ANALYSIS ON MOVEMENT OF PROFIT FOR THE PARTNER COMPANIES IN JOINT-DELIVERY SYSTEM

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1. Introduction

As well known, trucks transport is one of the primary factors which cause the traffic jam, environment pollution and such like problems in urban area. With time going, these problems become more and more serious recently. The challenge of how to reduce these negative impacts has inspired multifarious literatures. One popular way of previous studies on the efficiency of distribution systems is collective delivery, which was designed to decrease the delivery cost and social damage by integrating logistics companies' delivery facilities and activities for area delivery. In this paper we just aim to give some our ideas[1)] in this field and the following is what we do. First, we prove the rational of co-operative and second search for a suitable form of co-operative transport system with objective of analyzing and realizing it efficiently and simply. Third we use location model and shapely value to reveal the change of economic situation of the partner companies who are in the co-operative alliance. We think the result can be used as a judge condition for cooperative plan carrying into execution. Finally, a fictitious example is constructed to demonstrate our theories.

2. Rationales of co-operative transport system

Co-operative business has been studied from several theories. Under our certain circumstances, we would like to apply the Game Theory to explain the rationales of cooperation in the transport situation. Suppose there are two companies who want to cooperation. Then we have a classic problem of free ridership, yielding a prisoners dilemma, with a single Nash equilibrium of mutual non-operation, while cooperation would be preferable. As is well known(Axelrod,1984; Shapiro,1989)[2)], in a repeated game the dilemma may be escaped, and cooperation may arise on the assumption that the discounted present value of unbounded future cooperation exceeds the one-time gain of competition. So the most important things for implementing co-operative in logistics field here become to be whether there is more profit got by the partner companies than before cooperation. Actually, though co-operative can bring more profit by simple integration. Many economists point out the cooperation is inefficient on the ground of its too high transaction cost(a economic concept which here describes all the cost happened in the process of cooperation)[3)]. However the cooperation still continue to thrive and grow even on every competition market(Cook, 1995)[3)]. The explanation

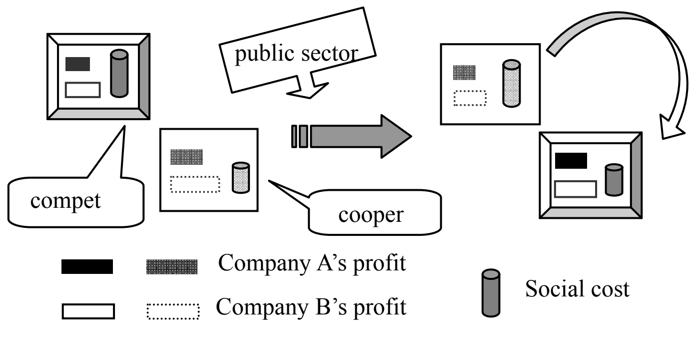

Figure 1 Movement of rational game matrix for case of two companies

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of this contradiction is that co-operatives enjoy public so they can get sustain by public sector. As a result, we can construct the rational game matrix depicted as Figure 1 to explain our game.

3. Forms of our co-operative system

Obviously, it is very important to begin the cooperative operation in a proper form and structure with much wariness. A research(Yamada ee.,1999)[4] pointed out that founding common freight terminals is the most strongly required by cooperative freight transport system. Hence constructing common joint-delivery freight terminals may be the most effective to promote cooperative transport system for logistics companies. Generally, there are three forms of joint-delivery systems as we thinking shown in Figure 2. In order to reduce the risk of losing costumers, we suppose that the logistics companies transport to their customers separately and only collective transport in the stage of not facing customers. So we get the following three cases. Case 1, logistics companies is employed by factories, then they collect the goods separately from factories but transport the goods to retail shops jointly by using joint-delivery DCs. Case 2, they seve for some retail shops, so they transport the goods to retail shops separately but collect from factories jointly by using joint–delivery DCs. Case 3 is a mixed case, companies belonging to both two situations above are involved. Anyway, as a simple and primary form, our joint-delivery system depending on common freight terminals is suitable for us to analyze the variety of profit obtained by these logistics companies.

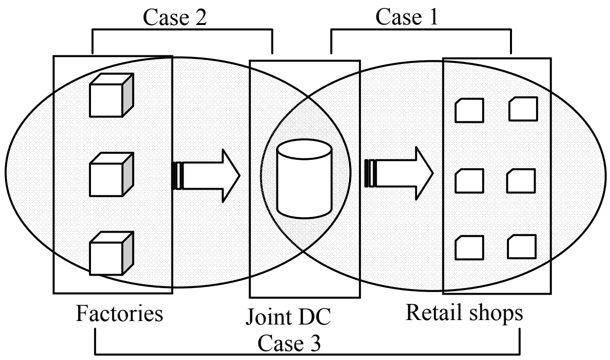

Figure 2 Stratified joint-delivery system

4. Theories in solving our problem

(1) Location problem

There are two important characteristics need pay attention to in building joint-delivery DCs. One is diversity of commodities. The other is effect of scale. For the first problem, the unit disposal cost of different commodities should be different in the different DCs because different type of DCs offers a different disposal capacity on a particular commodity with different fixed set-up cost. So unlike the usual traditional capacitated location problem, it is the purpose of this paper to process a location problem with both capacitated and multi-product, where, for instance, the capacities of DCs, the demand as well as the flows are separated with respect to some homogeneous commodities groups. And also the effect of scale should be expressed at the same time. Such multi-product capacitated model have been addressed by Geoffrion and Graves(1974) [5], Klincewicz et as.(1986), Barros and Labbe(1992,), Gao and Robinson Jr.(1992,1994) and Barros(1998)[6] . The following is our model according to the assumption.

Consider a set of retail shops, l∈L, l's demand for commodity i is D_{il}, a set of possible DCs, k∈K, where the throughput limited of the DC k is C_k and a set of factories which provides different commodities, i∈I, for the retail shops, its restrict of capacity is S_i. Let Y_{kl} be a binary variable that indicates whether DC k is served for retail shop l (Y_{kl}=1) or not (Y_{kl}=0) and also Z_{ik} indicates whether product i is operated in the DC k (Z_{ik}=1) or not (Z_{ik}=0). Denote C_{ikl} be the transport cost for unit commodities i from DC k to retail shop l; X_{ikj} be the corresponding amount of commodity i transported from DC k to retail shop l; denote f_{ik} be the fixed disposal cost of commodity i in DC k and v_k be the variable disposal cost coefficient of the DC k. Denote D_{il} be the demand of commodity

$$\min \sum_{i,k,l} C_{ikl} X_{ikl} + \sum_{i,k} f_{ik} Z_{ik} + \left(\sum_{i,k,l} v_k D_{il} Y_{kl}\right)^{\alpha}$$

$$\text{s.t} \quad \sum_{k} Y_{kl} = 1$$

$$\sum_{k,l} X_{ikl} \le S_i$$

$$X_{ikl} = D_{il} Y_{kl}$$

$$\sum_{i,l} D_{il} Y_{kl} \le C_k Z_{ik}$$

i by retail shop l. Finally, factor α (0< α <1) is taken into account for expressing the effect of the scale with increasing amount of commodities. Then, the location problem in situation of joint-delivery can be constructed as above:

2) Profit assignment

Cooperative game theory mainly concentrates on two topics: how to build the coalition and how to assign the wealth gained through cooperation. So, we can try to look for some solutions for our problems by using cooperative game theory. In the case of joint-delivery, we need a simple and impartial allocation method to obtain the expected profit assignment for the companies which want to attend the joint-delivery alliance. Taking one with another, the Shapley Value in Game Theory is the best way we can use.

It is a remarkable fact that a value φ can be decided by some Shapley axioms uniquely, simply, let N be the grand coalition, n the number of companies, and $|S|$ the cardinality of a given coalition, then the Shapley value for each company i can be expressed as following:

$$\varphi_i(\upsilon) = \sum_{S_i : i \in S \subseteq N_i} \frac{(|S|-1)!(n-|S|)!}{n!}[\upsilon(S) - \upsilon(S - \{i\})]$$

In the equation, $\upsilon(S)$ and $\upsilon(S-\{i\})$ is the payoff for coalition S and $S-\{i\}$. Thus the term $\upsilon(S)$-$\upsilon(S-\{i\})$ represents the increment in the total worth of the coalition S due to the entry of company i. $\varphi_i(\upsilon)$ is the assignment for i company.

5. Illustrative example

Here we construct a simple transport system to test our theories includes two commodities a, b which are produced in two factories 1 and 2 respectively. Three possible distribution centers 1, 2, 3 belonging to three different logistics

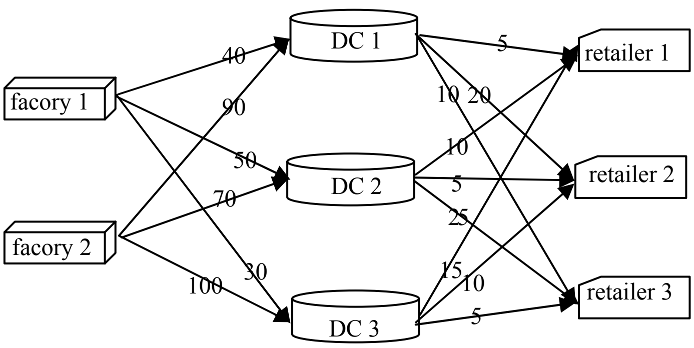

Figure 3 Position structure of the transport

Table 1 Fixed cost of DCs

	DC1	DC2	DC3
Product a	6000	5000	7500
Product b	8000	6000	8500

Table 2 Demand of customers

	retail 1	retail 2	retail 3
Product a	150	100	100
Product b	70	80	100

companies 1, 2, 3 serve for three different retail shops 1, 2, 3 independently. Then, for the only goal of revenue maximization, they want to form a joint-delivery alliance on condition that they can get the worthy payoff by cooperation. More details of the case is depicted in the figure 3 and table 1, 2. The variable disposal cost coefficient for DC 1, 2, 3 are v1=310， v2＝350 ,v3＝320. Obviously, this system is case 2 as we supposed in Chapter 3.

In order to reduce the complexity, we consider the effect of scale not by α ($\alpha = 1$), but by different throughput corresponding to different unit cost, in detail, if the throughput is over 300 then unit cost reduces to 95% and 500 to 90%, applying our theories, then we can get the new transport system shown in figure 4 and the difference in cost between before and after cooperation shown in figure 5. It shows that three companies can reduce their cost by 10.6%, 23.8%, 25.4% respectively. However, it should be noted that by now we still can not assert that cooperation should be implemented because the result above is somewhat partial. There also are some other costs need to be counted in. Anyway, the result of above can provide us one judge condition on implementing cooperative plan and also gives the companies some useful information of profit movement by taking this co-operative strategy.

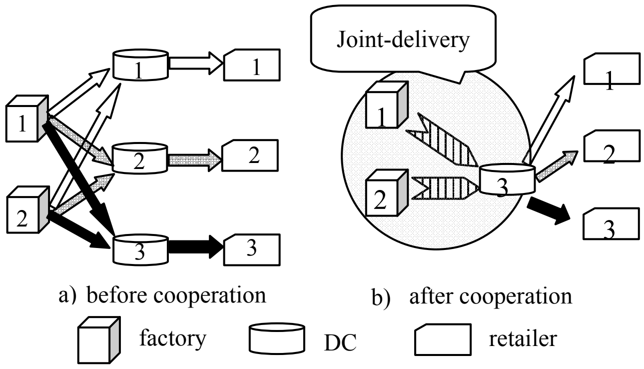

Figure 4 Movement of transport system

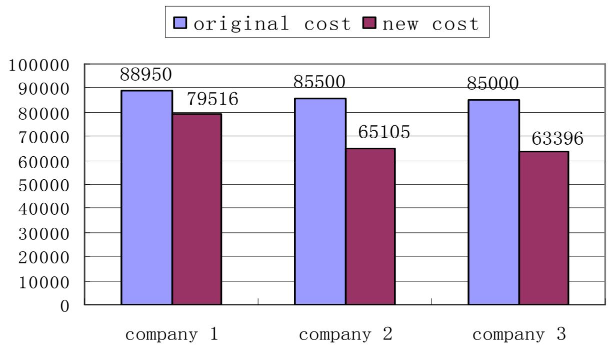

Figure 5 Movement of companies' cost

6. Conclusion

On the basis of demonstrating the possibility of implementing joint-delivery by game theory and proposing a suitable form as analytical ground, this paper focuses on revealing the margin for the partner logistics companies before and after cooperative alliance formation. Thereinto, location model is used to calculate the holistic margin got from facilities integration and this margin is assigned to every company by using shapely value. By a result of an illustrative example, it is easy to see every company can get block of payoff by theoretic cooperation. However, it is can not draw any conclusion because there are still some other problems left to be solved.

Though the delivery alliance, as new phenomena, is known of taking financial, economic and environment advantages, it might be claimed that in certain circumstances those advantages have not been achieved by reason of too high transaction cost which describes all these cost happened in the process of a special "transaction" just like cooperation. For example, some unpredictable risk which most come from such as possibility of changing strategic direction of some partner companies, too much expenditure in founding coalition or some other possible cost and so on[9]. These factors should be also counted in. Obviously, the margin between the profit calculated in this paper and transaction cost is the real payoff or deficit for a partner company in the cooperative plan. On basis of knowing this, the public sector as the third player as we said in chapter two will join this game, it is possible for them to analyze if it is worthy of introducing the cooperative plan through providing multifarious assistance, which is the just key to decided the cooperative plan feasible in economic or not and it is also the final destination of our research.

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