

Optimal Pricing Strategies and Computer Simulation of DCSC with Fairness Preference and Risk-Aversion Members

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Abstract

Firstly, this paper develop a basic two-echelon DCSC model as the comparative benchmark in the general case of the stochastic demand effected by the service level of the retailer, where the manufacturer's optimal direct price, wholesale price and the retailer's optimal retail price were achieved under Stackelberg game. Then, through incorporate the fairness preference and risk-aversion characteristics into the basic DCSC model, the manufacturer's optimal direct price, wholesale price and the retailer's optimal retail price were obtained under Stackelberg game. At last, by the numerical simulation, the effect of fairness preference and risk aversion level on the optimal pricing strategies and utility of DCSC was examined respectively. The results show that for a DCSC with fairness preference and risk aversion members, the manufacturer and the retailer will choose a reduced price to avoid income risk even if the market demand is stable. Although the decision makers can realize the improvement of their own utility in some circumstances, the utility of the whole supply chain always presents decreasing.

Keywords: dual-channel supply chain (DCSC), pricing strategies, fairness preference, risk-aversion, service level, computer Simulation

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1. Introduction

In real life, the theory of behavior science and a series of game tests always emphasized that besides people's selfish preference, people also have a fairness preference, and people not only concern their own material income, but also focus on whether the distribution result of their material income is fair or not [1-2]. There has been many documents incorporate the concept of fairness into the behavioral decision game and incentive mechanism of principal-agent problem at present [3-5]. On the other hand, the risk attitude of different decision subjects to market income risk is different. For example, the supply chain member who has a risk aversion attitude will choose conservative decision, but the risk preference members are usually pursuing the higher-risk and higher-yielding.

However, the documented literatures on DCSC at home and abroad mainly focus on the hypothesis of "rational economic man" and without consider people's behavior psychological factors, such as fairness preference, risk aversion attitude. Therefore, the previous research results do not real reflect the reality of supply chain management behavior and can not guide management practice effectively. So the research of DCSC based on behavior psychological factors becomes an important theoretical and practical problem and needs further development [6].

Given the real present and importance of behavior psychological factors in decision-making process of business contexts (including channel relationship), theorists and practitioners have called attention to the fairness preference and risk attitude of decision-makers. Increasing interest, more and more researchers, center on the pricing strategies and contracting mechanisms based on the behavior factors and extend previous analytical models in the traditional single retail channel supply chain management field. For instant, Cui [7] pointed out that no matter only the retailer concerns fairness, or both sides pay attention to fairness, a coordinating wholesale price contract can be designed with the linear demand. That is to say, the "double marginalization problem" can be eliminated, even though the supply chain members have fairness preference. Demirag [8] extend the results of Cui [7]. They

pointed out that comparing to linear demand function, the coordination conditions of a linear wholesale price under index demand function are relatively loose when only the retailer concerns fairness. Ho and Zhang [9] conducted a laboratory experiment to test whether the laboratory results consistent with the analytical predictions when the fixed fee was introduced to incentive channel efficiency. Surprisingly, the introduction of the fixed fee fails to increase channel efficiency because of the loss aversion of decision-makers.

In the context of DCSC, the behavior psychological factors of decision-makers may be appear more obvious. However, the literatures considering the behavior psychological factors of decision-makers in DCSC are very few. For a supply chain with a risk averse supplier and a risk averse retailer, Wang and Zhou [10] discussed the optimal direct price, retail price and the added value under centralized decision. They pointed out that the risk aversion of supply chain members lessening their optimal price. Li [11] constructed a two-level DCSC model considered the members' risk attitude and found that the optimal direct channel price and optimal retail price is influenced by risk aversion of two parties. But their model did not consider the effect of the retailer's service level on market demand. The studies of Xing [12] showed that when the retailer's market share is lesser, the manufacturer will not pay attention to whether the retailer feels fair or not; When the retailer's market share is larger, the manufacturer will focus on channel fairness to avoid the punishment from the retailer by setting higher retail price. In addition, the channel fairness can improve the "double marginalization problem" effectively. But the model they established is very simple and did not consider the effect of the retailer's effort factor on market demand.

It is clear that the existing literatures considering the fairness preference and risk aversion are very few. So the theory research that the effect of people's behavior psychological factors on decision-making in business relationships and channel relationships needs to be strengthened. In this paper, we incorporate the concept of fairness and risk aversion into the two-echelon DCSC to investigate how fairness preference and risk aversion affect the pricing strategies of both parties under Stackelberg master-slave game model. We assume the market demand is stochastic and effected by the service level of the retailer. As a first step, the manufacturer's optimal direct price, wholesale price and the retailer's optimal retail price were achieved under basic DCSC model. Then, through introduce the fairness preference and risk aversion characteristics into the basic DCSC model, the manufacturer's optimal direct price, wholesale price and the retailer's optimal retail price were analyzed. At last, the effect of fairness preference and risk aversion level on optimal pricing strategies and utility of DCSC was examined through the numerical example.

2. The Basic Model of DCSC

2.1. The Model Description

In the DCSC, the manufacturer (he) selling products to customer not only through the retailer (she) but also the direct channel (online sales by himself). Assume that the total market demand function of the product is $A = a + \varepsilon$, $\varepsilon \sim N(0, \sigma^2)$, a represents the basic market demand scale (Wang and Zhou, 2009). Let w be the manufacturer's wholesale price, c_s be the per unit production cost, p_r be the retail price of the retailer, p_e be the direct price. If the market demand scale is fixed, then the addition of direct channel by manufacturer will reduce the retailer's market share. In addition, the market demand of both bodies is closely related to their sales price and the retailer's service level. Therefore, supposing the market demand function of direct channel is given as follows:

$$d_e = (1 - \theta)A - b_1 p_e + \delta_1 p_r - \gamma_1 v \quad (1)$$

The market demand function of retail channel is given by:

$$d_r = \theta A - b_2 p_r + \delta_2 p_e + \gamma_2 v \quad (2)$$

In Equation (1) and Equation (2), θ represents the allocation proportion of product market aggregate demand in retail channel, $0 \leq \theta \leq 1$. Let b_i be the price elasticity of demand, δ_j be the cross price sensitivity, v be the retailer's service level, γ_j be the service elasticity of

demand. In addition, without loss of generality, we assume b_i , δ_j , and γ_j are greater than zero, $b_i > \delta_j$ and $b_i > \gamma_j$, $i=1,2$, $j=1,2$. The total service cost of the retailer under given service level is $C(v) = \eta v^2 / 2$. Differ to literature [13], we presume v is exogenous for the derivation of the necessary analytic expression. In addition, for ease of calculation and analysis, supposing $b_1 = b_2 = b$, $\delta_1 = \delta_2 = \delta$, $\gamma_1 = \gamma_2 = \gamma$.

According to Equation (1), Equation (2) and above hypothesis, we have the retailer's expected profit function as follows,

$$\begin{aligned} E[\pi_r] &= E[(p_r - w)d_r - C(v)] \\ &= (p_r - w)(\theta a - bp_r + \delta p_e + \gamma v) - \eta v^2 / 2 \end{aligned} \quad (3)$$

The manufacturer's expected profit function is:

$$\begin{aligned} E[\pi_m] &= E[(w - c_m)d_r + (p_e - c_m)d_e] \\ &= (w - c_m)(\theta a - bp_r + \delta p_e + \gamma v) \\ &\quad + (p_e - c_m)[(1 - \theta)a - bp_e + \delta p_r - \gamma v] \end{aligned} \quad (4)$$

The expected profit function of whole supply chain is:

$$\begin{aligned} E[\pi_{sc}] &= E[(p_r - c_m)d_r + (p_e - c_m)d_e - C(v)] \\ &= (p_r - c_m)(\theta a - bp_r + \delta p_e + \gamma v) \\ &\quad + (p_e - c_m)[(1 - \theta)a - bp_e + \delta p_r - \gamma v] - \eta v^2 / 2 \end{aligned} \quad (5)$$

2.2. Stackelberg Game Decision-Making

We take the assumption that the manufacturer is dominant in the supply chain. The sequence of Stackelberg game as follows: the manufacturer first to determine the direct price and wholesale price, then the retailer according to the observed information to identify the retail price. Using the reverse-derivation method, the retailer determines the retail price at the assumption of the known decision information of the manufacturer in the second stage. In the first stage, the manufacturer fully knows the retailer's decision information and based on which, the optimal direct price and wholesale price were determined. In the following analysis, in order to simplify the analysis, we think that there is only one optimal solution as long as the second-order of objective function is negative.

2.2.1. The Retailer's Optimal Decision

Under Stackelberg master-slave game, the first-order of the retailer's expected profit function in p_r is:

$$\frac{\partial E[\pi_r]}{\partial p_r} = \theta a - 2bp_r + \delta p_e + \gamma v + bw \quad (6)$$

It is easily to know that $\partial^2 E[\pi_r] / \partial p_r^2 = -2b < 0$, therefore, the retailer exists a unique optimal retail price p_r^{oo} . Ordering Equation (6) is equal to zero, the optimal retail price in p_e and w is given by:

$$p_r^{oo}(p_e, w) = \frac{\theta a + \delta p_e + \gamma v + bw}{2b} \quad (7)$$

Theorem 1 $\frac{\partial p_r^{oo}}{\partial p_e} = \frac{\delta}{2b} > 0$, $\frac{\partial p_r^{oo}}{\partial w} = \frac{1}{2} > 0$

Theorem 1 shows that the optimal retail price appears increasing with the increase of the direct price and the wholesale price. If the manufacturer's wholesale price increases one

unit, the optimal retail price will increase one-half unit; if the direct price increase one unit, the optimal retail price will increase less than one-half unit. Therefore, when the manufacturer in a leadership position, he can manipulate the retail price through adjusting the wholesale price and direct price, which affecting the retailer's income and make himself own gain the biggest share of the supply chain benefits.

2.2.2. The Manufacturer's Optimal Decision

Under Stackelberg master-slave game, the first-order of the manufacturer's expected profit function in p_e and w are given below:

$$\begin{aligned} \frac{\partial E[\pi_m]}{\partial p_e} &= \delta w + (b - \delta)c_m + [\delta(p_e - c_m) \\ &- b(w - c_m)] \frac{\delta}{2b} + (1 - \theta)a - 2bp_e + \delta p_r^{oo} - \gamma v \end{aligned} \quad (8)$$

$$\begin{aligned} \frac{\partial E[\pi_m]}{\partial w} &= \theta a - bp_r^{oo} + \delta p_e + \gamma v \\ &+ \frac{\delta(p_e - c_m) - b(w - c_m)}{2} \end{aligned} \quad (9)$$

From the above assumptions, we have $\partial^2 E[\pi_m] / \partial p_e^2 = (\delta^2 - 4b^2) / 2b < 0$ and $\partial^2 E[\pi_m] / \partial w^2 = -b / 2 < 0$. So, there is only a group of optimal equilibrium solution of the manufacturer. Substituting Equation (7) to Equation (8), Equation (9) and ordering Equation (8) and Equation (9) are equal to zero, we can get the optimal direct price and wholesale price are:

$$p_e^{oo}(w) = \frac{a(\delta\theta + 2b - 2b\theta) + b\delta(2w - c_m) - \gamma v(2b - \delta) + c_m(2b^2 - \delta^2)}{2(2b^2 - \delta^2)} \quad (10)$$

$$w^o(p_e) = \frac{\theta a + 2\delta p_e + \gamma v + c_m(b - \delta)}{2b} \quad (11)$$

According to Equation (7), Equation (10) and Equation (11), the equilibrium solution of Stackelberg master-slave game as follows:

$$\begin{cases} p_e^{oo} = \frac{a(\delta\theta + b - b\theta) - \gamma v(b - \delta) + c_m(b^2 - \delta^2)}{2(b^2 - \delta^2)} \\ w^o = \frac{a(\delta + b\theta - \delta\theta) + \gamma v(b - \delta) + c_m(b^2 - \delta^2)}{2(b^2 - \delta^2)} \\ p_r^{oo} = \frac{\delta p_e^{oo}}{b} + \frac{3\theta a + 3\gamma v + c_m(b - \delta)}{4b} \end{cases} \quad (12)$$

- Theorem 2** (i) $\frac{\partial p_r^{oo}}{\partial \theta} > 0$, $\frac{\partial p_r^{oo}}{\partial v} > 0$;
(ii) $\frac{\partial p_e^{oo}}{\partial \theta} < 0$, $\frac{\partial p_e^{oo}}{\partial v} < 0$;
(iii) $\frac{\partial w^o}{\partial \theta} > 0$, $\frac{\partial w^o}{\partial v} > 0$.

Theorem 2 shows that the optimal retail price is increasing with the increase of the retailer's market share and service level, however, the optimal direct price appears decreasing. Clearly, the optimal wholesale price is also increasing with the increase of the retailer's market share and service level. This is because when the market share and service level of the retail channel increasing gradually, the retailer will improve the retail price, however, the

manufacturer complete knowledge the retailer's decision information. Therefore, when observing the retailer's markup behavior, the manufacturer also will enhance the wholesale price accordingly so that sharing the retailer's increased income for markup. However, there is a competition relation between the direct channel and the retail channel, therefore, when the direct channel's market share and service level are at a disadvantage position, the manufacturer will choose the low direct price in order to improve the sales of the direct channel and get a maximum expected earnings.

3. The Dcsc Model of Fairness Preference and Risk Aversion

3.1. The Model Description

The retailer who has distinguishing fairness preference psychology in the selling terminal of the entire supply chain and closer to customers, is a natural person in many cases; the manufacturer as a company organization whose fairness preference psychology is not obvious. Therefore, taking the assumption that the retailer concerns fairness and the manufacturer is fairness neutral. The retailer always takes the manufacturer's profit for reference and weighs up whether she obtains fair outcome. Based on this, we adopt the fairness preference utility function Du [14] has used. Let $\alpha > 0$ be the fairness preference level. Algebraically, we have then:

$$U^f(\pi) = E[\pi_r] - \alpha E[(\pi_m - \pi_r)] \quad (13)$$

Equation (13) Shows that only when the retailer's material income is less than the manufacturer's, the retailer will occur the utility-losing, and the utility-increasing conversely. Divide Equation (13) by $(1 + \alpha)$, then the fairness preference utility function is given by:

$$U_r^f(\pi) = E[\pi_r] - \frac{\alpha}{1 + \alpha} E[\pi_m] = E[\pi_r] - \hat{\alpha} E[\pi_m] \quad (14)$$

$\hat{\alpha}$ also means the fairness preference parameter, is the simplified form of the expression in α . $\hat{\alpha} \in [0, 1)$ is increasing in α for $\alpha > 0$. When $\alpha = 0$, then $\hat{\alpha} = 0$, i.e., the retailer is fairness neutral; When $\alpha \rightarrow \infty$, then $\hat{\alpha} \rightarrow 1$, i.e., the retailer concerns fairness extremely.

As is known to all, both in the enterprise operation and individual's behavior decision-making, the decision-maker also choose to avoid risk for the fear of loss. Therefore, we also take the hypothesis that the manufacturer and the retailer are both the risk-aversers. Considering the risk-aversion behavior of the decision-maker, we taking the mean-variance method Lau [15] and Wang [10] have used to measure the decision-maker's expected utility. As shown in Equation (15):

$$U^a(\pi) = E[\pi] - k\sqrt{\text{Var}[\pi]} \quad (15)$$

In Equation (15), k is the risk-aversion level of the decision-maker. $k > 0$ means the decision-maker concerns risk-aversion, and $k = 0$ means the decision-maker is risk-neutral, at this time, the decision-maker's expected utility is equal to the expected profit.

The retailer's and the manufacturer's expected utility function from the above analysis is given by:

$$U_r(\pi) = E[\pi_r] - \hat{\alpha} E[\pi_m] - k_r \sqrt{\text{Var}[\pi_r]} \quad (16)$$

$$U_m(\pi_m) = E[\pi_m] - k_m \sqrt{\text{Var}[\pi_m]} \quad (17)$$

3.2. Stackelberg Game Decision-Making

The analysis method and steps of this subsection is same with subsection (2.2), therefore, we only list the final results for simplify.

3.2.1. The Retailer's Optimal decision

The retailer's utility function based on the fairness preference and risk-aversion level is:

$$\begin{aligned}
 U_r(\pi) &= E[\pi_r] - \hat{\alpha}E[\pi_m] - k_r\sqrt{\text{Var}[\pi_r]} \\
 &= (p_r - w)(\theta a - bp_r + \delta p_e + \gamma v) - \eta v^2 / 2 \\
 &\quad - \hat{\alpha}[(w - c_m)(\theta a - bp_r + \delta p_e + \gamma v) \\
 &\quad + (p_e - c_m)(a - \theta a - bp_e + \delta p_r - \gamma v)] \\
 &\quad - k_r(p_r - w)\theta\sigma
 \end{aligned} \tag{18}$$

Let the first-order of $U_r(\pi)$ in p_r is equal to zero, the optimal retail price in p_e and w is given by:

$$p_r^*(p_e, w) = \frac{\theta a - k_r\theta\sigma + \gamma v + \delta p_e + \hat{\alpha}[b(w - c_m) - \delta(p_e - c_m)] + wb}{2b} \tag{19}$$

3.2.2. The Manufacturer's Optimal Decision

The manufacturer's utility function based on the risk-aversion level is:

$$\begin{aligned}
 U_m(\pi_m) &= E[\pi_m] - k_m\sqrt{\text{Var}[\pi_m]} \\
 &= (w - c_m)[\theta a - bp_r^*(p_e, w) + \delta p_e + \gamma v] \\
 &\quad + (p_e - c_m)[(1 - \theta)a - bp_e + \delta p_r^*(p_e, w) - \gamma v] \\
 &\quad - k_m[(w - c_m)\theta + (p_e - c_m)(1 - \theta)]\sigma
 \end{aligned} \tag{20}$$

Let the first-order of $U_m(\pi_m)$ in p_e and w are equal to zero, we can get the optimal direct price and wholesale price are:

$$p_e^*(w) = \frac{2b\delta w(1 + \hat{\alpha}) + a(\delta\theta + 2b - 2b\theta) - \gamma v(2b - \delta) - \theta\sigma\delta k_r - 2k_m b(1 - \theta)\sigma + bc_m(2b - \delta) - 2\hat{\alpha}\delta c_m(b - \delta) - \delta^2 c_m}{2(2b^2 - \delta^2 + \hat{\alpha}\delta^2)} \tag{21}$$

$$w^*(p_e) = \frac{\theta a + k_r\theta\sigma - 2k_m\theta\sigma + 2\delta p_e + \gamma v + c_m(b - \delta) + 2\hat{\alpha}[\delta p_e + c_m(b - \delta)]}{2b(1 + \hat{\alpha})} \tag{22}$$

According to Equation (19), Equation (21) and Equation (22), the equilibrium solution of Stackelberg master-slave game as follows:

$$\begin{cases}
 p_e^* = \frac{a(\theta\delta + b - b\theta) - \gamma v(b - \delta) + c_m(b^2 - \delta^2) - k_m\sigma(\theta\delta + b - b\theta)}{2(b^2 - \delta^2)} \\
 w^* = \frac{\delta p_e^*}{b} + \frac{\theta a + k_r\theta\sigma - 2k_m\theta\sigma + \gamma v + c_m(b - \delta) + 2\hat{\alpha}c_m(b - \delta)}{2b(1 + \hat{\alpha})} \\
 p_r^* = \frac{\delta p_e^*}{b} + \frac{3\theta a - k_r\theta\sigma - 2k_m\theta\sigma + 3\gamma v + c_m(b - \delta) + 2\hat{\alpha}bc_m}{4b}
 \end{cases} \tag{23}$$

Theorem 3 (i) $\frac{\partial p_r^*}{\partial \hat{\alpha}} > 0$, $\frac{\partial p_r^*}{\partial k_r} < 0$, $\frac{\partial p_r^*}{\partial k_m} < 0$;

(ii) $\frac{\partial p_e^*}{\partial \hat{\alpha}} = 0$, $\frac{\partial p_e^*}{\partial k_r} = 0$, $\frac{\partial p_e^*}{\partial k_m} < 0$;

(iii) $\frac{\partial w^*}{\partial k_r} > 0$, $\frac{\partial w^*}{\partial k_r} > 0$, and if

$$\theta a + \theta \sigma(k_r - 2k_m) + \gamma v - c_m(b - \delta) > 0, \text{ then } \frac{\partial w^*}{\partial \hat{\alpha}} < 0.$$

Theorem 3 (i) shows that the optimal retail price is increasing with the increase of the retailer's fairness preference level, but decreasing with the increase of the risk-aversion level of the both sides. Theorem 3 (ii) shows that the optimal direct price is decreasing with the increase of the manufacturer's risk-aversion level, however, has nothing with the retailer's fairness preference and risk-aversion. Theorem 3 (iii) shows that the optimal wholesale price is decreasing with the increase of the manufacturer's risk-aversion level and increasing with the increase of the retailer's risk-aversion level. In addition, if $\theta a + \theta \sigma(k_r - 2k_m) + \gamma v - c_m(b - \delta) > 0$, the optimal wholesale price is decreasing with the increase of the retailer's fairness preference level. As a matter of fact, when confronting a retailer with stronger fairness preference psychology, the manufacturer will offer a lower wholesale price so as to maintain the stability of the channel relationship, no matter from the mathematical sense (the basic market demand a is a large number, the value of the other exogenetic parameters is very small) or intuitive thought. The theorem 4 also shows that all the manufacturer and the retailer who with the risk-aversion characteristic will choose mark-down to deal with the uncertain market demand and reduce the risk of income. Because the retailer also concerns fairness, therefore, she will improve the retail price to get what she thinks more fair income. So, the retailer needs to balance the effect of her fairness preference and risk-aversion level on her sales price and expected utility.

4. Computer Simulation

In order to discuss the model and illustrate the conclusion more specifically, this section through numerical example analysis the effect of the supply chain members' fairness preference and risk-aversion on their optimal pricing strategies and utility. Suppose a certain product has the following market characteristics: $a = 100$, $b = 1$, $\delta = 0.5$, $\gamma = 0.6$, $v = 5$, $\eta = 2$, $\theta = 0.4$, $c_m = 10$, $\sigma = 20$.

We put this parameters in the above model and make use of Matlab software, the optimal decision results of decision-makers in the basic model under Stackelberg game were obtained, as follows: $p_r^* = 62.17$, $p_e^* = 57.33$, $w^* = 52.67$, $\pi_r^* = 65.20$, $\pi_m^* = 1860.79$, $\pi_{sc}^* = 1925.99$.

When the fairness preference and risk-aversion characteristics were considered, in order to analysis

The effect of the supply chain members' fairness preference and risk-aversion on their optimal pricing strategies and utility, we assume that the market demand is stable, namely, $\sigma = 20$. In Stackelberg game, given the differ value of $\hat{\alpha}$, k_r and k_m , respectively, we have:

(i) When $\hat{\alpha} = 0$, $k_r = 0$ and $k_m = 0$, the retailer is fairness neutral and risk neutral, the manufacturer is also risk neutral. In this case, there exists $p_e^* = p_e^{oo}$, $w^* = w^o$ and $p_r^* = p_r^{oo}$.

(ii) When $\hat{\alpha} > 0$, $k_r > 0$ and $k_m > 0$, the manufacturer and the retailer are both the risk-avertter, the retailer also concerns fairness. We discuss the following three cases, as shown in Table 1-3.

Table 1 shows that when the fairness preference and risk-aversion level of the retailer are fixed, all the optimal wholesale price, direct price and retail price are decreasing with the increase of the manufacturer's risk-aversion level. However, the price decreasing rate of the retail channel is less than the direct channel and wholesale price. This may be the positive influence of the retailer's fairness preference on her pricing strategy so as to mitigate the price reduction. Therefore, the utility of the manufacturer is decreasing with the increase of his risk-aversion level, the retailer's utility is increasing with the increase of the manufacturer's risk-aversion level, however, the growing rate of the retailer's utility is smaller than the damping of the manufacturer's utility. So, the whole supply chain's utility is a decreasing function.

Table 1. The Optional Decision Results of DCSC under Different k_m

$\hat{\alpha}$	k_r	k_m	p_r^*	p_e^*	w^*	U_r^*	U_m^*	U_{sc}^*
0.5	0.5	0.2	61.80	55.20	45.53	-842.26	1625.38	783.12
0.5	0.5	0.4	59.94	53.07	43.40	-822.73	1466.93	644.20
0.5	0.5	0.6	58.07	50.93	41.27	-798.51	1317.11	518.60
0.5	0.5	0.8	56.20	48.80	39.13	-769.44	1175.78	406.34

Table 2. The Optional Decision Results of DCSC under Different $\hat{\alpha}$

$\hat{\alpha}$	k_r	k_m	p_r^*	p_e^*	w^*	U_r^*	U_m^*	U_{sc}^*
0.1	0.5	0.5	57.00	52.00	46.45	-125.04	1446.60	1321.56
0.3	0.5	0.5	58.00	52.00	44.08	-468.42	1414.56	946.14
0.5	0.5	0.5	59.00	52.00	42.33	-811.13	1390.98	579.85
0.7	0.5	0.5	60.00	52.00	41.00	-1154.30	1373.00	218.70
0.9	0.5	0.5	61.00	52.00	39.95	-1498.34	1358.80	-139.54

From the Table 2 we can see that when both the supply chain members' risk-aversion level are fixed, the optimal wholesale price is decreasing and the optimal retail price is increasing with the increase of the retailer's fairness preference level. The direct price remains unchanged due to it has nothing with the retailer's fairness preference level. Therefore, both the supply chain members' and the whole supply chain's utility are decreasing with the increase of the retailer's fairness preference level.

Table 3. The Optional Decision Results of DCSC under Different k_r

$\hat{\alpha}$	k_r	k_m	p_r^*	p_e^*	w^*	U_r^*	U_m^*	U_{sc}^*
0.5	0.2	0.5	59.60	52.00	41.53	-763.05	1379.86	616.81
0.5	0.4	0.5	59.20	52.00	42.07	-795.69	1387.49	591.80
0.5	0.6	0.5	58.80	52.00	42.60	-826.18	1394.92	568.74
0.5	0.8	0.5	58.40	52.00	43.13	-854.66	1403.06	548.40

Table 3 shows that if the fairness preference of the retailer and risk-aversion level of the manufacturer are fixed, the optimal wholesale price is increasing and the optimal retail price is decreasing with the retailer's risk-aversion level. The direct price remains unchanged due to it has nothing with the retailer's risk-aversion level. Therefore, the manufacturer's utility is increasing and the retailer's utility is decreasing with the increase of the retailer's risk-aversion level, and the damping of the retailer's utility is larger than the growing rate of the manufacturer's utility. So, the whole supply chain's utility is decreasing.

We can obtain the comprehensive viewpoints combined with the Table 2, Table 3 and Table 4: In the given value of the fairness preference and risk-aversion level, we have $p_e^* < p_e^{oo}$, $w^* < w^o$ and $p_r^* < p_r^{oo}$. The retailer's utility is decreasing with the increase of her fairness preference and risk-aversion level, is increasing with the increase of the manufacturer's risk-aversion level; The manufacturer's utility is decreasing with the increase of his risk-aversion level and the retailer's fairness preference level, is increase of the retailer's risk-aversion level. However, the growing rate of one's utility is always less than the damping of other's utility. So, there is always decreasing of the whole supply chain's utility.

5. Conclusion

This paper develops a two-echelon DCSC model with a manufacturer and a retailer. The behavior psychological characteristics, like fairness preference and risk-aversion, were considered. The results under Stackelberg game show that for a DCSC with fairness preference and risk aversion members, the manufacturer and the retailer will choose a reduced price to avoid income risk even if the market demand is stable, although the decision makers can realize the improvement of their own utility in some circumstances, however, the utility of

the whole supply chain always presents decreasing. That is to say, when considering the supply member's fairness preference and risk-aversion characteristic simultaneously in the pricing decisions of DCSC, the "double marginal utility" of the supply chain didn't get mitigation effectively.

The market demand function in our model is related to the retailer's market share and service level, therefore, the effect of the retailer's market share and service level on the optimal channel price under different decision-making modes was further examined and the intuitive explanation was given in the corresponding theorems. However, this paper also has the following limitations: Firstly, we do not consider the manufacturer's fairness preference and effort factor. The manufacturer will also concerns fairness and exerts effort activities to improve the sales of direct channel in the real commercial activity. The second is that it does not consider the substitutes on the market and ignore the competition between the owners of the substitute. Therefore, we will engage to this work in the later.

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