Effort Decision in the Retailer Dominated Supply Chain Considering Supplier's Fairness

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Abstract
I set the model of retailer dominated supply chain and analyze the impact of supplier's fairness concern on the wholesale price, bilateral efforts and profit. I prove that the supplier's fairness concern can improve his own effort, wholesale price and profit and increase the market sale, but it will reduce the retailer's effort and profit. So even if the retailer can dominate the supply chain and obtain most profit of supply chain, he should pay attention to the fairness concern of supplier, otherwise he will be revenged by supplier, and at the same time the supplier can utilize his fairness concern to improve his status in the supply chain and obtain more profit, and thus achieve more fair channel profit distribution.
Key words: RETAILER DOMINATED, FAIRNESS CONCERN, WHOLESALE PRICE, EFFORT LEVEL

Introduction

With the development of e-commerce and logistics technology, more and more suppliers sell products through large retailers, especially in fast moving consumer goods, electronics, home appliances and other products, such as Wal-Mart, Carrefour, Suning, Gome, etc. For the suppliers, they can expand the market demand through channel management, technical support, market research and other auxiliary. As from 2004, Lenovo Group taken various measures to take his downstream distributors, agents and chain retailers into his own management system to ensure the orderly channel efficiency. The 2012 financial statements shew that the Lenovo association still achieved a 10.3% increase rate in the global PC market sales fell by 8% of the cases. At the same time, retailers adopt product promotion, advertising, customer training, product descriptions and other marketing tools to increase sales, so the sale efforts of suppliers and retailers have become an important means to guide changes in demand. In addition, since the actual supply chain process, due to operational scale, market influence and other factors, each member of the supply chain has different position and power in the supply chain. The dominant enterprises try to transfer the costs and business

risks onto the vulnerable members by their strong bargaining power, making it difficult to achieve the optimum operation of the supply chain status. Such unfair trade practices will certainly stimulate or enhance fairness concern of the weaker party.

The widely used supply chain contracts, such as wholesale price contracts, buyback contracts, and revenue sharing contracts [1], have been regarded as an effective approach to coordinate supply chain and align targets of independent supply chain partners. However, some experimental and empirical research has suggested that they are not consistent with practice in many respects [2], and one of the issues is that the decision-makers' fairness concerns have been neglected [3]. Fairness preference plays an important role in maintaining a healthy channel relationships and achieving efficient operation. For example, If the retailer feels unfair distribution of profits, then they would take action to retaliate suppliers, such as raising sale price and thus reduce their profit gap with supplier, the consequences of doing so is to reduce its own sales, leading to profits felling of both supplier and retailer. So it's necessary to study the compact of fairness concern on the effort levels and profits of supply chain decision-maker. The widely used supply chain contracts, such as wholesale price contracts, buyback contracts, and revenue sharing contracts [1], have been regarded as an effective approach to coordinate supply chain and align targets of independent supply chain partners. However, some experimental and empirical research has suggested that they are not consistent with practice in many respects [2], and one of the issues is that the decision-makers' fairness concerns have been neglected [3]. Fairness preference plays an important role in maintaining a healthy channel relationships and achieving efficient operation. For example, If the retailer feels unfair distribution of profits, then they would take action to retaliate suppliers, such as raising sale price and thus reduce their profit gap with supplier, the consequences of doing so is to reduce its own sales, leading to profits felling of both supplier and retailer. So it's necessary to study the compact of fairness concern on the effort levels and profits of supply chain decision-maker.

Under the assumption of a linear uncertain market conditions demand the introduction of fairness preference newsboy model, the researchers found that as long as retailers focus on equity, then the supplier can always be higher than the marginal cost of the development of the wholesale price contract supply chain coordination. Zhao and Lv (2013) introduce the supplier's fairness concern into the retailer dominant VMI model of supply chain, they proved that the profit of supply chain member were influenced by negative fairness utility by comparing the marginal profit with each other [8]. So in this paper ,we will focus on the retailer dominant supply chain, and when the retailer's and supplier's efforts influence the market demand, the fairness concern of supplier will influence the supplier's wholesale price, efforts and profit, so as to expand the behavior supply chain.

1. Assumption and basic model

(1) Both the retailer's and supplier's efforts decide the market demand of product, and in general, the higher the effort level suppliers and retailers, the more sales.

(2) When neither retailer and supplier make effort, the market demand is 0, and the product sale can be denoted simply as $q = k_s e_s + k_r e_r$. $k_s e_s$ is the market demand increment after the supplier makes effort, e_s is the supplier's effort level of product sale and k_s is the effort effect coefficient of supplier, i.e. The increment demand caused by unit effort of supplier. $k_r e_r$ is the market demand increment after the retailer makes effort, e_r is the retailer's effort level of product sale and k_r is the effort effect coefficient of retailer, i.e. The increment demand caused by unit effort of retailer. When $e_s = 0$ and $e_r = 0$, the market demand is 0, i.e. $q = 0$. Besides, for the suppliers understand the product features better, and thus he can effectively provide products to meet customer needs, so the supplier's efforts can be prone to change the market demand, i.e. $k_s > k_r$.

(3) We assume that the effort cost of supplier and retailer is corresponding to $\frac{1}{2}e_s^2$ and $\frac{1}{2}e_r^2$, which means the harder supplier or retailer, the higher the effort cost, and marginal effort cost increase with effort level.

(4) w is the wholesale price provide by supplier for the retailer, p is the market sale price. We consider the full competition market, so p is determined by market completion and it is constant.

The supplier's profit function is:

$$\pi_s = w(k_s e_s + k_r e_r) - \frac{1}{2}e_s^2 \tag{1}$$

The retailer's profit function is

$$\pi_r = (p-w)(k_s e_s + k_r e_r) - \frac{1}{2}e_r^2 \tag{2}$$

The profit function of supply chain is

$$\pi_{sc} = p(k_s e_s + k_r e_r) - \frac{1}{2}e_s^2 - \frac{1}{2}e_r^2 \tag{3}$$

2. Model of fully rational supplier

In the supply chain dominated by retailer, although the market is perfectly competitive, retailer can use their dominant position to control supplier's wholesale price, and then the Stackelberg game process of supplier and retailer is as following: firstly, the retailer decides the wholesale price w and effort level e_r, and then the supplier decides his own effort level e_s according to the wholesale price w and effort level e_r. By backward induction method, the model can be as following:

$$\max_{w,e_r} \pi_r = (p-w)(k_s e_s + k_r e_r) - \frac{1}{2}e_r^2$$

$$\text{s.t. } \max_{e_s} \pi_s = w[k_s e_s + k_r e_r] - \frac{1}{2}e_s^2$$

It is easy to compute the optimal wholesale price w^*, effort level e_r^* of retailer and the optimal effort level e_s^* of supplier, which are as following:

$$w^* = \frac{(k_s^2 - k_r^2)p}{2k_s^2 - k_r^2} \tag{4}$$

$$e_s^* = \frac{k_s(k_s^2 - k_r^2)p}{2k_s^2 - k_r^2} \tag{5}$$

$$e_r^* = \frac{k_r k_s^2 p}{2k_s^2 - k_r^2} \tag{6}$$

It easy to get $w^* = [1 - \frac{1}{2 - (k_r^2/k_s^2)}]p < p$. Let $k = k_r/k_s$ ($0 < k < 1$), which denotes the ratio of retailer's effort and supplier's effort, and the ratio means the relative compact of supplier and retailer on the market. The bigger value of k means the retailer's influence on the market is more than supplier, on the contrary, the smaller value of k means the retailer's influence is smaller. Besides, it is easy to find $\frac{dw^*}{dk} < 0$, i.e. when the influence of supplier's efforts on the market is bigger, then the supplier will request and provide the higher wholesale price. But when the influence of supplier's efforts on the market is smaller, then the supplier will request and provide the lower wholesale price

From equation (5) and (6), when the market sale price is higher, then the efforts of supplier and retailer will be higher. This is because the retailer and supplier can get more profit from product sale with the increasing market price, so both of them will make more efforts to sell product. So we can compute the optimal effort ratio e^* of retailer and supplier and optimal sale quantity q^* is as following:

$$e^* = \frac{e_r^*}{e_s^*} = \frac{k_s k_r}{k_s^2 - k_r^2} \tag{7}$$

$$q^* = \frac{k_s^4 p}{2k_s^2 - k_r^2} \tag{8}$$

$$w^* = \frac{(k_s^2 - k_r^2)p}{2k_s^2 - k_r^2} \tag{9}$$

Take w^*, e_s^* and e_r^* into the profit function of supplier and retailer, and thus we can get the optimal profit of retailer and supplier is:

$$\pi_s^* = \frac{k_s^4 p^2 (2k_s^2 - 3k_r^2)}{2(2k_s^2 - k_r^2)^2} \tag{10}$$

$$\pi_r^* = \frac{k_s^2 p^2 (k_s^4 + 2k_s^2 k_r^2 - k_r^4)}{2(2k_s^2 - k_r^2)^2} \tag{11}$$

$$\pi_{sc}^* = \frac{k_s^2 p^2 (3k_s^4 - k_r^2 k_s^2 - k_r^4)}{2(2k_s^2 - k_r^2)^2} \tag{12}$$

3. Model of fairness-concern supplier

When supplier cares about fairness concern and the retailer's profit is more than supplier's, then supplier will be jealous about retailer and cause jealousy utility. On the contrary, when the retailer's profit is lower than supplier, the supplier will cause positive utility.

Here, we assume the utility function of supplier is linear, then the supplier's utility function is: $u_s = \pi_s - \lambda(\pi_r - \pi_s)$.

The backward induction method can also be adopted to solve the sub-game perfect equilibrium solution, i.e. the solution of the following model:

$$\max_{w,e_r} \pi_r = (p-w)(k_s e_s + k_r e_r) - \frac{1}{2}e_r^2$$

$$\text{s.t. } \max_{e_s} u_s = \pi_s - \lambda(\pi_r - \pi_s)$$

When take each parameters into the supplier's profit function and retailer's utility function, we can get

$$\max_{w,e_r} \pi_r = (p-w)(k_s e_s + k_r e_r) - \frac{1}{2}e_r^2$$

s.t.

$$\max_{e_s} u_s = (1+\lambda)w(k_s e_s + k_r e_r - \frac{1}{2}e_s^2) - \lambda[(p-w)(k_s e_s + k_r e_r) - \frac{1}{2}e_r^2]$$

The solution process is same to the condition of fully rational retailer, so we can compute the optimal wholesale price w^{F*}, the

efforts of supplier e_s^{F*} and the optimal effort of retailer e_r^{F*} is corresponding:

$$w^{F*} = \frac{(k_s^2 + 3\lambda k_s^2 - k_r^2 - \lambda k_r^2)p}{2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)}$$
(13)

$$e_r^{F*} = \frac{(1+\lambda)k_s^2 k_r p}{2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)}$$
(14)

$$e_s^{F*} = \frac{k_s(2\lambda k_s^2 + k_s^2 - k_r^2 - \lambda k_r^2)p}{2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)}$$
(15)

Then, we can compute the ratio of retailer's effort and supplier's effort e^{F*} and the product sale quantity q^{F*}

$$e^{F*} = \frac{e_r^{F*}}{e_s^{F*}} = \frac{k_r k_s(1+\lambda)}{(1+\lambda)(2k_s^2 - k_r^2) - k_r^2}$$
(16)

$$q^{F*} = \frac{k_s^3 p(k_s + 2\lambda k_r)}{2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)}$$
(17)

Take w^{F*}, e_s^{F*} and e_r^{F*} into the supplier's utility function and retailer's profit function, and we can get the supplier's utility u_s^{F*} and retailer's profit π_r^{F*} and utility of supply chain u_{sc}^{F*} is corresponding:

$$u_s^{F*} = \frac{k_s p^2 E(\lambda)}{H(\lambda)}$$
(18)

$$\pi_r^{F*} = \frac{k_s p^2 F(\lambda)}{H(\lambda)}$$
(19)

$$u_{sc}^{F*} = \frac{k_s p^2 G(\lambda)}{H(\lambda)}$$
(20)

Where $E(\lambda)$, $F(\lambda)$, $G(\lambda)$ and $H(\lambda)$ can be denoted as following:

$$E(\lambda) = \lambda^3 k_r^4 k_s + 2\lambda^2 k_r^4 k_s + \lambda k_r^4 k_s - 9\lambda^3 k_r^3 k_s^3 - 19\lambda^2 k_r^3 k_s^3 - 13\lambda k_r^2 k_s^3 - 3k_r^2 k_s^3 + 12\lambda^3 k_s^5 + 20\lambda k_s^5 + 2k_s^5$$

$$F(\lambda) = 4\lambda^2 k_r^2 k_s^2 + 6\lambda k_r^2 k_s^2 + 2k_r^2 k_s^2 + 2\lambda k_s^4 + k_s^4 - \lambda^2 k_r^4 - 2\lambda k_r^4 - k_r^4$$

$$G(\lambda) = \lambda^3 k_r^4 k_s + \lambda^2 k_r^4 k_s - \lambda k_r^4 k_s - k_r^4 k_s - 9\lambda^3 k_r^2 k_s^3 - 15\lambda^2 k_r^2 k_s^3 - 7\lambda k_r^2 k_s^3 - k_r^2 k_s^3 + 12\lambda^3 k_s^5 + 20\lambda^2 k_s^5 + 13\lambda k_s^5 + 3k_r^5$$

$$H(\lambda) = 2[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2$$

Proposition 1 When supplier is of fairness concern:

① The wholesale price proposed by retailer is increasing, then the retailer's effort level will be reduced;

② If the supplier improve his own effort, then the ratio of supplier's effort and retailer will increase;

③ The product sale quantity will decrease.

Proof. When we compare the wholesale price, sale quantity, supplier's effort level and the ratio of retailer and supplier, we can get

$$w^{F*} - w^* = \frac{2\lambda k_s^4 p}{(2k_r^2 - k_r^2)[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]} > 0,$$

$$e_r^{F*} - e_r^* = -\frac{2\lambda k_r k_s^4 p}{(2k_s^2 - k_r^2)[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]} < 0$$

$$e_s^{F*} - e_s^* = \frac{\lambda k_r^2 k_s^3 p}{(2k_s^2 - k_r^2)[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]} > 0$$

$$q^{F*} - q^* = -\frac{\lambda k_r^2 k_s^4 p}{(2k_s^2 - k_r^2)[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]} < 0$$

$$e^{F*} - e^* = -\frac{\lambda k_r k_s^3}{(k_s^2 - k_r^2)[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]} < 0$$

Q.E.D.

The proposition 1 illustrates that, the supplier's fairness preference help to improve his status in the supply chain, and thus take more profit. For the retailer's effort is lowered, and thus the product sale is decreasing, so the supplier's fairness concern will lower the retailer's profit.

Proposition 2 When the supplier cares about fairness concern, the wholesale price proposed by retailer, effort of supplier and product sale is positively related to the supplier's fairness concern, but the effort of retailer and the ratio of retailer's effort and supplier's effort is negatively related to the supplier's fairness concern.

Proof. By analyzing the relation between w^{F*}, e_s^{F*}, e_r^{F*}, e^{F*} and λ, we can obtain:

$$\frac{\partial w^{F*}}{\partial \lambda} = \frac{2k_s^4 p}{[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2} > 0$$

$$\frac{\partial e_r^{F*}}{\partial \lambda} = -\frac{2k_r k_s^4 p}{[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2} < 0$$

$$\frac{\partial e_s^{F*}}{\partial \lambda} = \frac{2k_r^2 k_s^4 p}{[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2} > 0$$

$$\frac{\partial e^{F*}}{\partial \lambda} = -\frac{2k_r k_s^3}{[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2} < 0$$

$$\frac{\partial q^{F*}}{\partial \lambda} = \frac{k_r^2 k_s^4 p}{[2\lambda k_s^2 + (1+\lambda)(2k_s^2 - k_r^2)]^2} > 0$$

Q.E.D.

Proposition 2 shows that when the disadvantaged supplier is concerned about fair distribution of profits, and when his fairness preference is stronger, then the supplier wants to narrow the gap between retailer's profit and his own profit so as to reduce the negative effect of the disadvantaged equity utility. So the supplier will increase level of effort to increase product sales and thus increase their profits.

This leads the impact of supplier on the market increasing, and the retailer will have to an increase wholesale price rightly in order to overcome the supplier's fairness disutility. However, due to the wholesale price increase will reduce the unit product profit, the retailer's effort level will drop, and therefore the supplier's effort level will crowd the retailer's effort.

Similarly, we can get the proposition 3 by analyzing the relation between u_s^{F*}, π_r^{F*}, u_{sc}^{F*} and λ.

Proposition 3 The stronger the supplier's fairness preference, the greater the supplier's utility and supply chain utility, but the lower the retailer's profit.

Proof.

$$\frac{\partial u_s^{F*}}{\partial \lambda} = \frac{\partial u_s^{F*}}{\partial e_s^{F*}} \cdot \frac{\partial e_s^{F*}}{\partial \lambda} > 0$$

$$\frac{\partial \pi_r^{F*}}{\partial \lambda} = \frac{\partial \pi_r^{F*}}{\partial e_r^{F*}} \cdot \frac{\partial e_r^{F*}}{\partial \lambda} + \frac{\partial \pi_r^{F*}}{\partial e_w^{F*}} \cdot \frac{\partial e_w^{F*}}{\partial \lambda} < 0$$

$$\frac{\partial u_{sc}^{F*}}{\partial \lambda} = \frac{\partial u_{sc}^{F*}}{\partial e_r^{F*}} \cdot \frac{\partial e_r^{F*}}{\partial \lambda} + \frac{\partial u_{sc}^{F*}}{\partial e_w^{F*}} \cdot \frac{\partial e_w^{F*}}{\partial \lambda} + \frac{\partial u_{sc}^{F*}}{\partial e_s^{F*}} \cdot \frac{\partial e_s^{F*}}{\partial \lambda} > 0$$

Q.E.D.

Proposition 3 shows that when we consider the disadvantaged supplier's fairness concern in the retailer dominating supply chain, the retailer should encourage supplier to improve and ensure the level of effort by transferring some of the profit to supplier, so as to promote the more balanced and right structure of upstream and downstream of supply chain and avoid vicious competition between members of the supply chain, ultimately improving the overall effectiveness of the supply chain.

Further, we can get the conclusion 1.

Conclusion 1 the supplier's fairness concern can

(1)Improving his own profit and effort level;

(2)Reducing the retailer's effort and profit;

(3)Increasing product sale and utility of supply chain.

5. Conclusion

This paper has set the model of retailer dominated supply chain and analyzed the impact of supplier's fairness concern on the wholesale price, bilateral efforts and profit. We have proved that the supplier's fairness concern can improve his own effort, wholesale price and profit, leading to increasing the market sale, but it will reduce the retailer's effort and profit. Besides, the greater the supplier's fairness intensity, the higher the wholesale price, supplier's effort and product sale, but the lower the retailer's effort and profit, but there are still some problems need to solve.

The research is under the simple linear demand function, and we can focus on the supplier-retailer game under nonlinear demand function, such as exponential distribution, normal distribution, and so on. Secondly, the fairness coefficient of each member is dependent on the external actions. For example, when the external action of retailer is stronger than that of supplier, then the fairness coefficient of retailer will become bigger, which means the more intense fairness concern. When the retailer increases the market scale or his market compact is strengthened, and thus the position in supply chain is improved, so the fairness coefficient of retailer would become bigger. Any factors influencing the contribution of each members, such as market factors or material suppliers will affect the fairness coefficient. For example, when the retailer expands the market demand by his own promotional or advertising efforts, the retailer will think his contribution to the supply chain is more than supplier, and thus the fairness coefficient should be raised too. When the retailer's marginal cost is reduced or retailer helps the supplier reduce his marginal cost, the fairness coefficient should be raised. So the future research can focus on the supplier-retailer game under the dynamic adjustment of fairness coefficient. Finally, we only considered the fairness concern of jealousy and emulation, and in real business, there are other preferences, such as altruism preference, reciprocal preference, sympathy, and so on, so the future research can introduce various preferences to study the more actual decision of decision-maker in supply chain.

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