RESEARCH ON THE INVENTORY OF ONLINE MERCHANTS IN THE PRE-SALE MODE OF DEPOSIT

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ABSTRACT. *In the e-commerce product market, the sale of many products is usually divided into two stages: pre-sale and official sale. Pre-sale is a sales method used to understand the market and help online merchants better organize their products and inventory. Today, this method has been widely used, so a reasonable inventory strategy is very important. Based on the deposit presold mode of "pay the deposit first, pay balance payment later", this paper solved the inventory to obtain the maximum expected revenue by establishing the expected revenue model, and discussed the relationship between the inventory and the deposit, the price of the commodity in the formal stage and the return rate under the optimal profit. And offer theoretical guidance for the merchant that takes earnest money to open to sale mode.*
Keywords: Pre-sale, The deposit, Inventory preparation, Consumer behavior

1. **Introduction.** Pre-sale is the act of understanding the market situation of the product and selling the product in advance. Now, pre-sale has become a pre-sale method widely used on e-commerce platforms. Through pre-sales, retailers can further understand the market through the effects of the pre-sale stage, and consumers can also lock in their favorite products in advance at a more favorable price.

At present, many scholars have conducted research on pre-sales. In the early years, Shugan and Xie [1] found in their research that pre-sales are generally used in markets with determined demand and heterogeneous consumers, and found that pre-sales merchants can further improve the problem of information asymmetry in the market. Tang et al. [2] proposed relevant discount items for products with short life cycles and unpredictable demand, analyzed the impact of pre-sale discounts on demand, and discussed the optimal discount that can maximize profits. Hui et al. [3] found that retailers can use pre-sale information to evaluate and reduce inventory risk based on Tang et al.'s research.

The consumer's choice behavior in the pre-sale of a product may have an impact on the estimated value of the product and other factors. Loginova et al. [4] adjusted the pre-sale price to control the number of pre-booked consumers based on whether the consumers had experience or not, and then predicted the market demand in the formal sales stage. Li et al. [5] compared the income situation under different service strategies. The optimal return price is the residual value of the product. Liu and Zhang [6] studied that when

the number of customers is uncertain, sellers should adopt the pre-sale discount pricing strategy. Akcay et al. [7] discussed how to take a pre-sale strategy when selling perishable products in order to relieve the competitive pressure during the limited sales period. Wang et al. [8] established models under the two strategies of allowing and disallowing returns to calculate the corresponding optimal pre-sale price and return price.

In addition to the research on the related strategies of pre-sales, some scholars also conduct research on the issues related to ordering and inventory in pre-sales. Cheng et al. [9] found that extending the sales period can increase sales while reducing inventory risk. Dai et al. [10] discussed inventory models for three different demand situations. Xu et al. [11] studied the relationship between the retailer's inventory strategy and the return price and return deadline. Xu et al. [12] studied the optimal one-time order strategy when the pre-sale period was not fixed, and at the same time analyzed the optimal strategy under the condition of fixed pre-sale period. Chen [13] studied inventory strategies, taking account of the effects of competition among merchants and customer returns. Xu and Ma [14] combined the time when consumers entered the market and made inventory and deposit decisions.

At present, the above-mentioned research does not specify when the order occurs. Therefore, this paper further clarifies the ordering time point in the research. In reality, ordering takes place after the end of the pre-sale, and the formal phase begins to sign. In this paper, the ordering time is fixed between the beginning of the formal sales stage and the end of the pre-sale stage, which is specific to the time points shown in Figure 1, and the ordering strategy under the pre-sale mode is analyzed by establishing a model and numerical simulation. In this way, we can get a result that is much closer to the actual sale. Next, this paper will establish the expected profit model and numerical simulation to discuss the inventory preparation strategy under the deposit presale mode.
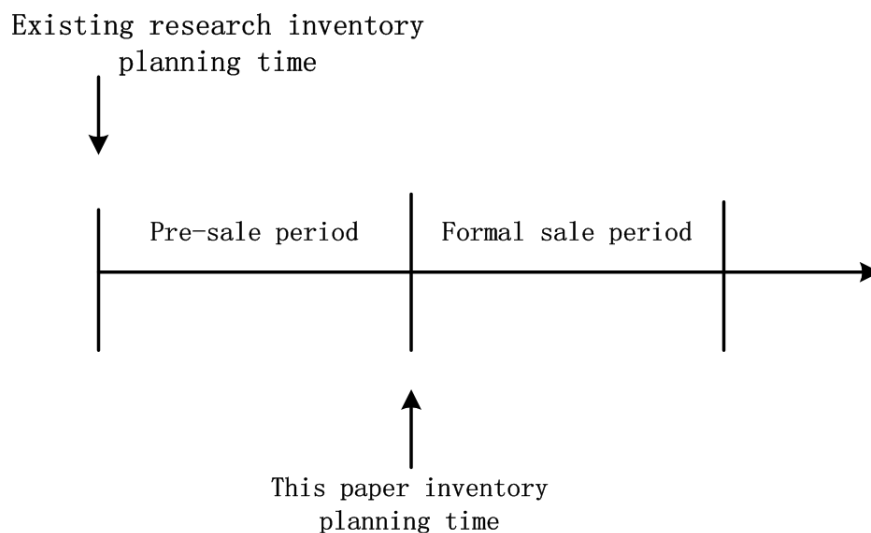

FIGURE 1. Inventory planning time in this paper

2. Symbolic Descriptions and Model Assumptions.

2.1. **Symbol description.** The symbols used are described in the following Table 1.

Among them, the market demand x in the formal sales stage obeys the normal distribution of $f(x)$ on (μ, σ^2), and its distribution function is $F(x)$. Consumers' evaluation v of the product obeys the uniform distribution on (L, H), and its probability density is $g(\cdot)$. Abandonment rate in pre-sale $\alpha \in (0, 1)$.

TABLE 1. Symbol description table

Symbol	Introduction	Symbol	Introduction
p_1	Pre-sale price	p_2	Formal sale price
m	Deposit	c	Unit inventory cost
s	Commodity residual value	x	Demand of formal sale
L	Minimum consumer valuation	H	Maximum consumer valuation
π_1	Pre-sale profit	π_2	Formal sale profit
π	Gross profit	n	Pre-sale inventory
q	Formal preparation of inventory	Q	Saleable inventory in formal sale
α	Abandonment rate in pre-sale	β	Product return rate
v	Consumer product evaluation		

2.2. Model assumptions.

1) Consider a single retailer on an e-commerce platform selling a new product to the market, and divide the entire sales cycle into two stages including the pre-sale stage and the formal sales stage. The retail price p_1 in the pre-sale stage is less than the retail price p_2 in the formal sale stage.

2) In the pre-sale and formal sales cycle, the retailer will only place an order once before the start of the formal sales period at the end of the pre-sale period, and no replenishment will be made in the subsequent sales process. And at the beginning of the sales cycle, the initial inventory is zero, and the inventory cost of the goods sold in the pre-sale stage is ignored.

3) Consumers are heterogeneous, each consumer only buys a single product, and consumers who exit the market during the pre-sale stage will not enter the market again. Consumers in the pre-sale stage have uncertain valuations, but we believe that the valuation of consumers entering the market in the formal stage is determined. The sold goods may be returned due to other reasons, and the returned goods will no longer be sold.

4) At the end of the entire sales cycle, the remaining products will not be stored but sold at a discount.

2.3. Model description and establishment.
An online retailer publishes product information through the e-commerce platform when the pre-sale starts, and at the same time announces the deposit m paid in the pre-sale phase, the price of the product p_1 in the pre-sale phase, and the sales price of the product in the formal phase is p_2 $(p_2 > p_1)$. Before the end of the pre-sale stage and the beginning of the formal sales stage, the retailer determines the order quantity of the goods through the pre-sale situation and completes the inventory preparation. At the beginning of the formal sales phase, consumers participating in the pre-sale can decide whether to pay the final payment $p_1 - m$. If the final payment is not paid, the paid deposit will not be refunded. At the end of the entire sales cycle, the remaining inventory and returned items will be treated at residual values.

Lemma 2.1. *In the case of consumers' valuation uncertainty in the pre-sale stage, there is a certain negative correlation between the abandonment rate in the pre-sale stage and consumer valuation. When the valuation range of the consumers participating in the pre-sale is larger or the deposit amount is higher, the abandonment rate in the pre-sale stage is smaller at this time.*

Proof: In the pre-sale stage, consumers can only decide whether to pay the deposit through the information released by the retailer on the e-commerce platform. At this time, consumers are uncertain about the valuation of the product. At the beginning of

the formal sales phase, consumers will have the latest evaluation of the product as v. If at this time, the utility of the consumer's payment of the final payment is less than the utility of abandoning the deposit, the consumer will abandon the payment of the final payment. As is shown in Figure 2, that is when $v - (p_1 - m) < v - m$, consumers participating in the pre-sale will waive the final payment. Otherwise, the order will be completed.
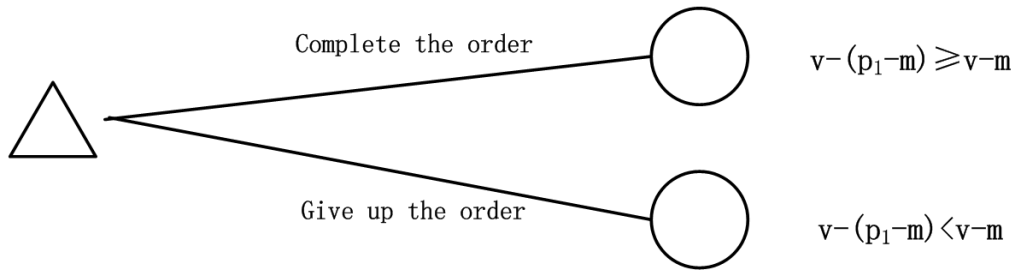

Complete the order $\quad v - (p_1 - m) \geqslant v - m$

Give up the order $\quad v - (p_1 - m) < v - m$

FIGURE 2. Pre-sale stage consumer decision diagram

At the beginning of the formal sales phase, if the consumer's evaluation of the product v has a situation of $g(p_1 - m) < g(m)$, the consumer will give up paying the balance. It is known that consumers' evaluation of goods v obeys a uniform distribution on (L, H). Therefore, the abandonment rate α is as follows:

$$\alpha = \int_{L}^{p_1 - m} g(v)dv = \frac{p_1 - m - L}{H - L} \tag{1}$$

According to Formula (1), it can be concluded that there is a certain negative correlation between the abandonment rate α and the consumer's valuation range H-L and the deposit m. The lemma is proved.

Proposition 2.1. *In the pre-sale stage, there is a positive correlation between the retailer's profit and the range of consumers' valuation and the amount of deposit. And when the abandoned order rate $\alpha = 0$, the retailer can obtain the maximum profit in the pre-sale stage.*

Proof: At the end of the pre-sale, the retailer can know the pre-sale order quantity through the platform, and the retailer will prepare an equivalent inventory quantity for the pre-sale order, that is, n. At this time, the retailer in the pre-sale stage can obtain the following benefits.

$$\pi_1 = (1 - \alpha)np_1 + \alpha nm - (1 - \alpha)\beta np_1 \tag{2}$$

Because the merchant is known about the pre-sale sales, the merchant is sure to be prepared to meet the quantity of goods for all pre-sale orders. The profit of the pre-sale stage in the type (2) is negatively related to the discard rate of the consumer, but the profit in the pre-sale stage decreases gradually when the discard rate increases. When the discard rate α achieves the maximum value, that is $\alpha - 1$, the retailer will reap the largest profit during the pre-sale phase. According to the reasoning, there is a negative correlation between the discard rate α and the consumer's valuation range. As a result, retailers can reap greater profits during the pre-sale phase when consumer valuations are large or deposits are higher in the market.

Proposition 2.2. *In the formal sales phase, in order to maximize the retailer's earnings, the retailer needs to prepare a quantity of $F^{-1}\left(\frac{(1-\beta)p_2 + \beta s - c}{(1-\beta)(p-s)}\right) - \alpha n$ goods on top of the pre-sale surplus inventory. And there is a positive correlation between the inventory reserve and the consumer's valuation range and deposit m.*

Proof: That the retailer will determine its inventory q in the formal sales phase before the formal sales phase begins. Due to the possible abandonment of orders by consumers during the pre-sale period, there will be a pre-sale inventory balance of αn prior to the start of the formal phase. Therefore, the actual prepared inventory for the formal sales phase is the difference between the actual possible sales volume and the inventory margin during the pre-sale period. There are two situations in formal sales phase.

1) The actual demand for goods is greater than or equal to the retailer's inventory at this stage, that is, $x \geq Q$. Then, all the goods in the inventory will be sold at this time, and the returned goods will be treated as residual value. At this time, the retailer's profit will be

$$\pi_2 = p_2 Q - \beta p_2 Q + \beta Q s - cQ$$

2) The actual demand for goods is less than the retailer's inventory at this stage, that is, $x < Q$. Then, at this time, the quantity of goods in inventory can fully meet all the demand, and there will be a certain amount of surplus. The remaining items in stock will be disposed of as salvage value s at the end of the formal sales phase. In this case, the retailer gains the following benefits:

$$\pi_2 = p_2 x - \beta p_2 x + \beta x s + (Q - x)s - cQ$$

In combination with these two scenarios, the retailer gains π_2 in the formal phase as follows:

$$\pi_2 = \begin{cases} p_2 Q - \beta p_2 Q + \beta Q s - cQ, & x \geq Q \\ p_2 x - \beta p_2 x + \beta x s + (Q - x)s - cQ, & x < Q \end{cases} \tag{3}$$

Then, the expected earnings of the retailer at this time are

$$E(\pi) = (p_2 Q - \beta p_2 Q + \beta Q s - cQ) - (1 - \beta)(p - s) \int_0^Q (Q - x)f(x)dx \tag{4}$$

In order to obtain the inventory of retailers when they obtain the highest profit, the first derivative of Equation (4) q_2 is obtained as follows:

$$\frac{dE(\pi_2)}{dq_2} = p_2 - \beta p_2 + \beta s - c - (1 - \beta)(p - s) \int_0^Q f(x)dx \tag{5}$$

The second derivative of Equation (4) q_2 is obtained as follows:

$$\frac{d^2 E(\pi_2)}{dq_2^2} = p_2 - \beta p_2 + \beta s - c - (1 - \beta)(p - s) \tag{6}$$

Now, the second derivative $\frac{d^2(E(\pi_2))}{dq_2^2}$ is less than zero. So when $\frac{d(E(\pi_2))}{dq_2} = 0$, there is the maximum of $E(\pi_2)$. At this moment the inventory $Q^* = F^{-1}\left(\frac{(1-\beta)p_2 + \beta s - c}{(1-\beta)(p-s)}\right)$. Because of $Q = q + n$, we can know the optimal stock reserve for the formal phase, like $q = Q^* - \alpha n = F^{-1}\left(\frac{(1-\beta)p_2 + \beta s - c}{(1-\beta)(p-s)}\right) - \alpha n$. According to the lemma, when the valuation range of consumers participating in the pre-sale is larger, and the amount of deposit is higher, the abandonment rate in the pre-sale stage is smaller, and more inventory preparation is required in the formal stage. Therefore, there is a certain positive correlation between the amount of inventory reserves in the formal stage, the scope of consumer valuation, and the deposit m.

The maximum profit a retailer can make on an order quantity of Q^* is

$$\pi^* = (1 - \alpha)np_1 + \alpha nm - (1 - \alpha)\beta np_1 + (p_2 Q^* - \beta p_2 Q^* + \beta Q^* s - cQ^*)$$
$$- (1 - \beta)(p - s) \int_0^{Q^*} (Q^* - x)f(x)dx.$$

This paper makes full use of the pre-sale order quantity information available to merchants by fixing the order time before the formal stage of the pre-sale phase. Next, this article will further analyze the relationship between inventory readiness and the remaining related factors through the study.

3. **The Example Analysis.** In this part we use MATLAB for numerical experiments. An online retailer sells a product through deposit pre-sale mode. In the formal sales stage, the number of consumers obeys the normal distribution of $\mu = 2000$ and $\delta^2 = 500$. The remaining relevant sales data are shown in the following table.

TABLE 2. Sales data table

Parameter	n	m	p_1	p_2	c	s	β
Numerical value	800	40	340	400	150	120	0.005

3.1. **The impact of consumer valuation and deposit on formal inventory.** Consumers in the market are divided into high-valued consumers and low-valued consumers. The valuations of high-valued consumers are uniformly distributed in the range of $[260, 410]$, and the valuations of low-valued consumers are distributed in the range of $[230, 350]$. The remaining values remain unchanged, so that the deposit m changes in the interval of $[10, 50]$. The following figure can be obtained by simulation.
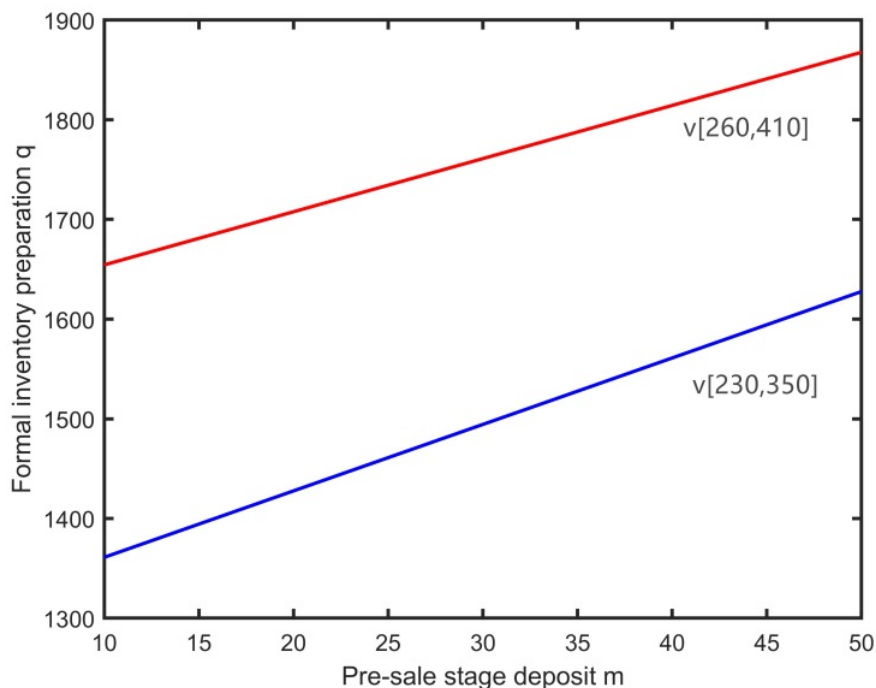

FIGURE 3. The relationship between pre-sale deposit and inventory preparation

As shown in the figure, as the pre-sale deposit m increases, customers who participate in the pre-sale phase will bear greater losses by giving up their orders, and the discard rate will gradually decrease at the end of the pre-sale, at which point the retailer will need to prepare more inventory for the formal sales phase. So, when retailers set a higher deposit amount during the pre-sale phase and provide sufficient information disclosure and publicity, more inventory preparation is required for the formal phase of inventory strategy development.

3.2. **The impact between the return rate and the inventory at the official stage.**
It is assumed here that all consumers have a high valuation level, that is, consumers' valuations are uniformly distributed in the interval of $[260, 410]$. The values of the remaining variables remain unchanged, so that the return rate β varies between 0.1% and 10%, and the results shown in Figure 4 below can be obtained.
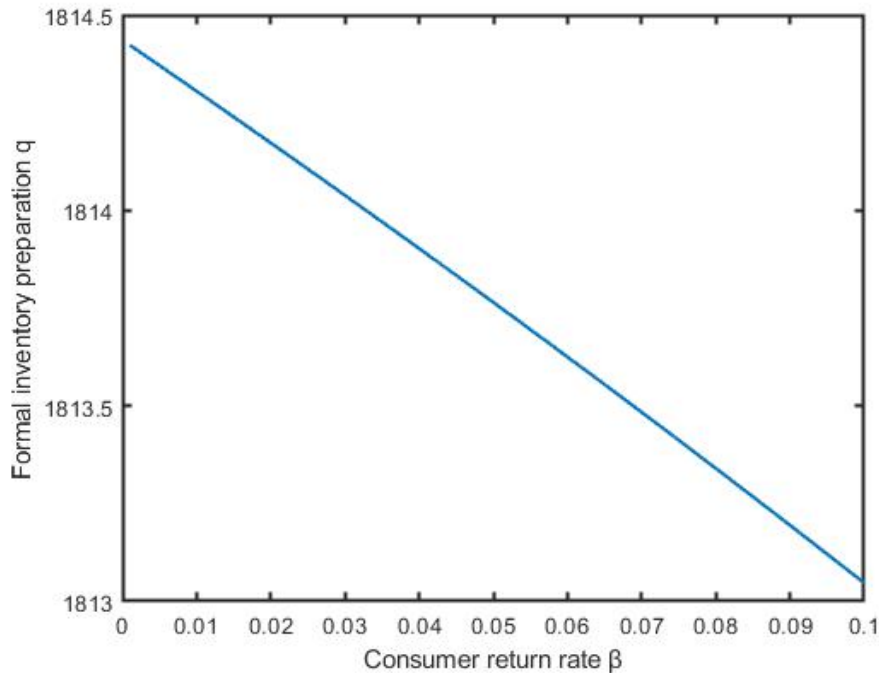

FIGURE 4. The relationship between return rate and inventory

As can be seen from the above Figure 4, there is a negative correlation between the amount of inventory that needs to be prepared during the formal sales phase and the return rate of consumers. Therefore, when the goods sold are prone to uncontrollable loss, the retailer can appropriately reduce the inventory preparation in the formal stage according to the specific situation.

3.3. **The relationship between commodity prices at the official stage and inventory reserves at the official stage.** It is still assumed that all consumers have a high valuation level, that is, the valuation of consumers obeys a uniform distribution in the interval of $[260, 410]$. The values of the remaining variables remain unchanged, so that the price of the formal stage changes in the interval of $[390, 450]$, and the result in Figure 5 can be obtained.

As can be seen from Figure 5, there is a positive correlation between the amount of inventory reserves at the official stage and the price at the official stage. Therefore, when the retailer sets a higher price for the product in the formal stage, it is necessary to appropriately increase the inventory preparation for the formal stage in the formulation of the inventory strategy.

4. **Summary and Prospect.** In this paper, the time of inventory preparation in the pre-sale mode is fixed at the end of the pre-sale and before the start of the formal sale stage. Meanwhile, considering the uncertainty of the valuation of consumers in the pre-sale, the inventory preparation in the formal stage of the pre-sale mode of online merchants is studied, and the results are closer to the actual results than previous studies. So far,
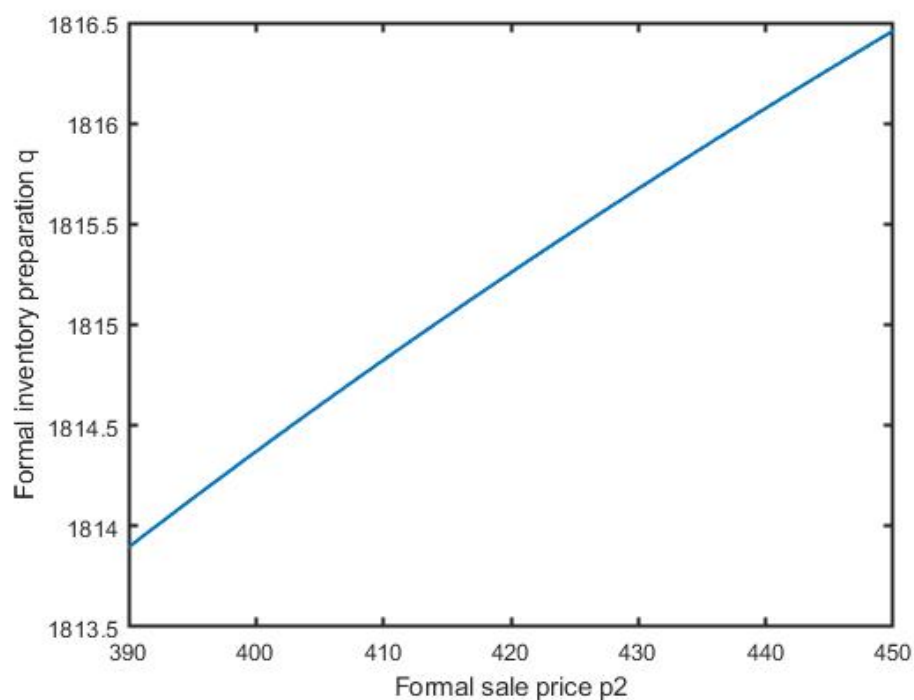
FIGURE 5. The relationship between commodity prices and inventory reserves at the official stage

the discussion in this paper is only limited to the level of monopoly manufacturers, and only considers the sales situation of a single product. Further research can be carried out in combination with these two directions.

REFERENCES

[1] M. S. Shugan and J. Xie, Advance pricing of services and other implications of separating purchase and consumption, *Journal of Service Research*, vol.2, no.3, pp.227-239, 2000.

[2] C. S. Tang, K. Rajaram, A. Alptekinoğlu and J. Ou, The benefits of advance booking discount programs: Model and analysis, *Management Science*, vol.50, no.4, pp.465-478, 2004.

[3] S. K. Hui, J. Eliashberg and E. I. George, Modeling DVD preorder and sales: An optimal stopping approach, *Marketing Science*, vol.27, no.6, pp.1097-1110, 2008.

[4] O. Loginova, H. Wang and H. C. Zeng, Advance selling in the presence of experienced consumers, *Working Papers*, 2011.

[5] Y. J. Li, L. Xu and X. L. Yang, Product pre-sale, return policy and consumer defect-free return behavior, *Nankai Business Review*, vol.15, no.5, pp.105-113, 2012.

[6] Q. Liu and D. Zhang, Dynamic pricing competition with strategic customers under vertical product differentiation, *Management Science*, vol.59, no.1, pp.84-101, 2013.

[7] Y. Akcay, H. P. Natarajan and S. H. Xu, Joint dynamic pricing of multiple perishable products under consumer choice, *Management Science*, vol.56, no.8, pp.1345-1361, 2010.

[8] X. T. Wang, G. L. Zhou and Y. L. Zhang, Research on new product pre-sale and return strategy under strategic consumer loss aversion, *System Engineering Theory and Practice*, vol.39, no.6, pp.1479-1486, 2019.

[9] Y. S. Cheng, H. Y. Li and A. Thorstenson, Advance selling with double marketing efforts in a newsvendor framework, *Computers & Industrial Engineering*, vol.118, pp.352-365, 2018.

[10] Z. Dai, F. Aqlan and K. Gao, Optimizing multi-echelon inventory with three types of demand in supply chain, *Transportation Research Part E: Logistics and Transportation Review*, vol.107, no.11, pp.141-177, 2017.

[11] L. Xu, Y. J. Li, K. Govindan and X. L. Xu, Consumer returns policies with endogenous deadline and supply chain coordination, *European Journal of Operational Research*, vol.242, no.1, pp.88-99, 2015.

[12] H. X. Xu, J. L. Zhang, Y. M. Gong and X. Wu, Research on the ordering strategy of network pre-sale products, *Journal of Systems Engineering*, vol.32, no.6, pp.843-854+864, 2017.

[13] J. X. Chen, Retailer pricing and inventory game model of customer returns effect, *Journal of Systems Engineering*, vol.29, no.1, pp.96-103, 2014.

[14] D. Xu and Z. H. Ma, Research on retailer deposit and inventory decision under returnable presale, *Technology and Management*, vol.19, no.3, pp.86-91, 2017.