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Supply Chain Contract Incorporating Fairness under Asymmetric Information

Guangxing Wei, Yao Tang

School of Economics and Management, Chongqing Jiaotong University, Chongqing, China
Email: wgx777@126.com

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Abstract

This paper obtains optimal settings of each parameter on a supply chain composed of a rational manufacturer and a fair retailer. Through the establishment of model under information symmetry and information asymmetry, in which the effort level of retailer can't be observed by manufacturer, the impact of retailer's fairness on his effort level and manufacturer's utility are explored and investigated. From the comparison, this paper find that retailer's effort level and manufacturer's utility under information asymmetry are higher than those under information symmetry, and the difference is directly proportional to the degree of retailer's fairness. Retailer's fairness has positive effect on his effort level and manufacture's utility under information asymmetry, and manufacturers tend to cooperate with the retailer who has higher degree of fairness.

Keywords

Supply Chain Contract, Asymmetric Information, Fairness

1. Introduction

In recent years, the improvement of the supply chain performances has become a key point of researches in the Supply Chain Management. Retailers are more and more developing familiarity with the market especially customers, they often organize various promotions to attract potential customers and expand sales. Therefore, how retailers can increase promotional effort level so as to improve the whole performance of supply chain has been the target of many scholars. For example, Wen, C.Z., Ji J. H. studied the coordination problem of supply chain assuming the retailer sales efforts to be verifiable. But actually, retailer's effort level cannot be observed by the manufacturer [1]. So, Xiao, Q., Ma S.H. studied how to reveal the real effort cost of retailers under unpredictable promotion cost, results show that under the condition of information asymmetry the optimal ordering quantity and sales effort level of retailer can only meet a sub-optimal result of Pareto improvement [2]. Moreover, with a large number of psychology and economics' researches repeatedly confirming that individuals have certain bias in behavioral decision, people are not completely rational. At this time, overconfidence and fairness being two important psychological factors which affect person's economic behavior were widely considered into researches aiming at supply chain coordination. For instance, Zhou, Y. W., Liu Z.R. evaluated if the supplier would apply or not contractual mechanisms to maximize profits when confronted with an overconfident retailer [3], Chen, Q., Yang X.T. analyzed the principal-agent relationship when the agent has overconfidence as well as

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the effect of overconfidence on principal-agent relationship [4], Pu, X.J., Gong. L., Zhang X. investigated the influence of fairness on the promotion effort and supply chain efficiency [5], and Xu, Y.F., Liu Z.R., Wang, H.J. combined information asymmetry (the effort level of the retailer can't be monitored by the manufacturer) and retailer's overconfidence, studied the influence of overconfidence on the retailer's promotion effort and the manufacturer's utility under information asymmetry as well as the value of the retailer's overconfidence information [6]. But there is no literature about the influence of retailer's fairness on his own promotion effort level and the manufacturer's utility when the promotion effort level of the retailer with fairness can't be observed. On that basis, this paper studies the influence of retailer's fairness on its own promotion effort level and manufacture's utility under information asymmetry (the unobserved sales effort of retailer), and analyzes the relationship between the fairness and the difference of retailer's sales effort and manufacturer's utility under symmetric and asymmetric information, the final results show that the manufacturer tends to cooperate with the retailer who has a higher degree of fairness.

2. Parameters and Hypothesis

Consider a supply chain made up of one manufacturer M and one retailer R, in which the manufacturer as the leading party is completely rational and the retailer is the follower with fairness. Production cost is c, manufacturer sells products to retailer at a wholesale price w, retailer sells products to consumers at a price p. p is an exogenous variable and it has no influence on market demand. w – c > 0 means that the marginal profit of manufacturer is greater than zero and p − w > 0 shows that the marginal profit of retailer is greater than zero. Assuming the market demand function is $D = a + he$, in which a stands for basic demand of market, h for the elastic coefficient that promotion effort level affects market demand, and e for the retailer's promotion effort level, $a > 0$, $e \geq 0$, $h > 0$. The retailer's promotion cost function is $c(e) = \frac{\varepsilon e^2}{2}$, ε is a promotion cost coefficient and $\varepsilon > 0$. $c(e)$ satisfies the condition that $c'(e) > 0$ and $c''(e) > 0$. The profits of the retailer and the manufacturer are respectively defined as $\pi_R = (p - w)(a + he) - \frac{\varepsilon e^2}{2}$, $\pi_M = (w - c)(a + he)$.

3. Supply Chain Contract Incorporating Fairness

In terms of theoretical description of fairness, the representative model is the F-S model (Fehr and Schmidt, 1999) [7]. This model considers that individuals are upset when their returns happens to be lower or higher than others. If returns are lower than others, their jealousy will lead to additional negative utility which is called inequity averse negative utility; In contrary, if their returns are higher than others, they will deserve sympathetic negative utility. According to the principle of the F-S model, the utility function of the retailer is defined as

$$U_R = \pi_R - \alpha \max(\rho\pi_M - \pi_R, 0) - \beta \max(\pi_R - \rho\pi_M, 0)$$

in which $\rho\pi_M$ is a reference for retailer to measure whether he gets equitable profit or not, namely, the supposed deserving equitable profit of retailer should be ρ times of manufacturer's profit. When $0 < \pi_R < \rho\pi_M$ retailer's profit is less than the fair standard, fairness then leads to jealousy negative utility, α is the degree of jealousy psychology; when $\pi_R \geq \rho\pi_M$ retailer's profit is more than the fair standard, fairness leads to sympathetic negative utility, β is the degree of sympathetic psychology. Hypothesis satisfy $\alpha > \beta > 0$ condition which stipulates that actors tend to put more emphasis on jealous negative utility which is bad for them instead of focusing on sympathetic negative utility which is good for them. To simplify the model we assume $\rho = 1$ and then the retailer's utility function becomes $U_R = \pi_R - \alpha(\pi_M - \pi_R)$, the manufacturer's utility function becomes $U_M = \pi_M$, here the utility of the retailer must be more than or equal to his reserved utility and meet participation constraint condition $U_R \geq U_{\bar{R}}$.

3.1. Optimal Contract under Information Symmetry

Assuming the retailer's effort is observable so the manufacturer can force the retailer to choose any effort level e. In this contract the manufacturer puts forward parameters (w, e) and the offered retailer's effort level ensures the retailer would accept such contract. Therefore, the contract just needs to meet the retailer's participation constraint.

$$(P1)\max_{w,e} U_{M1} = (w-c)(a+he) \tag{1}$$

$$\text{s.t.}(IR)U_{R1} = \pi_R - \alpha(\pi_M - \pi_R) \geq U_{\bar{R}} \tag{2}$$

Constructing Lagrange function based on (1) and (2) as follow:

$$L(w_1, e_1) = U_{M1} + \lambda(U_{R1} - U_{\bar{R}}) \tag{3}$$

We can get the optimal solution according to (3).

Theorem 1: The optimal setting of each parameter under information symmetry as follows:

$$w_1 = \frac{\alpha(3c^2h^2 - 2ch^2p - h^2p^2 - 2ac\varepsilon - 2ap\varepsilon) + c^2h^2 - h^2p^2 - 2ap\varepsilon + 2U_{\bar{R}}\varepsilon}{2(2\alpha+1)(ch^2 - h^2p - a\varepsilon)} \tag{4}$$

$$e_1 = \frac{h(p-c)}{\varepsilon} \tag{5}$$

In the case of information symmetry, the retailer's effort level is determined by the manufacturer, which is not affected by his own fairness.

3.2. Optimal Contract under Information Asymmetry

Actually, the effort level e of the retailer can't be observed by the manufacturer. At that time, the retailer's incentive compatibility constraint is considered and the manufacturer can't then force the retailer to choose the effort level which is good for the leading party. The key problem that the manufacturer faces is to choose a wholesale price w to satisfy the participation constraint and incentive compatibility constraint of the retailer and at the same time to maximize his own utility. In this circumstance, the manufacturer decides his wholesale price w before the retailer choose the optimal effort level according to his participation constraint and incentive compatibility constraint. The manufacture's utility will be maximized under:

$$(P2)\max_{w} U_{M2} = (w-c)(a+he) \tag{6}$$

$$\text{s.t.}(IR)U_{R2} = \pi_R - \alpha(\pi_M - \pi_R) \geq U_{\bar{R}} \tag{7}$$

$$e \in \arg\max_{e} U_{R2} = \pi_R - \alpha(\pi_M - \pi_R) \tag{8}$$

We can deduce e_2 through the partial derivative of (8) towards e:

$$e_2 = \frac{h(c\alpha + p\alpha - 2w\alpha + p - w)}{\varepsilon(\alpha+1)} \tag{9}$$

Combining (9), (7) and (6) we get the following theorem.

Theorem 2: The optimal setting of each parameter under information asymmetry follows:

$$w_2 = \frac{\alpha^2(2ch^2 + 2h^2p + 2a\varepsilon) + \alpha(-2ch^2 + 2h^2p + 2a\varepsilon) - ch^2}{h^2(2\alpha+1)(2\alpha-1)} \tag{10}$$

$$e_2 = \frac{ph^2 - ch^2 + 2a\varepsilon\alpha}{h\varepsilon(1-2\alpha)} \tag{11}$$

Under information asymmetry, every parameter is directly linked to the retailer's fairness. As the degree of fairness of the retailer becomes higher, the manufacturer will lower the wholesale price w to increase the retailer's promotion effort level. Facing different retailers with different fairness, the various combinations of w and e can maximize the manufacture's utility.

4. The Influence of Fairness on Contract

4.1. The Influence on Effort Level

Under information symmetry, $\frac{\partial e_1}{\partial \alpha} = 0$; under information asymmetry, according to (11) we have

$$\frac{\partial e_2}{\partial \alpha} = \frac{2a\varepsilon + 2h^2(p-c)}{h\varepsilon(1-2\alpha)^2} > 0 \tag{10}$$

Theorem 3: Under information symmetry, the effort level of the retailer would not be influenced by his fairness; under information asymmetry, the retailer's promotional effort is proportional to the degree of his fairness.

Under information symmetry, the effort level of the retailer is determined by the manufacturer. So, his fairness degree has no influence on his sales effort. Under information asymmetry, although the manufacturer cannot force the retailer to choose the effort level which is most beneficial to him, the retailer, due to a lower wholesale price offered by the manufacturer will put more efforts on sales in order to maximize his own utility. Besides, his higher degree of fairness will drive higher his effort level, that is to say, the retailer's promotional effort is proportional to the degree of his fairness.

4.2. The Influence on Manufacture's Utility

Under information symmetry, the manufacturer's utility is

$$U_{M1} = \frac{(\alpha+1)[h^2(c-p)^2 - 2a\varepsilon(c-p)] - 2U_{\bar{R}}\varepsilon}{2\varepsilon(2\alpha+1)} \tag{13}$$

So

$$\frac{\partial U_{M1}}{\partial \alpha} = \frac{-[h^2(c-p)^2 - 2a\varepsilon(c-p)] + 4U_{\bar{R}}\varepsilon}{2\varepsilon(2\alpha+1)^2} \tag{14}$$

We only discuss the case $0 < \pi_R < \pi_M$. Substituting π_{R1} and π_{M1} into inequality, we get $U_{\bar{R}} < \frac{h^2(p-c)^2 + 2a\varepsilon(p-c)}{4\varepsilon}$. So, $\frac{\partial U_{M1}}{\partial \alpha} < 0$.

Under information asymmetry, the manufacturer's utility is

$$U_{M2} = \frac{(1+\alpha)[4a^2\varepsilon^2\alpha^2 + 2a\varepsilon h^2(p-c) + h^4(p-c)^2]}{2h^2\varepsilon(1-4\alpha^2)} - U_{\bar{R}} \tag{15}$$

So,

$$\frac{\partial U_{M2}}{\partial \alpha} = \frac{2h^2\varepsilon[4a^2\varepsilon^2\alpha^2 + 2a\varepsilon h^2(p-c) + h^4(p-c)^2](4\alpha^2+8\alpha+1) + 16a^2\varepsilon^3h^2\alpha(1+\alpha)(1-4\alpha^2)}{[2h^2\varepsilon(1-4\alpha^2)]^2} \tag{16}$$

Since $e_2 = \frac{h^2(p-c) + 2a\varepsilon\alpha}{h\varepsilon(1-2\alpha)} > 0$, with $p-c>0$, $1-2\alpha>0$, then $1-4\alpha^2>0$. Hence, $\frac{\partial U_{M2}}{\partial \alpha} > 0$.

Theorem 4: Under information symmetry, the manufacturer's utility is inversely proportional to the retailer's fairness; under information asymmetry, it is proportional to the retailer's fairness.

4.3. Information Value of Fairness

Firstly, compare the difference between the retailer's effort level in two different cases: information symmetry and information asymmetry. From (5) and (11) we can get

$$\Delta e = e_1 - e_2 = \frac{2\alpha h^2(c-p) - 2a\varepsilon\alpha}{h\varepsilon(1-2\alpha)} < 0 \tag{17}$$

Secondly, compare the manufacturer's utility under the two information status. From (13) and (15) we can get

$$\Delta U_M = U_{M1} - U_{M2} = \frac{-2h^4\alpha(1+\alpha)(p-c)^2 - (1+\alpha)4a^2\varepsilon^2\alpha^2 - 4h^2a\varepsilon\alpha(1+\alpha)(p-c) + 4h^2\varepsilon\alpha U_{\bar{R}}(1-2\alpha)}{2h^2\varepsilon(1-4\alpha^2)} \tag{18}$$

Introducing $U_{\bar{R}} < \frac{h^2(p-c)^2 + 2a\varepsilon(p-c)}{4\varepsilon}$ into (18) we can get the following result

$$\Delta U_M = U_{M1} - U_{M2} < \frac{[h^4\alpha(p-c)^2 + 2a\varepsilon\alpha h^2(p-c)](-1-4\alpha) - (1+\alpha)4a^2\varepsilon^2\alpha^2}{2h^2\varepsilon(1-4\alpha^2)} < 0 \quad (19)$$

Theorem 5: Compared to information symmetry, under information asymmetry the retailer's effort level is higher; in both cases the difference of retailer's promotion effort level is proportional to the fairness.

Theorem 6: Compared to information symmetry, under information asymmetry the manufacturer's utility is higher; in both cases the difference of manufacturer's utility is proportional to the retailer's fairness.

In asymmetric information, since the manufacturer can't observe the retailer's effort level, he has to lower the wholesale price according to the retailer's fairness degree to incite the retailer to make greater efforts than that he does in symmetric information case. Although the manufacturer must pay certain incentive costs (lower the wholesale price), his additional returns which increased due to the retailer's higher effort level are higher than the incentive costs; the manufacturer's utility is therefore improved. The retailer's fairness has influence on his own effort level only under information asymmetry, in such case the manufacturer will lower the wholesale price to drive the retailer to pay more sales efforts to maximize his utility. Under information symmetry and information asymmetry, if the retailer has a low fairness preference, the difference of his effort level and the difference of the manufacturer's utility are both small. In real situation, the retailer's sales effort level cannot usually be observed but the retailer's fairness has positive value and it can make his own effort level and the manufacture's utility higher. Therefore, in the supply chain where retailers have fairness preference, manufacturers tend to cooperate with the retailer who has higher degree of fairness.

5. Conclusion

Under information symmetry, the retailer's fairness has no influence on his own effort level and it is inversely proportional to the manufacturer's utility; under information asymmetry the retailer's fairness has positive influence on his own effort level and it is proportional to the manufacturer's utility. From a series of analyses we concluded that under the condition of information symmetry and asymmetry both the difference of retailer's promotion effort level and the difference of manufacture's utility are proportional to the retailer's fairness. Due to the positive value of fairness, under information asymmetry manufacturers prefer to cooperate with the retailer who has higher degree of fairness.

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