The Wholesale Price Contract Under The Framework Of Fairness-Preferencing Nash-Bargain In A Two-Level Supply Chain

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ABSTRACT

The paper establishes a fairness preference framework based on game theory of Nash bargaining, and builds a utility system about fairness preference. On the basis, we expeands the newboy model to behavior research. The analysis shows that because of the retailer and suppliers' fairness preference, their optimal order quantities tend to became conservative, and the result shows that the greater the retailer's fairness preference, the smaller the optimal order quantity of the retailer and the supply chain system, and the change tendency of the supply chan is more obvious than that of retailer. the greater the supplier's fairness preference, the greater the optimal order quantity of the retailer and the supply chain system, and the change tendency of the supply chan is more obvious than that of retailer. Furthermore, we draw a conclusion that the wholesale price contract don't change the supply chain coordination. Finally, we make the sensitivity analysis of the wholesale price, the retail price, the manufacturing cost of supplier, the stortage cost of retailer and the stortage cost of supplier.

Keywords - Nash bargaining; newboy model; fairness preference; supply chain coordination; wholesale price contract

I. INTRODUCTION

In a decentralized two-level supply chain system. Each of the members of the supply chain tends to achieve their own maximizing interests,that often are inconsistent with the goal of maximizing the whole supply chain's profits, which is double marginalization effect. Double marginalization effect will lead to lower the profits and efficiency of the whole supply chain .In order to eliminate the double marginalization effect, we need to design appropriate supply chain contract to coordinate the supply chain. Common supply chain contracts include wholesale price contract buy-back contracts, revenue sharing contract and quantity discount contract, the most common form of which is the wholesale price contract.

Traditional supply chain contracts assume that the members of the supply chain are completely rational, that ecision-makers is always to maximize the benefits for decision-making criteria. In reality, members of the supply chain are great concerned about fairness, which is the fairness preference. Members of the supply chain are not only concerned about their own economic benefits, but also concerned about the division between the members of the supply chain profits fairness, the supply chain members may sacrifice their own income so as to achieve a more equitable distribution of income. Ho (2009) and Wei (2006) discovers that the behavior of fair preference will change the efficiency of the supply chain.And the behavior of fairness preference plays a significant role in the maintenance and development of the relationship between supply chain members. Marketing in many cases that fair preferences play a very important role in the development and maintenance of the relationship of channel .

Fairness is one of the most important factors in the design of the supply chain contract,the fairness-preferencing behavior of the members of the supply chain may affect the coordination of supply chain system. Cui (2007) and Ozgun (2010) discuss the two-level supply chain models by the manufacturer and retailer,considering the retailer's fairness preferences,and find that when supplier takes the wholesale price that is higher than the cost, the supply chain will coordinate. Caliskand (2010) considers a non-linear function of market demand,finding that under certain conditions the behavior of the retailer's fairness preference can coordinate the supply chain, and the condition is relatively relaxed conditions than the study of Cui. Tian Jianyin (2012) builds supply chain model that are composed of the retailer and the manufacturer, discussing how do the fairness-preferencing behavior of the retailer's revenue sharing contract affect the coordination of the supply chain. Du Shaofu (2010) considers the fairness-preferencing behavior of retailer on the basis of the newsboy model, finding that the preference behavior of the retailer does not change the coordination of supply chain. Du chan (2012) constructs a the newsboy model under the Nash bargaining framework, Considering the impact of of fairness-preferencing behavior of retailers on the supply chain decisions. Huang Song (2012) considers the fairness preference behavior of retailer and manufacturer, and uses the wholesale price contract to coordinate the supply chain, finding the wholesale price contract can not coordinate the supply chain. In summary, most of the literature don't consider the retailer's and the supply chain's fairness preference, and don't consider the storage cost, which have an impact on the coordination of the supply chain.

Therefore, the paper establishes a fairness preference framework based on game theory of Nash bargaining, and builds a utility system about fairness preference. On the basis, we expeands the newboy model to behavior research..analysing the impact of the retailer's fairness preference and the supplier's fairness preference on the optimal order quantity of the retailer and the supply chain system. Then the paper analyse the impact of the retailer's fairness preference and the supplier's fairness preference on the coordination of supply chain. Finally, we make the sensitivity analysis of the wholesale price, the retail price, the manufacturing cost of supplier, the stortage cost of retailer and the stortage cost of supplier.the introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. THE NEWSBOY MODEL UNDER THE FAIRNESS-NEUTRAL

Fairness-neutral is the case where the retailer and the supplier don't exist the behavior of fair-ness preference. Consider a two stage supply chain where the retailer orders products from the supplier at a wholesale price w and sells the products to customers at a retail price p. We assume that market demand is D and average demand is μ, $\mu = E(D)$. Also we use $f(x)$ represents probability density function and $F(x)$ represents cumulative distribution function. Respectively, $F(x)$ is a continuous, differentiable and strictly increasing function, also $F(0)=0$, $\overline{F}(x)=1-F(x)$. We suppose that c_r is the supplier's marginal cost, c_s is supplier's the unit cost of production, where $c=c_r+c_s$, and $c<p$; g_r is the stortage cost of retailer, g_s is the stortage cost of supplier, g is the stortage cost of supply chain, where $g=g_r+g_s$,and $g_r \geq g_s$; v is retailer's processing net salvage, where $v<c$. Retailer's expect sales $S(q)$ is given by $S(q)=\int_0^q \overline{F}(x) = q-\int_0^q F(x)$ .Transfer payments is given by $T_w(q,w)=wq$. π_r, π_s and π represent profit functions respecttively for retailer, supplier and the supply chain system.

$$\pi_r=(p-v+g_r)S(q)-(c_r-v+w)q-g_r\mu \tag{1}$$

$$\pi_s=g_sS(q)-(c_s-w)q-g_s\mu \tag{2}$$

$$\pi=\pi_r+\pi_s=(p-v+g)S(q)-(c-v)q-g\mu \tag{3}$$

And we have

$$\frac{d\pi_r}{dq}=(p-v+g_r)S'(q^*)-(c_r-v+w)$$

$$\frac{d^2\pi_r}{dq^2}=-(p-v+g_r)f(q)$$

Because $\frac{d^2\pi}{dq^2}<0$, $\pi_r(q)$ is a strictly concave function, so the retailer's optimal order quantity is the only one solution and the optimal quantity satisfy the situation:

$$\frac{d\pi(q^*)}{dq}=(p-v+g_r)S'(q^*)-(c_r-v+w)=0 \tag{4}$$

That

$$\overline{F}(q^*)=\frac{c_r-v+w}{p-v+g_r} \tag{5}$$

Similarly, we can gain

$$\overline{F}(q^o)=\frac{c-v}{p-v+g} \tag{6}$$

Because $c_r-v+w-(c-v)=w-c_s$,where $w>c_s$, so $c_r-v+w>c-v$. And because $p-v+g_r-(p-v+g)=-g_s<0$, so $\frac{c_r-v+w}{p-v+g_r}>\frac{c-v}{p-v+g}$. Thus $\overline{F}(q^*)>\overline{F}(q^o)$, and we can get $q^*<q^o$ .Finally, , we draw a conclusion that when the retailer and the supplier don't care fairness, the wholesale price contract don't change the supply chain coordination.

III. THE NEWSBOY MODEL UNDER THE FAIRNESS- PREFERENCING

Fairness-preferencing is the case where the retailer and the supplier exist the behavior of fairness preference. Game finally reach a stable distribution agreement $(\overline{\pi}_r,\overline{\pi}_s)$,which is Nash Solution.And, $\overline{\pi}_r+\overline{\pi}_s=\pi$, $\pi_s+\pi_r=\pi$.

λ_r and λ_s mean the fairness preference of the retailer and the supplier, where $\lambda_r>0$, $\lambda_s>0$.

q_λ^* and q_λ^o represent the optimal quantity of the retailer and the supply chain system. When the retailer and the supplier care fairness.

The retailer's utility is

$$u_r = \pi_r + \lambda_r(\pi_r - \overline{\pi}_r) = (1+\lambda_r)\pi_r - \lambda_r\overline{\pi}_r$$

The supplier's utility is

$$u_s = \pi_s + \lambda_s(\pi_s - \overline{\pi}_s) = (1+\lambda_s)\pi_s - \lambda_s\overline{\pi}_s$$

Based on the Nash bargaining, the solution of the model is:

$$\begin{cases} \max\limits_{\pi_r,\pi_s} U_r U_s \\ \pi_r + \pi_s = \pi \\ U_r, U_s > 0 \end{cases}$$

$$U_r U_s(\pi,\pi_r) = [(1+\lambda_r)\pi_r - \lambda_r\overline{\pi}_r][(1+\lambda_s)(\pi-\pi_r) - \lambda_s(\pi-\overline{\pi}_r)]$$

we have

$$\frac{d^2(U_rU_s)}{d\pi_r^2} = -2(1+\lambda_r)(1+\lambda_s) < 0$$

So it is a strictly concave function, there is only one maximum solution, and satisfy the following conditions:

$$\frac{dU_rU_s(\pi_r^*)}{d\pi_r} = -2(1+\lambda_r)(1+\lambda_s)\pi_r^* + (1+\lambda_r)\pi + (\lambda_r+\lambda_s+2\lambda_r\lambda_s)\overline{\pi}_r = 0$$

According to the fixed point theory, we can figure that $\pi_r^* = \overline{\pi}_r$. Through simultaneous of the above two equations, we can get further results:

$$\overline{\pi}_r = \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\pi$$

$$\overline{\pi}_s = \frac{1+\lambda_s}{2+\lambda_s+\lambda_r}\pi$$

We can get

$$u_r = (1+\lambda_r)\pi_r - \lambda\overline{\pi}_r = (1+\lambda_r)\pi_r - \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda_r\pi \tag{7}$$

$$u_s = (1+\lambda_s)\pi_s - \frac{1+\lambda_s}{2+\lambda_r+\lambda_s}\lambda_s\pi \tag{8}$$

$$u = u_r + u_s = (\lambda_r - \lambda_s)\pi_r + \frac{2+2\lambda_s+\lambda_r\lambda_s-\lambda_r^2}{2+\lambda_r+\lambda_s}\pi \tag{9}$$

We will get as in equation(1), equation(2) and equation(3).

$$u_r = (1+\lambda_r)\left[(p-v+g_r)S(q) - (c_r-v+w)q - g_r\mu\right] - \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda_r\left[(p-v+g)S(q) - (c-v)q - g\mu\right] \tag{10}$$

$$u = (\lambda_r-\lambda_s)\left[(p+b)S(q) + (w-c-b)q\right] + \frac{2+2\lambda_s+\lambda_r\lambda_s-\lambda_r^2}{2+\lambda_r+\lambda_s}\left[pS(q) - cq\right] \tag{11}$$

1. DECENTRALIZED DECISION-MAKING

Proposition 1 Retailer's utility function u_r is strictly concave function, so there is a unique optimal order quantity q_λ^* that make u_r reaches a maximum, meeting

$$\overline{F}(q_\lambda^*) = \frac{(2+\lambda_r+\lambda_s)(c_r-v+w) - \lambda_r(c-v)}{(2+\lambda_r+\lambda_s)(p-v+g_r) - \lambda_r(p-v+g)}$$

and the retailer's optimal order quantity is less than the optimal order quantity when the retailer and the supplier don't care fairness.

Proof . We have

$$\frac{du_r}{dq} = (1+\lambda_r)\left[(p-v+g_r)\overline{F}(q) - (c_r-v+w)\right] - \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda_r\left[(p-v+g)\overline{F}(q) - (c-v)\right] \tag{12}$$

$$\frac{d^2u_r}{dq^2} = -(1+\lambda_r)(p-v+g_r)f(x) + \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda(p-v+g)f(x)$$

Because $g_r \geq g_s$ and $\frac{\lambda_r}{2+\lambda_r+\lambda_s} < 1$,we have $\frac{d^2u_r}{dq^2} < 0$ that u_r is strictly concave function. so the retailer's optimal order quantity is the only one solution and the optimal quantity satisfy the situation:

$$\frac{du_r(q_\lambda^*)}{dq} = 0$$

That

$$\overline{F}(q_\lambda^*) = \frac{(2+\lambda_r+\lambda_s)(c_r-v+w) - \lambda_r(c-v)}{(2+\lambda_r+\lambda_s)(p-v+g_r) - \lambda_r(p-v+g)} \tag{13}$$

Because $\frac{c-v}{p-v+g} < \frac{c_r-v+w}{p-v+g_r}$,we have

$$\frac{(2+\lambda_r+\lambda_s)(c_r-v+w) - \lambda_r(c-v)}{(2+\lambda_r+\lambda_s)(p-v+g_r) - \lambda_r(p-v+g)} > \frac{c_r-v+w}{p-v+g_r}$$

.we obtain $\overline{F}(q_\lambda^*) > \overline{F}(q^*)$,

So

$$q_\lambda^* < q^* \tag{14}$$

Clearly, because of the retailer and suppliers' fairness preference, the optimal order quantities of the retailer tends to became conservative.

Inference 1 The greater the retailer's fairness preference, the smaller the optimal order quantity of the retailer; the greater the supplier's fairness preference, the greater the optimal order quantity of the supplier.

Proof. Given equation(12),we assume

$$t=\frac{du_r}{dq} \quad (15)$$

We have

$$\partial t(q_\lambda^*)/\partial\lambda_r=\left[(p-v+g_r)\overline{F}(q_\lambda^*)-(c_r-v+w)\right]-\frac{(1+2\lambda_r)(2+\lambda_r+\lambda_s)-\lambda_r(1+\lambda_r)}{(2+\lambda_r+\lambda_s)^2}\left[(p-v+g)\overline{F}(q_\lambda^*)-(c-v)\right]$$

Because $p-v+g_r < p-v+g$ and $\frac{(1+2\lambda_r)(2+\lambda_r+\lambda_s)-\lambda_r(1+\lambda_r)}{(2+\lambda_r+\lambda_s)^2}<1$,so

$$\partial t(q_\lambda^*)/\partial\lambda_r<\left[(p-v+g)\overline{F}(q_\lambda^*)-(c_r-v+w)\right]$$

$$-\left[(p-v+g)\overline{F}(q_\lambda^*)-(c-v)\right]=-(w-c_s)<0$$

According to the implicit function theorem,we have

$$\partial q_\lambda^*/\partial\lambda_r=-\frac{\partial t(q_\lambda^*)}{\partial\lambda_r}/\frac{dt(q_\lambda^*)}{dq_\lambda^*}<0$$

the greater the retailer's fairness preference, the smaller the optimal order quantity of the retailer.In other words, the greater the retailer's fairness preference λ_r , the smaller marginal utility $\partial u_r/\partial\lambda_r$,so retailer reduces the order qualitity. On the other hand, the retailer thinks he get even more unfair treatment, thereby by reducing the order quantity, it results in the lower profit of the supplier and playe the role of punishing supplier.

We will get as in equation(15)

$$\frac{\partial t(q_\lambda^*)}{\partial\lambda_s}=\frac{(1+\lambda_r)\lambda_r}{(2+\lambda_r+\lambda_s)^2}\left[(p-v+g)\overline{F}(q_\lambda^*)-(c-v)\right]$$

Because

$$\overline{F}(q_\lambda^*)=\frac{(2+\lambda_r+\lambda_s)(c_r-v+w)-\lambda_r(c-v)}{(2+\lambda_r+\lambda_s)(p-v+g_r)-\lambda_r(p-v+g)},$$

w e have $\frac{\partial t(q_\lambda^*)}{\partial\lambda_s}>0$

According to the implicit function theorem,we have

$$\partial q_\lambda^*/\partial\lambda_s=-\frac{\partial t(q_\lambda^*)}{\partial\lambda_s}/\frac{dt(q_\lambda^*)}{dq_\lambda^*}>0$$

The greater the supplier's fairness preference, the greater the optimal order quantity of the supplier. Because the greater the supplier's fairness preference λ_s , the greater marginal utility $\frac{\partial u_r}{\partial\lambda_s}$,so supplier increase the order qualitity.

Inference 2 The greater the wholesale price, the smaller the optimal order quantity of the retailer; the greater the retail price, the greater the optimal order quantity of the retailer; the greater the manufacturing cost of supplier, the greater the optimal order quantity of the retailer.

Proof. (1) we prove that the greater the wholesale price, the smaller the optimal order quantity of the retailer.

Given equation(15) we will get

$$\frac{\partial t(q_\lambda^*)}{\partial w}=-(1+\lambda_r)<0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^*}{\partial w}=-\frac{\partial t(q_\lambda^*)}{\partial w}/\frac{dt(q_\lambda^*)}{dq_\lambda^*}<0$$

Clearly, when the retailer and the supplier care fairness, the greater the wholesale price, the smaller the optimal order quantity of the retailer.Because when the wholesale price increases, the retailer's profit decline and the supplier's profits rise. Retailers profit accounted for in the supply chain reduces, and the retailer thinks he get even more unfair treatment, thereby the retailer reduces the order quantity.

(2) We prove that the greater the retail price, the greater the optimal order quantity of the retailer.

Given equation(15) we will get

$$\frac{\partial t(q_\lambda^*)}{\partial p}=(1+\lambda_r)\overline{F}(q_\lambda^*)-\frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda\overline{F}(q_\lambda^*)>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^*}{\partial p}=-\frac{\partial t(q_\lambda^*)}{\partial p}/\frac{dt(q_\lambda^*)}{dq_\lambda^*}>0$$

Clearly, when the retailer and the supplier care fairness, he greater the retail price, the greater the optimal order quantity of the retailer. Because as retail price growing, retailer's profit rise and retailer's profit accounted for the proportion of the supply chain system grows. So retailer fell a more equitable treatment, and increase the order quantity.

(3) We prove that the greater the manufacturing cost of supplier, the greater the optimal order quantity of the retailer.

Given equation(15) we will get

$$\frac{\partial t(q_\lambda^*)}{\partial c_s}=\frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^*}{\partial c_s} = -\frac{\partial t(q_\lambda^*)}{\partial c_s} / \frac{dt(q_\lambda^*)}{dq_\lambda^*} > 0$$

Clearly, the greater the manufacturing cost of supplier, the greater the optimal order quantity of the retailer. Because as the manufacturing cost of supplier growing, supplier's profit decreases and retailer's profit accounted for the proportion of the supply chain system grows. So retailer fell a more equitable treatment, and increase the order quantity.

Inference 3 The greater the stortage cost of the retailer, the greater the optimal order quantity of the retailer; the greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer.

(1) We prove that the greater the stortage cost of the retailer, the greater the optimal order quantity of the retailer.

Given equation(15) we will get

$$\frac{\partial t(q_\lambda^*)}{\partial g_r} = (1+\lambda_r)\overline{F}(q_\lambda^*) - \frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda\overline{F}(q_\lambda^*) > 0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^*}{\partial g_r} = -\frac{\partial t(q_\lambda^*)}{\partial g_r} / \frac{dt(q_\lambda^*)}{dq_\lambda^*} > 0$$

Clearly, when the retailer and the supplier care fairness, the greater the stortage cost of the retailer, the greater the optimal order quantity of the retailer. Bacause once out of stock, retailer faces huge losses. So the retailer increase the order quantity, preventing out of stock.

(2) We prove that the greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer.

Given equation(15) we will get

$$\frac{\partial t(q_\lambda^*)}{\partial g_s} = -\frac{1+\lambda_r}{2+\lambda_r+\lambda_s}\lambda\overline{F}(q_\lambda^*) < 0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^*}{\partial g_s} = -\frac{\partial t(q_\lambda^*)}{\partial g_s} / \frac{dt(q_\lambda^*)}{dq_\lambda^*} < 0$$

Clearly, when the retailer and the supplier care fairness, that the greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer. Because as the stortage cost of the supplier growing, retailer's profit accounted for the proportion of the supply chain system drops. So retailer fell a no equitable treatment, and decrease the order quantity

2 CENTRALIZED DECISION-MAKING

Proposition 2 If $\lambda_r > \lambda_s$, the supply chain system's utility function u is strictly concave function, so there is a unique optimal order quantity q_λ^o that make u reaches a maximum, meeting

$$\overline{F}(q_\lambda^o) = \frac{(2+2\lambda s+\lambda r\lambda s-\lambda_r^2)(c-v)+(\lambda_r-\lambda_s)(2+\lambda_r+\lambda_s)(c_r-v+w)}{(\lambda_r-\lambda_s)(2+\lambda_r+\lambda_s)(p-v+g_r)+(2+2\lambda s+\lambda r\lambda s-\lambda_r^2)(p-v+g)}$$

and the supply chain system's optimal order quantity is less than the optimal order quantity when the retailer and the supplier don't care fairness.

Proof. We have

$$\frac{du}{dq} = (\lambda_r-\lambda_s)\left[(p-v+g_r)\overline{F}(q)-(c_r-v+w)\right]$$

$$+\frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}\left[(p-v+g)\overline{F}(q)-(c-v)\right]$$

$$\frac{d^2u}{dq^2} = -(\lambda_r-\lambda_s)(p-v+g_r)f(q) - \frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}(p-v+g)f(q)$$

If $\lambda_r > \lambda_s$, we gain $\frac{d^2u}{dq^2} < 0$ .And we can find out that u is strictly concave function.,so the retailer's optimal order quantity is the only one solution and the optimal quantity satisfy the situation:

$$\frac{du(q_\lambda^o)}{dq} = 0$$

That

$$\overline{F}(q_\lambda^o) = \frac{(2+2\lambda s+\lambda r\lambda s-\lambda_r^2)(c-v)+(\lambda_r-\lambda_s)(2+\lambda_r+\lambda_s)(c_r-v+w)}{(\lambda_r-\lambda_s)(2+\lambda_r+\lambda_s)(p-v+g_r)+(2+2\lambda s+\lambda r\lambda s-\lambda_r^2)(p-v+g)}$$

Because $\frac{c-v}{p-v+g} < \frac{c_r-v+w}{p-v+g_r}$,we know $\overline{F}(q_\lambda^o) > \overline{F}(q^o)$,thus we have

$$q_\lambda^o < q^o$$

Inference 4 The greater the retailer's fairness preference, the smaller the optimal order quantity of the supply chain system; the greater the supplier's fairness preference, the greater the optimal order quantity of the supply chain system; the change tendency of the supply chan is more obvious than that of retailer.

Proof. We assume

$$t = \frac{du}{dq}$$

(19)

Given equation(19) we will get

$$\partial t(q_\lambda^0)/\partial\lambda_r = \left[(p-v+g_r)\overline{F}(q_\lambda^0)-(c_r-v+w)\right]$$

$$-\frac{2+4\lambda r+2\lambda r\lambda s+\lambda_r^2-\lambda_s^2}{(2+\lambda r+\lambda s)^2}\left[(p-v+g)\overline{F}(q_\lambda^0)-(c-v)\right]$$

Because

$$2+4\lambda r+2\lambda r\lambda s+\lambda_r^2-\lambda_s^2 < (2+\lambda r+\lambda s)^2,$$

we can gain

$$\partial t(q_\lambda^0)/\partial\lambda_r < \left[\left(p-v+g_r\right)\overline{F}(q_\lambda^0)-\left(c_r-v+w\right)\right]$$

$$-\left[(p-v+g)\overline{F}(q_\lambda^0)-(c-v)\right]<0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial\lambda_r}=-\frac{\partial t(q_\lambda^0)}{\partial\lambda_r}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}<0$$

Clearly, when the retailer and the supplier care fair, the greater the retailer's fairness preference, the smaller the optimal order quantity of the supply chain system. Because the greater the retailer's fairness preference λ_r, the smaller marginal utility $\frac{\partial u}{\partial\lambda_r}$,so the supply chain system reduces the order qualitity.

Given equation(19) we will get

$$\partial t(q_\lambda^0)/\partial\lambda_s=-\left[\left(p-v+g_r\right)\overline{F}(q_\lambda^0)-\left(c_r-v+w\right)\right]$$

$$+\tfrac{2+4\lambda r+2\lambda_r^2}{(2+\lambda r+\lambda s)^2}\left[(p-v+g)\overline{F}(q_\lambda^0)-(c-v)\right]$$

Beause $2+4\lambda r+2\lambda_r^2<(2+\lambda r+\lambda s)^2$ .so

$$\partial t(q_\lambda^0)/\partial\lambda_s>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial\lambda_s}=-\frac{\partial t(q_\lambda^0)}{\partial\lambda_s}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}>0$$

Clearly, he greater the supplier's fairness preference, the greater the optimal order quantity of the supply chain system. Because the greater the supplier's fairness preference λ_s, the greater marginal utility $\frac{\partial u}{\partial\lambda_s}$,so the supply chain system increases the order qualitity.

We have

$$\partial u_r/\partial\lambda_r=\left[(p-v+g_r)S(q)-(c_r-v+w)q-g_r\mu\right]$$

$$-\frac{2+\lambda_s+4\lambda_r+\lambda_r^2+2\lambda_r\lambda_s}{(2+\lambda_r+\lambda_s)^2}\left[(p-v+g)S(q)-(c-v)q-g\mu\right]$$

$$\partial u/\partial\lambda_r=\left[(p+b)S(q)+(w-c-b)q\right]-\tfrac{2+4\lambda r+2\lambda r\lambda s-\lambda_s^2}{(2+\lambda r+\lambda s)^2}\left[pS(q)-cq\right]$$

Simplification can be obtained

$$\left|\frac{\partial u}{\partial\lambda_r}\right|>\left|\frac{\partial u_r}{\partial\lambda_r}\right|$$

We can know that with λ_r increasing, the utility of the supply chain system changes significantly. In other words, the change tendency of the supply chan is more obvious than that of retailer.

Similarly, we have

$$\left|\frac{\partial u}{\partial\lambda_s}\right|>\left|\frac{\partial u_r}{\partial\lambda_s}\right|$$

We can know that with λs increasing, the utility of the supply chain system changes significantly. In other words, the change tendency of the supply chan is more obvious than that of retailer.

Proposition 3 The wholesale price contract don't change the supply chain coordination.

Proof. Given equation(13)and equation(17), we will get

$$\overline{F}(q_\lambda^*)-\overline{F}(q_\lambda^0)=\frac{\left(2+\lambda_r+\lambda_s\right)(c_r-v+w)-\lambda_r\left(c-v\right)}{\left(2+\lambda_r+\lambda_s\right)\left(p-v+g_r\right)-\lambda_r(p-v+g)}-$$

$$\frac{\left(2+2\lambda s+\lambda r\lambda s-\lambda_r^2\right)(c-v)+\left(\lambda_r-\lambda_s\right)\left(2+\lambda_r+\lambda_s\right)(c_r-v+w)}{\left(\lambda_r-\lambda_s\right)\left(2+\lambda_r+\lambda_s\right)\left(p-v+g_r\right)+\left(2+2\lambda s+\lambda r\lambda s-\lambda_r^2\right)\left(p-v+g\right)}$$

Simplification can be obtained

$$\overline{F}(q_\lambda^*)-\overline{F}(q_\lambda^0)>0$$

We can get

$$q_\lambda^*<q_\lambda^0$$

Then compared with equation(18), we gain

$$q_\lambda^*<q_\lambda^0<q^0$$

When the retailer and the supplier care fair, the wholesale price contract don't change the supply chain coordination,both in terms of achieving the maximum retailer profitability and in terms of attaining the maximum supply chain profitability and utility.

Inference 5 The greater the wholesale price, the smaller the optimal order quantity of the supply chain system; the greater the retail price, the greater the optimal order quantity of the supply chain system; the change tendency of the retailer is more obvious than that of the supply chain.

Proof.(1)We prove that the greater the wholesale price, the smaller the optimal order quantity of the supply chain system and the change tendency of the retailer is more obvious than that of the supply chain.

Given equation(19) we will get

$$\frac{\partial t(q_\lambda^0)}{\partial w}=-(\lambda_r-\lambda_s)<0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial w}=-\frac{\partial t(q_\lambda^0)}{\partial w}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}<0$$

Clearly, the greater the wholesale price, the smaller the optimal order quantity of the supply chain system. Because as the wholesale price growing, the supply chain's profit drop and the supply chain's unility drop. So the supply chain system decrease the order quantity.

We have

$$\frac{\partial q_\lambda^*}{\partial w}=-\frac{2+\lambda_r+\lambda_s}{(2+\lambda_r+\lambda_s)(p-v+g_r)f(x)-\lambda(p-v+g)f\left(x\right)}$$

$$\frac{\partial q_\lambda^0}{\partial w}=-\frac{(\lambda_r-\lambda_s)(2+\lambda r+\lambda s)}{(\lambda_r-\lambda_s)(2+\lambda r+\lambda s)\left(p-v+g_r\right)f(q)+(2+2\lambda s+\lambda r\lambda s-\lambda_r^2)(p-v+g)f(q)}$$

Simplification can be obtained

$$|\frac{\partial q_\lambda^*}{\partial w}|>|\frac{\partial q_\lambda^0}{\partial w}|$$

So the change tendency of the retailer is more obvious than that of the supply chain.

(2)We prove that the greater the retail price, the greater the optimal order quantity of the supply chain system and the change tendency of the retailer is more obvious than that of the supply chain.

Given equation(19) we will get

$$\frac{\partial q_\lambda^0}{\partial p}=(\lambda_r-\lambda_s)\overline{F}(q_\lambda^0)+\frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}\overline{F}(q_\lambda^0)>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial p}=-\frac{\partial t(q_\lambda^0)}{\partial p}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}>0$$

Clearly, the greater the retail price, the greater the optimal order quantity of the supply chain system. Because as the retail price growing, the supply chain's profit grow and the supply chain's utility grow. So the supply chain system increase the order quantity.

Simplification can be obtained

$$|\frac{\partial q_\lambda^*}{\partial p}|>|\frac{\partial q_\lambda^0}{\partial p}|$$

So the change tendency of the retailer is more obvious than that of the supply chain.

Inference 6 The greater the manufacturing cost of supplier, the smaller the optimal order quantity of the supply chain; the change tendency of the supply chain is more obvious than that of the retailer.

Proof. Given equation(19) we will get

$$\frac{\partial q_\lambda^0}{\partial c_s}=-\frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}<0$$

According to the implicit function theorem,we have

$$\frac{\partial t(q_\lambda^0)}{\partial c_s}=-\frac{\partial t(q_\lambda^0)}{\partial c_s}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}<0$$

Clearly, the greater the manufacturing cost of supplier, the smaller the optimal order quantity of the supply chain. Because as the manufacturing cost of supplier growing, the supply chain's profit drop and the supply chain's unility drop. So the supply chain system increase the order quantity.

Simplification can be obtained

$$|\frac{\partial q_\lambda^*}{\partial c_s}|<|\frac{\partial q_\lambda^0}{\partial c_s}|$$

So the change tendency of the supply chain is more obvious than that of the retailer.

Inference 7 The greater the stortage cost of the retailer, the greater the optimal order quantity of the supply chain; the change tendency of the retailer is more obvious than that of the supply chain. The greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer; the change tendency of the supply chain is more obvious than that of the retailer.

Proof.(1)We prove that the greater the stortage cost of the retailer, the greater the optimal order quantity of the supply chain; the change tendency of the retailer is more obvious than that of the supply chain.

Given equation(19) we will get

$$\frac{\partial t(q_\lambda^0)}{\partial g_r}=(\lambda_r-\lambda_s)\overline{F}(q_\lambda^0)+\frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}\overline{F}(q_\lambda^0)>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial g_r}=-\frac{\partial t(q_\lambda^0)}{\partial g_r}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}>0$$

Clearly, the greater the stortage cost of the retailer, the greater the optimal order quantity of the supply chain. Because as the stortage cost of the retailer growing, the retailer increases the order quantity. So the supply chain system increase the order quantity.

Simplification can be obtained

$$\frac{\partial q_\lambda^*}{\partial g_r}>\frac{\partial q_\lambda^0}{\partial g_r}$$

So the change tendency of the retailer is more obvious than that of the supply chain.

(2) We prove that the greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer; the change tendency of the supply chain is more obvious than that of the retailer.

Given equation(19) we will get

$$\frac{\partial t(q_\lambda^0)}{\partial g_s}=\frac{2+2\lambda s+\lambda r\lambda s-\lambda_r^2}{2+\lambda r+\lambda s}\overline{F}(q_\lambda^0)>0$$

According to the implicit function theorem,we have

$$\frac{\partial q_\lambda^0}{\partial g_s}=-\frac{\partial t(q_\lambda^0)}{\partial g_s}/\frac{dt(q_\lambda^0)}{dq_\lambda^0}>0$$

Clearly, the greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer. Because as the stortage cost of the supplier growing, the supply chain's profit grow and the supply chain's unility grow. So the supply chain system increase the order quantity.

Simplification can be obtained

$$\left|\frac{\partial q_\lambda^0}{\partial g_s}\right|>\left|\frac{\partial q_\lambda^*}{\partial g_s}\right|$$

So the change tendency of the supply chain is more obvious than that of the retailer.

IV. CONCLUSION

The paper establishes a fairness preference framework based on game theory of Nash bargaining, and builds a utility system about fairness preference. On the basis, we expeands the newboy model to behavior research. The analysis shows that because of the retailer and suppliers' fairness preference, their optimal order quantities tend to became conservative, and the result shows that the greater the retailer's fairness preference, the smaller the optimal order quantity of the retailer and the supply chain system, and the change tendency of the supply chan is more obvious than that of retailer. the greater the supplier's fairness preference, the greater the optimal order quantity of the retailer and the supply chain system, and the change tendency of the supply chan is more obvious than that of retailer. Furthermore, we draw a conclusion that the wholesale price contract don't change the supply chain coordination. Finally, we make the sensitivity analysis of the wholesale price, the retail price, the manufacturing cost of supplier, the stortage cost of retailer and the stortage cost of supplier. We find that the greater the wholesale price, the smaller the optimal order quantity of the retailer and the supply chain system; the change tendency of the retailer is more obvious than that of the supply chain. The greater the retail price, the greater the optimal order quantity of the retailer and the supply chain system; the change tendency of the retailer is more obvious than that of the supply chain. The greater the manufacturing cost of supplier, the greater the optimal order quantity of the retailer, the smaller the optimal order quantity of the supply chain; the change tendency of the supply chain is more obvious than that of the retailer. The greater the stortage cost of the retailer, the greater the optimal order quantity of the retailer and the supply chain; the change tendency of the retailer is more obvious than that of the supply chain. The greater the stortage cost of the supplier, the smaller the optimal order quantity of the retailer,the greater the optimal order quantity of the supply chain; the change tendency of the supply chain is more obvious than that of the retailer.

However, there are some limitations in the paper. Firstly, the paper doesn't consider the competition between suppliers, and between retailers. Secondly, the paper considers only this single act of fairness preference. But in real life, the decision may be more behavioral influences (such as reciprocity, compassion, jealousy, etc.). Therefore, the study can introduce reciprocity, compassion, jealousy, and other behavioral influences, to make it more practical significance

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REFERENCES

[1] J SPENGLER, Vertical integration and antitrust policy, *Journal of Political Economy, 58(4)*,1950,347-352.
[2] W J HOPP, Fifty years of management science, *Management Science, 50(1),* 2004, 1-7. Z. X. Luo, Both theory and engineering practice to cultivate creative talents. Experimental Technology and Management, vol.23, February, (2006).
[3] K ELEMA , DIAN Yanwu. Contracting in suppy chains: alaboratory investigation, *Management Science, 55(13),* 2009, 1953-1968.
[4] V PADMANABHAN, I P L PNG, Manufacturer's returns policy and retailer competion, *Marketing Science, 16(1),* 1997, 81-93.
[5] J H CAI, G G ZHOU, Influence of revenue sharing on the performance of a two-echelon supply chain, *Computer Integrated Manufacturing Systems, 14(8),* 2008, 1637-1642
[6] A DUMRONGSIRI, M FAN, A JAIN, et al . A supply chain model with direct and retail channels, *European Journal of Operational Research, 187(3)*,2008, 691-718.
[7] G FRANCESCA, P GARY,Toward a theory of behavioral operations, *Manufacturing Service Operations Management, 10(4),* 2008, 676-691.
[8] J DANA, SPIERK, Revenue-sharing and vertical control in the videorental industry, *Journal of Industry Economics, 59(3),* 2001, 223-245.
[9] T H HO, X M SU, Peer-induced fairness in games, *American Economic Review, 99(5)*,2009, 2022-2049.
[10] G X WEI, Y H QIN, Y J PU. Joint contracts: behavioral game analyses based on fairness preferences,*System Engineering, 24(9),* 2006, 32- 37.
[11] D N CORSTEN, KUMAR, Do suppliers benefit from collaborative relationships with large retailers? an empirical investigation of ECR adoption, *Marketing, 69(3),* 2005, 80-94.
[12] J W HAN, D Z ZHAO, Game analysis of behaviors of retailer-led supply chain Performance, *Management Science, 25(2),* 2012, 61-68.
[13] X LI,G H CAO, Research of incentive mechanism based on fairness preference, *Journal of Industrial Engineering and*

Engineering Management, 22(2), 2008,107-111.

[14] C H LOCH, Y Z WU, Social preferences and supply chain performance:an experimental study, *Management Science, 54(11),* 2008, 1835-1849.

[15] T H CUI, J S RAJU, Z J ZHANG, Fairness and channel coordination, *Management Science, 53(8),* 2007, 1303-1314.

[16] C D OZGUN, Y H CHEN, Channel coordination under fairness concerns and nonlinear demand, *European Journal of Opration Research, 207(22),* 2010, 1321-1326.

[17] D CALISKAN, Y CHEN, J LI. Channel coordination under fairness concerns, *European Journal of Operational Research, 207(3),* 2010, 1321-1325.

[18] J Y TIAN, B LI, The influence of retailer's fairness conceining behavior on coordination performance of revenue sharing contract, *East China Economic Management, 06(26)*, 2012, 45-50.

[19] S F DU, C DU, Supply chain coordination considering fairness concerns, *Journal of Management Sciences in China, 13(11),* 2010, 41- 48.

[20] S F DU, J A ZHU, C DU, Optimal deciaion-making for a nash-bargain fairness-concerning newsvendor in a two-level supply chain, *Journal of Management Sciences in China, 3,* 2012, 5-7.