the fact that the buy-back product obtained during the pre-sale period can be resold during the regular selling period.

The pre-sale strategy introduces uncertainty in consumers' valuation. In cases where a consumer pre-orders during the pre-sale stage but finds the actual valuation at the normal stage to be lower, they may experience a loss. Considering this aspect of pre-sale, strategic consumers evaluate the potential for negative payoffs and might opt to postpone their purchase decisions. To address this concern and attract advance purchases, retailers can implement the buy-back strategy, which guarantees consumer interests. By implementing this approach, consumers who have already placed pre-orders retain the ability to initiate a return for their purchase if actual valuation of the products is relatively low. By combining the pre-sale and buy-back strategies, retailers can optimize the pricing and order quantity of advance sales, reducing the likelihood of excessive orders and unnecessary resource wastage.

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This study explores the effectiveness and advantages of the combined strategy of pre-sale and buy-back, aiming to address existing issues in current research. The analysis compares the profits attained through the combined strategy with those generated by solely adopting the pre-sale strategy, with the objective of maximizing the retailer's overall expected profits.

2 Literature review

The pre-sale strategy refers to the sales behavior of accepting consumer orders in advance, at the original price or with a certain discount, before the delivery and consumption of products, while ensuring the availability of the pre-sold products [1]. ncentivizes consumers to make advance purchases prior to the official release of the product [2]. In numerous studies, it has been found that compared to traditional sales methods, the pre-sale strategy can attract consumers to make early purchases through advanced reservations, thereby reducing demand uncertainty, mitigating inventory risks, accelerating capital turnover, and lowering operational risks for retailers, among other benefits. For instance, customers who placed a pre-order for "Harry Potter and the Deathly Hallows", Amazon provided an enticing discount of 49% [3]. In Hong Kong, bakery shops stimulate consumers to pre-order mooncakes for the Mid-Autumn Festival, providing a 25% price discount for those who reserve their purchases one month ahead of the festival [4]. Retailers employ price discounts as incentives for consumers to pre-order products, transferring inventory risks to consumers who, in turn, consumers accept the inherent uncertainty in valuations while benefiting from the discounts offered during the pre-sale period. This is a common pre-sales marketing strategy [5].

Regarding the return policy, Heal first proposed in 1977 that guarantee policies could effectively distribute risks between retailers and consumers [6]. Li et al. contend that the majority of product returns can be attributed to consumer behavior rather than any concerns regarding the quality or functionality of the products [7]. Consequently, many scholars have started studying the buyback and resale policies. Su researched the influence of buy-back policies on the supply chain in a single-period model that incorporates consumer demand and valuation uncertainty. By establishing both the full buyback and partial buyback models, the investigation led to the conclusion that offering a refund equivalent to the remaining value of the product is the optimal choice [8]. Akcay et al. allowed consumers to initiate product returns to retailers request a complete or partial refund for products that fail to meet their expectations.Retailers have the option to recycle the products that are returned or to resell them as open-box items with discounted prices [9]. The resale of returned products creates additional revenue for retailers. Altug and Aydinliyim studied the impact of consumer purchasing behavior on the buy-back of products by online retailers, and the research indicates that for high-profit but low residual value goods, the optimal buyback price for retailers should not exceed the residual value of the product [10].

For the combined strategy of pre-sale and buyback strategies, Li et al. analyzed the impact of consumer valuation uncertainty on the three return strategies by establishing a retailer's profit model based on the newsboy problem [11]. Meng, Ruud, and Stuart investigated the conditions under which pre-sales or no refund are quite profitable. They compared the profits of three pre-sale strategies: pre-sale with no refund, no refund, and refund available, and found that for products with relatively small profit margins and small strategic market sizes, advance sales

with the option of refund were optimal [12]. However, it is unrealistic to consider the expectations and valuations of consumers as a distribution. In our study of the combined pre-sale and buyback strategy, we have taken into account the heterogeneity of consumer valuations for the product before and after the pre-sale period. Based on the heterogeneity of consumer valuations during the pre-sale and normal sale periods, we propose a new combined strategy of pre-sale and buyback.

3 Problem settings

Within this research, we introduce an innovative and distinctive approach by combining the strategies of pre-sale and buy-back. This strategy is based on the heterogeneity of consumer valuations during the pre-sale and normal selling periods, and aims to maximize the retailer's expected profits through the resale of returned products.

Consider a retailer who operates in two stages: pre-sale and normal selling. Throughout the pre-sale phase, the retailer establishes the pre-sale price, denoted as x, and ensures the timely delivery of products upon their release. Subsequently, the normal selling period commences, during which the retailer sets the normal selling price, represented as p, and offers consumers the option to return the purchased items at a repurchase price denoted by b. To facilitate analysis, we categorize consumers into two distinct groups: the informed and the uninformed. The informed consumers are aware of the pre-sale situation and make their purchase decisions during the first period, while the uninformed consumers enter the market during the second period without knowledge of the pre-sale phase. Table 1 presents a comprehensive compilation of the symbols utilized in this manuscript, while Figure 1 illustrates a chronological representation of the proposed framework.

3.1 Retailer settings

The product cost incurred by the retailer is denoted as c, and the normal selling price is set at p, with $0<c<p$.

During the pre-sale period, the retailer prices the product at x and announces the price p for the normal selling period. All orders are fulfilled after the product's release. Consumers are informed that they have the option to return the product within a specified timeframe at a price b (where $b \leq x$) if they are unsatisfied. The retailer then resells the returned products during the normal selling period at the price p. If $b>x$, consumers may engage in arbitrage, resulting in losses for the retailer.

Upon the conclusion of the preliminary selling phase, the retailer conducts a comprehensive analysis and prediction of the market demand during the subsequent normal selling period, utilizing the pre-orders gathered from consumers. By leveraging this valuable information, the retailer determines the appropriate quantity of repurchased items to be reintroduced into the market at the commencement of the normal selling period, subsequently facilitating their resale. The costs associated with repackaging and shipping the buy-back are assumed to be negligible.

3.2 Consumer settings

We assume a total of N consumers, which can be divided into two groups: N_1 (informed consumers) and N_2 (uninformed consumers). Specifically, we have $N_1 = \beta N (0 < \beta \leq 1)$ and

$N_2 = (1-\beta)N$. Additionally, it is assumed that consumer valuations vary across selling periods but maintain homogeneity within each respective period. During the pre-sale period, the valuation V_1 of a product is determined by a uniform distribution within the range $V_1 \sim U(l,h)$. Here, the functions $f(v)$ and $F(v)$ represent the probability density function and distribution function of V_1. On the other hand, the actual valuation V_2 during the normal selling period is a random variable characterized by an expected value of μ, a standard deviation of σ, and probability density function and distribution function denoted as $g(v)$ and $G(v)$.

Table 1. List of notations.

Parameters/variables concerning the retailer	
c	Cost price
p	Market price
Q_i	Quantity of products
R	Quantity of repurchased products
π	Retailer's profit
Parameters/variables concerning consumers and market	
N_i	Number of customers
D_i	Demands, $i = 1,2$ represent advance and normal selling seasons
V_1	The consumer's assessment of product value, denoted as V_1, follows a uniform distribution with a random variable v that lies within the range$[l,h]$. This random variable has a probability density function $f(v)$ and a distribution density function $F(v)$.
V_2	The consumer's realized of product value, denoted as V_2, follows a normal distribution, with mean μ and standard deviation σ, probability density function $g(v)$, and a distribution density function $G(v)$.
β	The probability of consumers who possess relevant information, and the probability of consumers who lack such information is $1-\beta$. $(0 < \beta \leq 1)$
Decision variables	
x	Pre-sale price
b	Buy-back price

During the period of pre-sale, to estimate the valuation V_1, consumers heavily depend on the sales website and promotional details. However, once the normal selling season begins, consumers encounter the real valuation V_2 instead., which influences their decision to keep or return the product.

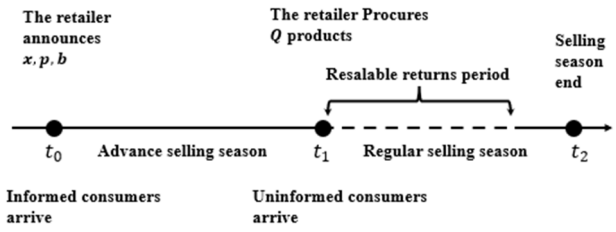

Fig. 1. Timeline of the model.

As illustrated in Figure 1, which presents the chronological sequence of events within the proposed model, at the commencement of the pre-sale period, the retailer publicly discloses the pre-sale price denoted as x, as well as the exogenously determined normal selling price represented by p. Additionally, the buy-back price b, is also announced during this initial phase. Apparently, $p \geq x \geq b \geq c$. Simultaneously, informed consumers enter the market and make decisions regarding preordering. In cases where the retailer incorporates a buy-back option, consumers are informed that they have the opportunity to return the product at a specified price b within a given timeframe during the normal selling season if they are unsatisfied. It is aim to reduce the risk of consumer valuation uncertainty and encouraged consumers to buy at pre-sale season.

During the normal selling period, the retailer is required to pre-determine the order quantity, denoted as Q. Simultaneously, uninformed consumers enter the market and make purchasing decisions based on the prevailing price p. And the informed consumers who order at the pre-sale season need to decide whether to return the product.

4 Pre-sale and buy-back strategy

4.1 Product demand Model (Retailer's order quantity)

In the pre-sale period, the consumer's assessment of product value, denoted as V_1, follows a uniform distribution with a random variable v that lies within the range $[l, h]$. This random variable has a probability density function $f(v)$ and a distribution density function $F(v)$. Consequently, the expected demand D_1 in the pre-sale period is calculated as:

$$E(D_1) = N_1 F(v \geq x) = \beta N \bar{F}(x) = \beta N \frac{h-x}{h-l} \tag{1}$$

During the normal selling period, the consumer's realized of product value, denoted as V_2, follows a normal distribution, with mean μ and standard deviation σ, probability density function $g(v)$, and a distribution density function $G(v)$. The expected demand D_2 in the normal selling period is:

$$E(D_2) = N_2 G(v \geq p) = (1-\beta) N \bar{G}(p) \tag{2}$$

Assuming buy-back are not considered, the aggregate demand for a single pre-sale (retailer order) is denoted as Q_1:

$$E(Q_1) = E(D_1 + D_2) \tag{3}$$

Proposition 1. Within the framework of a sole pre-sale strategy, the anticipated aggregate demand Q_1, diminishes as the pre-sale price rises, while it also diminishes as the normal selling price increases.

During the normal selling period, upon receiving the product, consumers' actual valuation V_2 follows a normal distribution $V_2 \sim U(\mu, \sigma)$. If the consumer returns the product because they are not satisfied, the retailer repurchases it at price b. Therefore, the expected quantity of products repurchased R is:

$$E(R) = E[D_1 G(b)] = \beta N \bar{F}(x) G(b) = \beta N \cdot \frac{h-x}{h-l} \cdot G(b) \tag{4}$$

The repurchased products are then sold at price p during the normal selling period. It's evident that a higher pre-sale price leads to a higher repurchase price, resulting in a greater quantity of returns. Let the aggregate demand for the combined approach of pre-sale and buy-back (retailer order) be denoted as Q_2 in our model's assumptions

$$E(Q_2) = E[D_1 + D_2 - R] \tag{5}$$

Proposition 2. The aggregate demand for the integrated strategy of pre-sale and buy-back, denoted as Q_2, exhibits a decline as the normal selling price, repurchase price, and pre-sale price increase.

4.2 Conditions for pre-sale and buy-back

During the pre-sale period, the consumers' expected payoff U_A is determined as

$$U_A = \int_x^h (v-x) f(v) dv - \int_l^x (x-v) f(v) dv \ = \frac{l+h}{2} - x \tag{6}$$

The expected payoff U_w for consumers who choose to wait until the normal selling period is

$$U_w = \int_p^h (v-p) f(v) dv \tag{7}$$

Consumers exclusively make purchases during the pre-sale period if $U_A \geq U_w$. Considering that $U_A \geq U_w$, then

$$\frac{l+h}{2} - x \geq \int_p^h (v-p) f(v) dv \tag{8}$$

That is

$$\begin{aligned} x &\leq \frac{l+h}{2} - \int_p^h (v-p) f(v) dv \\ &\leq \int_l^p p f(v) dv + \int_p^h p f(v) dv \\ &= p \end{aligned} \tag{9}$$

Therefore, if x is less than or equal to p, consumers will opt to make purchases solely during the pre-sale period. The expected demand for D_1 in the pre-sale period is

$$E(D_1) = N_1 F(v \geq x) = \beta N \bar{F}(x) = \beta N \frac{h-x}{h-l}$$

If the payoff from returning the product $x - b$, is smaller than the payoff from purchasing $x - v$, where $v < b$, the consumer decides to initiate the return process for the product. The retailer buys back the product and resells it at *p* during the normal sales period. Valuation *v* represents the actual value of the product received by the consumer during the normal sales period, $V_2 \sim U(\mu, \sigma)$. The expected quantity of products repurchased *R* is

$$E(R) = E[D_1 G(b)] = \beta N \bar{F}(x) \cdot G(b) = \beta N \cdot \frac{h-x}{h-l} \cdot G(b)$$

4.3 Demand and profit of the combined strategy of pre-sale and buy-back

Given the aggregate demand for the combined approach of pre-sale and buy-back (retailer order) as Q_2, we can infer that

$$\begin{aligned} E(Q_2) &= E[D_1 + D_2 - R] \\ &= [1 - G(b)]\beta N \cdot \tfrac{h-x}{h-l} + (1-\beta) N \bar{G}(p) \end{aligned} \tag{10}$$

During the normal selling period, the repurchased products are retailed at the price *p*. Suppose the total profit accrued by the retailer through the implementation of the combined strategy is denoted as π. Consequently, the anticipated profit $E(\pi)$, can be expressed as

$$\begin{aligned} E(\pi) &= E[D_1 \cdot (x-c) - R \cdot (b-p) + D_2 \cdot (p-c)\ ] \\ &= \beta N \cdot \tfrac{h-x}{h-l} \cdot [x - c - G(b)(b-p)] + (1-\beta) N \cdot \bar{G}(p) \cdot (p-c) \end{aligned} \tag{11}$$

Proposition 3. Under the combined strategy of pre-sale and buy-back, when the pre-sale price *x* and the buy-back price *b* satisfy

$$x^* = \tfrac{c+h+G(b^*)(b^*-p)}{2},\ b^* = \tfrac{pg(b^*)-G(b^*)}{g(b^*)}.$$

And

$$\frac{\partial^2 E(\pi)}{\partial x^2} \cdot \frac{\partial^2 E(\pi)}{\partial b^2} - \left(\frac{\partial^2 E(\pi)}{\partial x \partial b}\right)^2 \Big|_{\substack{x=x^* \\ b=b^*}} > 0\ ,\ \frac{\partial^2 E(\pi)}{\partial x^2}\Big|_{\substack{x=x^* \\ b=b^*}} < 0.$$

The retailer receives the largest expected profit $E(\pi)$.

In daily life, different businesses provide return services for pre-sale products. Some offer a seven-day no reason return policy, while others charge a certain handling fee for returning pre-sold products (such as shipping or repackaging fees), or even do not offer return services at all. Providing excessively lenient repurchase policies can have an impact on future production and sales, while not providing a return strategy can lead to delayed purchases and an inability to mitigate potential inventory risks for consumers. Therefore, we calculate the optimal pre-sale and buy-back prices to maximize retailer profits.

5 Conclusions

The primary focus of this research revolves around the synergistic utilization of pre-sale and buy-back as a combined strategy specifically tailored for fashion and seasonal products. In contrast to prior studies, this approach incorporates the diversity in consumers' product valuation during the pre-sale phase, alongside the resale of repurchased items at the normal selling price. By considering these factors, this strategy distinguishes itself from existing research. A mathematical model is established to calculate the optimal pre-sale price, buy-back price, and expected profit. The findings reveal that under this combined strategy, the aggregate demand decreases with increasing pre-sale and buy-back prices, while the optimal pre-sale price increases with an increase in the optimal buy-back price.

This research targets at monopoly sellers, and contributes to future studies for non-monopoly. Additionally, in real-life situations, the valuation distribution of the product may be divergent due to the different consumers' evaluations and demand degrees. Hence, future research is encouraged to investigate consumer heterogeneity.

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