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Research Article

A Comparative Study of Marketing Channel Multiagent Stackelberg Model Based on Perfect Rationality and Fairness Preference

Kaihong Wang,[1] Xu Yang,[2] Yiwan Sun,[3] and Chuan Ding[1]

[1] *School of Economic Mathematics, Southwestern University of Finance and Economics, Chengdu 610074, China*
[2] *Office of Student Affairs, Southwestern University of Finance and Economics, Chengdu 610074, China*
[3] *School of Economics and Management, Sichuan Agricultural University, Wengjiang, Chengdu 611130, China*

Correspondence should be addressed to Kaihong Wang; wangkaihong@swufe.edu.cn

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This paper studies channel consisting of a manufacturer and two retailers. As a basis for comparison, the first, multiagent Stackelberg model has been structured based on perfect rationality. Further, fairness preference theory will be embedded in marketing channel multiagent Stackelberg model, and the results show that if the retailers have a jealous fairness preference, the manufacturer will reduce the wholesale price, retailers will increase the effort level, product sales will be increased, and the total channel utility and manufacturers' utility will be pareto improvement, but the pareto improvement of retailers' utility is associated with the interval of jealousy fairness preference coefficient. If the retailers have a sympathetic fairness preference, the manufacturer increases wholesale price, retailers reduce the effort level, and the total channel utility, manufacturer's utility, and retailers' utility are less than that of the no fairness preference utility.

1. Introduction

In retail market, manufacturers usually sell their products through multiple retailers; a number of retailers work as sales agents of manufacturers' products, so in this paper we define this channel structure as multiagent; scholars had done substantial research on this channel structure. The research includes some aspects as follows.

First, how to achieve channel coordination. Ingene and Parry studied channel pricing decision based on one manufacturer and two retailers and how manufacturer set price to compel the coordination with two equal retailers [1]. They did not think it was possible to achieve coordination through two-part cost mechanism. However, channel coordination was achieved by special quality discount mechanism. In addition, Ingene and Parry studied the condition where manufacturer distributed goods through multiple independent retailers, who had their own business areas. Manufacturer normally gained higher profit by coordinating every channel with the wholesale price [2]. Xiao et al. researched the coordination problem of one manufacturer and two retailers in the condition of sales promotion and emergency management, and they found that proper price contract would enable the coordination of manufacturer and retailers [3].

Second, how to prevent multiple retailers from collusion. In order to earn more profit, retailers in the downstream of the channel may collude, so prevention mechanism was needed to be built. Tian et al. considered the problem of collusion between retailers in distribution system with one manufacturer and two retailers. They assumed that sales were sensitive to service level and that each retailer's sales volume was affected not only by its own service level, but also by the other retailers. They studied the manufacturer's optimal incentive problem in the case of distributors' noncollusion and the prevention problem in the condition of distributors' collusion. The research showed that when distributors conspired with each other and when the manufacturer had no awareness of it, the manufacturer would pay a greater price,

but the price could be cut down if the manufacturer took preventive measures. However, the profit gained from these two conditions was smaller than that of the condition when retailers did not conspire with each other [4]. The study of Fan and Chen [5] indicated that, regardless of types of channel structures, channel pricing decision was unaffected by the degree of retailer differences. When the cost of the product was higher than the critical value, the wholesale price and the retail price under the collusion of retailers were higher than those under the noncollusion of retailers. The collusion between retailers would benefit the retailers and harm the manufacturer.

Third, retailers had more information, so it was easier for them to know the change of consumers' need and to use different marketing methods according to different consumer groups. On the contrary, the manufacturer on the top of the channel had information inferiority. From the viewpoint of principal-agent theory, the relationship between the manufacturer and the retailers was essentially the principal-agent one. The manufacturer should design incentive mechanism to encourage the retailers hard work and not to hide information. Currently some research results about the manufacturer's and retailers' channel incentive had been achieved, such as what Tian et al. studied [4, 6]. See more details about other research at [7–10].

The results mentioned above were all based on the assumption of perfect rationality. In recent years, many researchers had been doubting this traditional assumption. They believed that at least not all humans' behaviors could be explained by the utility maximization of new classical economics. What is more, sometimes these explanations were not in concert with the reality. Some empirical studies demonstrated that manufacturer and retailers did not make decisions based all on their own utility maximization. In other words, the manufacturer and retailers were not only self-regarded, but also altruistic at times. For example, the empirical research was conducted by Kumar et al. The automotive sales channels in the US and the Netherland showed that trust and fairness were key factors to maintain the channel coordination [11]. Additionally, Kahneman and Knetsch also thought that corporations cared about fairness as well, and fairness played an important role in building and maintaining channel relationship. This was the fairness preference theory in behavioral economics [12], and finally ultimatum game, dictator game, gift exchange game, and trust game lay the foundation for "non-self." Many scholars constructed several fairness preference theoretical models. These fairness preference theoretical models could be divided into two types. One type is that people cared about not only their own material benefit but also others' [13]. The other type was that if one side insisted that the other was goodwill, then it would repay this kindness (good for good). If one side thought that the other was evil, then it would make reprisal (eye for eye) [14]. This outcome provided a strong explanation for altruistic behavior and coordination phenomenon. Using these theories, a few scholars had gotten several results about channel decision problem.

According to the theories mentioned above and the reality of marketing channel, there were reasons to believe that manufacturer and retailers had both self-interest preference and fairness preference, which means they were pursuing both their own profit and the fairness of profit distribution. Fairness preference and self-interest preference also affected the decision-making behaviors. Cui et al. 's [15] and Loch and Wu's [16] studies indicated that applying fairness preference theory to channel research could alleviate the double marginalization and help channels to cooperate with each other. Teck-Hua and Juanjuan's experiment discovered that the efficiency of linear contract was higher than that of two-part tariff contract because of manufacturer's risk aversion and fairness preference [17]. Cui et al. [15] assumed that if demand function was a linear one, they could use the method of theoretical models to prove that linear contract would promote the channel coordination when channel members had fairness preference. Teck-Hua and Juanjuan [17] assumed that demand function was a nonlinear one (exponential function), and the research showed that when retailers had fairness preference, they could realize the goal of channel coordination without strict conditions. Xing et al. [18] studied the influence of channel fairness on manufacturer's and retailers' equilibrium strategy, finding that when retailers' market share was relatively small, manufacturers would not care about whether retail channel was fair. When retailers' market share was relatively large, manufacturer would pay attention to channel fairness preference in order to avoid the punishment that retailers set high retail price. Besides, Wang and Hou [19] used principal-agent model to study the principal-agent problem of two-stage supply chain when retailers had fairness preference. Providing retailers had fairness preference and their maximum and minimum level of effort was predictable; they designed prompting contract of supply chain in the conditions of information symmetry and information asymmetry separately. Du et al. [20] introduced fairness preference to traditional two-stage supply chain, they researched the impact of fairness preference behavior tendency on supply chain contract and coordination. Under the hypothesis that retailers were concerned about fairness, they discussed the effect of retailers' fairness-concern behavior tendency on wholesale contract, revenue sharing contract, and return contract, respectively. Ma [21] studied the supply chain consisting of retailer and manufacturer who had fairness preference. Manufacturer, as the leader in Stackelberg game, provided wholesale price contract to retailers and suggested that fairness preference was a way for retailers to gain supply chain profit distribution.

However, their research was all based on the channel fairness preference decision containing one manufacturer and one retailer, and they did not refer to the condition with one manufacturer and more than one retailer. Usually, in marketing channel, the agent relationship refers to one manufacturer and several retailers because of its universality. For instance, Volkswagen has lots of retailers who buy its various types of cars in a number of big cities. So, based on the channel fairness preference, it is of great practical significance to study the channel agent problem with one manufacturer and several retailers.

As the basis of comparison, first, in the this paper, multi-agent Stackelberg decision model is structured in marketing

channel comprising of a manufacture and a number of retailers based on perfect rationality. Then, under limited rational, fairness preference theory will be embedded in marketing channel multiagent Stackelberg model. First, utility functions of both sides are constructed, and then game theory is used to build models. Finally, this paper compares and analyzes the two models. The result of this paper demonstrates that if the retailer has jealous fairness preference, the total channel utility and manufacturer's utility are pareto improvement, but retailers' utility is pareto improvement associated with the interval of jealousy fairness preference coefficient. If the retailer has sympathy fairness preference, manufacturer's utility and retailers' utility are less than that of the no fairness preference utility.

2. Definition and Assumption

To facilitate the study, we give the symbols and basic assumptions.

Assumption 1. Without loss of generality, this paper studies a manufacturer's product sold by two retailers.

Assumption 2. The manufacturer determines the product's wholesale price w based on product and market without price discrimination. The effort of retailer i is e_i, $i = 1, 2$, and the retail price p of the product is determined by the market. Thus, the relationship between them is shown in Figure 1.

Assumption 3. Sales of retailer i are $q_i = 1 - (1/2)p + e_i - (1/2)e_j$, $i = 1, 2$, $j = 3 - i$, where p is the market price of the product, and the expression of sales is simplified from the literature [22].

Assumption 4. Manufacturer's unit cost is c ($w > c$) and $a > c$ [21], not generally, in order to simplify the model, further assuming that $c = 0$, the variable cost of retailers only includes wholesale prices and the effort costs; other expenses (pavement rent, etc.) can be viewed as fixed costs. To simplify the model, further assumption is that fixed costs are zero.

Assumption 5. Monetary costs of retailers efforts are $c(e) = e^2$, satisfying $c'(e) > 0$ and $c''(e) > 0$.

3. Multiagent Channel Stackelberg Decision Model in Nonfairness Preference

Manufacturer's profit (utility) function is the total profits (utility) by selling products

$$\Pi = \sum_{i=1}^{2} \left[w \left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j \right) \right], \quad i = 1, 2, \ j = 3 - i. \tag{1}$$

Profit of retailers i is as follows:

$$\pi_i = (p - w) \left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j \right) - e_i^2, \quad i = 1, 2, \ j = 3 - i. \tag{2}$$

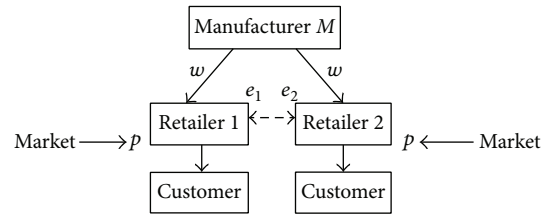

Figure 1: Multiagent channel system.

Equation (2)'s first-order conditions on p are as follows (2):

$$e_i^* = \frac{p - w}{2}. \tag{3}$$

Obviously it can come to the conclusion as follows.

Conclusion 1. In the channel system consisting of a manufacturer and multiple retailers, the efforts which different retailers pay in selling products have positive correlation with the difference between the retail price and the wholesale price of products (products' marginal profit (utility)).

Putting the retailer's reaction function (3) into the manufacturers' profit (utility) function (1), it will be as follows:

$$\max_w 2w - \frac{1}{2}pw - \frac{1}{2}w^2. \tag{4}$$

Manufacturer chooses w for maximized profit (utility). And then expression (4)'s first-order conditions on w are $w^* = 2 - (1/2)p$.

Then we use backward induction, put the result into the retailer's reaction function (3), and get

$$e_i^* = \frac{3}{4}p - 1. \tag{5}$$

So manufacturer and two retailers' profits (utility) are as follows:

$$\begin{aligned} \Pi^* &= \left(1 - \frac{1}{4}p \right) \left(2 - \frac{1}{2}p \right), \\ \pi_i^* &= \left(\frac{3}{4}p - 1 \right) (2 - p), \quad i = 1, 2. \end{aligned} \tag{6}$$

4. Multiagent Channel Stackelberg Decision Model Based on Fairness Preference Theory

4.1. Construction of Retailers' Fairness Preference Utility Function in the Channel. In the study of channel decision-making, the traditional assumption claims that manufacturers and retailers are of purely selfish preferences, where they only pursue the most individual profit instead of concerning the distribution of profit or motivation fairness.

Psychological studies [23–25] had shown that, due to the psychological impact of fairness, when people compared their material gains with others, it would generate additional

psychological effect. When their own material gain was less than others, they would feel jealous, forming jealousy negative utility. However, when their own material gain was higher than others, they would feel proud, forming proudness positive utility.

Based on the assumption, there exists fairness preference in retailers, and the differences, compared with the other retailer's gains, will cause psychological utility; that is to say, retailer i's gain will be compared with the retailer j ($i \neq j$, $i = 1, 2$)'s; thus the retailer's utility is as follows:

$$U_i = \pi_i - k \max\left(\pi_j - \pi_i, 0\right) - k' \max\left(\pi_i - \pi_j, 0\right). \quad (7)$$

On the right side of the equation, the first term represents the retailer i's certainty equivalent value in pure self-care preferences, the second term is the jealousy negative utility due to retailer j's gain being larger than the retailer i's, and the third is the sympathy negative utility because retailer i's gain is larger than the retailer j's, where k and k' are jealous and sympathetic fairness preference coefficient. Fehr and Schmidt's research suggested that jealousy effect was usually stronger than sympathy effect [25–27], which means that k is usually larger than k'; that is, $k' \leq k$, $0 \leq k' < 1$; therefore, the retailer i's utility function is simplified to

$$U_i = \begin{cases} \pi_i - k\left(\pi_j - \pi_i\right), & \pi_i \leq \pi_j, \\ \pi_i - k'\left(\pi_i - \pi_j\right), & \pi_i \geq \pi_j. \end{cases} \quad (8)$$

Putting (2) into (8), it comes to

$$U_i = \begin{cases} (1+k)\left[(p-w)\left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j\right) - e_i^2\right] \\ \quad -k\left[(p-w)\left(1 - \frac{1}{2}p + e_j - \frac{1}{2}e_i\right) - e_j^2\right], \\ \qquad\qquad \pi_i \leq \pi_j, \\ \left(1-k'\right)\left[(p-w)\left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j\right) - e_i^2\right] \\ \quad +k'\left[(p-w)\left(1 - \frac{1}{2}p + e_j - \frac{1}{2}e_i\right) - e_j^2\right], \\ \qquad\qquad \pi_i \geq \pi_j, \quad i = 1, 2, \ j = 3 - i, \end{cases} \quad (9)$$

where $\pi_i = (p-w)(1 - (1/2)p + e_i - (1/2)e_j) - e_i^2$ and $\pi_j = (p-w)(1 - (1/2)p + e_j - (1/2)e_i) - e_j^2$.

4.2. Multiagent Channel Stackelberg Decision Model Based on Retailers with Fairness Preference. Since this paper only considers retailers' fairness preference thinking, retailers choose the effort to maximize their utility. So from (9), it becomes

$$\max_{e_i} U_i = \begin{cases} \max_{e_i} (1+k)\left[(p-w)\left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j\right) - e_i^2\right] \\ \quad -k\left[(p-w)\left(1 - \frac{1}{2}p + e_j - \frac{1}{2}e_i\right) - e_j^2\right], \\ \qquad\qquad \pi_i \leq \pi_j, \\ \max_{e_i} \left(1-k'\right)\left[(p-w)\left(1 - \frac{1}{2}p + e_i - \frac{1}{2}e_j\right) - e_i^2\right] \\ \quad +k'\left[(p-w)\left(1 - \frac{1}{2}p + e_j - \frac{1}{2}e_i\right) - e_j^2\right], \\ \qquad\qquad \pi_i \geq \pi_j, \quad i = 1, 2, \ j = 3 - i. \end{cases} \quad (10)$$

4.2.1. Stackelberg Decision When $\pi_i \leq \pi_j$. When $\pi_i \leq \pi_j$, the first part of (10)'s first-order condition for the sale effort is

$$e_i = \frac{2 + 3k}{4(1+k)}(p - w). \quad (11)$$

Manufacturer's profit (utility) function (1) can become

$$\Pi = \left(2 - p + \frac{1}{2}e_i - \frac{1}{2}e_j\right) w. \quad (12)$$

Put (11) into (12) and get

$$\Pi = 2w - pw + \frac{2 + 3k}{8(1+k)}\left(pw - w^2\right) + \frac{2 + 3k}{8(1+k)}\left(pw - w^2\right). \quad (13)$$

Equation (13)'s first-order condition for the wholesale price is

$$w^{F*} = \frac{8(1+k) - (2+k)p}{2(2+3k)}. \quad (14)$$

Put (14) into (11) to get

$$e_i^{F*} = \frac{(6+8k)p - 8(1+k)}{8(1+k)}. \quad (15)$$

Let the optimal effort and the optimal wholesale price into both sides' profit (utility) functions to get

$$\begin{aligned} \Pi^{F*} &= \left[1 - \frac{p}{4(1+k)}\right] \times \frac{8(1+k) - (2+k)p}{2(2+3k)}, \quad 0 \leq k \leq 1, \\ U_i^{F*} &= \left[\frac{(6+7k)p - 8(1+k)}{2(2+3k)}\right]\left[\frac{4(1+k) - p}{8(1+k)}\right] \\ &\quad - \left[\frac{(6+8k)p - 8(1+k)}{8(1+k)}\right]^2, \quad 0 \leq k \leq 1. \end{aligned} \quad (16)$$

In this case, put the optimal decision variables into retailers' actual profit functions π_i and π_j, and get

$$\begin{aligned}\pi_i^{F*} &= \pi_j^{F*} \\ &= \left[p - \frac{8(1+k) - (2+k)p}{2(2+3k)}\right] \\ &\quad \times \left[1 - \frac{1}{2}p + \frac{(6+8k)p - 8(1+k)}{16(1+k)}\right] \\ &\quad - \left[\frac{(6+8k)p - 8(1+k)}{8(1+k)}\right]^2\end{aligned} \tag{17}$$

so it satisfies $\pi_i \le \pi_j$.

4.2.2. Stackelberg Decision When $\pi_i \ge \pi_j$. When $\pi_i \ge \pi_j$, the second part of (10)'s first-order condition for the sale effort is

$$e_i = \frac{2 - 3k'}{4(1-k')}(p - w). \tag{18}$$

Thus manufacturer's profit (utility) function (1) can be

$$\begin{aligned}\Pi &= 2w - pw + \frac{2-3k'}{8(1-k')}\left(pw - w^2\right) \\ &\quad + \frac{2-3k'}{8(1-k')}\left(pw - w^2\right).\end{aligned} \tag{19}$$

Equation (19)'s first-order condition for the wholesale price is as follows.

$$\widetilde{w}^{F*} = \frac{8\left(1-k'\right) - \left(2-k'\right)p}{2\left(2-3k'\right)}. \tag{20}$$

And then put (20) into (18) to get

$$\widetilde{e}_i^{F*} = \frac{\left(6-8k'\right)p - 8\left(1-k'\right)}{8\left(1-k'\right)}. \tag{21}$$

So in fairness preferences, the manufacturer's and two retailers' actual profit (utility) functions are as follows. In order to make $\widetilde{\Pi}^{F*} \ge 0$, $\widetilde{U}_i^{F*} \ge 0$, sympathy fairness preference factor k' should satisfy $0 \le k' \le (16p - 20)/(24 - 9p)$. Consider

$$\begin{aligned}\widetilde{\Pi}^{F*} &= \left[1 - \frac{p}{4(1-k')}\right] \\ &\quad \times \frac{8\left(1-k'\right) - \left(2-k'\right)p}{2\left(2-3k'\right)}, \quad 0 \le k' \le \frac{16p-20}{24-9p}. \\ \widetilde{U}_i^{F*} &= \left[\frac{\left(6-7k'\right)p - 8\left(1-k'\right)}{2\left(2-3k'\right)}\right]\left[\frac{4\left(1-k'\right) - p}{8\left(1-k'\right)}\right] \\ &\quad - \left[\frac{\left(6-8k'\right)p - 8\left(1-k'\right)}{8\left(1-k'\right)}\right]^2, \quad 0 \le k \le 1.\end{aligned} \tag{22}$$

In this case, put the optimal decision variables into retailers' actual profit (utility) functions π_i and π_j, and get

$$\begin{aligned}\widetilde{\pi}_i^{F*} &= \widetilde{\pi}_j^{F*} \\ &= \left[p - \frac{8\left(1-k'\right) - \left(2-k'\right)p}{2\left(2-3k'\right)}\right] \\ &\quad \times \left[1 - \frac{1}{2}p + \frac{\left(6-8k'\right)p - 8\left(1-k'\right)}{16\left(1-k'\right)}\right] \\ &\quad - \left[\frac{\left(6-8k'\right)p - 8\left(1-k'\right)}{8\left(1-k'\right)}\right]^2\end{aligned} \tag{23}$$

so it satisfies $\pi_i \ge \pi_j$.

5. Comparative Analysis of Two Kinds of Stackelberg Model: Fairness Preference and Nonfairness Preference

In Sections 3 and 4, we establish two Stackelberg models, respectively, under the conditions of fairness preference and nonfairness preference, and the following questions are considered.

(1) How do manufacturers change the wholesale prices of products?

(2) What will affect the optimal efforts made by retailers?

(3) Compared with these models, will the profits or utilities of manufacturer and retailers get pareto improvement after introducing fairness preference?

(4) How does retailers' fairness preference coefficient influence their decision variables?

For the four questions above, a comparative study is made.

5.1. Comparative Analysis of Decision Variables of Two Kinds of Stackelberg Model: Fairness Preference and Nonfairness Preference. In two kinds of Stackelberg model, will the entire marketing system get pareto improvement when retailers have fairness preference? Or does fairness preference make sense? The answers are given as follows in Conclusion 2.

Conclusion 2. If retailers have jealous fairness preference, then the following hold.

(i) When the retail price p of the product meets the requirement that $4/3 < p < 2$, manufacturer will lower the wholesale price; that is, $w^{F*} \le w^*$.

(ii) The two retailers will increase their efforts; that is, $e^{F*} \ge e_i^*$.

Proof. The proof of (i); the wholesale price without fairness preference is $w^* = 2 - (1/2)p$, and when retailers have jealous fairness preference, the wholesale price is $w^{F*} = (8(1+k) - (2+k)p)/2(2+3k)$, and w^{F*} is transformed into

$w^{F*} = 2-(1/2)[(4k+(2+k)p)/(2+3k)]$. So when $4/3 < p < 2$, it holds that $w^{F*} \le w^*$.

The proof of (ii): the optimal effort of retailers without fairness preference is $e_i^* = (3/4)p - 1$, because $e_i^* \ge 0$, $4/3 < p < 4$; so $e_i^{F*} - e_i^* = (((6+8k)p-8(1+k))/8(1+k))-(3/4)p+1 = kp/4(1+k) \ge 0$.

Conclusion 2 shows the thought of preference theory in this paper; when retailers have jealous fairness preferences, they will compare with each other's profits, which is an improved tournament. When others gain more than their own revenue, retailers will increase their efforts to get more profits to reduce income inequality. What is more, if manufacturer is aware that retailers have fairness preferences, manufacturer can lower wholesale prices in a reasonable way and then the two retailers will make more efforts in return. □

Conclusion 3. If retailers have sympathetic fairness preference, then the following hold.

(i) When the retail price p of the product meets the requirements that $4/3 < p < 2$, $2/3 < k' < 1$, manufacturer will raise the wholesale price; that is, $\widetilde{w}^{F*} \ge w^*$.

(ii) The two retailers will decrease their efforts; that is, $\widetilde{e}^{F*} \le e_i^*$.

Proof. The proof of (i): the wholesale price without fairness preference is $w^* = 2 - (1/2)p$. If retailers have sympathy fairness preference, the wholesale price is $w^{F*} = (8(1-k') - (2-k')p)/2(2-3k')$ and w^{F*} is transformed into $\widetilde{w}^{F*} = (8(1-k') - (2-k')p)/2(2-3k') = 2 + ((4k' - (2-k')p)/2(2-3k'))$. So when $4/3 < p < 2$, $2/3 \le k' \le 1$, it holds that $\widetilde{w}^{F*} \ge w^*$.

The proof of (ii): the optimal effort of retailers without fairness preference is $e_i^* = (3/4)p - 1$, because $e_i^* \ge 0$, $4/3 < p < 4$; it holds that $\widetilde{e}_i^{F*} - e_i^* = (((6-8k')p - 8(1-k'))/8(1-k')) - (3/4)p + 1 = -2k'p/8(1-k') \le 0$.

Conclusion 3 shows that if a retailer's revenue is higher than the other retailer's one, usually a feeling of sympathy is produced, which is sympathetic fairness preference. For its revenue is higher than the other's, the retailer may feel that it has got a lot of revenue, resulting in slack work and reduced efforts. So, in order to punish the lazy behavior of retailers, manufacturer may raise wholesale prices. This is the idea of mutually reciprocity fairness preference. □

Conclusion 4. If retailers have jealous fairness preference, then sales of product will increase. If the two retailers both have sympathetic fairness preference, sales of product will decrease.

The correctness of Conclusion 4 lies in that, without fairness preference, $q_i^* = 1 - (1/2)p + e^*$. In the situation with jealous fairness preference, $q_i^{F*} = 1 - (1/2)p + e^{F*}$. Based on Conclusion 2, in the situation with jealous fairness preference, marketing efforts increase by $(e^{F*} \ge e_i^*)$, so, $q_i^{F*} \ge q_i^*$. In the situation with sympathetic fairness preference, $\widetilde{q}_i^{F*} = 1 - (1/2)p + \widetilde{e}^{F*}$. Based on Conclusion 3, in the situation with sympathetic fairness preference, marketing efforts decrease by $(\widetilde{e}^{F*} \le e_i^*)$, so, $\widetilde{q}_i^{F*} \ge q_i^*$.

Conclusion 5. If retailers have jealous fairness preference, the following hold.

(i) Manufacturer's utility is not less than the profits gained when there is no fairness preference; that is, $\Pi^{F*} \ge \Pi^*$.

(ii) When jealous fairness preference coefficient k meets the requirement that $0 \le k \le k_1$, retailers' utility is not less than the profits gained when there is no fairness preference; that is, $U_i^{F*} \ge \pi_i^*$.

(iii) When jealous fairness preference coefficient k meets the requirement that $k_1 \le k \le 1$, retailer's utility is not more than the profits gained when there is no fairness preference; that is, $U_i^{F*} \le \pi_i^*$.

In the conclusion,

$$k_1 = \frac{32 - 15p^2 - p\sqrt{33p^2 - 128p + 128}}{32 + 8p - 24p^2}. \tag{24}$$

Proof. Because $4/3 < p < 2$, $0 \le k \le 1$,

$$\begin{aligned}
\Pi^{F*} - \Pi^* &= \left[1 - \frac{p}{4(1+k)}\right]\left[\frac{8(1+k)(2+k)p}{2(2+3k)}\right] \\
&\quad - \left(1 - \frac{1}{4}p\right)\left(2 - \frac{1}{2}p\right) \\
&\ge \left[1 - \frac{p}{8}\right]\left[\frac{8(1+k)(2+k)p}{2(2+3k)}\right] \\
&\quad - \left(1 - \frac{1}{4}p\right)\left(2 - \frac{1}{2}p\right) \\
&\ge \left[1 - \frac{p}{8}\right]\left[\frac{16p}{2(2+3k)}\right] - \left(1 - \frac{1}{4}p\right)\left(2 - \frac{1}{2}p\right) \\
&\ge \left[1 - \frac{p}{8}\right]\left[\frac{8p}{5}\right] - \left(1 - \frac{1}{4}p\right)\left(2 - \frac{1}{2}p\right) \\
&= p\left(\frac{13}{5} - \frac{3}{40}p\right) \ge p\left(\frac{5}{2}\right) \ge 0.
\end{aligned} \tag{25}$$

Also because

$$\begin{aligned}
U^{F*} - \pi_i^* &= \left[\frac{(6+7k)p - 8(1+k)}{2(2+3k)}\right]\left[\frac{4(1+k) - p}{8(1+k)}\right] \\
&\quad - \left[\frac{(6+8k)p - 8(1+k)}{8(1+k)}\right]^2 \\
&\quad - \left(\frac{3}{4}p - 1\right)(2-p).
\end{aligned} \tag{26}$$

Defining $U^{F*} - \pi_i^* = 0$, the results making use of *Matlab* are

syms $p\,k$

$$\begin{aligned} y = {} & \frac{[(6+7*k)*p-8*(1+k)]}{[2*(2+3*k)]} \\ & * \frac{[4*(1+k)-p]}{[8*(1+k)]} \\ & - \frac{[(6+8*k)*p-8*(1+k)]}{[8*(1+k)]} \\ & * \frac{[(6+8*k)*p-8*(1+k)]}{[8*(1+k)]} \\ & - \left(\frac{3}{4}*p-1\right)*(2-p); \\ \gg {} & \operatorname{solve}(y,k), \end{aligned} \tag{27}$$

Finding that

$$\begin{aligned} k &= \frac{32-15p^2-p\sqrt{33p^2-128p+128}}{32+8p-24p^2}, \\ k &= \frac{15p^2-32+p\sqrt{33p^2-128p+128}}{32+8p-24p^2}, \end{aligned} \tag{28}$$

(because $0 \le k \le 1$, $4/3 \le p \le 2$, reject the negative root). When

$$0 \le k \le \frac{32-15p^2-p\sqrt{33p^2-128p+128}}{32+8p-24p^2}, \tag{29}$$

$U_i^{F*} - \pi_i^* \ge 0$; that is $U_i^{F*} \ge \pi_i^*$; when

$$\frac{32-15p^2-p\sqrt{33p^2-128p+128}}{32+8p-24p^2} \le k \le 1, \tag{30}$$

$U_i^{F*} - \pi_i^* \le 0$; that is $U_i^{F*} \le \pi_i^*$.

Two points should be added about Conclusion 5.

At first, manufacturer's profit or utility can get pareto improvement, for that when one retailer has a tendency of jealous fairness preference and the other retailer's profits or utilities are higher than its, it will make more efforts to reduce the differences between them and further raise the sales, so that the manufacturer's profit or utility increases. Retailers get a fair deal, which makes retailers work harder to sell products or according to Conclusion 2, raises their level of effort and then increases the sales.

Secondly, for retailers, when jealous fairness preference coefficient is small, retailers' utility is higher than the utility in the situation with fairness preference for manufacturers' lowering wholesale prices result in increased profits, but too much jealousy can result in higher retailers' jealousy disutility, which will offset the profits brought by lowering wholesale prices. □

Conclusion 6. If retailers have sympathetic fairness preference, utilities of both manufacturer and retailers are not higher than the utility in the situation without fairness preference; that is, $\widetilde{\Pi}^{F*} \le \Pi^*$, $\widetilde{U}_i^{F*} \le \pi_i^*$.

Proof. Because $4/3 \le p \le 2$, $0 \le k' \le 1$,

$$\begin{aligned} \Pi^* - \widetilde{\Pi}^{F*} &= \left(1-\frac{1}{4}\right)\left(2-\frac{1}{2}p\right) \\ &\quad - \left[1-\frac{p}{4(1-k')}\right]\left[\frac{8(1-k')-(2-k')p}{2(2-3k')}\right] \\ &\ge \left(1-\frac{1}{4}\right)\left(2-\frac{1}{2}p\right) \\ &\quad - \left[1-\frac{p}{4(1-k')}\right]\left[\frac{4-p}{2(2-3k')}\right] \\ &\ge \left(1-\frac{1}{4}\right)\left(6-\frac{3}{2}p\right) \ge 0, \\ \pi_i^* - \widetilde{U}_i^{F*} &= \left(\frac{3}{4}p-1\right)(2-p) \\ &\quad - \left[\frac{(6-7k')p-8(1-k')-p}{8(1-k')}\right] \\ &\quad + \left[\frac{(6-8k')p-8(1-k')}{8(1-k')}\right]^2 \\ &\ge \left(\frac{3}{4}p-1\right)(2-p) \\ &\quad - \left[\frac{(6-7k')p-8(1-k')-p}{8(1-k')}\right] \\ &\ge \left(\frac{3}{4}p-1\right)(2-p)+3p\frac{(4-p)}{8} \\ &= \frac{1}{8}\left(32p-16-9p^2\right). \end{aligned} \tag{31}$$

Because $4/3 \le p \le 2$, $32p-16-9p^2 \ge 0$, and $\pi_i^* - \widetilde{U}_i^{F*} \ge 0$.

According to Conclusions 5 and 6, we can see the meaning of fairness preference in this paper. Based on their results, fairness preference includes the thought of jealous fairness preference and the thought of sympathetic fairness preference. We can see that if the other retailer's profit is higher, then the retailer will make more efforts to narrow the differences between the two. At that time, the manufacturer will be concerned about the concerns of retailers and lower wholesale prices in a reasonable way to improve the utilities of himself and the entire channel. But the feeling of sympathy is harmful for multicompetition channel because when the retailer's profit is higher than the other retailer's profit, it will produce complacency and lack of competitive pressure and then tend to reduce work efforts, which is detrimental to the channel members. □

5.2. Analysis of the Impact of Fairness Preference Coefficients k and k' on Decision-Making. In fairness preference theory, fairness preference coefficient is a very important parameter and has an important impact on the entire decision-making process. So this section mainly analyzes the impact of fairness preference coefficients k and k' on decision-making.

Conclusion 7. In a channel system consisting of multiple retailers, if the retailers have a jealous fairness preference, then the following hold.

(i) Retailer's effort increases as the fairness preference increases.

(ii) The wholesale price increases as the fairness preference increases.

(iii) The utility of manufacturer increases as fairness preference coefficient increases.

(iv) When jealous fairness preference coefficient k meets the requirements that $0 \le k \le k_2$, the utility of retailers increases as fairness preference coefficient increases. When $k_2 \le k \le 1$, the utility of retailers decreases as fairness preference coefficient increases. In these conclusions,

$$k_2 = \frac{64 - 72p^2 - 48p + 4\sqrt{248p^4 + 222p^3 - 296p^2}}{2\left(19p^2 + 24p - 32\right)}. \quad (32)$$

Proof. The proof of Conclusion 7's (i): $\partial e_i^{F*}/\partial k = p/4(1+k)^2 \ge 0$.

The proof of Conclusion 7's (ii):

$$\begin{aligned} \frac{\partial w_i^{F*}}{\partial k} &= \frac{(8-p)(2+3k) + (6+3k)p - 24(1+k)}{2(2+3k)^2} \\ &= \frac{1+2p}{(2+3k)^2} \ge 0. \end{aligned} \quad (33)$$

The proof of Conclusion 7's (iii):

$$\begin{aligned} &\frac{\partial \Pi^{F*}}{\partial k} \\ &= \frac{8\left(5p-4\right)(1+k)^2 - p^2\left(3k^2 + 12k + 8\right)}{8(1+k)^2(2+3k)^2} \\ &= \left(\left(40p - 32 - 3p^2\right)k^2 + \left(40p - 32 - 8p^2\right)\right. \\ &\qquad \left. +2\left(40p - 32 - 8p^2\right)k\right)\left(8(1+k)^2(2+3k)^2\right)^{-1} \\ &\ge \left(\left(40p - 32 - 9p^2\right)k^2 + \left(40p - 32 - 9p^2\right)\right. \\ &\qquad \left. +2\left(40p - 32 - 8p^2\right)k\right)\left(8(1+k)^2(2+3k)^2\right)^{-1} \\ &\ge \frac{\left(40p - 32 - 9p^2\right)(k+1)^2}{8(1+k)^2(2+3k)^2} = \frac{40p - 32 - 9p^2}{8(1+k)^2(2+3k)^2}. \end{aligned} \quad (34)$$

Because $4/3 \le p \le 2$, $40p - 32 - 9p^2 \ge 0$, and $\partial \Pi^{F*}/\partial k \ge 0$.

The proof of Conclusion 7's (iv):

$$\begin{aligned} U_i^{F*} = &\left[\frac{(6+7k)p - 8(1+k)}{2(2+3k)}\right]\left[\frac{1}{2} - \frac{p}{8(1+k)}\right] \\ &- \left[\frac{(6+8k)p}{8(1+k)} - 1\right]^2. \end{aligned} \quad (35)$$

Marking

$$\begin{aligned} f_1(k) &= \left[\frac{(6+7k)p - 8(1+k)}{2(2+3k)}\right]\left[\frac{1}{2} - \frac{p}{8(1+k)}\right], \\ f_2(k) &= -\left[\frac{(6+8k)p}{8(1+k)} - 1\right]^2, \\ &\qquad (0 \le k \le 1), \end{aligned} \quad (36)$$

so $U_i^{F*} = f_1(k) + f_2(k)$, because $f_2(k)$ is monotone decreasing with k; so only the monotonicity of $f_1(k)$ is needed to be discussed:

$$\begin{aligned} &\frac{\partial f_1(k)}{\partial k} \\ &= \left[(32 - 24p) + 2(32 - 24p)k + (32 - 24p)k^2\right. \\ &\qquad \left. -16P^2 - 36p^2k - 19p^2k^2\right]\left(16(2+3k)^2(1+k)^2\right)^{-1} \\ &= \left[\left(32 - 24p - 19p^2\right)k^2 + 2\left(32 - 24p - 36p^2\right)k\right. \\ &\qquad \left. + \left(32 - 24p - 16p^2\right)\right]\left(16(2+3k)^2(1+k)^2\right)^{-1}. \end{aligned} \quad (37)$$

When

$$0 \le k \le \frac{64 - 72p^2 - 48p + 4\sqrt{248p^4 + 222p^3 - 296p^2}}{2\left(19p^2 + 24p - 32\right)}, \quad (38)$$

$\partial f_1(k)/\partial k \ge 0$, it is monotone increasing.

When

$$\frac{64 - 72p^2 - 48p + 4\sqrt{248p^4 + 222p^3 - 296p^2}}{2\left(19p^2 + 24p - 32\right)} \le k \le 1, \quad (39)$$

$\partial f_1(k)/\partial k \le 0$, it is monotone decreasing. □

Conclusion 8. In a channel system consisting of multiple retailers, if the retailers have a sympathetic fairness preference, and sympathetic fairness preference coefficient meets the requirements that $0 \le k' \le (16p-20)/(24-9p)$, then the following hold.

(i) Retailer's effort decreases as the fairness preference increases.

(ii) The wholesale price increases as the fairness preference increases.

(iii) The utility of manufacturer increases as fairness preference coefficient increases.

(iv) The utility of retailer decreases as fairness preference coefficient increases.

Proof. The proof of Conclusion 8's (i): $\partial \widetilde{e}_i^{F*}/\partial k' = -k/4(1+k)^2 \le 0$.

The proof of Conclusion 6's (ii):

$$\frac{\partial \widetilde{w}_i^{F*}}{\partial k'} = \frac{(8-p)\left(2-3k'\right)+\left(6-3k'\right)p-24\left(1-k'\right)}{2\left(2-3k'\right)^2} = \frac{4-2p}{\left(2-3k'\right)^2} \ge 0. \tag{40}$$

The proof of Conclusion 6's (iii):

$$\begin{aligned}\frac{\partial \widetilde{\Pi}^{F*}}{\partial k'} &= \frac{8\left(5p-4\right)\left(1-k'\right)^2-p^2\left(3k'^2-12k'+8\right)}{8\left(1-k'\right)^2\left(2-3k'\right)^2} \\ &\le \left(\left(16p-32-3p^2\right)k'^2+\left(16p-32-3p^2\right)\right. \\ &\quad \left.-\left(16p-32-3p^2\right)k'\right)\left(8\left(1-k'\right)^2\left(2-3k'\right)^2\right)^{-1} \\ &\le \frac{\left(16p-32-3p^2\right)\left(1-k'\right)^2}{8\left(1-k'\right)^2\left(2-3k'\right)^2} = \frac{\left(16p-32-3p^2\right)}{8\left(2-3k'\right)^2}.\end{aligned} \tag{41}$$

Because $4/3 \le p \le 2$, $16p-32-3p^2 \le 0$, and $\partial \widetilde{\Pi}^{F*}/\partial k' \le 0$.

The proof of Conclusion 6's (iv):

$$\widetilde{U}_i^{F*} = \left[\frac{\left(6-7k'\right)p-8\left(1-k'\right)}{2\left(2-3k'\right)}\right]\left[\frac{4\left(1-k'\right)-p}{8\left(1-k'\right)}\right] - \left[\frac{\left(6-8k'\right)p}{8\left(1-k'\right)}-1\right]^2. \tag{42}$$

Marking

$$g_1\left(k'\right) = \left[\frac{\left(6-7k'\right)p-8\left(1-k'\right)}{2\left(2-3k'\right)}\right]\left[\frac{4\left(1-k'\right)-p}{8\left(1-k'\right)}\right], \quad g_2\left(k'\right) = -\left[\frac{\left(6-8k'\right)p}{8\left(1-k'\right)}-1\right]^2, \tag{43}$$

so $\widetilde{U}_i^{F*} = g_1(k') + g_2(k')$. Because $g_2(k')$ is monotone decreasing with k', only the monotonicity $g_1(k') = [((6-7k')p-8(1-k'))/2(2-3k')][(4(1-k')-p)/8(1-k')]$ with k' is needed to be studied. Because $0 \le k \le (16p-20)/(24-9p)$, $4/3 \le p \le 2$, it is easy to get that $\partial g_1(k')/\partial k' \le 0$. So $\widetilde{U}_i^{F*} = g_1(k') + g_2(k')$ with k' is monotone decreasing. □

6. Channel Management Inspiration and Practical Significance

Since the assumption of perfect rationality of channel members is difficult to achieve coordination in practice, it is more reasonable to assume that manufacturer and retailers are bounded rationality. It is easy to form a fairness preference in a long-term sales relationship between manufacturer and retailers. In particular, when the retailers are at the same level, they will concern about the profit of each other, thus affecting their behaviors.

Through the model analysis, we prove the importance of fair preference theory implanted channels Stackelberg decisions. When retailers have jealousy fairness thinking, they will increase effort level to reduce the inequality between them two. The manufacturers should reduce wholesale prices to encourage retailers to work harder. If the manufacturers give more humane care to the retailers, like giving retailers a lower wholesale price, taking a part of the promotion expenses, and offering to defer ordering cost or taking the initiative to guarantee helping retailers to obtain loans from financial institutions when the retailers' turnover is tense, reciprocal action of these series will not reduce the profits of the manufacturer; on the contrary, it stimulates the retailer's gratitude, so the retailers will try harder to sell products, will protect the manufacturers' reputation, and will not damage the brand of manufacturers as return. In practice, manufacturers and retailers should pay attention to each other's "concern." The appropriate transfer a portion of the profit to each other let the marketing channel more "harmonious," this is, the pareto improvement of channel members.

But if a retailer's profit is greater than other retailers', the retailer will have empathy that is detrimental to many sources of competition, because in this situation, the retailer will have psychological complacency, lack of competitive pressure, and thus ease to slack off work to reduce the effort. It is disadvantageous for channel members. So manufacturers should be appropriate to balance the profits of retailers, making the channels become more harmonious.

7. Conclusions and Future Research

The problem of principal: multiagents in channel have important theoretic and practical meanings. In this paper, first the multiagent Stackelberg model is built; then the fairness preference theory in economy is used to study the Stackelberg decision problem in marketing channel, structuring multiagent channel Stackelberg decision models with fairness preference thinking. The main conclusions are as follows.

First, in the channel system constructing by a manufacturer and multiple retailers, under the condition of no fairness preference, the higher the product's marginal profit, the more the retailers' effort.

Second, in the channel system including a number of retailers, if retailers have jealousy fairness preference, the retailers' effort will increase with the fairness preference condition. When jealousy fairness preference meets the certain

range, the retailers' utility will increase with the rise of fairness preference coefficient, but within other certain range the result is vice verse.

Third, in the channel system of several retailers, if retailers have sympathy fairness preference, and the sympathy fairness preference coefficient reaches a certain range, the retailers' effort will decrease with the decline of fairness preference degree. The wholesale price will be higher with the raise of fairness preference.

This paper uses fairness preference theory to study the channel multiagent problem, which is a preliminary attempt. Even though some meaningful results have been achieved, more problems deserve more research.

First, nowadays, consumers are more and more pursuing personality and fashion, unusual and out of ordinary. The channel members must meet the change of the consumers' needs, and only in this way can they adapt to the fierce competition of market environment and gain and maintain their desire market position. So it worth further research to bring customers into channel multiagent model, leading to the multichannel and multiagent problem.

Second, our models focus on the agent problem of multiple agents in one market, but there exists one important problem referring to multiagent problem, that is, conspiracy and anticollusion. An optional contract should be of anticollusion.

Third, this paper only studies the channel with one manufacturer and two retailers, not mentioning the Stackelberg decision problem in other channel structures, such as the channel of several manufacturers and one retailers and of multiple manufacturers and several retailers. We can predict that the model will be quite complex when researching these three channel with the theory of fairness preference.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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