

Research on Supply Chain Extended Warranty Service Strategy Under Fair Concern

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ABSTRACT

In order to find new profit points and improve competitive advantages, manufacturers and retailers are committed to providing paid extended warranty services. Considering fairness preference, establish a supply chain model in which manufacturers or retailers provide paid extended warranty services, and discover the influence between decision variables and fairness preference coefficients; The study found that when retailers provide extended warranty services, the wholesale price and selling price of products are directly proportional to the fair preference coefficient, while the selling price of paid extended warranty services, the profits of manufacturers and retailers are inversely proportional to the fair preference coefficient; when a manufacturer provides paid extended warranty services, the product price, manufacturer's profit and the fair preference coefficient are directly proportional, while the paid extended warranty service selling price, wholesale price and retailer's profit are inversely proportional to the fair preference coefficient; As the fairness preference increases, the total profit of the supply chain will have a negative impact; when the fairness preference coefficient is large, manufacturers are selected to provide extended warranty services, and when the fairness preference coefficient is small, retailers are selected to provide extended warranty services.

Keywords: *Extended Warranty Service, Fairness Preference, Manufacturer, Retailer.*

1. INTRODUCTION

The extended warranty service is a repair service that extends after the warranty period. It is an optional purchase contract provided by a manufacturer, retailer or third-party service provider. It not only provides customers with access to repairs after the end of the warranty period Service opportunities have also broadened the service market and become a new source of profits for enterprises [1,2]. Best Buy's operating profit through paid extended warranty service accounts for 50%, and almost all of Circuit City's operating profit comes from paid extended warranty services [3]. Therefore, paid extended warranty service has become the focus of academic research.

The current domestic and foreign research on paid extended warranty services can be roughly divided into three categories. Based on consumers' risk appetite and utility, the demand function is derived. Desai and Padmanabhan discovered that it is more beneficial for all parties to sell the extended warranty compared to the manufacturer's sales extension [4]. According to Hollis, researches the feasibility of providing extended warranty by third parties through the differences of

consumers [5]; Cohen and Whang discovered that consumers choose to purchase extended warranty among manufacturers and third-party service providers, and design the manufacturer's best quality warranty strategy [6]. According to kou, a profit model for manufacturers and retailers is established, and a service cost sharing contract for supply chain coordination is proposed [7,8]. Yi, Liang, and Tan discovered that the influence of fairness preference on the decision and coordination of supply chain extended warranty service, and constructed a supply chain model in which strong retailers provide extended warranty services and manufacturers have fair preferences [9,10]. Liu, Zhang, and Yang discovered that in the model MRR, for the manufacturer, the retailer can obtain higher profits by providing extended warranty; for third-party providers, choosing retailers to sell extended warranty is more beneficial to them [11].

To sum up, none of the above studies involved the influence of manufacturers or retailers on their decision variables and profits when they provide paid extended insurance services under fair preference. This paper establishes a supply chain model in which a

manufacturer or retailer provides a paid extended warranty service, studies the relationship between decision variables and profit and fairness preference coefficients, and provides theoretical guidance for company decision-making.

2. MATERIALS AND METHODS

2.1. Problem Description

This article constructs a two-level supply chain system of a manufacturer and a retailer without loss of generality. On the premise that manufacturers have fair preferences, a secondary supply chain is established in which manufacturers and retailers provide paid extended warranty services. When a manufacturer provides a paid extended warranty service, the manufacturer determines the sales price of the paid extended warranty service and the wholesale price of the product according to its own costs and expected benefits, and the retailer determines the product price based on its own costs and expected benefits. When a retailer provides a paid extended warranty service, the manufacturer determines the wholesale price of the product based on its own cost and expected revenue, and the retailer determines the paid extended warranty service and product price based on its own cost and expected revenue.

Model symbol: w is the wholesale price of the product; p is Sell the product; p_e is the sales price of the paid extended warranty service of the unit; t is the length of paid extended warranty service; b is the sensitivity coefficient of commodity demand and $b > 0$; t is the duration of the paid extended warranty service; d is the sensitivity coefficient of paid extended warranty demand and $d > 0$; q is the demand for the product; q_e is the demand for paid extended warranty service; c is the paid extended warranty cost per unit time; C_e is the total cost of a single paid extended warranty service; Π_i ($i = m, r$) is the total revenue of the supply chain when the paid extended warranty service is provided by i , where is the retailer $i = r$ and the manufacturer $i = m$.

The parameter marked with R in the upper right corner refers to the parameter under the extended warranty service provided by the retailer, and the parameter marked with M in the upper right corner refers to the parameter under the extended warranty service provided by the manufacturer.

2.2. Basic Assumption

Assuming that there is no inventory in the market, the quantity purchased by the retailer is the quantity

produced by the manufacturer. Assuming that consumers can purchase only a single product or a combination of products plus paid extended warranty services, this article only considers the combination of consumer purchases of products plus paid extended warranty services [12]. The unit cost of each product produced by the manufacturer is represented by c , and the retailer buys the product from the manufacturer at the wholesale price w , and then sells it to the consumer at the price p , so there is $p > w > c$. Since the unit production cost has no impact on the content of this article, it is not consider the influencing factors of unit cost. It is assumed that the unit cost is the same when the manufacturer or retailer provides the paid extended warranty service. Suppose the demand function of the product is represented by $q = 1 - bp$, the cost function of extended warranty is represented by $C_e = ct^2$, and the demand function of paid extended warranty is represented by $q_e = 1 - bp - d \frac{p_e}{t}$, where $b > d > 0$ [13].

3. SUPPLY CHAIN EXTENDED WARRANTY SERVICE DECISION MODEL UNDER FAIRNESS PREFERENCE

3.1. Decision Model Based On Extended Warranty Service Provided By Retailer

To characterize the utility function, the parameter λ is introduced as the fair preference coefficient [14]. When retailers provide extended warranty services, obtain the manufacturer’s fair preference U_m^R function, the manufacturer’s profit Π_m^R function, the retailer profit Π_r^R function

$$U_m^R = \pi_m^R - \lambda(\pi_r^R - \pi_m^R) \tag{1}$$

$$\Pi_m^R = w(1 - bp) \tag{2}$$

$$\Pi_r^R = (p - w)(1 - bp) + (p_e - ct^2) \left(1 - bp - \frac{dp_e}{t} \right) \tag{3}$$

The inverse method is used in the solution to obtain the product wholesale price w^R under the maximum effect, product price p^R and the price of paid extended warranty service p_e^R .

$$p^R = \frac{-(-2tb - 3\lambda bt + 6d + 10\lambda d + dbct^2 + sbct^2)}{(2 + 3\lambda)(bt - 4d)b} \tag{4}$$

$$p_e^R = \frac{(-2 - 2\lambda + 3bct^2 + 4\lambda bct^2 - 8ctd - 12ct\lambda d)t}{2(bt - 4d)(2 + 3\lambda)} \tag{5}$$

$$w^R = \frac{(bct^2 + 2\lambda bct^2 - 2 - 4\lambda)}{-2b(2 + 3\lambda)} \tag{6}$$

At this time, the profits and utility of the manufacturer, the profit of the retailer and the total profit of the supply chain can be further obtained:

$$\Pi_r^R = \frac{(b^2c^2t^4(8\lambda^2 + 3 + 10\lambda) - 4bc^2t^3d(2 + 3\lambda)^2 + (bct^2 - 1)(2\lambda + 2)^2)d}{4b(2 + 3\lambda)^2(bt - 4d)} \quad (7)$$

$$\Pi_m^R = \frac{(1 + 2\lambda)(-2 + bct^2)(1 + \lambda)d}{-2b(2 + 3\lambda)^2(bt - 4d)} \quad (8)$$

$$\Pi^R = \frac{d((4bct^2 - 4)(3 + 8\lambda + 5\lambda^2) + b^2c^2t^4(1 + 2\lambda)^2 - 4t^3bc^2d(2 + 3\lambda)^2)}{4b(2 + 3\lambda)^2(bt - 4d)} \quad (9)$$

$$U_m^R = \frac{(b^2c^2t^4(2\lambda + 1)^2 - bct^2(2\lambda + 2)^2 + 4(1 + \lambda)^2 - 4b\lambda c^2dt^3(3\lambda + 2))d}{-4(2 + 3\lambda)(bt - 4d)b} \quad (10)$$

3.2 Decision Model Based On The Extended Warranty Service Provided By The Manufacturer

When a manufacturer provides extended warranty services, the manufacturer's profit Π_m^M function, retailer profit Π_r^M function, and retailer's fair preference utility U_r^M function can be obtained:

$$\Pi_m^M = w(1 - bp) + (p_{em} - ct^2) \left(1 - bp - \frac{dp_{em}}{t} \right) \quad (11)$$

$$\Pi_r^M = (p - w)(1 - bp) \quad (12)$$

$$U_r^M = \Pi_r^M - \lambda(\Pi_m^M - \Pi_r^M) \quad (13)$$

The inverse method is used in the solution to obtain the product wholesale price w^M under the maximum effect, product price p^M and the price of paid extended warranty service p_{em}^M :

$$p^M = \frac{(-tb(1 + \lambda) + (dbct^2 + 6d)(1 + 2\lambda))}{-b(\lambda bt - 16\lambda d + tb - 8d)} \quad (14)$$

$$p_{em}^M = \frac{t((bct^2 - 1)(1 + \lambda) - 4ctd(1 + 2\lambda))}{\lambda bt - 16\lambda d + tb - 8d} \quad (15)$$

$$w^M = \frac{((4d - tb)(1 + \lambda) + 2dbct^2(1 + 3\lambda))}{-b(\lambda bt - 16\lambda d + tb - 8d)} \quad (16)$$

At this point, you can further get the manufacturer's profit, retailer's profit and utility, and the total profit of the supply chain.

$$\Pi_m^M = \frac{(2t^3bc^2d(1 + 2\lambda) + (1 - bct^2)(1 + \lambda))d}{-b(\lambda bt - 16\lambda d + tb - 8d)} \quad (17)$$

$$\Pi_r^M = \frac{d^2(1 + 4\lambda)(1 + 2\lambda)(-2 + bct^2)}{b(\lambda bt - 16\lambda d + tb - 8d)^2} \quad (18)$$

$$\Pi^M = \frac{d \left(\begin{matrix} 4d(1 + 2\lambda)^2(3 + 4t^3bc^2d - 3bct^2) \\ -2\lambda bt - t^4b^2c^2d(1 - 4\lambda^2) + (1 + \lambda)^2(b^2ct^3 - tb) \end{matrix} \right)}{b(\lambda bt - 16\lambda d + tb - 8d)^2} \quad (19)$$

$$U_r^M = \frac{d \left(\begin{matrix} b^2c^2dt^4(9\lambda + 20\lambda^2 + 1) - 16b\lambda c^2d^2t^3(2\lambda + 1)^2 \\ + 4\lambda^3d(4 + 3b^2c^2t^4 - 4bct^2) \\ + (1 - bct^2)(\lambda bt(1 + \lambda)^2 + 4d(8\lambda^2 + 5\lambda + 1)) \end{matrix} \right)}{b(\lambda bt - 16\lambda d + tb - 8d)^2} \quad (20)$$

4. RESULTS AND DISCUSSION

Under fair preference, take parameters $b = 1, c = 0.45, t = 2; d = 3$. Analyze the influence of fair preference coefficient on product selling price, extended service selling price, wholesale price and its supply chain income when the retailer or manufacturer provides extended warranty service.

4.1 The Relationship Between Parametric Variable and λ

Regardless of whether the manufacturer provides extended warranty service or the retailer provides extended warranty service, the sales price of the product increases with the increase of the fair preference coefficient, and there is a critical value for the product sales price between the two, as shown in Figure 1.

$\lambda \geq \frac{1 + \sqrt{29}}{14}$, the selling price of the product when the

retailer provides the extended warranty service is greater than or equal to the selling price of the product when the manufacturer provides the extended warranty service.

$\lambda < \frac{1 + \sqrt{29}}{14}$, the selling price of the product when the

retailer provides the extended warranty service is less than the selling price of the product when the manufacturer provides the extended warranty service.

Whether the manufacturer provides extended warranty service or the retailer provides extended warranty service, the sales price of paid extended warranty service decreases as the fair preference coefficient increases. When a retailer provides an extended warranty service, the selling price of the extended warranty service is higher than the selling price of an extended warranty service when the manufacturer provides the extended warranty service, as shown in Figure 2. When the manufacturer provides extended warranty service, the wholesale price of the product is higher than the wholesale price of the product when the retailer provides extended warranty service. When manufacturers increase the extended warranty service, the wholesale price of the product decreases with the increase of the fair preference coefficient, and when the retailer provides the extended warranty service, the wholesale price of the product increases with the increase of the fair preference coefficient, as shown in Figure 3.

4.2 The Relationship between Supply Chain Profit and λ

Regardless of whether the manufacturer provides extended warranty service or the retailer provides extended warranty service, the manufacturer's profit decreases as the fairness preference coefficient increases, and the manufacturer's profit when the retailer provides the extended warranty service is less than the

manufacturer provides the extended warranty service. Manufacturer's profit is shown in Figure 4.

When the retailer provides extended warranty service, the retailer's profit decreases with the increase of the fair preference coefficient; when the manufacturer provides the extended warranty service, the retailer's profit increases with the increase of the fair preference coefficient. The profit of the retailer when the retailer provides the extended warranty service is higher than the profit of the retailer when the manufacturer provides the extended warranty service, as shown in Figure 5.

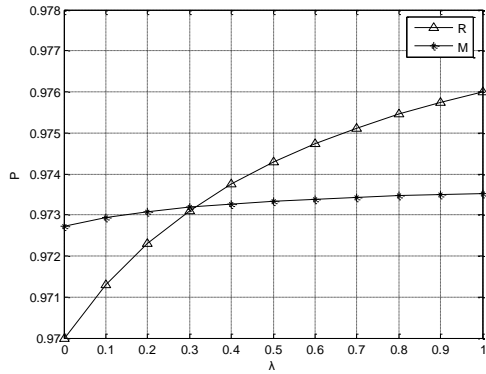


Figure 1 Relationship between product price and λ .

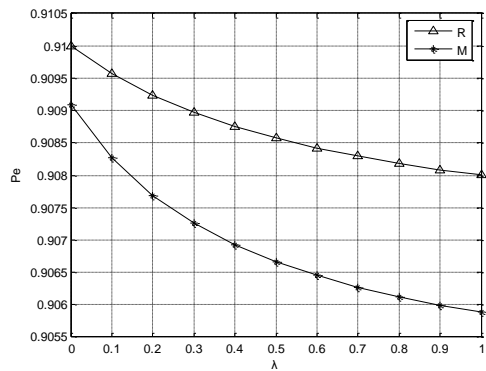


Figure 2 Relationship between the selling price of extended warranty service and λ .

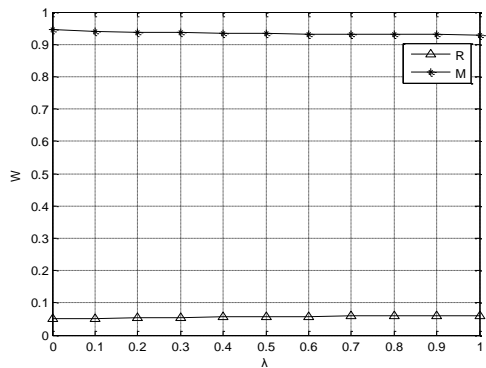
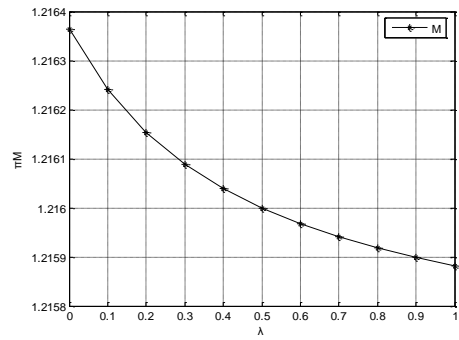
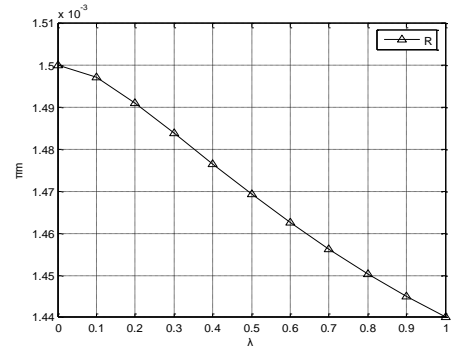


Figure 3 Relationship between product wholesale price and λ .

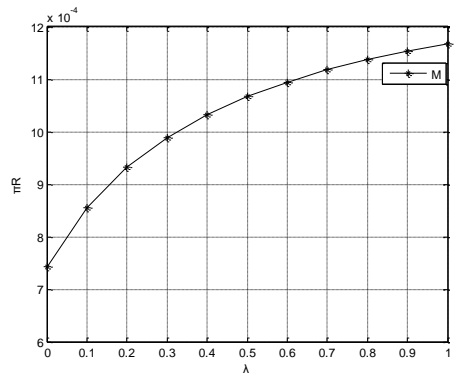


(a) Manufacturers provide extended warranty services

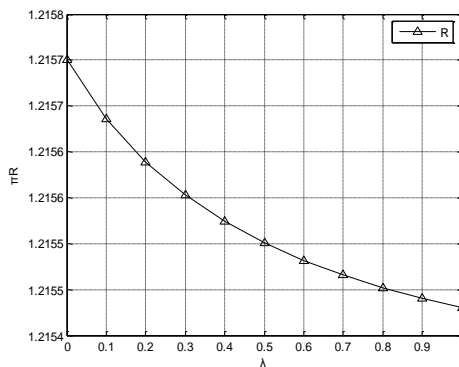


(b) Retailers provide extended warranty services

Figure 4 Relationship between manufacturer's profit and λ .



(a) Manufacturers provide extended warranty services



(b) Retailers provide extended warranty services

Figure 5 Relationship between retailer's profit and λ .

Whether the manufacturer provides extended warranty or the retailer provides extended warranty services, the profit of the supply chain decreases as the fairness preference coefficient increases [15]. This is because as the fair preference coefficient increases, the party with fair preference will pay more attention to the profit comparison between itself and upstream and downstream. With the increase in the strength of fairness preference, the more likely it is to make wrong decisions, and ultimately lead to the deviation of the supply chain from optimal decisions.

5. CONCLUSION

Under the premise of considering fair preference, establish a supply chain model in which retailers or manufacturers provide extended warranty services to explore the relationship between parameter variables and fair preference coefficients. The research results show that:

(1) Under fairness preference, when retailers provide paid extended warranty services, the sales price and wholesale price of products increase with the increase in the fair preference coefficient, and the sales price of paid extended warranty services decrease with the increase in the fair preference coefficient.

(2) Under fairness preference, when the manufacturer provides paid extended warranty services, the sales price of the product will increase with the increase in the fairness concern coefficient, and the sales price and wholesale price of the paid extended warranty service will decrease with the increase in the fairness preference coefficient.

(3) Under fairness preference, when retailers or manufacturers provide paid extended warranty services, the fairness preference coefficient is negatively related to the total profit of the supply chain;

In model analysis, the fair preference effect function used to simplify the analysis is a relatively simple linear function, but the non-linear function is more widely used in applications. The further study of this article can be extended to discuss the nonlinear function.

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