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Research on Order Cancellation Strategy of Omni-channel Retailers Considering Consumers' Disappointment and Aversion Behavior

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Abstract:

In the omni-channel retail environment, online and offline channels are highly integrated, which provides great convenience for consumers to buy products or return products that do not meet their needs anytime and anywhere. In order to further quantify the omni-channel retailer order cancellation strategy based on consumer disappointment and aversion behavior, based on the disappointment theory, this paper establishes an optimization model of omni-channel BOPS operation considering consumer disappointment and disgust behavior, and uses the Kmurt condition to obtain the optimal pricing and service radius of omni-channel retailer operation. The research shows that, first, the consumer loss aversion coefficient has a significant impact on retailers' order cancellation policies. Second, for long-distance consumers, omni-channel retailers should formulate appropriate cancellation policies; for nearby consumers, omni-channel retailers should formulate strict or loose cancellation policies. The formulation of omni-channel cancellation policy can help retailers gain more market share and improve their management and operation level.

***Keywords**: Omni-channel, Disappointment and aversion behavior, Order cancellation, Service area*

I. INTRODUCTION

With the rapid development of the network platform, many online shoppers enjoy the convenience of buying goods or services online. The online shopping regulations of "seven days without reason to return goods" and "travel order cancellation insurance" and other products let netizens temporarily change their mind and cancel their "wayward behavior" at any time [1]. However, for omni-channel retailers, consumers' random return or cancellation of orders at any time not only makes omni-channel retailers lose a certain cost of time and energy, but also produces a certain sense of disappointment and disgust after this shopping experience, so that they will no longer make secondary consumption to this online store in the future. This is undoubtedly a great loss for omni-channel retailers. Therefore, it is necessary to formulate a set of order cancellation strategy for omni-channel retailers in view of consumers' disappointment and aversion.

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The traditional research on omni-channel retailer order cancellation strategy mostly focuses on three aspects: the first is the omni-channel return path problem. For example, when Gao and Su considered that only consumers who bought through online channels could return goods, they analyzed the influence of omni-channel return (BOPS) mode on physical store inventory decision in the case of the same price [2]. Jin Ming et al analyzed the problem of setting the service area of BOPS returns, and compared the respective return paths of BOPS mode and ROPS mode under omni-channel [3]. The second is the operating cost of omni-channel retailers. Gao F believed that in the reality of information asymmetry, the soft power of operating costs of enterprises that achieve the BOPS (buy-on-line-and-pick-up-instore) model has a profound impact on their own interests and the overall interests of the supply chain [2]. Wang et al studied the joint inventory and pricing model when omni-channel retailers order the minimum quantity of goods from conventional and fast suppliers or the minimum quantity of goods from each supplier respectively during the limited planning period [4]. The third is the pricing strategy of omni-channel retailers. Forghani and others considered the inventory problem with price adjustment in the omni-channel order cycle [5]. Kim et al analyzed the best channel and pricing strategy, Kim attributed the channel service design to two aspects: one is the "internal digestion effect", and the other is the "competition effect", that is, the competition effect between the manufacturer and the retailers belonging to the same supply chain [6].

However, in the research of omni-channel retailer order cancellation strategy, there are still problems in the exploration of these aspects. First of all, a unified quantitative standard strategy has not been formed to measure the formulation process of omni-channel retailer order cancellation strategy. Secondly, it is not combined with the specific omni-channel operation model (such as consumer shopping experience) to consider the formulation of omni-channel retailer order cancellation strategy. Finally, the related research on these three aspects can not form a complete system to better guide omni-channel retailers to formulate omni-channel operation order cancellation strategy.

In view of the shortcomings of previous studies, this study will use the optimization theory to build an optimization model to study the omni-channel retailer order cancellation strategy considering consumer disappointment and aversion behavior. In order to try to answer the following three questions: first, how to construct the omni-channel retailer order cancellation strategy model considering consumers' disappointment and aversion behavior? What is the economic significance of the model? Second, what is the impact of consumers' disappointment and aversion behavior on omni-channel retailer order cancellation strategy? Third, what is the impact of the distance between consumers and physical stores on omni-channel retailers' order cancellation strategy?

II. MODEL CONSTRUCTION

2.1 Problem Description and Symbol Description

Considering that omni-channel retailers sell goods through BOPS mode and offline mode, consumers have uncertain perceived value v_p, and the demand is random. According to the actual situation,

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consumers who choose the BOPS mode cannot directly touch or touch the physical object and may find that the product is not suitable and return the product by post for a refund, resulting in low value or disappointment.

In addition, based on the research and formulation of retailer order cancellation policy by Ming Jin and Gang Li [3], this paper considers customers' disappointment avoidance and pleasure-seeking behavior, that is, customers' happiness-seeking behavior when the perceived value is higher than the actual cost and disappointment avoidance behavior in unexpected situations.

The problem to be solved in this paper is how to introduce customer disappointment avoidance and pleasure-seeking behavior into retailers' joint decision-making of optimal order cancellation policy and pricing, construct a joint decision-making model of omni-channel retailer order cancellation policy and pricing based on disappointment theory, and then determine the optimal order cancellation policy of retailers in different service regions with the goal of maximizing retailer profits. And further analyze how the customer disappointment avoidance and pleasure-seeking behavior affect retailers to formulate the optimal order cancellation policy.

Then we will introduce the disappointment theory, introduce low-value (online) and out-of-stock (offline) disappointment aversion behavior into the consumer utility model, and test consumers' purchase decisions. In order to clearly describe the joint decision-making problem of omni-channel retailers making optimal order cancellation policy and pricing based on disappointment theory, Table 1 gives the definition and explanation of mathematical symbols involved in the above problems:

TABLE 1. Symbolic variables and their meanings

SYMBOL	MEANING
x	When consumers buy goods, they get a good return
y	When consumers buy goods, they get a terrible return
p_x	The probability that happens when consumers get a good return
μ	Consumers expect economic returns
e	The influence coefficient of consumers' happiness degree of economic utility
d	The influence coefficient of the disappointment degree of consumers' economic utility
U	The overall expected utility of consumers
k	The disappointment and aversion of consumers
ε	The amount of goods that the customer has outside the store time of the retailer.
v_p	Customer perceived value
$v_{L/H}$	Very low / high perceived value of consumers
$p_{y/k/s}$	The price of goods under the strict / loose / moderate order cancellation policy
o	A refund of the returned product
$h_{y/k/s}$	The troublesome cost of strict / loose / moderate order cancellation policy $h_y = 1,\ \ h_{k/s} \in (0,1)$

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a	The probability when the expected net utility of a random customer is positive
v_p	Consumers' perceived value
t	The cost of travel per unit distance for consumers
v	Average customer arrival rate
b	Under the loose / moderate order cancellation policy, the probability of consumers choosing to buy after experiencing the product
$d_{y/k/s}$	Consumers' expected demand at T moment under the strict / loose / moderate order cancellation policy
ρ	Potential customer distribution density
$D_{y/k/s}$	The total demand of consumers within $[0,T]$ under the strict / loose / moderate order cancellation policy
$Q_{y/k/s}$	The quantity of orders for goods under the strict / loose / moderate order cancellation policy
$I_{y/k/s}(T)$	The inventory cost of retailers at T moment under the strict / loose / moderate order cancellation policy
c	Inventory cost per unit time per product
$C_{y/k/s}$	The total inventory cost of a retailer in a sales cycle under a strict / loose / moderate order cancellation policy
$r_{y/k/s}$	Service radius of BOPS region under strict / loose / moderate order cancellation policy
$\Pi_{y/k/s}$	The profit of retailers under the strict / loose / moderate order cancellation policy

2.2 Disappointment-Pleasure Utility Function

According to the theory of psychological disappointment proposed by Bell et al [7]. Disappointment (or happiness) is a psychological reaction, which is caused by comparing the actual results with individual expectations when making decisions under uncertain conditions. Bell's research is the first prescriptive model to integrate the concept of disappointment into utility theory. The model assumes that the total utility perceived by consumers facing uncertainty is a combination of economic surplus and psychological satisfaction.

Total utility = economic return + psychological perceived utility

Among them, "economic return" refers to the economy that consumers think they have saved, while "psychological perceived utility" refers to consumers' disappointment to avoid and happy to seek utility, that is, disappointment-happy utility.

Suppose that when a consumer buys a product, he will get a good return x and a bad return y ($x>y$),The corresponding probabilities of x and y are p_x and $1-p_x$, respectively. When a good return is made, consumers will be happy to seek behavior. On the contrary, when bad returns are made, consumers will be disappointed and evasive. Then consumers expect a financial return of $\mu = p_x x + (1-p_x)y$.

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Psychological perceived utility is composed of consumers' happy utility and disappointing utility.

Psychological perceived utility = p_x * happy utility + ($1-p_x$) * disappointment utility

If the results get better (or worse), disappointment and happiness are proportional to different expected results and expected economic returns. When the actual results are preferred by consumers, they will be happy.

$$\text{Happy utility} = e(x-\mu) = e(1-p_x)(x-y)$$

On the contrary, when the actual results are not preferred by consumers, they will be disappointed from the bad results.

$$\text{Disappointment utility} = d(\mu-y) = dp_x(x-y)$$

Among them, $e>0$ and $d>0$ are the degrees of happiness and disappointment that affect the economic utility of consumers. Therefore, the total expected utility of consumers is:

$$U = p_x x + (1-p_x)y - p_x(1-p_x)(d-e)(x-y) \quad (1)$$

Another $k=d-e$, then k represents the difference in the influence of happiness or disappointment. Suppose that in the same amount of economic returns, negative disappointment always dominates physical happiness. That is, k is always positive. According to the research of the following literature [8-10], Then we define k as the degree of disappointment and disgust.

2.3 Customer Utility Function Considering Disappointment Theory

When consumers shop online, they do not know the actual value of the goods in advance. At this time, consumers' happiness or disappointment depends on the price of the goods. When $v_L < p < v_H$, if the consumer likes an item and buys it online. They will have a high perceived value v_H, and some expected returns $v_H - p$.Otherwise, they will have a low perceived value v_L and a returned product o for a refund. Some omni-channel retailers have adopted a full refund order cancellation policy. However, some retailers have adopted a partial refund order cancellation policy. For example, Zappos.com and Shoebacca.com have adopted a full refund order cancellation policy within one year. However, BestBuy, Amazon and eBay have adopted a partial refund order cancellation policy.

Different order fulfillment modes mean that consumers face different levels of difficulties and troublesome costs for canceling orders. According to Jin M and Li G's research [3], The order cancellation policy is divided into three categories: the first is the strict order cancellation policy, the second is the moderate order cancellation policy, and the third is the loose order cancellation policy. The strict order

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cancellation policy is that once an order is confirmed, it is not allowed to be cancelled. The moderate order cancellation policy is that when the order is cancelled, the consumer can get a partial refund. The loose order cancellation policy is that once the order is cancelled, the consumer will get a full refund. But it takes time and cost to wait for a refund. These three kinds of order cancellation policies are common in practice. The troublesome cost h is introduced here, which represents the non-refundable proportion or time cost. For strict order cancellation policy, $h=1$, while for moderate and loose order cancellation policy $h \in (0,1)$.

Under the BOPS operation mode, customers need to pay in time. If you come to a physical store to pick up the product and find that the product is not suitable for you, the customer can apply for a refund based on the retailer's order cancellation policy. The expected net utility U_B of a random customer is the a of $v_p - tvT - p$ probability or the $1-a$ of $-tvT-p$ probability. Therefore, the average utility functions of a random BOPS customer under different order cancellation policies are:

$$E(U_y) = a(v_p - t\,v\,T - p_y) + (1-a)(-t\,v\,T - p_y) + a(1-a)(d-e)v_p \tag{2}$$

$$E(U_s) = a(v_p - t\,v\,T - h_s p_s) + (1-a)(-t\,v\,T - h_s p_s) + a(1-a)(d-e)v_p \tag{3}$$

$$E(U_k) = a(v_p - t\,v\,T - h_k p_k) + (1-a)(-t\,v\,T - h_k p_k) + a(1-a)(d-e)v_p \tag{4}$$

When the expected net utility of BOPS customers is positive, they will decide to buy this product. Under the moderate and loose order cancellation policy, a proportion of b customers will choose to buy goods rather than return them after experiencing goods in brick-and-mortar stores. Therefore, the expected requirements of BOPS customers at the moment T are as follows:

$$d_y(T) = \int_{\frac{atvT + ap_y + (1-a)(tvT + p_y)}{a + a(1-a)(d-e)}}^{1} 2\pi vT\rho dv_p = 2\pi vT\rho[1 - \frac{atvT + ap_y + (1-a)(tvT + p_y)}{a + a(1-a)(d-e)}] \tag{5}$$

$$d_s(T) = b\int_{\frac{atvT + ah_s p_s + (1-a)(tvT + h_s p_s)}{a + a(1-a)(d-e)}}^{1} 2\pi vT\rho dv_p = 2b\pi vT\rho[1 - \frac{atvT + ah_s p_s + +(1-a)(tvT + h_s p_s)}{a + a(1-a)(d-e)}] \tag{6}$$

$$d_k(T) = b\int_{\frac{atvT + ah_k p_k + (1-a)(tvT + h_k p_k)}{a + a(1-a)(d-e)}}^{1} 2\pi vT\rho dv_p = 2b\pi vT\rho[1 - \frac{atvT + ah_k p_k + (1-a)(tvT + h_k p_k)}{a + a(1-a)(d-e)}] \tag{7}$$

The total demand in the $[0,T]$ of BOPS customers can be obtained from formulas (1), (2) and (3) respectively:

$$D_y(T) = \int_0^T d_y(T)dT = \pi v\rho T^2 - \frac{2a\pi v^2 \rho t}{3a + 3a(1-a)(d-e)}T^3 - \frac{2(1-a)\pi v^2 \rho t}{3a + 3a(1-a)(d-e)}T^3 - \frac{a\pi v\rho p_y}{a + a(1-a)(d-e)}T^2 - \frac{(1-a)\pi v\rho p_y}{a + a(1-a)(d-e)}T^2 \tag{8}$$

$$D_s(T) = \int_0^T d_s(T)\, dT = b\pi v\rho T^2 - \frac{2ab\pi v^2 \rho T^3}{3a + 3a(1-a)(d-e)} - \frac{2(1-a)b\pi v^2 \rho t T^3}{3a + 3a(1-a)(d-e)} - \frac{ab\pi v\rho h_s p_s T^2}{a + a(1-a)(d-e)} - \frac{(1-a)b\pi v\rho h_s p_s T^2}{a + a(1-a)(d-e)} \tag{9}$$

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$$D_k(T)=\int_0^T d_k(T)dT=b\pi v\rho T^2-\frac{2ab\pi v^2 t\rho T^3}{3a+3a(1-a)(d-e)}-\frac{2(1-a)b\pi v^2\rho t T^3}{3a+3a(1-a)(d-e)}-\frac{ab\pi v\rho h_k p_k T^2}{a+a(1-a)(d-e)}-\frac{(1-a)b\pi v\rho h_k p_k T^2}{a+a(1-a)(d-e)} \tag{10}$$

According to the economic theory, T can get the inventory of physical stores at the moment as follows:

$$I_y(T)=Q_y-D_y=Q_y-\pi v\rho T^2+\frac{2a\pi v^2\rho t}{3a+3a(1-a)(d-e)}T^3+\frac{2(1-a)\pi v^2\rho t}{3a+3a(1-a)(d-e)}T^3+\frac{a\pi v\rho p_y{}^2}{a+a(1-a)(d-e)}T^2+\frac{(1-a)\pi v\rho p_y}{a+a(1-a)(d-e)}T^2 \tag{11}$$

$$I_s(T)=Q_s-D_s=Q_s-b\pi v\rho T^2+\frac{2ab\pi v^2\rho T^3}{3a+3a(1-a)(d-e)}+\frac{ab\pi v\rho h_s p_s T^2}{a+a(1-a)(d-e)}+\frac{2(1-a)b\pi v^2\rho t T^3}{3a+3a(1-a)(d-e)}+\frac{(1-a)b\pi v\rho h_s p_s T^2}{a+a(1-a)(d-e)} \tag{12}$$

$$I_k(T)=Q_k-D_k=Q_k-b\pi v\rho T^2+\frac{2ab\pi v^2 t\rho T^3}{3a+3a(1-a)(d-e)}+\frac{ab\pi v\rho h_k p_k T^2}{a+a(1-a)(d-e)}+\frac{2(1-a)b\pi v^2\rho t T^3}{3a+3a(1-a)(d-e)}+\frac{(1-a)b\pi v\rho h_k p_k T^2}{a+a(1-a)(d-e)} \tag{13}$$

When a sales cycle ends, the inventory is 0. So if you bring $T=T_y$, $T=T_s$, $T=T_k$ into (11), (12), (13) respectively, you can get $I_y(T_y)=0$, $I_s(T_s)=0$, $I_k(T_k)=0$.Therefore, the expression of the order quantity is:

$$Q_y=\pi v\rho T_y^2-\frac{2a\pi v^2\rho t}{3a+3a(1-a)(d-e)}T_y{}^3-\frac{2(1-a)\pi v^2\rho t}{3a+3a(1-a)(d-e)}T_y{}^3-\frac{a\pi v\rho p_y}{a+a(1-a)(d-e)}T_y{}^2-\frac{(1-a)\pi v\rho p_y}{a+a(1-a)(d-e)}T_y{}^2$$

$$Q_s=b\pi v\rho T_s{}^2-\frac{2ab\pi v^2\rho T_s{}^3}{3a+3a(1-a)(d-e)}-\frac{ab\pi v\rho h_s p_s T_s{}^2}{a+a(1-a)(d-e)}-\frac{2(1-a)b\pi v^2\rho t T_s{}^3}{3a+3a(1-a)(d-e)}-\frac{(1-a)b\pi v\rho h_s p_s T_s{}^2}{a+a(1-a)(d-e)}$$

$$Q_k=b\pi v\rho T_k{}^2-\frac{2ab\pi v^2 t\rho T_k{}^3}{3a+3a(1-a)(d-e)}-\frac{ab\pi v\rho h_k p_k T_k{}^2}{a+a(1-a)(d-e)}-\frac{2(1-a)b\pi v^2\rho t T_k{}^3}{3a+3a(1-a)(d-e)}-\frac{(1-a)b\pi v\rho h_k p_k T_k{}^2}{a+a(1-a)(d-e)}$$

Under different cancellation policies available from (4), (5) and (6), the inventory costs in a sales cycle are:

$$C_y=c\int_0^{T_y} I_y dT=c[\frac{2}{3}\pi v\rho T_y^3+\frac{(8a-3)\pi v^2\rho t}{6a+6a(1-a)(d-e)}T_y{}^4+\frac{(2-4a)\pi v\rho p_y}{3a+3a(1-a)(d-e)}T_y{}^3]$$

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$$C_s = c\int_0^{T_s} I_s dT = c[\frac{2}{3}b\pi v\rho T_s^{\ 3} - \frac{b\pi v^2 \rho t}{2a+2a(1-a)(d-e)}T_s^{\ 4} - \frac{2b\pi v\rho h_s p_s}{3a+3a(1-a)(d-e)}T_s^{\ 3}]$$

$$C_k = c\int_0^{T_k} I_k dT = c[\frac{2}{3}b\pi v\rho T_k^{\ 3} - \frac{b\pi v^2 \rho t}{2a+2a(1-a)(d-e)}T_k^{\ 4} - \frac{2b\pi v\rho h_k p_k}{3a+3a(1-a)(d-e)}T_k^{\ 3}]$$

The objective functions are established with $p_{y/k/s}$ and $r_{y/k/s}$ as decision variables. Under the strict and loose order cancellation policy, the retailer's profit is the retailer's annual income minus the inventory cost. Under the moderate order cancellation policy, retailers' profits can be divided into three parts: annual income and non-refundable income minus inventory costs. That is:

$$\max_{p_y, r_y} \Pi_y = p_y Q_y - C_y \qquad \max_{p_s, r_s} \Pi_s = p_s Q_s + h_s p_s - C_s \qquad \max_{p_k, r_k} \Pi_k = p_k Q_k - C_k$$

$$s.t. 1-\frac{atvT_y + ap_y + (1-a)(tvT_y + p_y)}{a+a(1-a)(d-e)} > 0 \quad s.t. 1-\frac{atvT_s + ah_s p_s + (1-a)(tvT_s + h_s p_s)}{a+a(1-a)(d-e)} > 0 \quad s.t. 1-\frac{atvT_k + ah_k p_k + (1-a)(tvT_k + h_k p_k)}{a+a(1-a)(d-e)} > 0$$

III. MODEL SOLVING AND CONCLUSION ANALYSIS

From the $K-T$ condition, the retailer's optimal pricing and service radius and other optimal results under three different order cancellation policies can be obtained in Table 2.

From the above solution results, the following conclusions can be determined. **Proposition 1:** when strategic consumers have disappointment and aversion, retailers formulate strict order cancellation policies, respectively, the optimal pricing, the optimal service and profit of BOPS operation are:

$$r_y^{\ *} = \begin{cases} \dfrac{2\pi\rho + 2\sqrt{\pi^2\rho^2 - v^2\zeta_1\zeta_2}}{4\zeta_1 v} & c > tv \\ \dfrac{v_2^{\ 2} - 3v_1 v_2}{9v_1^{\ 2}v_5} + v_5 + \dfrac{v_2}{3v_1} & c \le tv \end{cases}$$

$$p_y^{\ *} = \begin{cases} \dfrac{av + av(1-a)(d-e)}{2vr_1^{\ *}} + \dfrac{(2a-1)tr_{y1}^{\ *}}{3} - \dfrac{(1-2a)r_{y2}^{\ *}}{3v} & c > tv \\ a + a(1-a)(d-e) - tr_{y2}^{\ *} & c \le tv \end{cases}$$

$$\Pi_y^{\ *} = \frac{3\pi\rho vp^* r_y^{\ *} - 2\pi\rho r_y^{\ *3}}{3v^2} + \frac{(8a-4)\pi\rho tvp_y^{\ *} r_y^{\ *3} - 6\pi\rho vp_y^{\ *2} r_y^{\ *2} - (8a-3)\pi\rho tr_y^{\ *4} - (4-8a)\pi\rho p_y^{\ *} r_y^{\ *3}}{6av^2 + 6av^2(1-a)(d-e)}$$

Proof: Constructing Lagrangian functions for p_y and r_y:

$$g_{(p_y, r_y)} = \Pi - \mu(1 - \frac{atr + ap_y + (1-a)(tr_y + p_y)}{a+a(1-a)(d-e)})$$

It can be obtained from the $K-T$ condition:

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$$\begin{cases} \frac{\partial g_{(p_y,r_y,\mu)}}{\partial p_y} = \frac{\partial(p_yQ_y - C_y)}{\partial p_y} + \mu\frac{\partial(1-\frac{atr_y + ap_y + (1-a)(tr_y+p_y)}{a+a(1-a)(d-e)})}{\partial p_y} = 0 \\ \frac{\partial g_{(p_y,r_y,\mu)}}{\partial r_y} = \frac{\partial(p_yQ_y - C_y)}{\partial r_y} + \mu\frac{\partial(1-\frac{at_{ry} + ap_y + (1-a)(tr_y+p_y)}{a+a(1-a)(d-e)})}{\partial r_y} = 0 \\ \mu \geq 0, 1-\frac{atr_y + ap_y + (1-a)(tr_y+p_y)}{a+a(1-a)(d-e)} \geq 0, \mu(1-\frac{atr_y + ap_y + (1-a)(tr_y+p_y)}{a+a(1-a)(d-e)}) = 0 \end{cases}$$

By solving the above equations, we can get two optimal strategies for retailers to make strict order cancellation policies when strategic consumers are disappointed and disgusted.

when $c > tv$, $p_{y1}{}^* = \frac{av + av(1-a)(d-e)}{2vr_{y1}{}^*} + \frac{(2a-1)tr_{y1}{}^*}{3} - \frac{(1-2a)r_{y1}{}^*}{3v}$ $r_{y1}{}^* = \frac{2\pi\rho + 2\sqrt{\pi^2\rho^2 - v^2\zeta_1\zeta_2}}{4\zeta_1 v}$

$$\Pi_{y1}{}^* = \frac{3\pi\rho v p_{y1}{}^* r_{y1}{}^* - 2\pi\rho r_{y1}{}^{*3}}{3v^2} + \frac{(8a-4)\pi\rho t v p_{y_1}{}^* r_{y1}{}^{*3} - 6\pi\rho v p_{y_1}{}^{*2} r_{y1}{}^{*2} - (8a-3)\pi\rho t r_{y1}{}^{*4} - (4-8a)\pi\rho p_{y1}{}^* r_{y1}{}^{*3}}{6av^2 + 6av^2(1-a)(d-e)}$$

when $c \leq tv$, $p_{y2}{}^* = a + a(1-a)(d-e) - tr_{y2}{}^*$ $r_{y2}{}^* = \frac{v_2{}^2 - 3v_1v_2}{9v_1{}^2 v_5} + v_5 + \frac{v_2}{3v_1}$

$$\Pi_{y2}{}^* = \frac{3\pi\rho v p_{y2}{}^* r_{y2}{}^* - 2\pi\rho r_{y2}{}^{*3}}{3v^2} + \frac{(8a-4)\pi\rho t v p_{y2}{}^* r_{y2}{}^{*3} - 6\pi\rho v p_{y2}{}^{*2} r_{y2}{}^{*2} - (8a-3)\pi\rho t r_{y2}{}^{*4} - (4-8a)\pi\rho p_{y2}{}^* r_{y2}{}^{*3}}{6av^2 + 6av^2(1-a)(d-e)}$$

Because the expression of the calculated service radius is too tedious, for the sake of conciseness, make:

$$\zeta_1 = \frac{\pi\rho t(2a-1)[(4a-2)vt-2+4a]}{3av^2 + 3av^2(1-a)(d-e)} - \frac{\pi\rho(1-2a)[(4a-2)vt-2+4a]}{3av^3 + 3av^3(1-a)(d-e)} - \frac{2(8a-3)\pi\rho t}{3av^2 + 3av^2(1-a)(d-e)}$$
$$-\frac{2\pi\rho t^2(2a-1)^2}{9[av + av(1-a)(d-e)]} + \frac{2\pi\rho(1-2a)^2}{9v^2[av + av(1-a)(d-e)]} + \frac{4\pi\rho t(2a-1)(1-2a)}{9v[av + av(1-a)(d-e)]}$$

$$\zeta_2 = \frac{2\pi\rho(1-2a)}{3v^2} - \frac{2\pi\rho t(2a-1)}{3v} + \frac{3\pi\rho[(4a-2)vt-2+4a]}{6v^2} + \frac{\pi\rho t(2a-1)}{3v} - \frac{\pi\rho(1-2a)}{3v^2}$$

$$v_1 = \frac{14\pi\rho t - 20a\pi\rho t - 16a\pi\rho t^2 v - 4\pi\rho t^2 v - 12a\pi\rho}{3av + 3av(1-a)(d-e)} \quad v5 = [\frac{v_2{}^3}{27v_1{}^3} + ((\frac{v_4}{2v_1} - \frac{v_2{}^3}{27v_1{}^3} + \frac{v_2v_3}{6v_1{}^2})^2 - (\frac{v_2{}^2}{9v_1{}^2} - \frac{v_3}{3v_1})^3)^{\frac{1}{2}} - \frac{v_4}{2v_1} - \frac{v_2v_3}{6v_1{}^2}]^{\frac{1}{3}}$$

$$v_2 = \frac{4a\pi\rho t v^2 + 4a\pi\rho v - 2\pi\rho v - 2\pi\rho - \pi\rho t v}{v}$$

The certificate is completed.

Proposition 2: when strategic consumers have disappointment and aversion, the optimal pricing corresponding to loose order cancellation policy, the optimal service radius and profit of BOPS operation are:

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$$p_k{}^* = \begin{cases} \dfrac{atv - av - tv + ach_k}{3vh_k} r_{k1} + \dfrac{av + av(1-a)(d-e)}{2vh_k} & c > \dfrac{tv}{a} \\ \dfrac{a + a(1-a)(d-e) - tr_{k2}{}^*}{h_k} & c \le \dfrac{tv}{a} \end{cases} \quad r_k{}^* = \begin{cases} \dfrac{-\zeta_4 + \sqrt{\zeta_4{}^2 - 4\zeta_3\zeta_5}}{2\zeta_3} & c > \dfrac{tv}{a} \\ \dfrac{-\zeta_7 + \sqrt{\zeta_7{}^2 - 4\zeta_6\zeta_8}}{2\zeta_6} & c \le \dfrac{tv}{a} \end{cases}$$

$$\Pi_k{}^* = \frac{(3p_k{}^* - 2cr)b\pi\rho r_k{}^*}{3v^2} + \frac{(atv - av - tv + ach_k)4b\pi\rho p_k{}^* r_k{}^{*3} - 3b\pi\rho h_k p_k{}^{*2} r_k{}^{*2} + 18c\pi\rho t r_k{}^{*4}}{6av^2 + 6av^2(1-a)(d-e)}$$

Table 2. Retailer's optimal pricing, service radius and optimal order quantity

	UNDER THE STRICT ORDER CANCELLATION POLICY		**UNDER THE LOOSE ORDER CANCELLATION POLICY**		**UNDER THE MODERATE ORDER CANCELLATION POLICY**	
p^*	$\frac{av + av(1-a)(d-e)}{2vr_{y1}{}^*} + \frac{(2a-1)tr_{y1}{}^*}{3} - \frac{(1-2a)r_{y1}{}^*}{3v}$	$c > tv$	$\frac{atv - av - tv + ach_k}{3vh_k} r_{k1}{}^* + \frac{av + av(1-a)(d-e)}{2vh_k}$	$c > \frac{tv}{a}$	$\frac{av + av(1-a)(d-e)}{2vh_s} + \frac{at - a - t}{3h_s} r_{s1}{}^* + \frac{ac}{3av} r_{s1}{}^* + h_s$	$c > \frac{tv}{a+h-ah}$
	$a + a(1-a)(d-e) - tr_{y2}{}^*$	$c \le tv$	$\frac{a + a(1-a)(d-e) - tr_{k2}{}^*}{h_k}$	$c \le \frac{tv}{a}$	$\frac{a + a(1-a)(d-e) - tr_{s2}{}^*}{h_s}$	$c \le \frac{tv}{a+h-ah}$
r^*	$\frac{2\pi\rho + 2\sqrt{\pi^2\rho^2 - v^2\zeta_1\zeta_2}}{4\zeta_1 v}$	$c > tv$	$\frac{-\zeta_4 + \sqrt{\zeta_4{}^2 - 4\zeta_3\zeta_5}}{2\zeta_3}$	$c > \frac{tv}{a}$	$\frac{-\zeta_{10} + \sqrt{\zeta_{10}{}^2 - 4\zeta_9\zeta_{11}}}{2\zeta_9}$	$c > \frac{tv}{a+h-ah}$
	$\frac{v_2{}^2 - 3v_1v_2}{9v_1{}^2v_5} + v_5 + \frac{v_2}{3v_1}$	$c \le tv$	$\frac{-\zeta_7 + \sqrt{\zeta_7{}^2 - 4\zeta_6\zeta_8}}{2\zeta_6}$	$c \le \frac{tv}{a}$	$\frac{-\zeta_{13} + \sqrt{\zeta_{13}{}^2 - 4\zeta_{12}\zeta_{14}}}{2\zeta_{12}}$	$c \le \frac{tv}{a+h-ah}$
Π^*	$\frac{3\pi\rho v p_{y1}{}^* r_{y1}{}^* - 2\pi\rho r_{y1}{}^{*3}}{3v^2} + \frac{(8a-4)\pi\rho tv p_{y1}{}^* r_{y1}{}^{*3} - 6\pi\rho v p_{y1}{}^{*2} r_{y1}{}^{*2}}{6av^2 + 6av^2(1-a)(d-e)} - \frac{(8a-3)\pi\rho t r_{y1}{}^{*4} + (4-8a)\pi\rho p_{y1}{}^* r_{y1}{}^{*3}}{6av^2 + 6av^2(1-a)(d-e)}$	$c > tv$	$\frac{(3p_{k1}{}^* - 2cr_{k1}{}^*)b\pi\rho r_{k1}{}^*}{3v^2} + \frac{(atv - av - tv + ach_k)4b\pi\rho p_{k1}{}^* r_{k1}{}^{*3}}{6av^2 + 6av^2(1-a)(d-e)} - \frac{3b\pi\rho h_k p_{k1}{}^{*2} r_{k1}{}^{*2} - 18c\pi\rho t r_{k1}{}^{*4}}{6av^2 + 6av^2(1-a)(d-e)}$	$c > \frac{tv}{a}$	$\frac{(3p_{s1}{}^* - 2cr_{s1}{}^*)b\pi\rho r_{s1}{}^*}{3v^2} + \frac{(atv - av - tv + ach_s)4b\pi\rho p_{s1}{}^* r_{s1}{}^{*3}}{6av^2 + 6av^2(1-a)(d-e)} - \frac{3b\pi\rho h_s p_{s1}{}^{*2} r_{s1}{}^{*2} - 18c\pi\rho t r_{s1}{}^{*4}}{6av^2 + 6av^2(1-a)(d-e)} - h_s p_{s1}{}^*$	$c > \frac{tv}{a+h-ah}$

Proof: the Lagrangian functions with respect to p and r are constructed.

$$g_{(p_k, r_k)} = \Pi - \mu\left(1 - \frac{atr_k + ah_k p_k + (1-a)(tr_k + h_k p_k)}{a + a(1-a)(d-e)}\right)$$

It can be obtained from the $K-T$ conditions:

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$$\begin{cases} \dfrac{\partial g_{(p_k,r_k,\mu)}}{\partial p_k} = \dfrac{\partial(p_kQ_k - C_k)}{\partial p_k} + \mu\dfrac{\partial(1-\dfrac{atr_k + ah_kp_k + (1-a)(tr_k + h_kp_k)}{a + a(1-a)(d-e)})}{\partial p_k} = 0 \\ \dfrac{\partial g_{(p_k,r_k,\mu)}}{\partial r_k} = \dfrac{\partial(p_kQ_k - C_k)}{\partial r_k} + \mu\dfrac{\partial(1-\dfrac{atr_k + ah_kp_k + (1-a)(tr_k + h_kp_k)}{a + a(1-a)(d-e)})}{\partial r_k} = 0 \\ \mu \ge 0, 1-\dfrac{atr_k + ah_kp_k + (1-a)(tr_k + h_kp_k)}{a + a(1-a)(d-e)} \ge 0, \mu(1-\dfrac{atr_k + ah_kp_k + (1-a)(tr_k + h_kp_k)}{a + a(1-a)(d-e)}) = 0 \end{cases}$$

By solving the above equations, we can get two optimal strategies for retailers to make strict order cancellation policies when strategic consumers are disappointed and disgusted.

when $c > \dfrac{tv}{a}$, $p_{k1}{}^* = \dfrac{atv - av - tv + ach_k}{3vh_k} r_{k1}{}^* + \dfrac{av + av(1-a)(d-e)}{2vh_k}$,

$$r_{k1}{}^* = \frac{-\zeta_4 + \sqrt{\zeta_4{}^2 - 4\zeta_3\zeta_5}}{2\zeta_3}, \Pi_{k1}{}^* = \frac{(3p_{k1}{}^* - 2cr_{k1}{}^*)b\pi\rho r_{k1}{}^*}{3v^2} + \frac{(atv - av - tv + ach_k)4b\pi\rho p_{k1}{}^* r_{k1}{}^{*3} - 3b\pi\rho h_k p_{k1}{}^{*2} r_{k1}{}^{*2} + 18c\pi\rho t r_{k1}{}^{*4}}{6av^2 + 6av^2(1-a)(d-e)}$$

when $c \le \dfrac{tv}{a}$, $p_{k2}{}^* = \dfrac{a + a(1-a)(d-e) - tr_{k2}{}^*}{h_k}$, $r_{k2}{}^* = \dfrac{-\zeta_7 + \sqrt{\zeta_7{}^2 - 4\zeta_6\zeta_8}}{2\zeta_6}$,

$$\Pi_{k2}{}^* = \frac{(3p_{k2}{}^* - 2cr_{k2}{}^*)b\pi\rho r_{k2}{}^*}{3v^2} + \frac{(atv - av - tv + ach_k)4b\pi\rho p_{k2}{}^* r_{k2}{}^{*3} - 3b\pi\rho h_s p_{k2}{}^{*2} r_{k2}{}^{*2} + 18c\pi\rho t r_{k2}{}^{*4}}{6av^2 + 6av^2(1-a)(d-e)}$$

Because the expression of the calculated service radius is too tedious, for the sake of conciseness, make:

$$\zeta_3 = \frac{4b\pi\rho h_k(atv - av - tv + ach_k]^2}{9v^2h_k{}^2[av + av(1-a)(d-e)]} + \frac{2bc\pi\rho t}{av^2 + av^2(1-a)(d-e)}$$

$$\zeta_4 = \frac{4b\pi\rho(atv - av - tv + ach_k) - b\pi\rho v(atv - av - tv + ach_k)}{3v^2h_k} - \frac{2bc\pi\rho}{v}$$

$$\zeta_5 = \frac{b\pi\rho[av + av(1-a)(d-e)]}{v^2h_k} - \frac{b\pi\rho[av + av(1-a)(d-e)]}{2vh_k}$$

$$\zeta_6 = \frac{2ab\pi\rho t - 2ab\pi\rho t^2}{h_k[av + av((1-a)(d-e)]}r_k{}^2$$

$$\zeta_7 = \frac{2ab\pi\rho t - 2ab\pi\rho - 2b\pi\rho t}{vh_k} - \frac{2b\pi\rho t}{v^2} + \frac{4b\pi\rho t}{vh_k} - \frac{2ab\pi\rho t^2 - 2ab\pi\rho t - 2b\pi\rho t^2}{h_k[3av + 3av(1-a)(d-e)]}$$

$$\zeta_8 = \frac{b\pi\rho t}{vh_k}$$

The certificate is completed.

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Proposition 3: when strategic consumers are disappointed and disgusted, the retailer formulates a moderate order cancellation policy corresponding to the optimal pricing, the optimal service radius and the optimal profit of BOPS operation:

$$p_s^* = \begin{cases} \dfrac{av+av(1-a)(d-e)}{2vh_s} + \dfrac{at-a-t}{3h_s} r_{s1}^* + \dfrac{ac}{3av} r_{s1}^* + h_s & c > \dfrac{tv}{a+h_s-ah_s} \\ \dfrac{a+a(1-a)(d-e)-tr_{s2}^*}{h_s} & c \le \dfrac{tv}{a+h_s-ah_s} \end{cases}$$

$$r_s^* = \begin{cases} \dfrac{-\zeta_{10}+\sqrt{\zeta_{10}^2-4\zeta_9\zeta_{11}}}{2\zeta_9} & c > \dfrac{tv}{a+h_s-ah_s} \\ \dfrac{-\zeta_{13}+\sqrt{\zeta_{13}^2-4\zeta_{12}\zeta_{14}}}{2\zeta_{12}} & c \le \dfrac{tv}{a+h_s-ah_s} \end{cases}$$

$$\Pi_s^* = \frac{(3p_s^*-2cr_s^*)b\pi\rho r_s^*}{3v^2} + \frac{(atv-av-tv+ach_s)4b\pi\rho p_s^* r_s^{*3} - 3b\pi\rho h_s p_s^{*2} r_s^{*2} + 18c\pi\rho t r_s^{*4}}{6av^2+6av^2(1-a)(d-e)} - h_s p_s^*$$

Proof: the Lagrangian functions with respect to p and r are constructed.

$$g_{(p_s,r_s)} = \Pi - \mu\left(1 - \frac{atr+ah_s p_s+(1-a)(tr+h_s p_s)}{a+a(1-a)(d-e)}\right)$$

It can be obtained from the $K-T$ conditions:

$$\begin{cases} \dfrac{\partial g_{(p_s,r_s,\mu)}}{\partial p_s} = \dfrac{\partial(p_sQ_s+h_sp_s-C_s)}{\partial p_s} + \mu\dfrac{\partial\left(1-\dfrac{atr_s+ah_sp_s+(1-a)(tr_s+h_sp_s)}{a+a(1-a)(d-e)}\right)}{\partial p_s} = 0 \\ \dfrac{\partial g_{(p_s,r_s,\mu)}}{\partial r_s} = \dfrac{\partial(p_sQ_s+h_sp_s-C_s)}{\partial r_s} + \mu\dfrac{\partial\left(1-\dfrac{atr_s+ah_sp_s+(1-a)(tr_s+h_sp_s)}{a+a(1-a)(d-e)}\right)}{\partial r_s} = 0 \\ \mu \ge 0, 1-\dfrac{atr_s+ah_sp_s+(1-a)(tr_s+h_sp_s)}{a+a(1-a)(d-e)} \ge 0, \mu\left(1-\dfrac{atr_s+ah_sp_s+(1-a)(tr_s+h_sp_s)}{a+a(1-a)(d-e)}\right) = 0 \end{cases}$$

By solving the above equations, we can get two optimal strategies for retailers to make strict order cancellation policies when strategic consumers are disappointed and disgusted.

when $c > \dfrac{tv}{a+h-ah}$, $p_{s1}^* = \dfrac{av+av(1-a)(d-e)}{2vh_s} + \dfrac{at-a-t}{3h_s} r_{s1}^* + \dfrac{ac}{3av} r_{s1}^* + h_s$,

$r_{s1}^* = \dfrac{-\zeta_{10}+\sqrt{\zeta_{10}^2-4\zeta_9\zeta_{11}}}{2\zeta_9}$, $\Pi_{s1}^* = \dfrac{(3p_{s1}^*-2cr_{s1}^*)b\pi\rho r_{s1}^*}{3v^2} + \dfrac{(atv-av-tv+ach_s)4b\pi\rho p_{s1}^* r_{s1}^{*3} - 3b\pi\rho h_s p_{s1}^{*2} r_{s1}^{*2} + 18c\pi\rho t r_{s1}^{*4}}{6av^2+6av^2(1-a)(d-e)} - h_s p_{s1}^*$

when $c \le \dfrac{tv}{a+h-ah}$, $p_{s2}^* = \dfrac{a+a(1-a)(d-e)-tr_{s2}^*}{h_s}$, $r_{s2}^* = \dfrac{-\zeta_{13}+\sqrt{\zeta_{13}^2-4\zeta_{12}\zeta_{14}}}{2\zeta_{12}}$,

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$$\Pi_{s2}{}^{*}=\frac{(3p_{s2}{}^{*}-2cr_{s2}{}^{*})b\pi\rho r_{s2}{}^{*}}{3v^{2}}+\frac{(atv-av-tv+ach_{s})4b\pi\rho p_{s2}{}^{*}r_{s2}{}^{*3}-3b\pi\rho h_{s}p_{s2}{}^{*2}r_{s2}{}^{*2}+18c\pi\rho tr_{s2}{}^{*4}}{6av^{2}+6av^{2}(1-a)(d-e)}-h_{s}p_{s2}{}^{*}$$

Because the expression of the calculated service radius is too tedious, for the sake of conciseness, make:

$$\zeta_{9}=\frac{4b\pi\rho(atv-av-tv+ch_{s})^{2}}{9v^{2}h_{s}[av+av(1-a)(d-e)]}+\frac{2bc\pi\rho t}{av2+av2(1-a)(d-e)}$$

$$\zeta_{10}=\frac{-b\pi\rho(at-a-t)}{3vh_{s}}-\frac{bc\pi\rho}{3v^{2}}+\frac{c}{vh_{s}}-\frac{bc\pi\rho}{v}+\frac{4b\pi\rho(atv-av-tv+ch_{s})[a+a(1-a)(d-e)+2h_{s}]}{3vh_{s}[av+av(1-a)(d-e)]}$$

$$\zeta_{11}=-\frac{b\pi\rho[a+a(1-a)(d-e)]}{2vh_{s}}-\frac{b\pi\rho h_{s}}{v}+\frac{b\pi\rho[av+av(1-a)(d-e)+2vh_{s}]^{2}}{v^{2}h_{s}[av+av(1-a)(d-e)]}+\frac{3a+3a(1-a)(d-e)}{2}+at-a-t$$

$$\zeta_{12}=\frac{2ab\pi\rho t-2ab\pi\rho t^{2}}{h_{s}[av+av((1-a)(d-e)]}r_{s}{}^{2}$$

$$\zeta_{13}=\frac{2ab\pi\rho t-2ab\pi\rho-2b\pi\rho t}{vh_{s}}-\frac{2b\pi\rho t}{v^{2}}+\frac{4b\pi\rho t}{vh_{s}}-\frac{2ab\pi\rho t^{2}-2ab\pi\rho t-2b\pi\rho t^{2}}{h_{s}[3av+3av(1-a)(d-e)]}$$

$$\zeta_{14}=\frac{b\pi\rho t}{vh_{k}}-t$$

The certificate is completed.

Corollary 1: when strategic consumers have disappointment aversion, the optimal profit of retailers with strict order cancellation policy and loose order cancellation policy decreases with the expansion of the optimal service radius, and the change of optimal profit with the optimal pricing is not obvious.

Corollary 1 shows that retailers make strict order cancellation policies and loose order cancellation policies should be implemented in appropriate service areas. Combining proposition 1 and proposition 2, We can know that the optimal service radius that can be achieved through strict and loose order cancellation strategies are:

$$r_{y}{}^{*}=\begin{cases}\dfrac{2\pi\rho+2\sqrt{\pi^{2}\rho^{2}-v^{2}\zeta_{1}\zeta_{2}}}{4\zeta_{1}v} & c>tv\\[2ex] \dfrac{v_{2}{}^{2}-3v_{1}v_{2}}{9v_{1}{}^{2}v_{5}}+v_{5}+\dfrac{v_{2}}{3v_{1}} & c\le tv\end{cases}\qquad r_{k}{}^{*}=\begin{cases}\dfrac{-\zeta_{4}+\sqrt{\zeta_{4}{}^{2}-4\zeta_{3}\zeta_{5}}}{2\zeta_{3}} & c>\dfrac{tv}{a}\\[2ex] \dfrac{-\zeta_{7}+\sqrt{\zeta_{7}{}^{2}-4\zeta_{6}\zeta_{8}}}{2\zeta_{6}} & c\le\dfrac{tv}{a}\end{cases}$$

Corollary 2: when strategic consumers have disappointment aversion, the optimal profit of retailers making moderate order cancellation policy increases with the expansion of the optimal service radius, and the change of the optimal profit with the optimal pricing is not obvious.

Corollary 2 shows that the retailer's moderate order cancellation policy is suitable to be implemented in areas with a large service radius. Combined with proposition 1 and proposition 2, the optimal service

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radius that a moderate order cancellation policy can implement is:

$$r_s^* = \begin{cases} \dfrac{-\zeta_{10} + \sqrt{\zeta_{10}^2 - 4\zeta_9\zeta_{11}}}{2\zeta_9} & c > \dfrac{tv}{a + h_s - ah_s} \\ \dfrac{-\zeta_{13} + \sqrt{\zeta_{13}^2 - 4\zeta_{12}\zeta_{14}}}{2\zeta_{12}} & c \le \dfrac{tv}{a + h_s - ah_s} \end{cases}$$

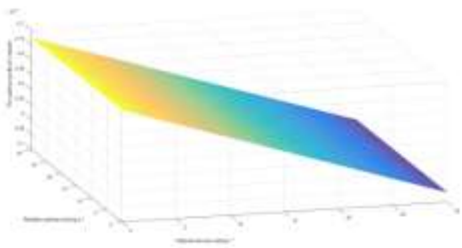
IV. NUMERICAL ANALYSIS

4.1 The Influence of Optimal Service Radius and Optimal Pricing on Optimal Profit under Different Order Cancellation Policies

Because the analytical expressions of the optimal decision and profit function of retailers under different order cancellation policies are more complex, it is difficult to analyze and quantitatively study the relationship between the optimal service radius and the optimal profit of omni-channel retailers under different order cancellation policies. therefore, we carry out numerical simulation analysis and use MATLAB7.5 to calculate. Study on the value of environmental parameters of the model according to MingJin et al [3]. And make reasonable improvement on the basis of its research. The values of the main parameters are shown in TABLE 3.

TABLE 3. Values of environmental parameters of the model

PARAMETERS	a	c	t	v	ρ	k	b
VALUE	0.5	1	0.5	1	0.8	0.5	0.5



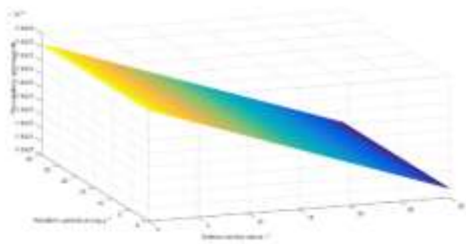


Fig 1: the optimal result under strictorder cancellation policy

Fig 2: the optimal result under loose order cancellation policy

Figures 1 and 2 describe the changing trend of optimal profit with optimal service radius and optimal pricing under strict order cancellation policy and loose order cancellation policy, respectively. It can be seen that when retailers make strict order cancellation policy and loose order cancellation policy, the change trend of optimal profit is roughly the same. with the increase of optimal service radius, the optimal profit of retailer shows a decreasing trend, but with the increase of optimal pricing, the change of retailer's optimal profit is not particularly obvious. Thus it can be seen that retailers making strict order cancellation

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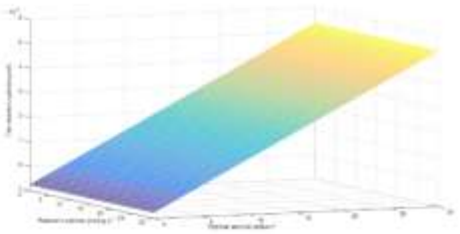
policy and loose order cancellation policy are not suitable for areas far away from physical stores.



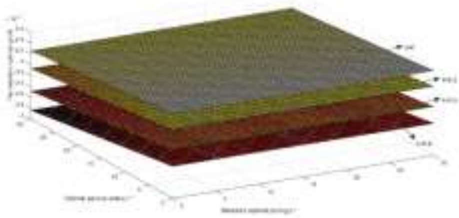


Figure 3: under the moderate order cancellation policy, the retailer's optimal profit changes with the optimal service radius and optimal pricing (Left)

Figure 4: the impact of k on retailer's optimal pricing and optimal service radius under strict order cancellation policy (Right)

Figure 3 depicts the trend of optimal profit with the optimal service radius and optimal pricing when retailers make a moderate order cancellation policy. It can be seen that with the increase of the optimal service radius, the optimal profit of retailers also shows a gradual increasing trend. Consistent with Figures 1 and 2, the change in the retailer's optimal profit is also not particularly obvious with the increase of optimal pricing. Thus it can be seen that it is appropriate for retailers to formulate moderate order cancellation policies in service areas far away from physical stores.

4.2 The Influence of k Degree of Consumers' Disappointment and Aversion on Retailer's Optimal Decision

Under three different order cancellation policies, the impact of consumer disappointment and aversion on retailer optimal pricing and optimal service radius is shown in Figures 4, 5 and 6. Among them, the environmental parameters of the model refer to the study of Ming Jin et al [3]. Because their research does not consider the factors of consumer behavior, but this study takes into account the factors of consumer behavior. Therefore, the value of environmental parameters is added to the value of consumers' disappointment and disgust, and the values of other environmental parameters are based on their study. The values of the main parameters are shown in TABLE 4:

TABLE 4. Values of environmental parameters of the model

PARAMETERS	k_1	a	c	t	v	ρ	k	b
EXAMPLE 1	0	0.5	1	0.5	1	0.8	0.5	0.5
EXAMPLE 2	0.2	0.5	1	0.5	1	0.8	0.5	0.5
EXAMPLE 3	0.5	0.5	1	0.5	1	0.8	0.5	0.5
EXAMPLE 4	0.8	0.5	1	0.5	1	0.8	0.5	0.5

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Figure 4, Figure 5 and Figure 6 describe the influence of k on the optimal pricing and service radius of retailers under three different order cancellation policies, respectively. With the increase of consumers' aversion loss coefficient k, the optimal profit of retailers shows a decreasing trend. This conclusion is obviously consistent with the actual situation, so the consideration of consumers' aversion loss enriches the research conclusion of this model.

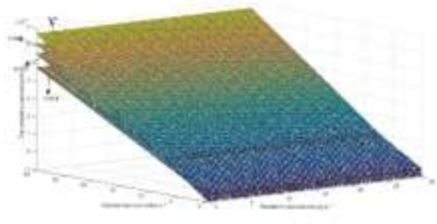

Figure 5: the impact of k on retailer's optimal pricing and optimal service radius under loose order cancellation policy (Left)

Figure 6: the impact of k on retailer's optimal pricing and optimal service radius under moderate order cancellation policy (Right)

V. CONCLUSION

Under the omni-channel background, based on the disappointment theory, this paper studies the impact of customer disappointment aversion behavior on the formulation of optimal order cancellation policy by omni-channel retailers. Under the consideration of customer disappointment and aversion behavior, omni-channel retailers formulate the optimal pricing, optimal service radius and other corresponding optimal results of strict order cancellation policy, loose order cancellation policy and moderate order cancellation policy respectively. Theoretical analysis shows that for consumers who are far away, omni-channel retailers can make moderate order cancellation policies, while for nearby consumers, omni-channel retailers should formulate strict order cancellation policies or loose order cancellation policies. The research results provide a theoretical basis for retail stores to strive for more market share and improve their management and operation level.

This study only considers the disappointment and aversion behavior of customers when formulating order cancellation policies for omni-channel retailers, but in practice, there are many factors to be considered when formulating order cancellation policies for omni-channel retailers. For example, the inventory cost of a retailer, Some relevant policies of the country, etc. In view of the omni-channel retailer's order cancellation policy studied in this paper, it can be further discussed in the future: in addition to consumer behavior factors, what other important factors should be considered when omni-channel retailers formulate order cancellation policies.

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REFERENCES

[1] Li G, Zhang T, Tayi G K (2019) Inroad into omni-channel retailing: Physical showroom deployment of an online retailer. European Journal of Operational Research 283:676-691.
[2] Gao Fei, Su Xuanming (2017) Online and offline information for omnichannel retailing. Manufacturing & Service Operations Management 19:84-98.
[3] Jin M, Li G, Cheng TC E (2018) Buy online and pick up in-store: Design of the service area. European Journal of Operational Research 268:613-623.
[4] Wang S T (2018) Integrating KPSO and C5. 0 to analyze the omnichannel solutions for optimizing telecommunication retail. Decision Support Systems 09: 39-49.
[5] Forghani K, Mirzazadeh A, Rafiee M (2013) A price-dependent demand model in the single period inventory system with price adjustment. Journal of Industrial Engineering 109:1-9.
[6] Kim J C, Chun S H (2018) Cannibalization and competition effects on a manufacturer's retail channel strategies: Implications on an omni-channel business model. Decision Support Systems, 109: 5-14.
[7] Bell D (1985) Disappointment in decision making under uncertainty. Operations Research 33: 1-27.
[8] Gill, D., Prowse, V (2012) A structural analysis of disappointment aversion in a real effort competition. Am. Econ. Rev 102:469-503.
[9] Koszegi, B., Rabin, M (2007) Reference-dependent risk attitudes. Am. Econ. Rev 97: 1047-1073.
[10] Liu, Q., Shum, S (2013) Pricing and capacity rationing with ustomer disappointment aversion. Prod. Oper. Manag 22:1269-1286.