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Analysis of Gaming Behaviour based on a Defect-free Return Policy

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Abstract: Shopping gradually shifted from offline to online to facilitate the life needs of the general public, but this also brings a series of problems. In this paper, we first analyse and model the consumers' behaviour, establish the consumers' purchase decision model and return probability model according to the consumers' expected and actual utility of the product and the proportion of return shipping cost, based on which, we also establish the retailers' profit model under different sales modes and analyse their optimal order quantity. It is concluded that the optimal order quantity of e-commerce retailers decreases when the return rate of consumers increases; the order quantity is positively correlated with profit; the optimal order quantity decreases when the proportion of return shipping cost borne by e-commerce retailers increases; and the optimal order quantity of e-commerce retailers increases with the increase of the supplier's repurchase price.

Keywords: Defect-free Return Policy; Gaming Behaviour; Return Shipping Rates.

1. Introduction

In this paper, a practical and effective model has been developed by drawing on domestic and international literature. Retailers can allow consumers to return products without defects, and there are three different sales modes in which consumers decide whether to make a purchase or decide whether to return a product after making a purchase by considering the proportion of the shipping cost and the pricing of the product. Since consumers make decisions on a case-by-case basis, there is a game between the consumer and the retailer when the consumer makes a purchase. When the retailer gets the specific sales volume and return rate of the product, it will affect the buyback behaviour of the supplier, and then the game between the retailer and the supplier will occur. The game behaviours of consumers and e-retailers as well as suppliers under these three models are studied.

2. Literature Review

2.1. Research Related to Retailers under the No-Defect Return Policy

Sun Jun and Sun Liang analysed the problem from the perspective of online retailers and studied the strategies of retailers' freight assumption, and concluded that it can be studied through the free shipping strategy with conditions and the mixed freight assumption strategy [1]. While Shen Chenglin and Zhang Xinxin calculated and analysed the profit income of online retailers under different return policies and concluded that the cost of goods sold by online retailers exists a critical value regardless of the return policy, and only by controlling the cost of goods sold below the critical value, online retailers can reach the optimal decision [2]. Yang Peng and Sun Junqing used the optimal control theory to establish a dynamic decision-making model of the product life cycle for the problem of defect-free returns, to obtain the optimal decision-making of the model in some cases, and to expand the research scope of Ferguson's study on defect-free returns under static conditions, to provide some guidance for the enterprise's decision-making [3].

2.2. Consumer-related Research under the Defect-Free Return Policy

Zhao Xiaomin and Hu Shuhui chose to start from the problem of return shipping cost assumption, focusing on comparing the three strategies of consumers' assumption of return shipping cost, merchants' assumption of return shipping cost, and both parties' joint assumption of return shipping cost, and explored the optimal pricing of online retailers and their profitability under different strategies [4]. Bi Yuqi and Shao Bingjia establish a model of the impact of defect-free return policy on consumers, adding the consideration of consumers' personal risk preferences, analysing the impact of different return policies on consumers, and concluding that the return cost as well as the level of effort increases the likelihood of purchase, and that the earlier the deadline reduces the probability of consumers returning goods [5].

2.3. A Study of Supply Chain Coordination under a Defect-Free Return Policy

Huang X also considers the profitability of reducing false returns in a reverse supply chain through costly efforts [6]. JI G et al. study the optimal pricing of false returns gains in a dual-channel supply chain as well as return policies. Four current return policies are analysed where the manufacturer operates both an e-store and sells products through physical retailers [7]. Peng Y et al. investigated the impact of retail price and sales service investment on customer demand and false failure returns in a dynamic environment, applying optimal control theory to a profit maximisation model considering price and sales service investment to obtain the optimal policy under two specific conditions [8].

3. Research Design

3.1. Analysis of Consumer Behaviour based on Defect-free Return Policy

3.1.1. Model Assumptions and Notation

The model assumptions are as follows:

Assumption 1: Returned products are prioritized by the retailer over unsold products.

Assumption 2: The retailer pays for positive shipping costs and offers a full refund.

Assumption 3: Retailers and suppliers have sufficient stock.

Assumption 4: Consumers are rational and do not engage in malicious behaviour such as fraud.

Table 1. Meaning of symbols in the model

Symbol	Meaning	Symbol	Meaning
p	Product sales price	V	Consumer valuation of the product
λ	Vendor's share of return shipping costs	U	Expected utility of the consumer
l	Return shipping cost of the product	V	Consumer valuation of the product

3.1.2. Consumer Decision-making Analysis

Here we assume that the consumer's valuation of the product before purchasing the product $V_1 \in [a,b]$, the distribution function is $G(v_1)$. The expected utility of the product before the consumer makes a purchase decision is U. The consumer makes a decision based on factors such as the ratio of the selling price of the product to the percentage of the return shipping cost that he or she will bear.

The consumer chooses to return the item because he/she feels that it is not worth keeping. Consumer utility is:

$$P\{a \le V_1 \le p-(1-\lambda)l\} = \int_a^{p-(1-\lambda)l} -(1-\lambda)lg(v_1)dv_1 \quad (1)$$

The expected value to the consumer is greater than the selling price of the product and the consumer decides to keep it, the consumer utility when the consumer decides to keep the product is:

$$P\{p-(1-\lambda)l \le V_1 \le b\} = \int_{p-(1-\lambda)l}^{b} (V_1 - p)g(v_1)dv_1 \quad (2)$$

The expected total utility of the consumer can be obtained as:

$$U = b - p - \int_{p-(1-\lambda)l}^{b} G(v_1)dv_1 \quad (3)$$

The expected total utility of the consumer is greater when the retailer bears a greater proportion of the freight costs.

Consider two special cases for comparison at this point

$$U(\lambda=1) - U(\lambda=0) = \int_p^b G(v_1)dv_1 - \int_{p-l}^{b} G(v_1)dv_1 \quad (4)$$

Verify the above conclusion: U is positively related to λ. So when retailers want consumers to increase their expected total utility of a product, they can increase the percentage of return shipping costs they cover.

3.1.3. Consumer Return Probability Model

Consumer return behavior often occurs after the consumer has already received the goods, when the consumer's true value of the product is V_2. The consumer's true utility distribution function is $H(v_2)$.

When $a \le V_2 \le p-(1-\lambda)l$, the value of the returned goods is greater than the consumer's actual estimated value, the consumer feels that the goods are not worth keeping and chooses to return the goods, at this time the loss is $(1-\lambda)l$, get the consumer's return probability is $H(p-(1-\lambda)l)$. Because $\frac{\partial P}{\partial \lambda} \ge 0$, and a positive relationship. When the retailer bears a larger proportion of the freight cost, the greater the probability of the consumer's return.

3.2. Retailer Profit Analysis based on Defect-Free Return Policy

3.2.1. Problem Description and Symbol Description

Table 2. Meaning of symbols in the model

Symbol	Meaning	Symbol	Meaning
p	Product sales price	q	Retailer's order quantity
λ	Vendor's share of return shipping costs	b	Repurchase price per unit of product
l	Return shipping cost of the product	k	Proportion of returned products re-sold at original price
X	Random variable of market demand	π	Retailer's profit
w	Wholesale price per unit of product	e	Returns processing cost

3.2.2. Profit Analysis of Retailers in the Case of One Sale Without Repurchase

In this paper, shopping is carried out in a web-based environment where consumers have a large degree of randomness, so a stochastic demand function is used. The retailer's order quantity is, then the supplier outputs the product and the retailer stocks it. So, the expected sales volume of the retailer is:

$$S(q) = E\min(D,q) = q[1-F(q)] + \int_0^q f(x)dx = q - \int_0^q F(x)dx \quad (5)$$

The profit function is the difference between the retailer's gain from successfully selling the product and the product return and cost. We categorise the retailer's gains and losses in this model as follows: the gain from the first sale of the product, and the freight costs incurred in returning the product after the first sale. The retailer's profit function at this point is:

$$\prod_1 = \left[p_1 - (p_1 + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right] S(q) - wq \tag{6}$$

The optimal ordering quantity is obtained as:

$$q_1^* = F^{-1}\left[1 - \frac{w}{p_1 - (p_1 + \lambda l) H\left(p_1 - (1-\lambda) l\right)}\right] \tag{7}$$

The profit under the retailer's optimal order quantity at this point in time is obtained as:

$$\prod_1 = \left[p_1 - (p_1 + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right]\left[q_1^* - \int_0^{q_1^*} F(x) dx\right] - wq_1^* \tag{8}$$

3.2.3. Profit Analysis for Retailers with Buybacks on One Sale

What is considered at this time is the model of the retailer accepting the return after the first normal sale after the order and the supplier carrying out the buyback. We divide retailers' income and loss under this model into the following aspects: income from the first sale of products, freight borne by the return of products after the first sale, wholesale cost of products, retailers' income from repurchasing returned products, and retailers' income from repurchasing remaining products. At this time, the retailer's pricing is the best price that can be formulated p_1, and the consumer's return probability is $H\left(p_1 - (1-\lambda) l\right)$. The retailer's profit function at this time is:

$$\prod_2 = \left[p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right] S(q) + (b - w) q \tag{9}$$

To ensure that the retailer is profitable, the profit must be greater than 0, so there are the following constraints:

$$p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right) \geq \frac{(w-b) q}{S(q)} > 0 \tag{10}$$

The optimal order quantity is:

$$q_2^* = F^{-1}\left[1 - \frac{w-b}{p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right)}\right] \tag{11}$$

So as $H\left(p_1 - (1-\lambda) l\right)$ increase, q_2^* decrease. As the return rate increases, the optimal order quantity decreases.

Therefore, as the buyback price increases, the optimal order quantity increases, and the profit under the optimal order quantity is as follows:

$$\prod_2 = \left[p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right]\left[q_2^* - \int_0^{q_2^*} F(x) dx\right] + (b - w) q_2^* \tag{12}$$

3.2.4. Retailer Profit Analysis with Repurchase in the Case of Secondary Sales

At this time, the model considered is that the retailer orders and makes two sales before accepting the return and the supplier carries out the buyback. The retailer's profit function at this time is:

$$\prod_3 = \left\{p_1 - b + \left[(1-k)(b - p_1) - ek - \lambda l\right] H\left(p_1 - (1-\lambda) l\right)\right\} S(q) + (b - w) q \tag{13}$$

The optimal order quantity obtained by the retailer is:

$$q_3^* = F^{-1}\left[1 - \frac{w-b}{p_1 - b - \left[ek + \lambda l - (1-k)(b - p_1)\right] H\left(p_1 - (1-\lambda) l\right)}\right] \tag{14}$$

The profit under the optimal order quantity is:

$$\prod_3 = \left\{p_1 - b + \left[(1-k)(b - p_1) - ek - \lambda l\right] H\left(p_1 - (1-\lambda) l\right)\right\}\left[q_3^* - \int_0^{q_3^*} F(x) dx\right] + (b - w) q_3^* \tag{15}$$

3.2.5. Comparison of Three Sales Models

The profit of the seller for only one sale is:

$$\prod_1 = \left[p_1 - (p_1 + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right] S(q) - wq \tag{16}$$

The profit from the seller's one sale and the supplier's buyback is:

$$\prod_2 = \left[p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right)\right] S(q) + (b - w) q \tag{17}$$

The profit of the seller for two sales and the supplier for repurchase is:

$$\prod_3 = \left\{p_1 - b + \left[(1-k)(b - p_1) - ek - \lambda l\right] H\left(p_1 - (1-\lambda) l\right)\right\} S(q) + (b - w) q \tag{18}$$

When the product prices of these three sales models are the same (meet the constraint conditions and the sellers bear the same proportion of return freight, the supplier's buyback strategy is the best, and the seller's two sales and supplier's buyback strategy is better than the seller's one sale and supplier's buyback strategy.

The optimal order quantity for a seller with only one sale is:

$$q_1^* = F^{-1}\left[1 - \frac{w}{p_1 - (p_1 + \lambda l) H\left(p_1 - (1-\lambda) l\right)}\right] \tag{19}$$

The optimal order quantity for the seller to make a sale and the supplier to make a buyback is:

$$q_2^* = F^{-1}\left[1 - \frac{w-b}{p_1 - b - (p_1 - b + \lambda l) H\left(p_1 - (1-\lambda) l\right)}\right] \tag{20}$$

The optimal order quantity for the seller to sell twice and the supplier to buy back is:

$$q_3^* = F^{-1}\left[1 - \frac{w-b}{p_1 - b - \left[ek + \lambda l - (1-k)(b - p_1)\right] H\left(p_1 - (1-\lambda) l\right)}\right] \tag{21}$$

When the product pricing of these three sales models is the same (meeting the constraint conditions) and the proportion of return freight borne by the seller is the same, the optimal order quantity of the supplier for repurchase is the largest, and the optimal order quantity of the seller for two sales and the supplier for repurchase is greater than the optimal order quantity of the seller for one sale and the supplier for repurchase.

when the product pricing of these three sales models is the same (meeting the constraint conditions) and the seller bears the same proportion of return freight, the seller conducts two sales and the supplier carries out the maximum optimal purchase volume of buyback, which is the best strategy. In the actual situation, retailers basically use the way of secondary sales, which verifies the conclusion of this chapter, retailers can get the maximum profit during secondary sales.

4. Conclusion

The main conclusions of this paper are as follows:

(1) Analyze and model consumer behavior. Based on consumers' expected utility and actual utility of products, as well as the proportion of return freight borne by consumers, the purchase decision model and return probability model of

consumers are established, and the following results are obtained: Retailers who choose to cover most or all of the return shipping costs are significantly more attractive to consumers than those who cover a small or no return shipping costs.

(2) When the proportion of freight borne by retailers increases, the return rate of consumers increases and the optimal order quantity decreases. When the retailer's order quantity increases, the retailer's profit increases. When the proportion of return freight borne by retailers increases, the return rate of consumers increases and the optimal order quantity of retailers decreases. The maximum profit and optimal order quantity under the three models are obtained.

This paper aims at the game problem based on the no-defect return policy in the online shopping environment, and the research object is the supply chain system composed of an e-commerce supplier, e-commerce retailer and rational consumers with strategic behavior. By modeling the uncertain factors in the supply chain system, the research conclusion is drawn.

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