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Research on Benefit Distribution of Express Enterprises based on Cooperative Game

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Abstract

With the rapid development of economic globalization, express delivery enterprises in the market competition is more and more fierce, express delivery enterprises to expand the alliance is imperative. This paper proposes an improved Shapley value benefit distribution model and the core theory of cooperative game to study the income distribution and stability of alliance. The results show that : there is a more reasonable profit distribution mechanism that takes into account risk taking, market competitiveness and investment, which fills the gap in the research on benefit distribution of members with different abilities in the alliance.

Keywords

express enterprise alliance, Shapley value, benefit distribution.

1. Introduction

With the rapid development of e-commerce, express delivery enterprises are also more and more, the competition is more and more fierce. And most express delivery companies have been suffering from low freight rates and lack of capacity. In addition, under the circumstance of low income and high marginal cost, express delivery enterprises must turn from fierce competition to cooperation, which enables express delivery enterprises to obtain additional benefits by sharing limited resources and risks, which is the main purpose of express delivery enterprises' cooperation. However, express enterprise alliances are not always as stable as expected. T., R Gulati and n. Nohria (1998) [1] believe that when individual rationality conflicts with collective rationality, or when the distribution of interests of the alliance cannot guarantee the satisfaction of each member, the alliance may tend to be reorganized or disintegrated. Many relevant scholars, such as Cullinane and Khanna(1999)[2], Song and Panayides(2002)[3], have demonstrated the importance of alliances for the development of transport. Peng weizhen (2012) [4] determined the coefficient of revenue sharing contract through Shapley value, zhou yefu (2017) [5] introduced comprehensive correction factor to benefit distribution of agricultural product supply chain, and zheng shiyuan (2013) [6] discussed the definition of the core solution of transport cooperation game and the general algorithm to find the core solution based on the transport cooperation game model. Gao xinqin (2018) [7] et al. constructed the cooperative game model of alliance collaborative optimization. Famous scholars such as Mitsuhashi and Greve(2009)[8], Huang and Yoshida(2013)[9] have conducted theoretical research on the potential motivation of alliance formation. Yao anqi (2015) [10] analyzed the organizational model and coordination mechanism of the alliance. Yang jianhua (2015) [11] et al. believe that the failure of logistics alliance is due to the lack of management ability. Cheng and Lee (2006)[12], Huang and Zhou(2013)[13] respectively used Delphi method and quality function expansion method (QFD) to rank the motives of alliances according to their importance. In fact, the instability of enterprise alliance is caused by many factors. Klling (1988)[14], Hennart (1991)[15] and wang shihui (2015)[16] believe that there are mutual trust among members, the number of partners and the contribution to the alliance. However, Midoro and Pitto (2000) [17] argue that intra-alliance competition is the main driver of this high degree of instability.

In view of individual rationality, it is inevitable for members to pursue a larger profit sharing ratio, so intra-alliance competition occurs from time to time. However, when the distribution of profits is not proportional to the contribution of alliance members to the alliance, competition deteriorates and gets out of control, resulting in inefficiency and instability of the alliance. Therefore, in-depth study of reasonable profit distribution has important practical significance for the alliance. The aim of this paper is to establish a reasonable distribution mechanism to study the relationship between the stability of alliance and the profit distribution of members with different abilities.

2. Shapley Distribution Model

2.1. Assumptions of the Shapley Model

It is assumed that there are three express enterprises in the cooperative game that can choose alliance strategy or "go it alone" strategy, denoted as 1, 2 and 3. In addition, let S(1,2,3) be the largest alliance, and F_i $(i = 1,2,3)$ be the shares of I express company in the alliance. Assuming that the profit of each express company in independent operation or small alliance is expressed as:

$$V_1 = a, V_2 = b, V_3 = c, V_{(1,2)} = t_1,\ V_{(2,3)} = t_2,\ V_{(1,3)} = t_3,\ V_{(1,2,3)} = m$$

2.2. Establishment of the Shapley Model

references Based on the traditional Shapley benefit distribution model, the shares of alliance $S(1,2,3)$ can be calculated. Let $W|S|$ be the weight factor, and $V|S|$ be the profit of alliance $V(S \setminus i)$is a union S without I express company profits. In this case, can pass $[V|S| - V(S \setminus i)]$to infer the I express company's contribution to the alliance S, the results are shown in table 1, 2, 3.

Here, in order to determine the profit distribution rate, take an example to analyze. Assuming the profits of the three "go it alone" delivery companies 1, 2, and 3 are 20,000, 30,000, and 60,000 respectively, minor alliances $S(1,2)$, $S(1,3)$, and $S(2,3)$can guarantee minimum profits of 70,000, 180,000, and 300,000, respectively. In addition, alliance S(1,2,3) can reach at least 500,000; The profits of each alliance are shown in table 4. Therefore, can be deduced is the profit distribution of each delivery company, $\Phi_1 = 235000, \Phi_2 = 105000, \Phi_3 = 160000$.

Table 1: Profit Share of the 1 Company

S	$S(1)$	$S(1,2)$	$S(1,3)$	$S(1,2,3)$
$V(S)$	a	t_1	t_2	m
$V(S \setminus i)$	0	b	c	t_2
$\lvert S\rvert$	1	2	2	3
$W\lvert S\rvert$	$2!/3! = 1/3$	$1!/3! = 1/6$	$1!/3! = 1/6$	$2!/3! = 1/3$
$W[S] * [V(S) - V(S \setminus i)]$	$a/3$	$(t_1 - b)/6$	$(t_3 - c)/6$	$(m - t_2)/3$
Φ_1	$[2(a + m - t_2) + t_1 + t_3 - b - c]/6$			

Table 2: Profit Share of the 2 Company

S	$S(1)$	$S(1,2)$	$S(1,3)$	$S(1,2,3)$
$V(S)$	b	t_1	t_2	m
$V(S \setminus i)$	0	a	c	t_2
$\lvert S \rvert$	1	2	2	3
$W\lvert S \rvert$	$2!/3! = 1/3$	$1!/3! = 1/6$	$1!/3! = 1/6$	$2!/3! = 1/3$
$W[S] * [V(S) - V(S \setminus i)]$	$b/3$	$(t_1 - a)/6$	$(t_2 - c)/6$	$(m - t_3)/3$
Φ_1	$[2(b + m - t_3) + t_1 + t_2 - a - c]/6$			

Table 3: Profit Share of the 3 Company

S	$S(1)$	$S(1,2)$	$S(1,3)$	$S(1,2,3)$
$V(S)$	c	t_2	t_3	m
$V(S \setminus i)$	0	b	c	t_2
$\lvert S \rvert$	1	2	2	3
$W\lvert S \rvert$	$2!/3! = 1/3$	$1!/3! = 1/6$	$1!/3! = 1/6$	$2!/3! = 1/3$
$W[S] * [V(S) - V(S \setminus i)]$	$a/3$	$(t_2 - b)/6$	$(t_3 - c)/6$	$(m - t_2)/3$
Φ_1	$[2(c + m - t_1) + t_2 + t_3 - b - a]/6$			

Table 4: An Example of a Three-Player Cooperative Game

Alliance	Profits expression	Value
$S(1)$	A	60000
$S(2)$	B	30000
$S(3)$	C	20000
$S(1,2)$	t_1	300000
$S(1,3)$	t_2	180000
$S(2,3)$	t_3	70000
$S(1,2,3)$	M	500000

The above allocation is, to a certain extent, equitable for each member, but there are also shortcomings. The contribution of express enterprises to the alliance is considered separately, while other factors affecting the profit distribution ratio are ignored, such as risk sharing factors that are proportional to the profit. In addition, in real life, companies that take higher risks should have a larger share. Meanwhile, market competitiveness and investment level of alliance members will also affect the distribution of benefits. In this paper, three factors are considered to improve the traditional Shapley model and make it more reasonable for benefit distribution.

3. Improvement to the Traditional Shapley Model

Let $V(I)$ be the total profit of the three express enterprise alliances, and $\alpha_m (m = 1,2,3)$ be the weight of the influencing factors, which can reflect the motivation of the alliances to some extent. Suppose the weight of the express company in each influencing factor K_{mi} is represented by the difference between the ability level of the express company A_{mi} and the average level of the three express companies 1 / n. Therefore, these relations can be expressed as:

$$\sum_{m=1}^{3}\alpha_m=1 \qquad \sum_{i=1}^{3}k_{mi}=\sum_{i=1}^{3}\left(A_{mi}-\frac{1}{n}\right)=1 \tag{1}$$

The weighted index can be obtained by quantifying risks through AHP and other methods. R_i represents the risk coefficient of I express company ($i=1,2,3$), where:

$$\sum_{i=1}^{3}R_i=1 \tag{2}$$

Market competitiveness can determine the ability and position of express delivery enterprises in the express delivery market, which can be directly measured by market share. Therefore, this paper USES the market share in the alliance (represented by K_i) to measure the competitiveness of I express company, and the investment proportion of I express company in the alliance is represented by E_i. On the basis of the hypothesis and considering the comprehensive factors, the improved benefit distribution model is as follows:

$$\begin{gathered}\phi_i^*=\phi_i+\sum_{m=1}^{3}\alpha_m K_{mi}V(I)\\ \phi_i^*=\phi_i+\alpha_1\left(R_i-\frac{1}{3}\right)V(I)+\alpha_2\left(K_i-\frac{1}{3}\right)V(I)+\alpha_3\left(\frac{E_i}{\sum_{i=1}^{3}E_i}-\frac{1}{3}\right)V(I)\end{gathered} \tag{3}$$

Total profits for all members are:

$$\begin{aligned}\sum_{i=1}^{3}\phi_{ii}^*=\sum_{i=1}^{3}\phi_i+\alpha_1\left(\sum_{i=1}^{3}R_i-1\right)V(I)+\alpha_2\left(\sum_{i=1}^{3}K_i-1\right)V(I)\\ +\alpha_3\left(\sum_{i=1}^{3}\frac{\sum_{i=1}^{3}E_i}{\sum_{i=1}^{3}E_i}-1\right)=\sum_{i=1}^{3}\phi_i=V(I)\end{aligned} \tag{4}$$

The above equation shows that the sum of the profits of the three members is equal to the total profit of the union $V(I)$. In other words, the benefits of the alliance can be fully distributed, in line with Shapley's principle of effectiveness. To verify the effectiveness of the improved model, use the previous example again. If the alliance wants its members to actively participate in the investment, assume that the weighting ratio of the influencing factors is equal to $\alpha_1:\alpha_2:\alpha_3=1:2:3$. In addition, according to Huang, s. t. and s. Yoshida (2013) 'S analysis of the key factors of strategic alliance of liner transport companies, the coefficient of cooperation risk of the three companies is $R_1=0.3, R_2=0.3, R_3=0.4$. In terms of investment, the three members invested 300, 450 and 350 respectively, assuming the weights of $E_1=0.2, E_2=0.3, E_3=0.5$. In this case, the revised profit distribution after taking the compensation factor into account is:

$$\Phi_1^*=194848.5, \Phi_2^*=115606.1, \Phi_3^*=189545.4$$

This is the improvement of the former benefit distribution model by adding influence factors. The profit of express delivery company 3 has increased, thus it can be concluded that when a company has a higher risk, market competitiveness or investment level, the alliance's return will improve. Therefore, the modified benefit distribution mechanism is more fair and reasonable.

3. Analysis of the results

According to the above distribution results, the relationship between shareholding ratio and parameters can be deduced as follows:

(1)Φ_i share i express company profit is proportional to the independent operation, and other independent business express is inversely proportional to the company's profits. To Φ_1 for example, a value, the greater the share of Φ_1 is greater; Express company 2 and 3 profits, that is, the greater the value of b and c, Φ_1 value instead.

(2) Φ_i share and i express company to participate in profit is proportional to the minor leagues, together with other Courier companies operating profit is inversely proportional to. To Φ_1, for example, t_1 or t_3 value, namely the union $S(1,2)$ or $S(1,3)$ profit, the greater the Φ_1 value is larger; Union S(2, 3) profits of t_2 values, the greater the Φ_1 value instead.

(3) In these three factors, Φ_i share is proportional to the i, ability level, and the rest of the ability to express company is inversely proportional to the level. Such as risk capacity, market competitiveness, namely R_1, K_1, E_1 investment degree value, the greater the Φ_1 value also is larger; But $R_2, R_3, K_2, K_3, E_2, E_3$ value, the greater the Φ_1 the smaller values.

These results show that the greater the profits of all the alliances in which i express participates, the greater its share in the big leagues. Therefore, by improving the profitability, contribution and risk taking ability of the enterprise, it is possible for the enterprise to attract the cooperation of other members, so as to increase its profit sharing ratio.

4. Concluding Remarks

This paper makes an in-depth study on the interests, stability and profit distribution of express enterprise alliance by using cooperative game theory. In addition, the model and method in this paper can also be applied to other alliances of different scopes. In particular, an improved Shapley value model is proposed. The method in this paper also has some limitations, which need to be modified in the future research. For the modified Shapley value benefit distribution mechanism, the reasonable quantitative method of risk bearing and other influencing factors needs to be further studied. And in reality, it is difficult to quantify the weight of these influencing factors in alliance income distribution. In future studies, other influencing factors, such as the number of alliance members, will be taken into account to analyze the relationship between alliance stability and express enterprises.

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