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**Research Article**

# Research on TPL Service Level and Pricing Models in Supply Chain Coordination and Benefits Allocation

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**Abstract:** Research on the method to strengthen the cooperation among members to achieve win-win result is an important subject in SCM. Nevertheless, most studies to date on supply chain pricing have only assumed that the market demand is only influenced by retail price but not by logistics service level. That is why our work is concerned with logistics service and product pricing strategies in supply chain consisting of the manufacturer, the retailer and the TPL provider. For three-echelon supply chain system with TPL service level, use game theory to analyze its pricing, production, service levels and profit allocation. Three different models are discussed which are based on Stackelberg games and cooperative game. We find that the whole supply chain profit brought by collaborative decision-making is much higher than it independent decision-making brings based on the research. And it can increase the whole profit through reasonable setting of allocation proportion of profit. The study proposes multiple effective distribution methods of supply chain profit and takes an example to perform empirical analysis on the results to proof effectiveness.

**Keywords:** Game theory, profit allocation, supply chain, service level, synergy and coordination

## INTRODUCTION

Profit is the nature of enterprise. Formerly, the common enterprises compress cost in order to "squeeze out" profits through the integration of internal resource. At present, with the economy globalization and refining social division of labor, Enterprises' concern gradually move from the internal integration to external cooperation in order to seek new profit source, namely the formation of new profit based on the basis of cooperation. The 21st century's market competition is no longer the competition among enterprises, but the competition among industrial cluster whose formation is around the core enterprises and the link of supply chain. This study will focus on the research perspective of the supply chain cooperation among enterprises, through the coordination of each node in the supply chain to achieve maximum profit of the whole system. Then, the Third-Party Logistics (TPL) plays an important role in supply chain management, which refers to a manner of logistics operation and management that manufacturer focuses on the core business by outsourcing the logistics to the professional logistics service provider.

TPL service-demand enterprises outsource the logistics to TPL service provider in order to enhance its core market competitive power. TPL service providers often increase their income by increasing their service price on the basis of their own professional advantage of logistics services. However, this just goes against the TPL service demand enterprise' purpose of reducing the cost by outsourcing logistics. Moreover, different ex-factory prices, sale prices and service level can also affect the market demand of the products. Due to the asymmetry of information, each node enterprise in the supply chain system is independent for its own benefit maximization and the conflict of interest among enterprises is difficult to coordinate (Vagstad, 2000), which makes it difficult to realize efficient economic model.

Ilaria and Pontrandolfo (2004) put forward a supply chain contract model, by changing the contract parameters to achieve the interests and the reasonable distribution among enterprises in the supply chain. Most supply chain prices researches are two-layer models, such as Albert analyzed how the supplier pricing to gain the customer's demand with competition or non-cooperative (Albert *et al.*, 2003). Sun and Gong (2007) studied the incentive effect between the support of logistics outsourcing enterprise and TPL service provider's work.

Recent studies have indicated that core enterprises in the supply chain which has logistics service demand to strengthen the competitiveness, usually outsourcing the logistics to the TPL provider (Gong *et al.*, 2008). However, the TPL service provider that has advantage in logistics and information management maximizes its

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profit through the raise of the service price. As a result, the logistics service of the supply chain improved and other members of the supply chain such as manufacturer and the retailer have to shift the product prices correspondingly to maintain the profits. Meanwhile, all these behaviors stimulate the demand change in turn. Generally speaking, because of the unsymmetrical information and core enterprises' pursuing for maximizing itself profits only, it's pretty hard to coordinate the profits among them and to achieve the Pareto Optimality. Thus, research on the coordinating strategies for the supply chain is of importance.

The literature dealing with both product pricing and service pricing at the same time is sparse, with some exceptions such as Xie and Li (2007, 2008) and Gong *et al*. (2008, 2009). In these studys, the authors proposed a service pricing compared coordinated strategies and profits with uncoordinated ones. The difference between this study and their works is that we consider product pricing and service level will affect the profits sharing and supply chain coordination.

In this study, a product pricing and service pricing decision model for supply chain coordination is suggested. And it can increase the whole profit through reasonable setting of allocation proportion of profit. How should they share the extra joint profits achieved by moving to cooperation? The study proposes multiple effective distribution methods of supply chain profit.

## SYSTEM SPECIFICATION, ASSUMPTIONS AND THE BASIC MODEL

In the following sections, we focus on supply chain with the manufacturer, the retailer and the TPL participated. Suppose all the members in the supply chain know mutual cost with complete information. Recalls from the last section in the process, the sequence of events are as follows:

The retailer places an order with the manufacturer (suppose the product availability meets the market demand perfectly)

The TPL provides services such as transportation and distribution for other members in the supply chain.

The retailer sells only the manufacturer's product:

**Manufacturer:** In this study we suppose the manufacturer charges the retailer $p_1$ per unit in every product with $c_1$ per unit to produce.

**TPL:** The logistic service pricing consists of two parts: the fundamental service price at $w_0$ and the extra service price $c_3'''$. Thus, the unit service price w is a monotone decreasing function of order quantity Q, while proportional to the service level s itself provide with a fundamental service price $w_0$, which can be given as:

$$w = w_0 - kQ + c_3''' s^2 \tag{1}$$

where, $w_0$, k, $c_3''' > 0$

Here, we note $c_3 = c_3' + c_3'' s^2$ as the operating cost of TPL (where, $c_3', c_3'', > 0$, $c_3'$ is the primary unit operating cost, $c_3''$ is a float factor for service level). Note that, when $c_3'''$ equals to $c_3''$ , the additional service cost would be full burdened by the manufacturer and the retailer. Suppose the manufacturer and the retailer were responsible for the service price together, namely $k_1$ and $k_2$ percentage of the pay for service respectively, where $k_{1+}\ k_{2=1}$. In reality operation, the manufacturer would like to pay $Qwk_1$ as a payment in advance which is often less than half of the total cost. The rest of the cost would be paid by the retailer once he got the cargo which is based on the negotiation between the manufacturer and the retailer (Bao *et al*., 2010).

**Retailer:** It's obvious that the order quantity (or the demand) Q is a decreasing function of retailer's selling price $p_2$ and an increasing function of TPL's service level $s$ , which can be given as:

$$Q = \alpha - \beta p_2 + \gamma s \tag{2}$$

where, α, β, γ > 0, β=P elasticity
γ = Service elasticity
s = s service level

Besides, the retailer spent $c_2$ per unit on customer service, inventory and something else. Therefore, the revenue of the manufacturer is:

$$\Pi_1(p_1, w, Q) = (p_1 - c_1 - k_1 w)Q \tag{3}$$

The revenue of the retailer is:

$$\begin{aligned}\Pi_2(p_2, w, Q) &= (p_2 - p_1 - c_2 - k_2 w)Q \\ &= [(\alpha - Q + \gamma s)/\beta - p_1 - c_2 - k_2 w]Q\end{aligned} \tag{4}$$

The revenue of the TPL is:

$$\Pi_3(w, Q) = (w - c_3)Q = (w - c_3' - c_3'' s^2)Q \tag{5}$$

The revenue of the total supply chain is:

$$\Pi = \Pi_1 + \Pi_2 + \Pi_3 \tag{6}$$

## THE THREE GAME SCENARIOS FOR PRODUCT PRICING AND SERVICE PRICING

**Stackelberg Game Scenario:** According to the Stackelberg Game, the members of the supply chain are profit-oriented, as a sequential non-cooperative game with the retailer as the leader and TPL and the manufacturer as the follower, which is as follows:

- The retailer places an order Q with the manufacturer to maximize its profit
- The TPL provides services level s at the cost of w per unit to maximize its profit
- The manufacturer satisfies demand for the retailer at $p_1$ per unit to maximize its profit

In this sequence, the order quantity Q, the $p_1$ and the selling price $p_2$ can be calculated as follows:

$$p_1 = \{\alpha + \gamma s - \beta[c_2 + k_2(k_2 c_3 - c_1)]\} / \beta(1+k_2) \quad (7)$$

$$Q = \{k_2[\alpha - \beta(c_3 + c_2 + c_1) + \gamma s]\} / 4(1+k_2) \quad (8)$$

$$w = [\alpha - \beta(c_2 + c_1 - c_3 - 2c_3 k_2) + \gamma s] / 2\beta(1+k_2) \quad (9)$$

$$p_2 = [\beta k_2(c_2 + c_1 + c_3) + (\alpha + \gamma s)(4 + 3k_2)] / 4\beta(1+k_2) \quad (10)$$

As $c_3 = c_3' + c_3'' s^2$ holds, the revenues can be calculated as follows:

$$\Pi_1^* = \frac{k_2[\alpha - \beta(c_3' + c_2 + c_1) + (\gamma s - \beta c_3'' s^2)]^2}{8\beta(1+k_2)} \quad (11)$$

$$\Pi_2^* = \frac{k_2^2[\alpha - \beta(c_3' + c_2 + c_1) + (\gamma s - \beta c_3'' s^2)]^2}{16\beta(1+k_2)^2} \quad (12)$$

$$\Pi_3^* = \frac{k_2[\alpha - \beta(c_3' + c_2 + c_1) + (\gamma s - \beta c_3'' s^2)]^2}{8\beta(1+k_2)^2} \quad (13)$$

Therefore, the revenue of the total supply chain is:

$$\Pi^* = \frac{k_2(4+3k_2)[\alpha - \beta(c_3' + c_2 + c_1) + (\gamma s - \beta c_3'' s^2)]^2}{16\beta(1+k_2)^2} \quad (14)$$

Based on the analysis of the revenue listed above, we have the following Conclusions:

**Conclusion 1:** The revenue of each member in supply chain is proportional to the retailer's percentage of the pay for service $k_2$. When $k_2 = 1$ holds, profits reach the maximum. The lower manufacturer's prepayment (represented by $k_1$), the better the logistic service the TPL would like to provide, which would promote the sale.

**Conclusion 2:** No matter the members or the whole supply chain, the profits would decrease as the cost of the members increase. The optimal service level may be implemented at the point $\max(\gamma s / \beta - c_3'' s^2)$, which means the deviation between extra profit and the extra cost.

**Pairwise Cooperation Decision-making:** In order to research supply chain coordination decision more deeply, firstly analyze all sorts of pairwise cooperation decision-making of the supply chain enterprises. Pair wise cooperation decision-making situation:

- Manufacturers and retailer cooperation
- Manufacturers and TPL service provider cooperation
- Retailer and TPL service provider

**Manufacturers and retailer cooperation:** According to the Stackelberg Game, the members of the supply chain are profit-oriented, as a sequential non-cooperative game with the retailer and manufacturer as the leader, TPL as the follower, which is as follows:

- The retailer and manufacturer places an order Q to maximize its profit
- The TPL provides services level s at the cost of w per unit to maximize its profit

The profit of the manufacturer and retailer:

$$\begin{aligned}\Pi_{12} &= (p_2 - c_1 - c_2 - w)Q \\ &= [(\alpha - Q + \gamma s)/\beta - c_1 - c_2 - w]Q\end{aligned} \quad (15)$$

The profit of the TPL provider:

$$\Pi_3(w, Q) = (w - c_3)Q = (w - c_3' - c_3'' s^2)Q \quad (16)$$

In this sequence, the order quantity Q′, the TPL provides services level s at the cost of w per unit, the profit of the manufacturer and retailer $\Pi_2^*$ and the profit of the TPL provider $\Pi_3^*$ can be calculated as follows:

$$Q^* = 0.25[\alpha - \beta(c_1 + c_2 + c_3) + rs] \quad (17)$$

$$w^* = [\alpha - \beta(c_1 + c_2 + c_3) + rs] / 2\beta \quad (18)$$

$$\Pi_{12}^* = [\alpha - \beta(c_1 + c_2 + c_3) + rs]^2 / 8\beta \tag{19}$$

$$\Pi_3^* = [\alpha - \beta(c_1 + c_2 + c_3) + rs]^2 / 16\beta \tag{20}$$

**Manufacturers and TPL service provider cooperation:** Manufacturers and TPL service provider cooperation, equivalent to the manufacturer provide TPL service. According to the Stackelberg Game, the members of the supply chain are profit-oriented, as a sequential non-cooperative game with the retailer as the leader, the manufacturer and TPL as the follower. The profit of the manufacturer and TPL:

$$\Pi_{13} = (p_{13} - c_1 - c_3^{'} - c_3^{''} s^2) Q \quad ( p_{13} = p_1 + w - k_1 w ) \tag{21}$$

The profit of the retailer:

$$\Pi_2(p_1, w, Q) = (\frac{a - Q + \gamma s}{b} - p_{13} - c_2) Q \tag{22}$$

In this sequence, the order quantity $Q^*$, the manufacturer and TLP satisfy demand for the retailer at $p_{13}$ per unit , the profit of the manufacturer and TPL$\Pi_{13}^*$ and the profit of the retailer $\Pi_2^*$ can be calculated as follows:

$$Q^* = 0.25[\alpha - \beta(c_1 + c_2 + c_3) + rs] \tag{23}$$

$$p_{13}^* = [\alpha + \beta(c_1 - c_2 + c_3) + rs] / 2\beta \tag{24}$$

$$\Pi_{13}^* = [\alpha - \beta(c_1 + c_2 + c_3) + \gamma s]^2 / 8\beta \tag{25}$$

$$\Pi_2^* = [\alpha - \beta(c_1 + c_2 + c_3) + \gamma s]^2 / 16\beta \tag{26}$$

**Retailer and TPL service provider:** Retailer and TPL service provider cooperation, equivalent to the retailer provide TPL service. According to the Stackelberg Game, the members of the supply chain are profit-oriented, as a sequential non-cooperative game with the retailer and TPL as the leader, the manufacturer as the follower.
The profit of the retailer and TPL:

$$\Pi_{23} = [(\alpha - Q + \gamma s) / \beta - p_1 - c_2 - c_3^{'} - c_3^{''} s^2] Q \tag{27}$$

The profit of the manufacturer:

$$\Pi_1(p_1, w, Q) = (p_1 - c_1) Q \tag{28}$$

In this sequence, the order quantity Q′, the manufacturer satisfy demand for the retailer at $p_1$ per unit , the profit of the manufacturer $\Pi_1^*$ and the profit of the retailer and TPL $\Pi_{23}^*$ can be calculated as follows:

$$Q^* = 0.25[\alpha - \beta(c_1 + c_2 + c_3) + rs] \tag{29}$$

$$p_1^* = [\alpha + \beta(c_1 - c_2 - c_3) + rs] / 2\beta \tag{30}$$

$$\Pi_1^* = [\alpha - \beta(c_1 + c_2 + c_3) + \gamma s]^2 / 8\beta \tag{31}$$

$$\Pi_{23}^* = [\alpha - \beta(c_1 + c_2 + c_3) + \gamma s]^2 / 16\beta \tag{32}$$

**Cooperative Game Scenario:** In this section, we analyze the revenue under cooperative situation, in which the manufacturer, the TPL and the retailer are allied to maximize the revenue of the total supply chain and achieve win-win by sharing information, risks and profits. Thus, the overall value can be addressed as:

$$\begin{aligned} \Pi &= (p_2 - c_1 - c_2 - c_3^{'} - c_3^{''} s^2) Q \\ &= (\frac{\alpha - Q + \gamma s}{\beta} - c_1 - c_2 - c_3^{'} - c_3^{''} s^2) Q \end{aligned} \tag{33}$$

when it gets the Nash Equilibrium, the quantity ordered would be:

$$Q^{**} = 0.5[\alpha - \beta(c_1 + c_2 + c_3) + rs] \tag{34}$$

Therefore, the maximum revenue of the total supply chain is:

$$\Pi^{**} = [\alpha - \beta(c_1 + c_2 + c_3^{'} + c_3^{''} s^2) + \gamma s]^2 / 4\beta \tag{35}$$

The difference of total supply chain revenue between Stackelberg game scenario, in section 3.1 and cooperative game scenario, in section 3.3, can be addressed as:

$$\Delta\Pi = \frac{(2 + k_2)^2 (\alpha - \beta(c_1 + c_2 + c_3^{'} + c_3^{''} s^2) + \gamma s)^2}{16\beta(1 + k_2)^2} \geq 0 \tag{36}$$

Then we have another conclusion as:

**Conclusion 3:** The revenue of the total supply chain in cooperative game scenario is always larger than that in Stackelberg game scenario, which helps to improve the revenue of the total supply chain and achieve a Pareto improvement.

However, the members would be reluctant to cooperate unless the revenue they get in cooperation is greater than not.

So the revenue of the total supply chain is assigned to the manufacturer, the retailer and the TPL by ratio $\lambda_1$ . $\lambda_2$, 1- $\lambda_1$- $\lambda_2$($0 \leq \lambda_1$, $\lambda_2$, $\lambda_1 + \lambda_2 \leq 1$) respectively.

Then, the revenue of the each member is calculated as follows: $\Pi_1^{**} = \lambda_1\Pi^{**}$, $\Pi_2^{**} = \lambda_2\Pi^{**}$, $\Pi_3^{**} = (1-\lambda_1-\lambda_2)\Pi^{**}$. To ensure the revenue of each member in cooperative game scenario is larger than that in Stackelberg game scenario, it should satisfy the following inequalities:

$$\begin{cases} \lambda_1 \geq k_2/2(1+k_2) \\ \lambda_2 \geq k_2(2+3k_2)/4(1+k_2)^2 \\ \lambda_2 \leq (2+3k_2+2k_2^2)/2(1+k_2)^2 \end{cases} \tag{37}$$

Then we have the 4th conclusion as:

**Conclusion 4:** Note that the allocation ratios are not correlated with the service level s as long as $\lambda_1$, $\lambda_2$ fall in the zone formulated by the inequalities (37). By cooperative game, the revenues achieve a Pareto improvement, yet another question arises: how to distribute the revenue or cost fairly.

## EFFECTIVE DISTRIBUTION METHODS

**Shapley:** Shapley's "distribution reasonable" assumption is:

- Each person's allotment has nothing to do with the symbol (Symmetry)
- If the members have no contribution to participate in cooperation and then it should not share the profit. (Validity)
- The sum of the allotment of members in all the cooperation shall be equal to the total cooperation benefits
- Each member's total allotment should be equal to the sum of allotments what he participate in cooperative

**Nucleolus:** In 1959, Gillies (1959) put forward a cooperative game theory solution concept "Nucleolus", It is shown that there always exist payoff allocations which are in the core of the game. It is the set of cost/payoff allocations, where no subset of coalition has an incentive to leave the grand coalition. In other words, each allocation scheme can be accepted by any alliance or sub-alliance. According to the basic thought, A reasonable allocation scheme x = $(x_1, x_2, \dots, x_n)$ should satisfy two conditions. Firstly, the accumulative total cost of the son of alliance (S) $\sum_{i\in S} x_i$ is not more than the original cost of alliance C(S); then, the accumulative total costs of all members $\sum_{i\in N} x_i$ should be equivalent to the total cost of alliance (N) , C(N) C(N).

In the actual application, because it maybe appear contradictory situation between the sub-alliance cost constraint and the total cost alliance (N), C(v) may be empty set. So, we bring in parameter ε, ε is additional charges from every sub-alliance when it appears contradictory situation between the sub-alliance cost constraint and the total cost alliance (N). Our goal is to minimize total additional charges. But, For any one of the members, their cost still must satisfy $x_i \leq C(i)$, Otherwise the members are not involved in alliance cooperation. Minimum core method can be used to solve this problem and the mathematics model is as follows:

$$\min \ \varepsilon \qquad s.t. \begin{cases} \sum_{i\in s} x_i \leq C(S)+\varepsilon, x_i \geq 0 \ \ \forall S \subset N \\ \sum_{i\in N} x_i = C(N), x_i \leq C(i) \ \ \forall i \in N \end{cases} \tag{38}$$

**GQP(Game Quadratic Programming):** The objective function of game quadratic programming is min Z=$\sum_{i=1}^{n}(x_i - v_i)^2$, which means the gap between the actual allocation $x_i$ of each member and ideal allocation $v_i$ is as small as possible. The mathematics model is as follows:

$$\min Z = \sum_{i=1}^{n}(x_i - v_i)^2 \qquad s.t. \begin{cases} \sum_{i=1}^{n} x_i = C(N) \\ \sum_{i\in S} x_i \leq C(S) \end{cases} S \in 2^N \tag{39}$$

where, $C(S)$ = The total cost of sub-alliance $S$ $C(N)$ = The total cost of alliance $N$ $v_i$ = Ideal allocation of member $i$, $v_i = c(I)-c(I-i), i = 1, 2, \dots, n$ where, $c(I-i)$ = The total cost of alliance $I$ except member $i$, $i = 1, 2, \dots, n$ $c(I)$ = the total cost of alliance.

**Minimum Cost-Remaining Savings (MCRS):** First determining the upper and lower bound of distribution $X_{min} \leq X \leq X_{max}$, $X_{max} = (u_1, u_2, \dots, u_n)$, $X_{min} = (l_1, l_2, \dots, l_n)$.Then, the ligature of $X_{max}$ and $X_{min}$ traverses hyper plane $\sum_{i=1}^{n} x_i = \Pi^{**}$ and get the point of intersection $X^*$ as the optimal solution. Usually, the upper and lower bounds of the distribution in MCRS method can be solved by linear programming and in the simplified MCRS method, it can directly defined:

$$\begin{cases} X_{max} = U \\ X_{min} = \Pi^{**}(N) - \Pi^{*}(N-\{i\}), \ \forall i \in N \end{cases} \tag{40}$$

The ideal apportion of each member and expenses and non cooperation costs are as its lowest and highest bound of distribution.

**Nash negotiation model:** Let $\Pi^* = \{\Pi_1^*, \Pi_2^*, \dots, \Pi_n^* \}$ is a set of the maximum gain of each enterprise when they are non-cooperative. Let X= ($x_1$, $x_2$, …, $x_n$) is a set of the allocated gain of each enterprise when they are cooperative. Obviously, $\sum_{i\epsilon N} -\Pi^{**} = 0\ \ \Pi_i^* < x_i$ where, $\Pi^{**}$ is the total gain when the entire members are cooperative. According to the Nash negotiation theory, its negotiating solution can be defined as strong effective vector $X^*$ that can make Nash product $\prod_{i\epsilon N}(x_i - \Pi_i^*)$ maximize.

## NUMERICAL SIMULATION AND OMPARISON

In this section, we assume a virtual supply chain which consists of a manufacturer, a retailer and a TPL service provider. Specifically, the market demand is assumed as: Q = 9-1/3$p_2$+s; And the costs of the manufacturer, the retailer and the TPL are $c_1$= 4, $c_2$ = 2, $c_3$ = 1+0.5$s^2$.

In addition, the retailer pays fully for the logistic service provided by the TPL, which makes $k_1$ = 0, $k_{21}$ = 1. we can get that with different service levels, the revenue of the total supply chain in cooperative game scenario is far larger than that in Stackelberg game scenario. Compared with the Stackelberg game scenario, the product's retail price decreases, benefiting the end-customers and achieving a Pareto improvement. Specially, when logistics service level s = 3, the revenue of the total supply chain gets the maximum (50.021). Thus, the combination of $p_2$ = 23.75 and Q = 4.083 is the best solution to the model.

When the cost of manufacturing ($c_1$) and cost of selling ($c_2$) are given, the total profit of supply chain only depended on sales price $p_2$and TPL service level. In order to further in-depth analysis of the development rules of supply chain and the possibility of supply chain cooperation, this study studies different kinds of pairwise cooperation. And make numerical comparison analyze about the profit of different ways of cooperation at the best service level (s = 3), the results are shown in Table 1.

In the table, it is obvious that the gross profit of pair wise operation is lager than the total profit of independent cooperation, but it is smaller than the total profit of supply chain cooperation. And manufacturers profit appears abnormal. Their profit when retailers cooperate with TPL is larger than it of tripartite cooperation. The main reasons are:

Table 1: Profit of different ways of cooperation at the best service level (s = 3)

| Cooperative participants | $\Pi_1^*$ | $\Pi_2^*$ | $\Pi_3^*$ | $\Pi$ |
|---|---|---|---|---|
| Non-cooperative | 12.505 | 3.126 | 6.253 | 21.884 |
| Manufacturers and retailer | [31.5104] | | 15.7552 | 47.2656 |
| Manufacturers and TPL | | 15.7552 | | 47.2656 |
| Retailer and TPL | 31.5104 | [15.7552] | | 47.2656 |
| All the cooperation | 21.884 | 12.505 | 15.632 | 50.021 |

[31.5104] is the total profit of manufacturers and retailer, [15.7552] is the total profit of retailer and TPL

Table 2: Distribution results based on various methods

| Method | $\Pi_1$ | $\Pi_2$ | $\Pi_3$ |
|---|---|---|---|
| Shapley | 24.531 | 11.963 | 13.527 |
| Nucleolus | 27.17713 | 11.42193 | 11.42193 |
| GQP | 27.17713 | 11.42193 | 11.42193 |
| MCRS | 24.8987 | 11.8881 | 13.2342 |
| Nash model | 21.884 | 12.505 | 15.632 |

- Different methods of profit distribution when it is tripartite cooperation will have slightly different results and we use Nash negotiation model
- Weather retailers cooperate with TPL depends on themselves and has nothing to do with the manufacturer

Distribution results based on various methods (Shapley, Nucleolus, GQP, MCRS and Nash model) are showed as Table 2.

Compare the five kinds of methods, we find that different methods get different results. From the view of the results, the minimum core method and GQP method have the same results (this case is coincidence and in fact the two methods are close) and manufacturers profit is extremely high. Retailer has the same profit with TPL. this kind of result is not much correlated to profit of independent operation; The results of simplified MCRS method and Shapley value method are close and the dominant party obtains more profit; the results of Nash negotiation model is relatively balanced and the weak party gets the sympathy.

## CONCLUSION

In this study, the pricing and coordination strategies are discussed for the supply chain composed by a manufacturer, a third-party logistics provider and a retailer. Through comparing the revenue of the total supply chain and respective profits in Stackelberg game scenario and in cooperative game scenario, we find that cooperative decision-making contributes to improve the respective profits significantly. Therefore, if members want their competitiveness be improved, they'd better to strengthen the mutual members. The allocation ratio was introduced to the pricing and coordination strategies, with which the manufacturer could determine the wholesale price and share the profits fairly with other members. If each other members are not satisfied with the profits allocation, the manufacturer can change the allocation ratio properly to achieve the coordination.

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