Research on Commodity Optimal Pricing Strategy with Return Time Limit

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***Abstract*—The main research content of this paper is the optimal pricing strategy of the enterprise under the e-commerce environment, based on the analysis of factors affecting consumers' purchase and return behavior, with the goal of maximizing the profit of enterprise, this paper concluded the optimal price that consumers can accept. Then, we established the mathematical model based on the sellers' profits, by solving this model we acknowledged the optimal commodity return price and the initial inventory. Finally, proving the conclusion in this paper by numerical calculation carried out by Matlab software, and analyzing the influence of various factors on the results, and proposing corresponding suggestions.**

Keywords-E-commerce; return time limit; optimal pricing strategy; return policy

I. INTRODUCTION

Different from the traditional supply chain which contains "manufacturers-distributors-wholesalers-retailers", e-commerce is a process that eliminates the intermediate process, from the supplier directly to retailers, to achieve the goal of reducing the distribution cost of enterprises. The rise of e-commerce has brought great convenience for enterprises and consumers: enterprises can lower their costs, improve customer satisfaction and promote market competitiveness; consumers will have more product choice, more efficient purchasing process and will get better service at lower cost with e-commerce platform. Though e-commerce has the characteristics of high efficiency, convenience, large amount of information, meanwhile, the information asymmetry existed between the suppliers and the demand side will cause the consumers' return behavior. Research has shown that the return rate of traditional retailers is usually lower than 10%, while the e-commerce market retailers' return rate is higher than 35% [1]. From the perspective of the profits of e-commerce enterprise, the return policy has two sides. On the one hand, generous return policy can increase customer satisfaction, and can promote more consumers to buy, thus leading to the increase of sales profits. On the other hand, the generous return policy will inevitably lead to the increase of the amount of return commodities and the operating costs of enterprise, thus resulting in a decrease of retailers' sales profits.

In the academic community, research on e-commerce reverse logistics focus on the following aspects: returns management, service outsourcing, no reason return policy and return channels, reverse logistics and pricing strategy. In terms of no reason return policy of the supply chain based on consumers' preferences, Hong Jiang, Er-shi Qi, Daojian Yang, and Yanfang Huo studied when there is bulk discount deals between manufacturers and retailers, the optimal return policy of the overall supply chain and each part of supply chain [2]. Savaskan and others think that there are three typical reverse logistics channels in e-commerce: return to the manufacturer, return to the network retailers and return to the third-party enterprise [3]. In terms of characteristics of different return logistics channels under e-commerce environment, Chunjuan Zhai and Yong Li analyzed three typical e-commerce return logistics channels respectively, that are return to the manufacturer, return to the network retailers and return to the third-party enterprise, and made a thorough comparison for three return channels' advantages and disadvantages, processing methods and specific business situation etc, and proposed rational strategies of developing reverse logistics mode of operation [4]. Considering the return time limit in the return policy, Yinju Ma, Hong Chen, and Xiaozhi Wu established respectively no time limits return strategic model and time-bound return strategic model, and drawed the optimal ordering policy for the network retailers, and by analyzing numerical examples further drawed that the optimal return policy for the network retailers is the refund policy which has no time limits and is below the initial price [5]. On the basis of the China's e-commerce market pricing and return development status, Feiyu Wang analyzed e-commerce reverse logistics risk, and established pricing optimal strategies based on Six-membered structure and return perfecting mechanism of five-dimensional one [6]. In the context of distance buying, Wood studied by practical research that return policy effects on the consumers purchase decisions. The research result shows that orders is fluctuated greatly by return generosity, that is a more generous return policy leads to the order to increase the probability of occurrence. His research uses statistical models to demonstrate the relationship between return policy, retail price, and time factors in the apparel industry, and it is shown that there is a positive correlation between return quantity and retail price [7].

II. ASSUMPTIONS

In reality, there are many factors that affect the consumers' behavior and the network retailers' decision, which cannot be fully involved in this study. Considering the impact of multiple factors will increase the complexity of the model, which is unfavorable to draw a conclusion. To simplify the research and highlight the main issues of the study, this paper makes the following hypothesis:

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(1) Each consumers in the effective sales period only purchase once and purchase one unit of commodities, after the end of the sales period, all surplus commodities are sold at a discount price *s* and not allowed to return. Assume that all the commodities can be sold out.

(2) The commodities sold at the original price can only be returned once, and the return commodities cannot be returned to the same market, that is to say, the return commodities can only be processed at a discount price.

(3) The average transportation cost of each item is basically the same, so this paper will not consider. Return shipping costs for each product is integrated in the refunds *R*, not considered separately, which means the network retailers pay the return shipping cost.

Assuming that the consumers' estimated value of the commodity *U* as a random function, its distribution function is *G(u)*, the density function is *g (u)* and $\overline{G}(u)=1-G(u)$. The return period is the time limit that consumers can apply for return the commodities and return successfully after they purchased and received the commodities from e-commerce platform, regarded as *T*. Assuming that return period *T* is an independent random variable. Consumers' return time means the interval between receiving commodities to applying for return, recorded as *t*. Assuming that *t* is an independent random variable, its distribution function is *H(t)* ($\overline{H}(t)=1-H(t)$), and the density function is *h (t)*.

III. MODEL

A. Analysis of Consumers' Purchase Behavior

E-commerce process is carried out through the network, consumers cannot directly obtain the information of product quality and consumers evaluate the product value through the product information that the network retailers provided online and other consumers' evaluation. Combining theoretical and practical analysis, the factors that affect the purchase behavior of consumers include: price, purchase evaluation, payment security, after-sales service, etc. Before consumers make purchase decisions, they will collect relevant information through a variety of channels, the estimated value of the commodity is *U*, if the price of commodities *p* higher than the upper limit of the estimated value, consumers will not purchase the product. On the contrary, if the price is lower than the lower limit of the estimated value, consumers will make purchase decisions. That is to say consumers will choose to buy commodities under the conditions that $U>p$.

B. Analysis of Consumers' Return Behavior

After consumers receive commodities, they have more real experience on commodities and they will re-evaluate the estimated value of the commodity. Consumers decide whether return or not when they analyzed the estimated value of the commodity and the network retailers' return decision. Assuming that consumers' estimated value of commodities is *U*, the network retailers provide a refund for the amount of r, the criteria for consumers choose return is $r\geq U$ or $r<U$. If $r\geq U$, consumers choose to return commodities; if $r<U$, consumers choose to keep the commodities. Only when consumers' estimated value of commodities is less than the refund amount that the network retailers provided, consumers will choose to return commodities.

When consumers choose to return commodities, they need to consider the question of the return time limit, because commodities can only be successfully returned within the return time limit. Considering return time limit, consumers' purchase behaviors can be divided into: (1) Consumers think that commodities do not meet their needs, have the intention to return, and make return decision within the limited time, then they can return successfully; (2) Consumers think that commodities do not meet their needs, have the intention to return, but return time limit is exceeded, then they cannot make return; (3) Consumers think that commodities meet their own needs, so they choose to keep the commodities.

According to the above analysis of the requirements that consumers successfully return, the probability of consumers choose to return commodities is $p(u\leq r)=G(r)$, recorded as *G(r)*, so the probability that consumers choose to keep commodities is $\overline{G}(r)=1-G(r)$.

C. Optimal Selling Price with Return Time Limit

According to the above three kinds of without reason return decisions: (1) the expected utility that consumers have the intention to return commodities and return successfully is $V_1=r-p$; (2) the expected utility that consumers choose to return commodities but they cannot return commodities successfully because the return time limit is $V_2=U-p$; (3) the expected utility that consumers choose to keep the commodities is $V_3=U-p$.

According to the above analysis of consumers' utilities and probabilities, we can make a conclusion that consumers' expected utility is:

$$EV=+\int_r^{+\infty}(u-p)g(u)du+\int_0^r(r-p)g(u)duH(T)+\int_0^r(u-p)g(u)du\overline{H}(T) \tag{1}$$

Simplified:

$$EV=rGH(T)+U[\overline{G}+G\overline{H}(T)]-p \tag{2}$$

Only if the expected utility of consumers is not less than 0($EV\geq 0$), consumers will choose to purchase commodities. Thus the prerequisite that consumers choose to purchase is $EV\geq 0$.

As $EV\geq 0$, when consumers choose to purchase commodities, the acceptable commodities prices constraint is:

$$p\leq rGH(T)+U[\overline{G}+G\overline{H}(T)] \tag{3}$$

To enable the network retailers to get the most profit, they can develop optimal price Max *p*:

$$\max\ p = H(T)\int_0^r (r-u)g(u)du + EU = (r-U)GH(T) + EU \quad (4)$$

Therefore, when considering return time limit, in order to obtain the maximum benefit, the network retailers can develop optimal selling price:

$$p^* = H(T)\int_0^r (r-u)g(u)du + EU \quad (5)$$

From above we can conclude that when the network retailers provide return policy with return time limit, the optimal selling price of the commodities is equal to the consumers' estimated value of commodities *EU* plus the effective return utility which means utility difference result from consumers in the limited return period who have intention to choose to return commodities ultimately return successfully:

$$H(T)\int_0^r [(r-p)-(u-p)]g(u)dv \quad (6)$$

It can be seen that, when T=0, the network retailers do not offer return policy, *H(T)=0*, then optimal selling price is *p*=EU* which means consumers' purchase behavior is related to consumers' estimated value; when $T\to\infty$, the network retailers offer return policy with no return time limit, *H(T)=1*, then network retailers' optimal selling price is $p^* = EU + (r-U)G$, Simplified: $p^* = E_{\max}(U,r)$.

D. Optimal Return Policy with Return Time Limit

Assuming that consumers' demand for the commodities is *D*, and the distribution function is *F(d)*, and the density function is *f(d)*, *F(0)=0* and $\overline{F}(d) = 1 - F(d)$. Retailers decided the inventory of commodities before sales period called *q*, unit production costs called *c*.

Combined with consumers' behavior, when the network retailers provide return policy with return time limit, profits can be divided into four categories: (1) Selling at the original price without return; (2) Selling at the original price and returning commodities successfully; (3) Selling at the original price, but returning failure beyond return time limit; (4) Processing returned commodities and surplus commodities at a discount price.

According to the four different situations, we can know that the network retailers obtained profit recorded as *P* when they offer a return policy with return time limit.

$$\begin{aligned} P &= p\overline{G}E\min(X,q) + (p-r+s)GE\min(X,q)H(T) \\ &\quad + pGE\min(X,q)\overline{H}(T) + s(q - E\min(X,q)) - cq \\ &= \left[p - s + (s-r)GH(T)\right]E\min(x,q) - (c\_s)q \end{aligned} \quad (7)$$

The first item is the profits when the commodities are sold at the full price and consumers choose to retain the commodities. The second item is the profits when the commodities are sold at the full price and consumers choose to return the commodities and successfully return. The third item is the profits when the commodities is sold at the full price and the consumers want to return but return failure due to the return time limit. The fourth item is the profits of the return commodities which sold at a discount. The fifth item is the cost of all the sold commodities.

In order to obtain maximum profits, the network retailers' selling price is p^*, and the profit function is:

$$P = [(s-U)GH(T) + EU - s]E\min(X,q) - (c-s)q \quad (8)$$

Only if *r=s*, *P* reached the maximum. The optimal amount of refund $r^*=s$, the network retailers obtain maximum profit. The profit is:

$$\begin{aligned} P_m &= [H(T)\int_0^s (s-u)g(u)du + EU - s]E\min(X,q) \\ &\quad -(c-s)q \end{aligned} \quad (9)$$

When *q=X* (there are neither stock losses nor overstock), and it satisfies the following conditions:

$$X \ge \frac{c-s}{H(T)\int_0^s (s-u)g(u)du + EU - s} \quad (10)$$

Network retailers reach the maximum profits. The optimal initial inventory is:

$$q^* = \overline{F}^{-1}\left(\frac{c-s}{H(T)\int_0^s (s-u)g(u)du + EU - s}\right) \quad (11)$$

The above conclusions showed that the selling price of returning commodities is the optimal amount of refund that the network retailers provide. When the network retailers provide return policy with return time limit, in order to reach the maximum profits, the return policy that they make should satisfy the following conditions: the amount of refund is equal to the discount price of the network retailers' return commodities and surplus commodities after the end of the sales period, the result is same to the optimal amount of refund with no return time limit [8], and this conclusion suggests that return time limit *T* have no direct effect on the optimal return price r^*. The optimal amount of refund depends primarily on clearing price at the end of market sales period. The clearing price is closer to the selling price of commodities, then network retailers offer higher the amount of refund to consumers, and the refund policy is closer to a full refund. The network retailers' maximum profit is P_m, and increasing the return period makes the network retailers' sales profits increase, and when the return period T is independent random variables, the network retailers provide longer time limits for return policy that can achieve higher sales profits, and further verify that generous return policy can give the network retailers to bring more benefits.

The optimal initial stock q^* and the return time limit *T* are directly linked. Because $\overline{F}(q^*)$ is a decreasing function of q^*, so the optimal initial inventory is an increasing function of the return time limit *T*. This is due to the generous return policy is attractive for consumers to buy, and therefore the optimal initial inventories increases.

IV. CASES ANALYSIS

A network retailers' sell a commodity *A* online, provide return policy with the return time limit *T*, the refund amount

is r. Consumers' estimated value U of commodity A obey normal distribution, $U\sim(\mu, \sigma^2)$.

A. Mean Analysis of Estimated Value

Analyzing the influence that the mean of consumers' estimated value of the commodities changing to the optimal selling price. When $\mu_1=13$, $\mu_2=15$, $\mu_3=17$, $\sigma=5$, $r=90\%$, calculating the optimal selling price, the changes of the optimal selling price of the commodity are shown in Table I.

Table I shows that when the ratio of the refund amount r and the mean of the estimated value μ is stable, if the mean of the estimated value μ increases, the change rate of the network retailers' optimal selling price is increased. This shows that if the ratio of the refund amount r and the mean of estimated value μ keep constant, the higher value of the commodities leads to the higher the optimal selling price.

TABLE I. THE OPTIMAL SELLING PRICE CHANGES OVER TIME— MEAN ANALYSIS OF ESTIMATED VALUE

μ	H(T)				
	0.1	***0.2***	***0.3***	***0.4***	***0.5***
μ1=13	13.077	13.154	13.232	13.309	13.386
μ2=15	15.082	15.164	15.246	15.327	15.409
μ2=15	17.084	17.169	17.253	17.337	17.421
μ	**H(T)**				
	0.6	***0.7***	***0.8***	***0.9***	***1***
μ1=13	13.463	13.540	13.618	13.695	13.772
μ2=15	15.491	15.573	15.655	15.737	15.819
μ2=15	17.506	17.590	17.674	17.759	17.843

B. Variance Analysis of Estimated Value

Analyzing the influence that the variance of consumers' estimated value of commodities changes to the optimal selling price. When $\mu=15$, $\sigma1=3$, $\sigma2=5$, $\sigma3=7$, $r=12$, using MATLAB software to calculate, the optimal selling commodity price changes are shown in Figure 1.

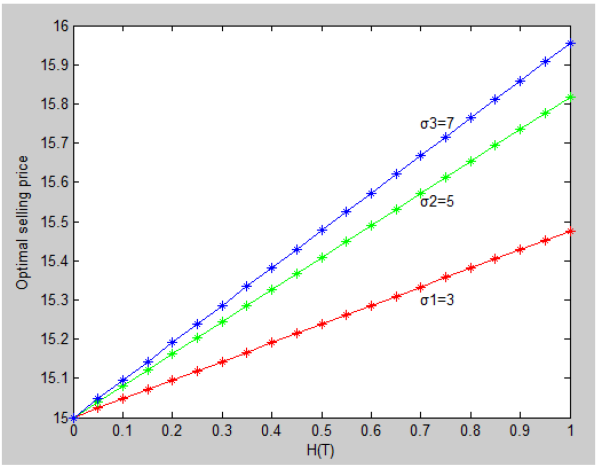

Figure 1. The optimal selling price changes over time—variance analysis of estimated value

Figure 1 shows that when the return time limit T is independent random variables, the optimal selling price of commodities and the return period $H(T)$ showed a monotonically increasing linear relationship. This indicates that when the network retailers provide return policy with time limit, longer return time limit leads to higher optimal selling price of commodity. In addition, by comparing the analysis results, Figure 1 concluded that the variance of estimated value of commodities become greater, the optimal selling price becomes higher. This shows that difference between different consumers' estimated value of the same commodity is greater, then the optimal selling price is higher.

C. Analysis of Refund Amount

Analyzing of the influence that the refund amount that the network retailers provide for the consumers change to the optimal selling price. When $\mu=15$, $\sigma=5$, $r1=15$, $r2=12$, $r3=10$, using MATLAB software to calculate, the optimal selling commodity price changes are shown in Figure 2.

Figure 2 shows that in the case of the same time-limited ($H(T)$ is the same), with refund amount changing, the optimal selling price is not changing at the same time. Consequently, there is an optimal amount of the refund which can make the highest optimal selling price.

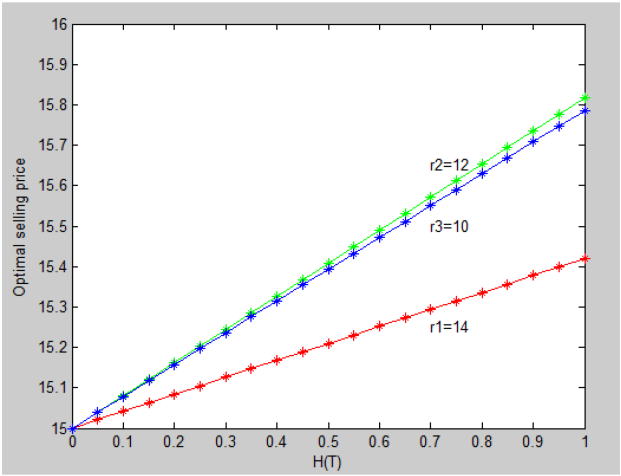

Figure 2. The optimal selling price changes over time— refund amount analysis

D. Results

From the above analysis, whatever the consumers' mean or variance of the estimated value of commodities and the refund amount that the network retailers provided changes, optimal selling price of commodities is an increasing function of return time limit. When the return time limit is constant, commodity selling price is an increasing function of the mean of consumers' estimated value of commodities, and in the case of return time limit determined, the greater mean of estimated value of commodities are, the smaller the rate of change of the optimal selling price is, and that is the optimal selling prices closer to consumers' estimated value. As the sales price is an increasing constant function of the

return time limit, the network retailers should tend to provide consumers return policy with a longer return time limit.

V. CONCLUSION

By analyzing consumers purchase behavior and return behavior, this paper studied how to develop selling price and return policy for the network retailers reach maximum profits, and provide a reference for the network retailers who develop rational price and return policy. This paper draws the following conclusions by establishing mathematical models based on the network retailers' profit:

(1) When the network retailers provide return policy with return time limit, the optimal selling price of commodities is equal to the consumers for the estimated value of commodities plus the effective return utility, and increasing return time limit make the optimal selling price increased, because the effective return utility increased as the return time limit increased.

(2) The optimal refund that the network retailers provide is equal to the clearing price of the return commodities and the surplus commodities after the sales period, and return time limit have no direct impact on the optimal refund.

(3) According to the calculating results of this paper, longer return time limit make the optimal initial inventory increased.

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