

Research on Supply Chain Coordination of TPL Supplier Participation*

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ABSTRACT

This paper used the Game Theory to research how to coordinate a kind of supply chain, which is made up of a dominant manufacturer, a TPL supplier and some retailers. It also discussed the node enterprises' decision models in three situations: no coordination, partly coordination and all coordination based on symmetric information and proved system's profit was optimal in the situation of all coordination. And then some ways of profit distribution were laid out. Finally, verified the validity of the models and ways of profit distribution through examples.

Keywords: Supply Chain Coordination, Third Party Logistics, Profit Distribution

1. Introduction

Enterprises tend to enhance their core competence through outsourcing logistics service under the fierce market condition. The demand for third party logistics, TPL for short, has growing gradually, so people pay more attention to the relationship between TPL providers and TPL demanders. Aidan. Reference [1] established a logistics service pricing model, which optimized the profits of both parties in a simple supply chain based on the assumption of linear demand. Reference [2] compared the pricing and profit conditions of TPL provider and demander before and after cooperation. Reference [3] analyzed some horizontal methods of the two parties used to coordinate the conflicts and contradictions in the outsourcing process. Reference [4] used game theory to study the coordination problem in a supply chain composed of a manufacturer, a TPL provider and a retailer. Reference [5] designed a TPL revenue sharing contract, and proved that this contract can form a sound internal incentive mechanism through a dynamic game approach.

It can be found that, current research mainly focus on the coordination issue between TPL provider and a single TPL demander. Little has done on the game relationship and coordination mechanism among the TPL provider, upstream and downstream enterprises. Also the condition

of more than one retailer and partial cooperation has seldom been paid attention to.

2. Model Description

Gong Deyan [6] established a supply chain model with a manufacturer, a retailer and a TPL provider. The difference between this paper to his is that, more than one retailer was considered, and the situation of partial cooperation was discussed, which makes the analysis more practical and can obtain more new conclusions. Node enterprises operated themselves as follows: first, the manufacturer selected a profit-optimizing wholesale price, p_m ; retailer selected a service price p_l , which can maximize his own profit based on the given wholesale price; finally, retailer i decided his optimal p_i and order quantity q_i . p_l was shared by the manufacturer and TPL together, and the sharing ratios are θ_1 , θ_2 respectively. The costs of manufacturer, TPL and retailer are c_m , c_l , c_r .

The following assumptions were made:

Assumption 1: Information was perfectly symmetrical through the whole supply chain.

Assumption 2: All supply chain members were risk-neutral, and they were to maximize their own profits.

Assumption 3: The market demand is a linear function of the retailer price, that is, $p = a - bQ$, and a , b were constants, $a > 0$, $b > 0$.

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Assumption 4: The unit cost and wholesale price for each retailer are the same.

Assumption 5: The manufacturer's capacity and TPL's ability were large enough to satisfy all demands..

3. Set up and Solve the Model

3.1. Decentralized Model

The manufacturer, TPL provider and retailers made their own decisions separately, that is, no alignment has been formed. So the Stackelberg model is:

$$\begin{aligned} \max \pi_m(p_m) &= (p_m - c_m - \theta_1 p_l)Q \\ \text{s.t.} \max \pi_l(p_l) &= (p_l - c_l)Q \\ \text{s.t.} \max \pi_{ri}(p_i) &= (p_i - c_r - p_m - \theta_2 p_l)q_i \end{aligned}$$

Adopt the reverse inductive method, all the members' price decision can be solved as followed:

Phase 1, retailer i will optimize his profit on a given p_l , which is

$$\begin{aligned} \max \pi_{ri}(p_i) &= (p_i - c_r - p_m - \theta_2 p_l)q_i \\ &= (a - bQ - c_{ri} - p_m - \theta_2 p_l)q_i \end{aligned}$$

Suppose $Q = q_i + Q_j$, we can get,

$$\max \pi_{ri}(p_i) = (a - bq_i Q_j - c_{ri} - p_m - \theta_2 p_l)q_i,$$

$$\frac{\partial \pi_{ri}}{\partial q_i} = -2bq_i - bQ_j + a - c_{ri} - p_m - \theta_2 p_l$$

Because $Q = nq$, $Q_j = Q - q_i = nq_i - q_i$

Therefore, $\frac{\partial \pi_{ri}}{\partial q_i} = -2b(n+1)q_i + a - c_{ri} - p_m - \theta_2 p_l$

Let it equals 0, it can be solved that,

$$q_i = \frac{a - c_{ri} - p_m - \theta_2 p_l}{b(n+1)} \quad \text{So,}$$

$$Q = nq_i = \frac{n(a - c_{ri} - p_m - \theta_2 p_l)}{b(n+1)}$$

Phase 2, TPL provider will optimize his profit at a given p_m ,

$$\max \pi_l(p_l) = (p_l - c_l)Q$$

Substitute the value of Q , we can get,

$$p_l = \frac{a + \theta_2 c_l - c_{ri} - p_m}{2\theta_2}$$

Phase 3, the manufacturer optimizes his profit,

$$\max \pi_m(p_m) = (p_m - c_m - \theta_1 p_l)Q$$

Substitute the value of Q and p_l , the optimal p_m , p_m^* is arrived.

$$p_m^* = \frac{a + \theta_2 c_m - \theta_2^2 c_l - c_{ri}}{\theta_2 + 1}$$

Then we can get the optimal p_l^* and p_i^* :

$$p_l^* = \frac{a + (2\theta_2 + 1)c_l - c_r - c_m}{2(\theta_2 + 1)}, \quad p_i^* = a - \frac{n\theta_2 R}{2(n+1)(\theta_2 + 1)}$$

The total order quantity of all retailers is:

$$Q^* = \frac{n\theta_2 R}{2b(n+1)(\theta_2 + 1)}$$

So the profit of each supplier is:

$$\pi_m^* = \frac{n\theta_2 R^2}{4b(n+1)(\theta_2 + 1)}, \quad \pi_l^* = \frac{n\theta_2 R^2}{4b(n+1)(\theta_2 + 1)},$$

$$\pi_{ri}^* = \frac{\theta_2^2 R^2}{4b(n+1)^2 (\theta_2 + 1)^2}$$

The profit of the whole supply chain is:

$$\pi_{sc}^* = \pi_m^* + \pi_l^* + \pi_r^* = \frac{(n^2 + n + 1)\theta_2^2 + (2n^2 + 2n)\theta_2}{4b(n+1)^2 (\theta_2 + 1)^2} R^2$$

Here, $R = a - c_r - c_m - c_l > 0$

3.2. Centralized Model

Ye Fei and Li Yina [7] discussed the cooperation problem of a type of three-echelon supply chain with a manufacturer, a wholesaler and a retailer. Consider the partial cooperation in their paper, the following forms of alliances can be induced.

1) The manufacturer and TPL provider form a small scale alliance, and the retailers are not included. So the Stackelberg model should be:

$$\max (\pi_m + \pi_l)(p_m, p_l) = (p_m - c_m - c_l + \theta_2 p_l)Q$$

$$\text{s.t.} \max \pi_{ri}(p_i) = (p_i - c_r - p_m - \theta_2 p_l)q_i$$

Solve the model with reverse inductive method,

$$Q^{**} = \frac{nR}{2b(n+1)}, \quad p_i^{**} = a - \frac{nR}{2(n+1)}$$

$$(\pi_m + \pi_l)^{**} = \frac{nR^2}{4b(n+1)}, \quad \pi_{ri}^{**} = \frac{R^2}{4b(n+1)^2},$$

$$\pi_{sc}^{**} = \frac{(n^2 + 2n)}{4b(n+1)^2} R^2$$

2) TPL and retailers form a small scale alliance, and the manufacturer is not included. Now the Stackelberg model is:

$$\max \pi_m(p_m) = (p_m - c_m - \theta_1 p_l)Q$$

$$s.t. \max (\pi_l + \pi_r)(p_l, p_i) = (p_i - c_r - c_l - p_m + \theta_1 p_l)Q$$

Solve the model, we can get: $Q^{***} = \frac{R}{4b}$, $p_i^{***} = a - \frac{R}{4}$,

$$\pi_m^{***} = \frac{R^2}{8b}, (\pi_l + \pi_r)^{***} = \frac{R^2}{16b}, \pi_{sc}^{***} = \frac{3R^2}{16b}$$

3) The manufacturer and retailers form a small scale alliance, and TPL provider is not included. The Stackelberg model is:

$$\max (\pi_m + \pi_r) = (p_i - c_r - c_m - p_l)Q$$

$$s.t. \max \pi_l(p_l) = (p_l - c_l)Q$$

Solve the model,

$$Q^{****} = \frac{R}{4b}, p^{****} = a - \frac{R}{4}, \pi_l^{****} = \frac{R^2}{8b},$$

$$(\pi_m + \pi_r)^{****} = \frac{R^2}{16b}, \pi_{sc}^{****} = \frac{3R^2}{16b}$$

4) The manufacturer, TPL provider and retailers form a large scale alliance and make decisions together, so the profit function of the alliance is:

$$(\pi_m + \pi_l + \pi_{ri})(p_i) = (p_i - c_m - c_l - c_r)Q$$

Solve the function, $Q^{*****} = \frac{R}{2b}$,

$$p_i^{*****} = \frac{a + c_m + c_l + c_r}{2}, \pi_{sc}^{*****} = \frac{R^2}{4b}$$

3.3. Model Analysis

Conclusion 1: In the decentralized model, with the increase of θ_2 , the retailer price decreases, the sales volume increases, and the profits of the manufacturer, retailer, TPL provider and the whole supply chain increases. Their profits reach the peak when $\theta_2 = 1$.

Prove: from

$$p_i^* = a - \frac{n\theta_2 R}{2(n+1)(\theta_2 + 1)} = a - \frac{nR}{2(n+1)\left(1 + \frac{1}{\theta_2}\right)},$$

it is found that p_i^* is an decreasing function of θ_2 .

From $Q^* = \frac{n\theta_2 R}{2b(n+1)(\theta_2 + 1)} = \frac{nR}{2b(n+1)\left(1 + \frac{1}{\theta_2}\right)}$, we

know Q^* is an increasing function of θ_2 .

And

$$\pi_m^* = \frac{nR^2}{4b(n+1)\left(1 + \frac{1}{\theta_2}\right)}, \pi_l^* = \frac{nR^2}{4b(n+1)\left(\theta_2 + \frac{1}{\theta_2} + 1\right)},$$

$$\pi_{ri}^* = \frac{nR^2}{4b(n+1)^2\left(1 + \frac{1}{\theta_2}\right)^2}$$

Because $\theta_2 \leq 1$, π_m , π_l , π_{ri} are increasing functions of θ_2 , and from $\pi_{sc} = \pi_m + \pi_l + \pi_r$, so π_{sc} is an increasing function of θ_2 too. And when $\theta_2 = 1$, π_m , π_l , π_{ri} , π_{sc} reach their peak value.

Conclusion 1 explains that, when outsourcing logistics service to TPL, the manufacturer burdens a low fee rate θ_1 , that lowers his wholesale price, which in turn to reduce the retail price and increase the sales volume (decreasing rate of retail price is smaller than the increasing rate of sales volume), and finally all parts' profit are improved. Therefore, the supply chain can get a Pareto improvement through rational sharing of logistics fee between the retailers and manufacturer.

Conclusion 2: In decentralized model, along with the increase of n , retailers' retail price and order quantity will increase, the profits of the manufacturer and TPL provider will increase, but retailer's profit will decrease.

Proof: from

$$p_i^* = a - \frac{n\theta_2 R}{2(n+1)(\theta_2 + 1)} = a - \frac{\theta_2 R}{2\left(1 + \frac{1}{n}\right)(\theta_2 + 1)},$$
 it is easy

to find out that p_i^* is a decreasing function of n .

From $Q^* = \frac{n\theta_2 R}{2b(n+1)(\theta_2 + 1)} = \frac{\theta_2 R}{2b\left(1 + \frac{1}{n}\right)(\theta_2 + 1)}$, we

know Q^* is an increasing function of n .

From $\pi_m^* = \frac{\theta_2 R^2}{4b\left(1 + \frac{1}{n}\right)(\theta_2 + 1)}$,

$$\pi_l^* = \frac{\theta_2 R^2}{4b\left(1 + \frac{1}{n}\right)(\theta_2 + 1)^2}, \pi_{ri}^* = \frac{\theta_2^2 R^2}{4b(n+1)^2(\theta_2 + 1)^2},$$
 It

can be found that π_m , π_l are increasing functions of n but π_{ri} is decreasing function of n .

Conclusion 2 tells that, the manufacturer will choose more retailers to lower the retailer price, thus to increase the sales volume and enhance his own profit; however, the retailer expects fewer competitors, thus he can increase his profit by raising retail price.

Conclusion 3: In the centralized model, when the three form a big alliance, the whole supply chain's profit reaches the highest point and vice versa. In types of cooperation relationship, supply chain's profit is maximized in the manufacturer-TPL case. That is,

$$\pi_{sc}^* < \pi_{sc}^{****} = \pi_{sc}^{*****} \leq \pi_{sc}^{**} < \pi_{sc}^{*****}$$

Proof:

$$\pi_{sc}^* - \pi_{sc}^{***} = \left[(n^2 + 2n - 3)\theta_2^2 + 2(n^2 - 2n - 3)\theta_2 - 3(n+1)^2 \right] \frac{R^2}{16b(n+1)^2(\theta_2 + 1)^2}$$

a) when $n = 1$,

$$\pi_{sc}^* - \pi_{sc}^{***} = -4(2\theta_2 + 3) \frac{R^2}{16b(n+1)^2(\theta_2 + 1)^2} < 0, \text{ then}$$

$$\pi_{sc}^* < \pi_{sc}^{***};$$

b) when $n > 1$,

$f(\theta_2) = (n^2 + 2n - 3)\theta_2^2 + 2(n^2 - 2n - 3)\theta_2 - 3(n+1)^2$ is a concave parabolic curve with the vertex Y-coordinate

$$-3(n+1)^2 - \frac{(2n^2 - 4n - 6)^2}{4(n+3)(n-1)} < 0.$$

Since $f(0) = -3(n+1)^2 < 0$, $f(1) = -8n - 12 < 0$, it can be induced that $f(\theta_2) < 0$, $0 \leq \theta_2 \leq 1$

And from $f(0) = -3(n+1)^2 < 0$, so

$$f(1) = -8n - 12 < 0, f(\theta_2) < 0, 0 \leq \theta_2 \leq 1$$

And $\pi_{sc}^* - \pi_{sc}^{***} < 0$, which means

$$\pi_{sc}^* < \pi_{sc}^{***} = \pi^{****} \tag{1}$$

Since $\pi_{sc}^{****} - \pi_{sc}^{**} = (1-n)(3+n) \frac{R^2}{16b} \leq 0$, so

$$\pi_{sc}^{****} \leq \pi_{sc}^{**} \tag{2}$$

That is, $\pi_{sc}^{**} - \pi_{sc}^{****} = -1 < 0$, so

$$\pi_{sc}^{**} < \pi_{sc}^{****} \tag{3}$$

Combine Function (1), (2) and (3), it can be concluded that,

$$\pi_{sc}^* < \pi_{sc}^{***} = \pi_{sc}^{****} \leq \pi_{sc}^{**} < \pi_{sc}^{*****}$$

Conclusion 3 shows that, in the large scale alliance case, all parties enhance supply chain's profit through reducing retail price and increasing sales. Therefore, in this case, not only all supply chain members maximize their profits but also customers are well off. However, partial cooperation can be a compromise if evitable obstacles exist in the process of all-round cooperation. Moreover, among the types of partial cooperation, supply chain's profit is maximized in the manufacturer-TPL case, which tell us that the retailer's competition can make customers, TPL and the manufacturer well off.

4. Revenue Distribution under Joint Decision Making

From the above analysis, it is clear that large scale alliance can bring about greatest profit. However, revenue conflict will lead to inefficient cooperation, the supply chain can only be coordinated through reasonable fair distribution of revenue.

Suppose that the revenue distributing coefficients of manufacturer, TPL provider and retailer are respectively k_m, k_l, k_r , and $k_m + k_l + k_r = 1$. Only when each party's profit of a large scale alliance is bigger than that of the small scale alliance and even no alliance, supply chain members have the motive to participate in a large scale alliance.

4.1. Revenue Distribution Based on Nash Bargaining Model

Take each party's revenue (no alliance situation) as the bargaining points, i.e., $\pi_m^*, \pi_l^*, \pi_r^*$ are bargaining points, establish a bargaining model to solve each's revenue after cooperation based on Nash bargaining model.

$$\max Z = (k_m \pi_{sc}^{*****} - \pi_m^*) (k_l \pi_{sc}^{*****} - \pi_l^*) (k_r \pi_{sc}^{*****} - \pi_r^*)$$

$$s.t. \quad k_m \pi_{sc}^{*****} \geq \pi_m^*, \quad k_l \pi_{sc}^{*****} \geq \pi_l^*, \quad k_r \pi_{sc}^{*****} \geq \pi_r^*$$

$$(k_m + k_l) \pi_{sc}^{*****} \geq (\pi_m + \pi_l)^{**}$$

$$(k_l + k_r) \pi_{sc}^{*****} \geq (\pi_l + \pi_r)^{***}$$

$$(k_m + k_r) \pi_{sc}^{*****} \geq (\pi_m + \pi_r)^{****}$$

$$k_m + k_l + k_r = 1$$

4.2. Revenue Distribution Based on Minimum Core Method

According to minimum core method, a linear planning model is set up as follows:

$$\min \varepsilon,$$

$$s.t. \quad k_m \pi_{sc}^{*****} \geq \pi_m^*, \quad k_l \pi_{sc}^{*****} \geq \pi_l^*, \quad k_r \pi_{sc}^{*****} \geq \pi_r^*$$

$$(k_m + k_l) \pi_{sc}^{*****} + \varepsilon \geq (\pi_m + \pi_l)^{**},$$

$$(k_l + k_r) \pi_{sc}^{*****} + \varepsilon \geq (\pi_l + \pi_r)^{***},$$

$$(k_m + k_r) \pi_{sc}^{*****} + \varepsilon \geq (\pi_m + \pi_r)^{****}$$

$$k_m + k_l + k_r = 1$$

4.3. Revenue Distribution Based on Simplified MCRS Method

According to simplified MCRS Method, the linear function group is set up as follows:

$$\begin{cases} \pi_j = \pi_{j\min} + \lambda(\pi_{j\max} - \pi_{j\min}), j = m, l, r \\ \sum_{j=1}^n \pi_j = \pi_{sc}^{*****} \end{cases}$$

And, $\pi_{j\max}$, $\pi_{j\min}$ are defined as:

$$\begin{cases} \pi_{m\max} = \pi_{sc}^{*****} - (\pi_l + \pi_r)^{***} , \\ \pi_{l\max} = \pi_{sc}^{*****} - (\pi_m + \pi_r)^{****} , \\ \pi_{r\max} = \pi_{sc}^{*****} - (\pi_m + \pi_l)^{**} , \\ \pi_{m\min} = \pi_m^* , \pi_{l\min} = \pi_l^* , \pi_{r\min} = \pi_r^* \end{cases}$$

5. Numerical Analysis

Utilizing some data from reference 4 and 6, the parameters' value are set as follows: $a = 30$, $b = 0.2$, $c_m = 5$, $c_l = 2$, $c_r = 3$, $\theta_2 = 0.8$.

1) θ_2 's influence on order quantity, all parties' pricing decisions and profits.

When $n = 3$:

From **Figure 1**, it's clear that along with the increase of θ_2 , the wholesale price, logistics service price and retail price decrease while the order quantity increases, and the increase rate of Q is bigger than the decrease rate of p_i .

And from **Figure 2**, when θ_2 increases, all parties' profits as well as the whole supply chain's profit increase. They reach the peak when $\theta_2 = 1$.

2) n 's influence on order quantity, all parties' pricing decisions and profits.

From **Table 1**, in the decentralized model and small scale alliance situation, the order quantities increase with the increase of n , and when retailer is included into the alliance, *i.e.*, the large scale alliance situation, the value of n has no effect on order quantities.

From **Table 2**, in the decentralized model and small scale alliance situation, the retail prices increase with the increase of n , and when retailer is included into the alliance, *i.e.*, the large scale alliance situation, the value of n has no effect on retail prices.

From **Table 3**, in the decentralized model and small scale alliance situation, the total profits of the supply chain increase with the increase of n , and when retailer is included into the alliance, *i.e.*, the large scale alliance situation, the value of n has no effect on total supply chain profits. And in the decentralized model, the profits of manufacture and TPL provider increase with the increase of n , and the retailer's profit is just opposite. Therefore, the manufacturer can increase the whole supply chain's profit and his own profit by increasing the number of retailers, but he should consider some bad effects such as retailers' joint boycotts.

3) the comparison of order quantity, retail price and sales volume and profit under three circumstances.

From the three above tables, it can be concluded that in decentralized model, the order quantity was minimized,

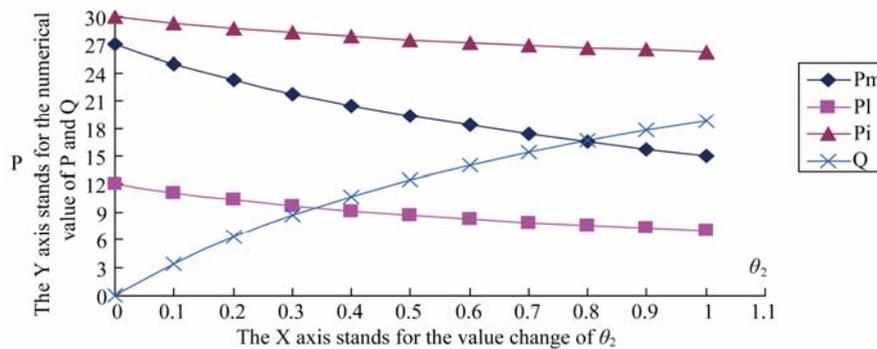


Figure 1. θ_2 's influence on order quantity, all parties' pricing decisions.

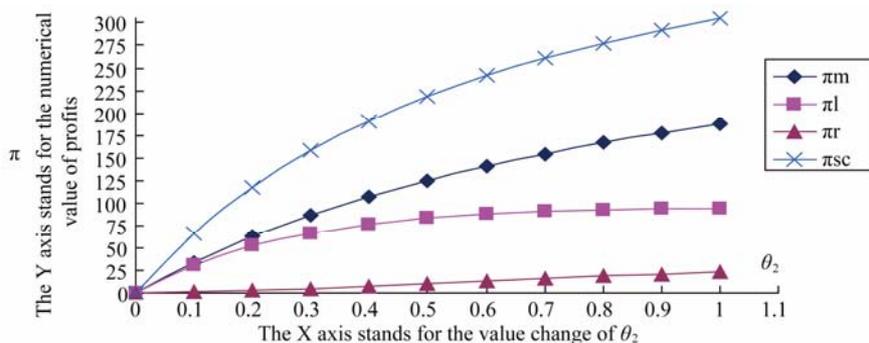


Figure 2. θ_2 's influence on all parties' profits and total supply chain profit.

Table 1. Order quantities in all situations.

	Decentralized decision		Small scale alliance		Large scale alliance
	Q*	Q**	Q***	Q****	Q*****
n = 1	11.111	25.000	25.000	25.000	50.000
n = 2	14.815	33.333	25.000	25.000	50.000
n = 3	16.667	37.500	25.000	25.000	50.000
n = 4	17.778	40.000	25.000	25.000	50.000
n = 5	18.519	41.667	25.000	25.000	50.000

Table 2. Retail prices of all situations.

	Decentralized decision		Small scale alliance		Large scale alliance
	p _i *	p _i **	p _i ***	p _i ****	p _i *****
n = 1	27.778	25.000	25.000	25.000	20.000
n = 2	27.037	23.333	25.000	25.000	20.000
n = 3	26.667	22.500	25.000	25.000	20.000
n = 4	26.444	22.000	25.000	25.000	20.000
n = 5	26.296	21.667	25.000	25.000	20.000

Table 3. Supply chain member' profits and total profits of all situations.

	Decentralized decision			Small scale alliance			Large scale alliance
	π_m^*	π_l^*	π_r^*	π_{sc}^*	π_{sc}^{**}	π_{sc}^{***}	π_{sc}^{****}
n = 1	111.111	61.728	24.691	197.531	375.000	375.000	375.000
n = 2	148.148	82.305	21.948	252.401	444.444	375.000	375.000
n = 3	166.667	92.593	18.519	277.778	468.75	375.000	375.000
n = 4	177.778	98.765	15.802	292.346	480.000	375.000	375.000
n = 5	185.185	102.881	13.717	301.783	486.111	375.000	375.000

the retail price was the highest and the total profit was the lowest, while in large scale alliance case they are totally opposite. And in the small scale alliance case, the total profit maximized when the manufacturer and TPL provider form the alliance.

Use Excel and Lingo to calculate the profits of all parties and their growth rates under different revenue distribution method, the results are shown in **Tables 4 and 5**.

It is clear that in this numerical case, when adopting the Minimum core method, the TPL provider gains all the extra profit of the system, *i.e.*, the manufacturer and retailer's profits are not improved. Therefore, this method cannot be used to distribute profits, but it can be a basis for the three parties to negotiate. Each party's profit

is improved greatly though the growth extent is not the same when adopting Nash bargaining model and Simplified MCRS method. The manufacturer and TPL provider's profits are maximized under the simplified MCRS method while the retailer's profit is maximized under Nash bargaining model, which means when the three begin to negotiate they prefer different revenue distribution methods. Since here is the supply chain situation led by the manufacturer, which means he has the strongest bargaining power, so the simplified MCRS method will be used by the alliance. Besides that, the growth extent of retailer's profit under this method is greater than under the other two methods, so in this case, the simplified MCRS method is the ideal one. The distributing coeffi-

Table 4. All parties' profits under different revenue distribution method.

	Nash bargaining model	Minimum core method	Simplified MCRS Method
Manufacturer	240.741	166.667	244.186
TPL provider	166.667	314.814	197.674
retailer	92.592	18.519	58.140

Table 5. Growth rates under different distribution method.

		Nash bargaining model	Minimum core method	Simplified MCRS method
Decentralized model	manufacturer	44.44%	0.00%	46.51%
	TPL provider	80.00%	240.00%	113.49%
	retailer	399.98%	0.00%	213.95%
Small scale alliance	M + L	8.64%	28.39%	17.83%
	L + R	107.41%	166.67%	104.65%
	M + R	166.67%	48.15%	141.86%

cients are separately 0.488, 0.396, 0.116.

6. Conclusions

Based on the above analysis of wholesale price contract, the supply chain coordination problem with TPL participation was discussed associated with revenue sharing and distribution theory. The following conclusions are obtained:

1) In the decentralized model, Pareto improvement can be realized through reasonable distribution of the logistics fee between the retailer and manufacturer; as the supply chain leader, the manufacturer has to choose a certain number of retailers to balance their profits.

2) In the three types of small scale alliances, the total supply chain profit is the greatest when the manufacturer and the TPL provider form a alliance.

3) All node enterprise's profits are maximized in the large scale alliance, and minimized in the decentralized model.

4) Supply chain firms can choose an appropriate revenue distribution method, such as Nash bargaining model, minimum core method and simplified MCRS method to coordinate the supply chain.

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