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Supply chain coordination considering loss aversion and fairness concern under revenue

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ABSTRACT

The impacts of the loss aversion and fairness concern of retailer on the relative decision of retailer and supply chain are analyzed. When the loss aversion and fairness concern of retailer is considered, the revenue sharing contract still can coordinate the supply chain. Then, the optimal order quantity of retailer and supply chain will decrease as loss aversion increase, but the changing trend of the optimal order quantity caused by fairness concern depends on the coefficient of revenue sharing, and the changing degree of optimal quantity of retailer is more obvious than that of supply chain.

KEYWORDS

Fairness concern; Loss aversion; Supply chain; Coordination; Revenue sharing contract.

INTRODUCTION

All the supplier, manufacturer and retailer are the independent decision element in supply chain, and the decision and behavior of each member is always in contradiction with the benefit of whole supply chain, so the various contracts were applied to coordinate supply chain[1]. The reasonable designed contract can improve the efficiency of supply chain, and many scholars proposed various and different contracts to achieve coordination of supply chain, such as wholesale price contract, buyback contract, revenue sharing contract and so on. The revenue sharing contract was adopted to achieve the profit sharing and risk pooling between each member of closed supply chain[2]. Omkar and Palsule (2013) found that the revenue sharing contract can increase the profit of supply chain to 7%[3]. All the above research assumed that each partner of supply chain was loss neural and fairness neutral, but in fact the supply chain members are always concerned about loss and fairness, i.e. loss aversion and fairness concern. Loss aversion means the decision behavior avoiding loss, and the loss aversion behavior of supply chain members could affects the coordination of supply chain system[4]. Ye (2012) confirmed that the revenue sharing contract can coordinate the supply chain when both retailer and supplier were loss aversion[5]. Zhang (2011) assumed only the retailer was of loss aversion, and he concluded that the buyback contract, revenue sharing contract and the combination of these two contracts can coordinate the supply chain, and the joint contract of buyback contract and revenue sharing contract can achieve the more efficient coordination efficiency. Meanwhile, many studies show that people pay great attention to the revenue distribution, i.e. fairness concern[6]. Du (2012) built a newsboy model of Nash bargaining framework by assuming that both the retailer and supplier were fairness concerned, and they proved that the wholesale price contract couldn't achieve supply chain coordination[7].

So far, only few researches taken the loss aversion and fairness concern behavior into account, and the loss aversion and fairness concern maybe affect the supply chain coordination and optimal decision of members. In view of this, this paper will study two-stage supply chain adopting the revenue sharing contract, and in the first place, we will study the optimal order quantity and supply chain coordination effect in the traditional condition where both the supplier and retailer are loss neutral and fairness neutral. Then, we will analyze the revenue sharing from loss and fairness behavior, and by comparing the optimal order quantity of the traditional retailer and the retailer under both loss aversion and fairness concern so as to study the influence of loss aversion and fairness concern on the supply chain coordination. Finally, sensitivity analysis of the parameters such as wholesale price, retail price, production costs, revenue sharing and so on will be implemented to find out the sensitive parameters affecting the retailer decision making, so as to provide some management insights in practice.

MODEL ASSUMPTION AND DEMONSTRATION

The model studied included one supplier and one retailer, and the supplier is fairness neutral and loss neutral. The retailer and supplier are in Stackelberg game, the supplier is leader, the retailer is follower, the supplier raised wholesale price and revenue sharing coefficient, and the retailer make decision on the optimal order quantity accordingly. The main parameters and denotations in this paper are as following: $D > 0$ is the random market demand, and the probability density function and distribution function is $f(x)$ and $F(x)$ respectively. $F(x)$ is continuous, differentiable and increasing strictly, $F(0) = 0$, $\overline{F}(x) = 1 - F(x)$. q is the order quantity of retailer, p is the sale price of retailer, w is the wholesale price of retailer and c is the unit production cost of supplier subjected to $p > w > c$. ϕ ($0 \le \phi \le 1$) is the revenue sharing coefficient and it means the ratio of sale revenue shared by the retailer is ϕ, and accordingly, the supplier is $1-\phi$. $S(q)$ denote the expected sale quantity of retailer and $S(q) = q - \int_0^q F(x)$. L_r denote the expected sale, and $L_r = -\phi p \int_0^{\frac{wq}{\phi p}} F(x)dx$. λ_r ($\lambda_r \ge 0$), β_r ($\beta_r \ge 1$) denote the degree of fairness concern and loss aversion accordingly. The bigger the λ_r is, the bigger the degree of fairness concern is, and the retailer pay more attention to fair distribution and the retailer is willing to pay a huge cost to maintain fair distribution, when $\lambda_r = 0$, that is to say the retailer is fairness neutral, which is equal to the traditional condition. With β_r increasing, the degree of loss aversion of decision maker is increasing, especially when $\beta_r = 1$, it means the retailer is not concerned about loss. q^* and q^0 is the corresponding optimal order quantity of retailer and supply chain when the retailer is fairness neutral and loss neutral. $q^*_{\lambda\beta}$ and $q^0_{\lambda\beta}$ is the corresponding optimal order quantity of retailer and supply chain when the retailer is fairness concern and loss aversion. π_r, π_s and π is the expected profit of retailer, supplier and supply chain system. U_r, U_s and U is the utility of retailer, supplier and supply chain system.

When the retailer is fairness neutral and loss neutral, the expected profit of retailer, supplier and supply chain system is as following:

$\pi_r = \phi p S(q) - wq$; $\pi_s = (1-\phi) p S(q) + (w-c)q$; $\pi = pS(q) - cq$

It is easy to get $d^2\pi_r / dq^2 = -\phi pf(q) < 0$, π_r is strictly concave function, so there exists unique optimal solution q^*, subjected to $\overline{F}(q^*) = \frac{w}{\phi p}$. Similarly, the optimal order quantity maximizing the profit of supply chain is q^0 with $\overline{F}(q^0) = \frac{c}{p}$. For $p > w > c$ and $0 \le \phi \le 1$, we can get $\overline{F}(q^*) > \overline{F}(q^0)$, i.e. $q^* < q^0$.

Therefore, the traditional supply chain can't achieve coordination by revenue sharing contract. In addition, the factors influencing the optimal order quantity of retailer are wholesale price, retail price and revenue sharing coefficient, and the factors influencing the optimal order quantity of supply chain are only including supplier production costs and retail price.

We will applied the following model to denote the utility function of retailer and supply chain, when the retailer is loss aversion and fairness concern.

$U_r = \pi_r + \lambda_r(\pi_r - \pi_s) + (\beta_r - 1)L_r$, $U = \pi + \lambda_r(\pi_r - \pi_s) + (\beta_r - 1)L_r$

Take each parameters into the above equation, we can get:

$$U_r = \phi pS(q) - wq + \lambda_r[(2\phi - 1)pS(q) - 2wq + cq] - (\beta_r - 1)\phi p\int_0^{\frac{wq}{\phi p}} F(x)dx$$

$$U = pS(q) - cq + \lambda_r[(2\phi - 1)pS(q) - 2wq + cq] - (\beta_r - 1)\phi p\int_0^{\frac{wq}{\phi p}} F(x)dx$$

THE OPTIMAL DECISION OF RETAILER

Proposition 1: When $\beta_r > \phi p(\lambda_r p - \phi p - 2\phi p\lambda_r)/[w^2 f(\frac{wq}{\phi p})] + 1$, the utility function of retailer is strictly concave function, and there exists unique optimal solution $q^*_{\lambda\beta}$ maximizing U_r, subjected to $\overline{F}(q^*_{\lambda\beta}) = \frac{(\beta_r - 1)wF(\frac{wq^*_{\lambda\beta}}{\phi p}) + 2\lambda_r w - \lambda_r c + w}{\phi p + \lambda_r(2\phi - 1)p}$.

Conclusion 1: When $\phi > \frac{2w - c}{2p\overline{F}(q)} + \frac{1}{2}$, the optimal order quantity of retailer is increasing with fairness concern degree rising, and when $\phi < \frac{2w - c}{2p\overline{F}(q)} + \frac{1}{2}$, the optimal order quantity is increasing with fairness concern degree decreasing.

Conclusion 2: The optimal order quantity of retailer decrease as loss aversion and whole sale price increase, but it will increase as the supplier production cost and revenue sharing coefficient increase.

With the increase of the loss aversion degree of retailers or wholesale price, the retailer's optimal order quantity decreasing. The more retailers fear loss, the more conservative his order quantity become. As wholesale price increases, the share obtained from unit sale revenue by retailer is decreasing, but the share of supplier is increasing, so the retailer will feel the unfair distribution and reduce the order quantity to punish the supplier. In practice, the lower wholesale price should be applied to improve the fairness utility of retailer to increase the order quantity. Besides, with retail price increasing, the share obtained from unit sale revenue by retailer is increasing, leading to utility increasing of retailer, so the retailer will increase the order quantity. When the production cost increase, although the profit of retailer is constant, the profit of supplier is decreasing, so the revenue share of retailer in the supply chain is increasing, he will feel the more fair treatment and increase the order quantity to encourage and reward the supplier. When the loss aversion and fairness concern is not referred, the retailer will not pay attention to the profit of supplier, so the optimal order quantity decision is not affected by production cost of supplier, but when the he loss aversion and fairness concern is considered, the retailer will compare his own profit with the profit of supplier, so the optimal order quantity of retailer will affected by production cost.

THE OPTIMAL DECISION OF SUPPLY CHAIN

$$\beta_r > -\phi^2 pf(q)(1+2\phi\lambda_r-\lambda_r)/[w^2 f(\frac{wq}{\phi p})]+1$$

Proposition 2: When , the utility function of supply chain is strictly concave, and there exists the unique optimal solution $q_{\lambda\beta}^0$ to maximize U, and $q_{\lambda\beta}^0$ subjected to

$$\overline{F}(q_{\lambda\beta}^0)=\frac{(\beta_r-1)wF(\frac{wq_{\lambda\beta}^0}{\phi p})+c+2\lambda_r w-\lambda_r c}{\phi p+\lambda_r(2\phi-1)p}.$$

Proposition 3: when the retailer is of loss aversion and fairness concern, if coordination $\phi=\frac{p(\beta_r+c-\lambda_r c+2\lambda_r w)}{(w-c)(1+2\lambda_r w)}$, the revenue sharing contract can coordinate the supply chain.

Conclusion 3: When $\phi>\frac{2w-c}{2p\overline{F}(q)}+\frac{1}{2}$, the optimal order quantity of supply chain increase as fairness concern degree of retailer increase. When $\phi<\frac{2w-c}{2p\overline{F}(q)}+\frac{1}{2}$, the optimal order quantity of supply chain decrease as fairness concern degree of retailer increase. Besides, the change trend of optimal order quantity of retailer is more obvious than that of supply chain system.

Conclusion 4: The optimal order quantity of the supply chain decrease as the degree of loss aversion, wholesale price increase, and it increase as the retail price, supplier production cost and revenue sharing coefficient increase. Besides, the change trend of optimal order quantity of retailer is more obvious than that of supply chain system.

NUMERICAL ANALYSIS

We will adopt the data in Du (2010)[8] and apply Excel to analyze the model. We assume that the product market demand follow the normal distribution $N(1000,100^2)$ and the relative parameters are as following: $p=160$, $w=90$, $c=40$, $\phi=0.7$.

We will analyze the impact of λ_r and β_r on the optimal order quantity of retailer and supply chain, and provide sensitivity analysis to w, p, c, ϕ.

TABLE 1 : The influence of λ_r and β_r on the optimal decision of retailer and supply chain

λ_r	βr	q^*	π_r	π_s	π	U_r	U
0.19	2.60	1021	16526	97514	114040	879.34	98393.34
0.17	3.30	1021	16526	97514	114040	2385.81	99899.81
0.15	4.00	1021	16526	97514	114040	3892.28	101406.28
0.13	4.66	1021	16526	97514	114040	5405.23	102919.23
0.11	5.35	1021	16526	97514	114040	6913.32	104427.32

From TABLE 1, the optimal order quantity of retailer and supply chain remain equal and unchanged. Therefore, when the retailer is of loss aversion fairness concern, the revenue sharing contract can achieve supply chain coordination. Besides, the influence of λ_r and β_r on the $q_{\lambda\beta}^*$ and $q_{\lambda\beta}^0$ is illustrated in Figure 1 and Figure 2 (R denote the optimal order quantity of retailer, and SC denote the optimal order quantity of supply chain).

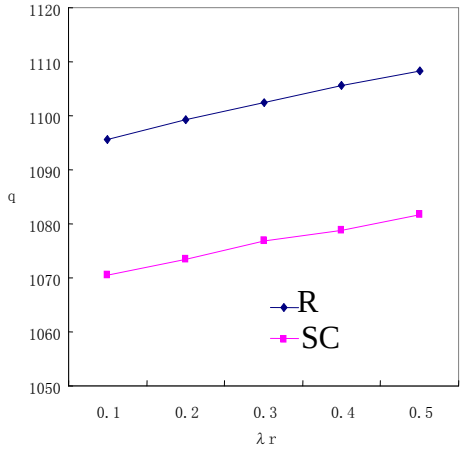

Figure 1 : Influence of λ_r on $q^*_{\lambda\beta}$ and $q^0_{\lambda\beta}$

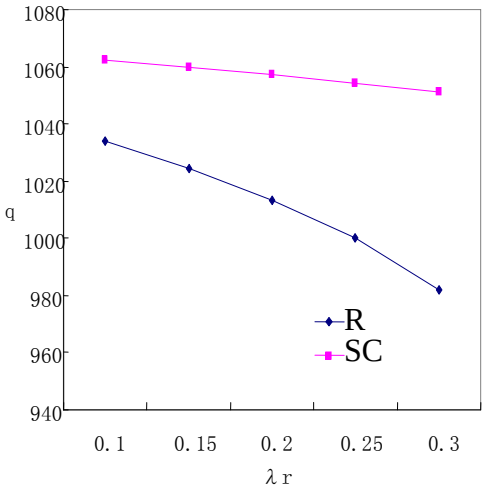

Figure 2 : Influence of λ_r on $q^*_{\lambda\beta}$ and $q^0_{\lambda\beta}$

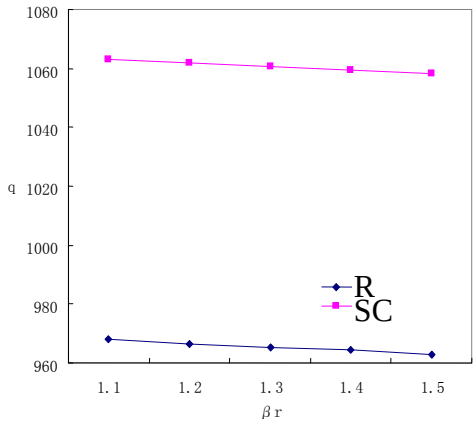

Figure 3 : Influence of β_r on $q^*_{\lambda\beta}$ and $q^0_{\lambda\beta}$

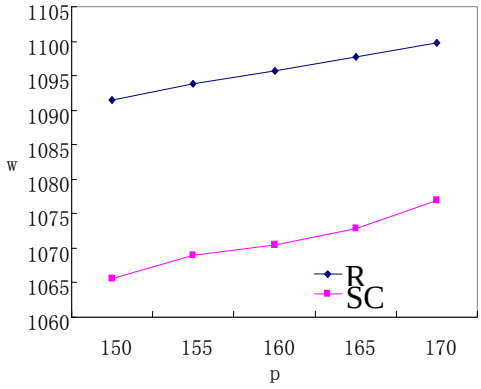

Figure 4 : Influence of p on $q^{*}_{\lambda\beta}$ and $q^{0}_{\lambda\beta}$

In Figure 1, when $\phi > \frac{2w-c}{2p\overline{F}(q)} + \frac{1}{2}$, with the fairness concern of retailer increasing, the optimal order quantity of retailer and supply chain system is increasing, and the the change trend of optimal order quantity of retailer is more obvious than that of supply chain system. In Figure 2, when $\phi < \frac{2w-c}{2p\overline{F}(q)} + \frac{1}{2}$, with the fairness concern of retailer increasing, the optimal order quantity of retailer and supply chain system is decreasing, which has verified conclusion 1 and conclusion 3. From Figure 3, with the loss aversion increasing, the he optimal order quantity of retailer and supply chain system is decreasing, and the change trend of optimal order quantity of retailer is more obvious than supply chain system, which has verified the conclusion 2 and conclusion 4.

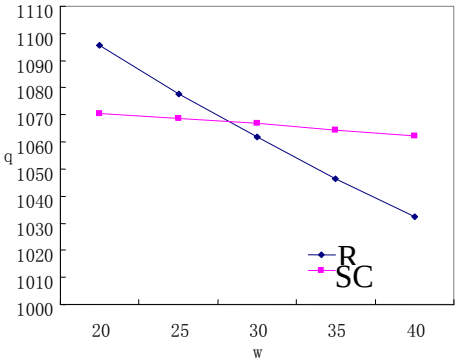

Figure 5 : Influence of w on $q^{*}_{\lambda\beta}$ and $q^{0}_{\lambda\beta}$

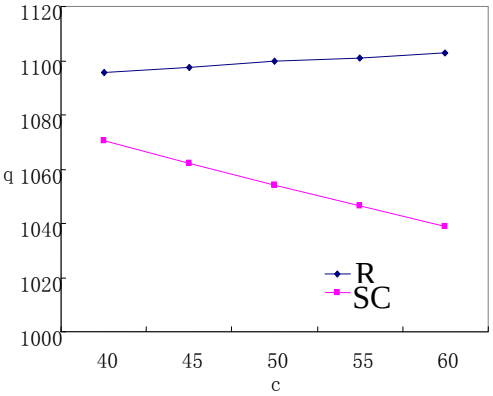

Figure : 6 Influence of c on $q^{*}_{\lambda\beta}$ and $q^{0}_{\lambda\beta}$

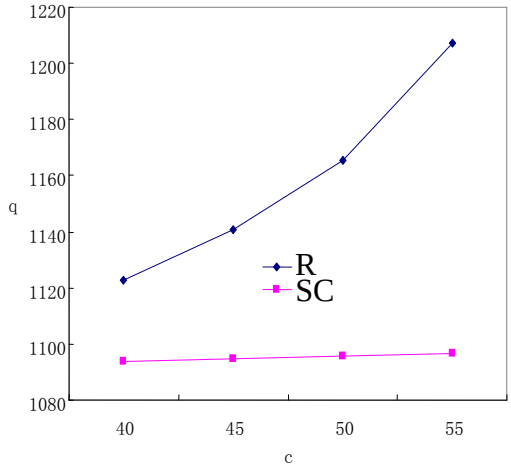

Figure 7 : Influence of c on $q^*_{\lambda\beta}$ and $q^0_{\lambda\beta}$

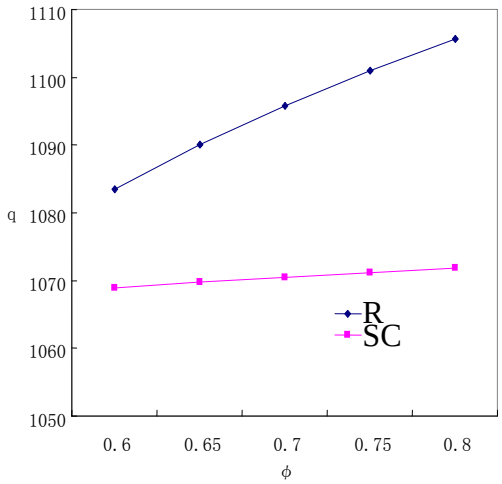

Figure 8 : Influence of ϕ on $q^*_{\lambda\beta}$ sand $q^0_{\lambda\beta}$

In Figure 4, with the increase in retail price, the optimal order quantity of retailer and supply chain showed a rising trend. From Figure 5, with wholesale price increasing, the optimal order quantity of retailer and supply chain decreasing, and the change trend of optimal order quantity of retailer is more obvious than supply chain system. Figure 6 and 7 showed the influence of production cost on the optimal order quantity, with the increase in production costs, the retailer's optimal order quantity increments, the optimal order quantity diminishing supply chain system. From Figure 7, the time, under $\lambda_r < 1$, with the increase in production costs, optimal order quantity of retailer increase, but the optimal order quantity of supply chain decrease. When $\lambda_r > 1$, as shown in Figure 7, with the increase in production costs, optimal order quantity of both retailer and supply chain increase, which verified conclusion 2 and conclusion 4. From Figure 8, we can find that the optimal order quantity of both retailer and supply chain will increase as the revenue sharing coefficient increase, and the change trend of optimal order quantity of retailer is more obvious than supply chain system.

CONCLUSION

A two-stage supply chain including one supplier and one retailer was set, and the revenue sharing contract considering the loss aversion and fairness concern of retailer was applied to coordinate the supply chain. The impacts of the loss aversion and fairness concern of retailer on the relative decision of retailer and supply chain was analyzed. Our research showed that when the retailer is of loss aversion and fairness concern, the revenue sharing contract can coordinate supply chain. The optimal order quantity of both retailer and supply chain decrease as the degree of loss aversion increase, but the change trend to the fairness concern depending on the different revenue sharing coefficient, i.e. when the revenue sharing coefficient is bigger, the optimal order quantity increase in the fairness concern of retailer, but when the coefficient is

smaller, it will decrease in fairness concern, and furthermore, the changing trend of optimal order quantity of retailer is obvious than that of supply chain. Then, the sensitivity analysis is applied to the relative factors, such as wholesale price, retail price, production cost and revenue sharing coefficient. So the retailer's loss aversion behavior and fairness preference has influence on the optimal decision of retailer and supply chain, and when the revenue sharing is applied to coordinate the supply chain, the loss aversion and fairness concern should be identified fully to coordinate the supply chain better.

But there are some limits to our paper. Firstly, only the fairness concern and loss aversion of retailer was considered, but there was no reference to the fairness concern or loss aversion of supplier, so the future research may study the fairness concern and loss aversion of both supplier and retailer on the optimal decision. Secondly, we didn't consider the competition between suppliers and retailers. In this paper the simple supply chain including one supplier and one retailer is considered, the future research can extend the supply chain members. Finally, only the influence of loss aversion and fairness concern on the optimal decision was studied, but the decision of supply chain members may be affected by other various preferences, such as reciprocity, sympathy, envy, and so on, so the future research can introduce these various preferences to analyze the optimal decision of supply chain members.

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