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# Pricing Strategy in a Dual-channel Supply Chain with Return Policy

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**Abstract:** This study considers a dual-channel supply chain which consists of one manufacturer and one retailer. The manufacturer sells product to customer through traditional channel and Internet channel respectively. According to the preference of customer, we group the product market into three parts, which is more close to the reality. The manufacturer forecasts the demand for three groups, but the actual demand is less than his expectation. We introduce a full-refund return policy and service value into model to investigate the performance of supply chain. In order to maximize their profits, manufacturer and retailer should make decisions on the pricing strategies. Through numerical simulations, we find that the return policy can effectively reduce the risk which is caused by the demand uncertainty. And the service value has two sides, which should be paying more attention on. We also derive several conclusions on the optimal sale strategy for the manufacturer and retailer in this study.

**Keywords:** Demand uncertainty, dual-channel, return policy, service value

## INTRODUCTION

Because of the popularity of Internet, shopping online is a new fashion for people, especially in the youth. It occupies a large proportion of consumption pattern. More and more manufacturers gradually realize that there are lots of advantages in selling product through the Internet, which the traditional retail channel does not have. The manufacturer can reduce the middleman in the supply chain and better understanding the need of customer. In nowadays, the B2C mode is getting better and better. So many manufacturers set up specialty stores on the Internet and earn more market share and profit.

As so far, the investigations on the dual-channel supply chain have been considered in a variety of papers. Lots of researchers have got meaningful findings. Yan and Pei (2009) examined the impact of retail service in a dual-channel competitive market. They found that the increasing of retail service can indirectly benefit the profit of manufacturer and improves the performance and coordination of whole supply chain. Chen *et al*. (2013) introduced the service value into a dual-channel supply chain with the stochastic demand. Through analyses, they found that the service value can decrease the threats of Internet channel to traditional channel and it also can rises the profit of manufacturer. But they did not pay attention to the preference of customer for consumption pattern. Huang *et al*. (2013) studied the pricing and production quantity decision in a dual-channel supply chain under the production cost and demand disruptions. Different from previous studies, they introduced the preference of customer for different channels. So did Chen *et al*. (2012). But they did not consider the service value of traditional channel.

The manufacturer and retailer always do their best to make the optimal pricing policies to pursue the maximum profit. However, due to the fierce competition in the market, they cannot effectively handle risks only by their own. So many manufacturers develop partnerships with suppliers and distributors who are in the same supply chain. And return policy is widely used. Hsieh and Wu (2009) developed a revenue-sharing, return policy and combination of revenue-sharing and return policy coordination models in a two level supply chain. And they examined the influences of retailer's attitude toward risk, product substitutable, demand and supply uncertainty on the performance of supply chain. Ai *et al*. (2012) considered two competing supply chains with full returns policy. They got the situations under which both manufacturers and retailers prefer returns policies or not. Chen and Bell (2012) investigated the optimal pricing and ordering strategies in full-refund and no-refund channels respectively.

Different from previous researches, we group the product market into three parts according to the preference of people for consumption pattern, which are the people just like shopping online, the people just shopping in solid shop and the people choose between two channels. It is more close to the reality and the results that we concluded will be more practical and reasonable.

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In this study, we set up a dual-channel model which the manufacturer sells product to customers through traditional and Internet channels. The manufacturer estimates the demand for three groups and delivers the reasonable quantity of product to retailer. The rest is left for the Internet sales. However, the actual demand for product is less than he expected. So the fluctuation of market is inevitable. In order to maximize the profit of whole supply chain, we introduce a return policy into model and compare the performance of it with the basic one's. We got the optimal pricing strategies of manufacturer and retailer in two models. Furthermore, we applied numerical simulations to analyze the influences of price sensitive coefficient, demand uncertainty and service value on the performances of two models respectively. We found out that, the Return Policy model can effectively transfer some profit of supply chain from manufacturer to retailer and migrate the effects of demand uncertainty, which motivates the enthusiasm of the retailer. And the supply chain with return policy can perform better and gets more profit in the fierce market competition.

## MATERIALS AND METHODS

This study focuses on a dual-channel supply chain which manufacturer sells product to the retailer through the traditional channel and directly to customers through the Internet channel. Compared with the Internet channel, the retailer can provide better service for the customers. The manufacturer forecasts the demand for products firstly. Then, based on the preference of customer for different channels, he delivers suitable quantity of product to retailer. However, the actual demand which the customer need is less than the manufacturer expected. So the manufacturer and the retailer need to make the optimal sale strategies to earn more profits:

- $w$ : Wholesale price of product per unit
- $p_i$ : Retail price of channel i (i = 1, 2, where 1 represents the traditional channel and 2 represents the Internet channel)
- $v$ : The service value per unit in the traditional retail channel
- $D_{ij}$ : The expected demand for product in channel i from Group j (i = 1, 2, j = 1, 2, 3)
- $d_i$ : The actual demand for product in channel $i$ (i = 1, 2)
- $c_m$ : Production cost of product per unit
- $s_i$ : Salvage value per unit of unsold product in channel i (i = 1, 2)
- $\Pi_M$ : Expected profit of manufacturer
- $\Pi_R$ : Expected profit of retailer

**Assumption 1:** The pricing strategy which the retailer made is percentage-makeup. It denotes the retail price of product which the retailer makes is based on the wholesale price, which is satisfied with $p_1 = (1 + \theta)$ w. where θ is the percentage retail margin and it is selected by the retailer.

**Assumption 2:** According to the data accumulated previously and market researches they have gained, the manufacturer groups the potential customers who are in the product market into three parts.

Group 1 doesn't like shopping on line. They think that it can leak their personal information and the quality of products cannot be guaranteed. So the expected demand for Group 1 is related to the retail price and service value of the traditional retail channel, which can be expressed as $D_{11} = \alpha_1 - \beta_1 (p_1 - v)$.

Group 2 just likes shopping online. This kind of people thinks that shopping online is so convenient. They can get the goods they like without going out. What's more, the goods that sell on the Internet are much cheaper. So the expected demand for Group 2 is only related to the retail price of the Internet channel, which can be expressed as $D_{22} = \alpha_2 - \beta_2 p_2$.

Group 3 chooses between the two channels. And it is the main group in the product market. When people want to buy something, they will compare the price of product in two channels. If the retail price of Internet channel is too much lower, they will buy product on the Internet. If the difference between retail prices of two channels is small, they will buy it from the retail shop. Because they can choose the product and get it immediately. So it will cause competition between two channels. The expected demand for traditional retail channel from Group 3 is defined as $D_{13} = \alpha_3 - \beta_{13} (p_1 - v) \gamma_{13} p_2$ and the expected demand for Internet channel from Group 3 is defined as $D_{23} = \alpha_3 - \beta_{23} p_2 + \gamma_{23} (p_1 - v)$.

Where $\alpha_i$ demonstrates the demand for Group i which manufacturer estimates. The parameter $\beta_1$, $\beta_2$, $\beta_{13}$ and $\beta_{23}$ are the self-price sensitive coefficients and $\gamma_{13}$, $\gamma_{23}$ are the cross-price sensitive coefficients. And we assume that $\beta_1$, $\beta_2$, $\beta_{13}$, $\beta_{23}$ are larger than $\gamma_{13}$, $\gamma_{23}$, which means that the demand for product is more sensitive to its own price. So we can get the total demand for the product of two channels, which are given as follows:

$$D_1 = \alpha_1 + \alpha_3 - (\beta_1 + \beta_{13})(p_1 - v) + \gamma_{13} p_2$$
$$D_2 = \alpha_2 + \alpha_3 - (\beta_2 + \beta_{23}) p_2 + \gamma_{23} (p_1 - v)$$

**Assumption 3:** We assume that the service cost of traditional channel is satisfied with $c_v = \eta \frac{v^2}{2}$, where $\eta$ is the service cost coefficient.

**Assumption 4:** We assume that the actual demand in two channels are satisfied with $d_i = D_i - \Delta\alpha_i$ ($\Delta\alpha_i > 0$, i = 1, 2 where $\Delta\alpha_i$ is the market share that manufacturer overestimated.

In the basic model, we assume that the manufacturer estimates the demand for product in two channels firstly. Then he decides the wholesale price and Internet retail price of product. After that, he delivers the suitable quantity to the retailer and leaves the rest for Internet sales. At last, the retailer determines the traditional retail price of product. And the product which is beyond the actual demand in two channels has salvage values.

The expected profit functions of the retailer is as follows:

$$\Pi_R = p_1 d_1 - (w + c_v) D_1 + s_1 (D_1 - d_1)$$

Solving $\frac{\partial \Pi_R}{\partial \theta} = 0$, we can get the traditional retail price $p_1$ with the manufacturer's decision on the wholesale price:

$$p_1 = \frac{\alpha_1 + \alpha_3 - \Delta\alpha_1 + \gamma_{13} p_2}{2(\beta_1 + \beta_{13})} + \eta \frac{v^2}{4} + \frac{v + w}{2} \quad (1)$$

Because:

$$\frac{\partial^2 \Pi_R}{\partial \theta^2} = -2w^2 (\beta_1 + \beta_{13}) < 0$$

the expected profit of retailer $\Pi_R$ is concave in θ.
The expected profit of manufacturer is formulated as:

$$\Pi_M = wD_1 + p_2 d_2 - c_m (D_1 + D_2) + s_2 (D_2 - d_2) \quad (2)$$

Taking (1) into (2), we can get the optimal wholesale price w* and Internet retail price $p_2$* in the basic model:

$$w^* = \frac{\alpha_1 + \alpha_3 + \Delta\alpha_1}{B}\left[\frac{1}{2(\beta_1 + \beta_{13})} + \frac{\gamma_{23}(1-B)}{(\gamma_{13} + \gamma_{23})(\beta_1 + \beta_{13})}\right]$$

$$+ \frac{2(1-B)}{(\gamma_{13} + \gamma_{23})B}(\alpha_2 + \alpha_3 - \Delta\alpha_2)$$

$$+ \frac{c_m}{B}\left[\frac{1}{2} + \frac{\gamma_{13} - \gamma_{23}}{4(\beta_1 + \beta_{13})} - \frac{\gamma_{13}(1-B)}{\gamma_{13} + \gamma_{23}}\right]$$

$$+ (\eta \frac{v^2}{2B} - \frac{v}{B})\left[\frac{\gamma_{23}(1-B)}{\gamma_{13} + \gamma_{23}} - \frac{1}{2}\right]$$

$$p_2^* = \frac{(\alpha_1 + \alpha_3)(\gamma_{13} + 3\gamma_{23})}{4AB(\beta_1 + \beta_{13})} + \frac{(\gamma_{13} - \gamma_{23})\Delta\alpha_1}{4AB(\beta_1 + \beta_{13})}$$

$$+ \frac{\alpha_2 + \alpha_3 - \Delta\alpha_2}{AB} + \frac{c_m}{B}\left[\frac{1}{2} + \frac{\gamma_{23} - \gamma_{13}}{4A} - \frac{\gamma_{23}(1-B)}{\gamma_{13} + \gamma_{23}}\right]$$

$$+ (\eta \frac{v^2}{2} - v)\frac{\gamma_{23} - \gamma_{13}}{4AB}$$

where,

$$A = 2(\beta_2 + \beta_{23}) - \frac{\gamma_{13}\gamma_{23}}{\beta_1 + \beta_{13}}$$

and,

$$B = 1 - \frac{(\gamma_{13} + \gamma_{23})^2}{4A(\beta_1 + \beta_{13})}$$

Because the determinate of the Hessian:

$$\det \text{H} = 2(\beta_1 + \beta_{13})(\beta_2 + \beta_{23}) - \gamma_{13}\gamma_{23} - (\frac{\gamma_{13} + \gamma_{23}}{2})^2 > 0$$

we can conclude that, the expected profit of manufacturer $\Pi_M$ is concave in w* and $p_2$*.

Taking w* and $p_2$* into (1), we can get the optimal traditional retail price $p_1$* in the basic model:

$$p_1^* = \frac{\alpha_1 + \alpha_3 - \Delta\alpha_1 + \gamma_{13} p_2^*}{2(\beta_1 + \beta_{13})} + \eta \frac{v^2}{4} + \frac{v + w^*}{2}$$

Then, we introduce a return policy into the model which aims to set up cooperation relationship between manufacturer and retailer and improve the profits of them. We assume that the retailer can get full-refund on the unsold product which is beyond the actual demand. So the retailer needs to choose the optimal pricing strategy to compete with the Internet channel. And the salvage value of unsold product which the manufacturer has is denoted as $s_0$.

The expected profit function of retailer and manufacturer can be expressed as follows:

$$\Pi_R^0 = (p_1 - w)d_1 - c_v D_1$$

$$\Pi_M^0 = wd_1 + p_2 d_2 - c_m (D_1 + D_2) + s_0 (D_1 + D_2 - d_1 - d_2)$$

Through solving, we can get the optimal wholesale price $W^0$ and retail price of two channels $P_1^0$, $P_2^0$ in the Return Policy model:

$$w^0 = \frac{\alpha_1 + \alpha_3 - \Delta\alpha_1}{B}\left[\frac{1}{2(\beta_1 + \beta_{13})} + \frac{\gamma_{23}(1-B)}{(\gamma_{13} + \gamma_{23})(\beta_1 + \beta_{13})}\right]$$

$$+ \frac{2(1-B)}{(\gamma_{13} + \gamma_{23})B}(\alpha_2 + \alpha_3 - \Delta\alpha_2)$$

$$+ \frac{c_m}{B}\left[\frac{1}{2} + \frac{\gamma_{13} - \gamma_{23}}{4(\beta_1 + \beta_{13})} - \frac{\gamma_{13}(1-B)}{\gamma_{13} + \gamma_{23}}\right]$$

$$+(\eta\frac{v^2}{2B}-\frac{v}{B})[\frac{\gamma_{23}(1-B)}{\gamma_{13}+\gamma_{23}}-\frac{1}{2}]$$

$$p_2^{\,0}=\frac{(\alpha_1+\alpha_3-\Delta\alpha_1)(\gamma_{13}+3\gamma_{23})}{4AB(\beta_1+\beta_{13})}+\frac{\alpha_2+\alpha_3-\Delta\alpha_2}{AB}$$

$$+\frac{c_m}{B}[\frac{1}{2}+\frac{\gamma_{23}-\gamma_{13}}{4A}-\frac{\gamma_{23}(1-B)}{\gamma_{13}+\gamma_{23}}]+(\eta\frac{v^2}{2}-v)\frac{\gamma_{23}-\gamma_{13}}{4AB}$$

$$p_1^{\,0}=\frac{\alpha_1+\alpha_3-\Delta\alpha_1+\gamma_{13}p_2^{\,0}}{2(\beta_1+\beta_{13})}+\eta\frac{v^2}{4}+\frac{v+w^0}{2}$$

## RESULTS AND DISCUSSION

In this section, we applied numerical simulations to analyze the influences of price sensitive coefficient, demand uncertainty coefficient and service value on the performances of basic and Return Policy (RP) models respectively. The parameters are setting as follows:

$\alpha_1=50$, $\alpha_2=30$, $\alpha_3=300$, $\beta_1=5$, $\beta_2=4$, $\beta_{13}=7$, $\beta_{23}=6$, $\gamma_{13}=3$, $\gamma_{23}=2$, $\eta=0.5$, $v=3$, $s_1=2$, $s_2=1$, $s_0=3$, $c_m=5$, $\Delta\alpha_1=10$, $\Delta\alpha_2=8$

The effects of self-price sensitive coefficient on the performances of two models are illustrated in the Fig. 1 and 2. The value of wholesale price and retail price of two channels are decreasing while $\beta_{13}$ is higher. That is because the bigger the self-price sensitive coefficient is, the greater influences will be caused by its own price. The wholesale price and tradition retail price in the RP model are lower than that of the basic model, which means that the return policy can pass price advantage from manufacturer to retailer.

From Fig. 2, we can find that the profit of whole supply chain in the RP model is more than the basic model's. So the return policy can make the supply chain earned more profit and be more competitive. The profit of manufacturer is higher in the basic model, but the retailer's is larger in the RP model. It demonstrates that the return policy can transfer some profit of supply chain from manufacturer to retailer, which motivates the enthusiasm of retailer. But the fluctuation of retailer's profit is not obvious under the changing of self-price sensitive coefficient.

The influences of cross-price sensitive coefficient are shown in the Fig. 3 and 4. As $\gamma_{13}$ is increasing, the competition between two channels is serious. Through two figures, we can find that the wholesale price, retail prices of two channels and the expected profit of supply chain are all increasing when $\gamma_{13}$ is higher, which is opposite to the situation of self-price sensitive coefficient. The result reveals that the competitions between two substitutable products are good for the performance of supply chain and it also can strengthen the profit of it. In order to earn more profit, it is a good way to increase the sensitive of customer to substitutable product.

The influences of demand uncertainty coefficient are revealed in Fig. 5 and 6. When $\Delta\alpha_1$ is higher, the wholesale price is increasing in the basic model, but is decreasing in the RP model. It means the return policy can effectively lower the risk which is caused by demand uncertainty. As $\Delta\alpha_1$ is climbing, the market

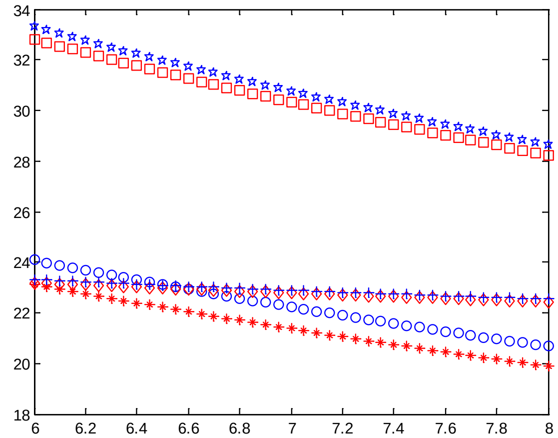


Fig. 1: Impact of self-price sensitive coefficient $\beta_{13}$
*: Wholesale price of RP model; o: Wholesale price of basic model; □: Traditional retail price of RP model; ☆: Traditional retail price of basic model; ◇: Internet retail price of RP model; +: Internet retail price of basic model

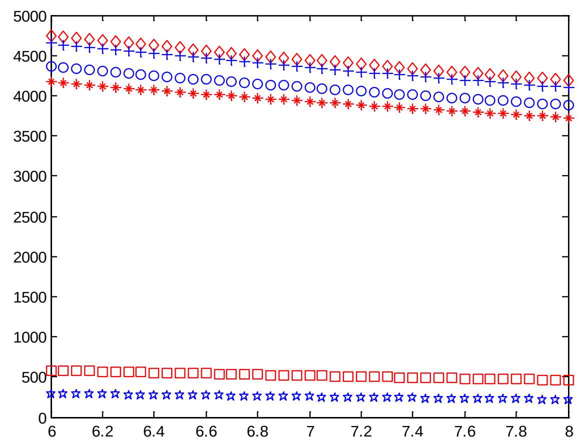


Fig. 2: Impact of self-price sensitive coefficient $\beta_{13}$
*: Profit of manufacturer in RP model; o: Profit of manufacturer in basic model; □: Profit of retailer in RP model; ☆: Profit of retailer in basic model; ◇: Profit of whole supply chain in RP model; +: Profit of whole supply chain in basic model

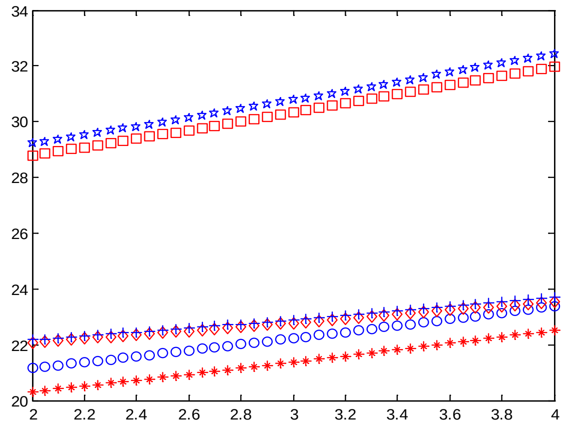


Fig. 3: Impact of cross-price sensitive coefficient $\gamma_{13}$
*: Wholesale price of RP model; o: Wholesale price of basic model; □: Traditional retail price of RP model; ☆: Traditional retail price of basic model; ◇: Internet retail price of RP model; +: Internet retail price of basic model

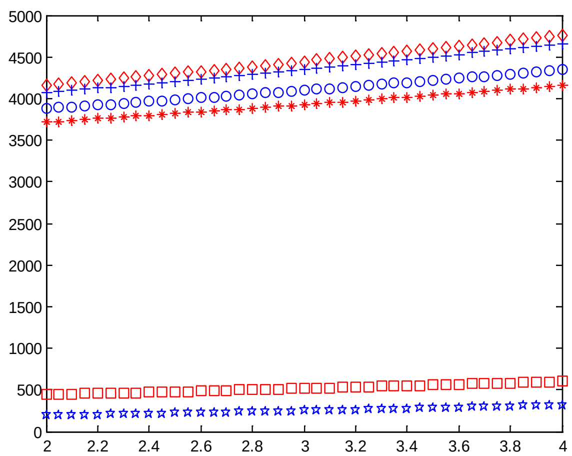


Fig. 4: Impact of cross-price sensitive coefficient $\gamma_{13}$
*: Profit of manufacturer in RP model; o: Profit of manufacturer in basic model; □: Profit of retailer in RP model; ☆: Profit of retailer in basic model; ◇: Profit of whole supply chain in RP model; +: Profit of whole supply chain in basic model

fluctuation of traditional channel is large. So the traditional retail price of two models is declining and the Internet retail price does not change too much.

In the basic model, $\Delta\alpha_1$ leads to the increasing of manufacturer's profit and the declining of retailer and whole supply chain's profit. On the contrary, although the profits of manufacturer and supply chain are smaller than before, the retailer's profit does not change too much in the RP model. So the performance of supply chain in the RP model is better than the basic one's.

Figure 7 and 8 illustrate the effects of service value v on the performances of two models. When v is

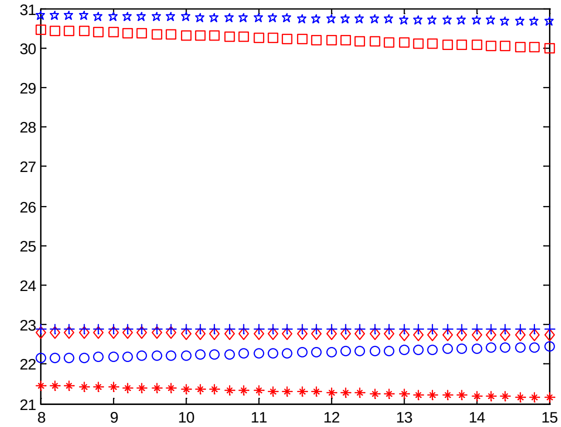


Fig. 5: Impact of demand uncertainty coefficient $\Delta\alpha_1$
*: Wholesale price of RP model; o: Wholesale price of basic model; □: Traditional retail price of RP model; ☆: Traditional retail price of basic model; ◇: Internet retail price of RP model; +: Internet retail price of basic model

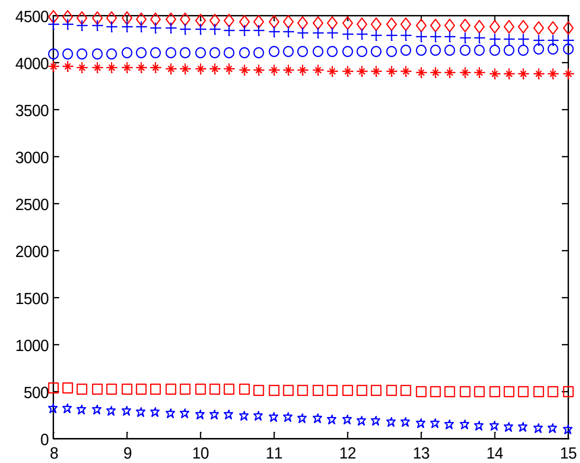


Fig. 6: Impact of demand uncertainty coefficient $\Delta\alpha_1$
*: Profit of manufacturer in RP model; o: Profit of manufacturer in basic model; □: Profit of retailer in RP model; ☆: Profit of retailer in basic model; ◇: Profit of whole supply chain in RP model; +: Profit of whole supply chain in basic model

higher, the traditional retail prices of two models increase fast. That is because the bigger the service value is, the higher the service cost will be caused.

However, the curve of wholesale price rises firstly and then drops slightly. And the profits of retailer and manufacturer also appear the same situation. From the expression of wholesale price, we can find that service value affects w by the part "$\eta\frac{V^2}{2} - v$". We easily calculate it to get the minimum point v = 2 under the situation of $\eta = 0.5$, which just explains the condition of wholesale price curve. Similarly, we can get the

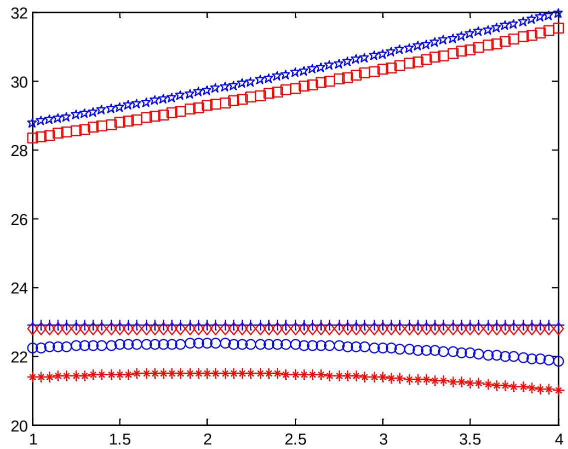


Fig. 7: Impact of service value v
*: Wholesale price of RP model; o: Wholesale price of basic model; □: Traditional retail price of RP model; ☆: Traditional retail price of basic model; ◇: Internet retail price of RP model; +: Internet retail price of basic model

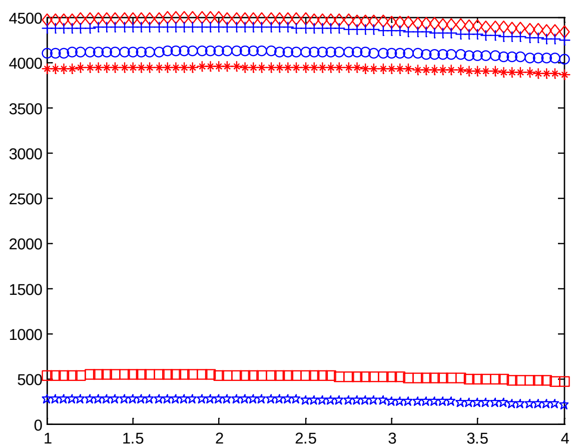


Fig. 8: Impact of service value v
*: Profit of manufacturer in RP model; o: Profit of manufacturer in basic model; □: Profit of retailer in RP model; ☆: Profit of retailer in basic model; ◇: profit of whole supply chain in RP model; +: Profit of whole supply chain in basic model

extreme points of manufacturer and retailer's profit curves. Because good service quality will not only attract more customers to buy product in the traditional channel, but also lead to large service cost. So the retailer must balance the two sides and plan out the optimal sale strategy.

## CONCLUSION

In this study, we set up a dual-channel supply chain model. And the manufacturer sells product to the retailer through the traditional channel and directly to customer through the Internet channel respectively. Different from previous studies, we take the preference of customer and service value into consideration. Based on the preference of customer for different channels, we group the product market into three parts, which is more close to the reality. The manufacturer forecasts the demand for three groups firstly. Then he delivers the suitable quantity of product to retailer and leaves the rest for network sales. The actual demand for product is less than manufacturer's estimate. In order to improve the performance of whole supply chain, we also introduce a return policy in the model, which the retailer can get full-refund on unsold product from manufacturer.

Through numerical simulations, we compare the performance of the Return Policy model with the basic one's. And we draw several practical conclusions from the analyses. Firstly, the higher the self-price sensitive coefficient is, the lower the profit of supply chain will be. Whereas the cross-price sensitive coefficient rises, the competition between two channels will benefit the whole supply chain. Besides that, the risk which the growing fluctuation of market causes can be effectively weakened by the return policy. What's more, the return policy can effectively transfer some profit of supply chain from manufacturer to retailer, which motivates the enthusiasm of retailer and improves the sales volume. As the service value is increasing, the changing trends of wholesale price and supply chain's profit present the form of parabolic curve. According to the particularity of service value, the retailer should efficiently use this factor to attract more customers and earn more profit.

Finally, the models which we develop in this study have some limitations. There are only one manufacturer and one retailer in the model, the actual demand we consider is less than expectation and so on. So there are several extensions of this study that could be considered for future researches. We recommend to other researchers to take the delivery time of Internet channel into consideration, which will actually affect customer's preference. And it is vital to investigate this situation with other coordination mechanisms. Besides that, it is also meaningful to study a multi-period model or multi-retailers and multi-manufacturer model.

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