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Research on Knowledge Sharing Game between Logistics Enterprises

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Abstract

This paper studies the knowledge sharing between logistics enterprises using related game theory. To simplify the analysis, only two logistics enterprises *A* and *B* are considered the game model. To achieve knowledge sharing between enterprises, both enterprises involved in the game model must develop a feasible and optimal strategic combination, the strategic portfolio includes input cost for knowledge sharing and the final knowledge achievement, this paper focuses on the analysis of these two factors: the sharing input cost and the profit sharing ratio. According to game characteristics, basic assumptions, the backward inductive method is adopted to solve the Stackelberg equilibrium of the game model, then the related factors that affect the knowledge sharing between enterprises are analyzed, and learning that knowledge sharing security coefficient is proportional to enterprise's optimal profit value, and the knowledge sharing mechanism is also affected by the profit distribution proportion.

Key words: Logistics enterprise; Game; Knowledge sharing; Profit Allocation proportion

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INTRODUCTION

With the advent of knowledge economy, knowledge has become a key resource for all kinds of enterprises to gain competitive advantage. Especially for logistics enterprises, the application of knowledge management can improve market competitiveness, maximize enterprise profit and minimize cost. In knowledge management, knowledge sharing is especially important. Knowledge operation among logistics enterprises is complicated, because the logistics resources of single enterprise are limited, it is difficult to achieve low-cost and high-quality logistics services, also can not bring customers high satisfaction. Through knowledge sharing among related logistics enterprises, logistics enterprises without large-scale investment can take advantage of the knowledge of the partner companies, especially logistics service resources to increase the variety and expand geographic coverage of logistics services to provide customers "one-stop" service, expand market share and improve competitiveness, and thus benefit from joint marketing and sales activities. Therefore, the knowledge sharing among related logistics enterprises in the supply chain will help reduce logistics cost and improves the income of the enterprise and supply chain, so as to further enhance the core competitiveness of the supply chain to achieve the goal of "win-win". This article is trying to use the method of game analysis, seek the Stackelberg equilibrium of knowledge sharing between logistics enterprises to obtain the conditions for knowledge sharing between logistics enterprises, and present related measures for your reference.

1. BASIC ASSUMPTIONS OF MODEL AND VARIABLE SETTINGS

1.1 Model Basic Assumptions

- Game participants collection. To simplify the analysis, only two logistics enterprises *A* and *B* are considered the game model.

- Game participates are rational person. Rational people have a well-defined preference, which can maximize their own preferences consciously facing given constraints. They usually want to get the maximum interests as the decision-making principle.
- Take the initiative to collect information. For a more comprehensive and accurate understanding of the role of both sides in the game, each partner wants to understand the strategy, payment and other information of other enterprise on the initiative.

1.2 Model Variables Settings

- The total investment cost. The knowledge sharing process can be divided into two processes, namely "Supply" and "demand", so enterprise investment cost can be divided into two parts of the knowledge supply cost D^s and the knowledge demand cost D^d, and this can be seen:

$$D=D_A+D_B$$
$$D_A=D^s{}_A+D^d{}_A,\ D_B=D^s{}_B+D^d{}_B.$$

Knowledge sharing expected revenue E, the allocation of income for $\overline{E}$. This article is for the forecast and judgment of economical efficiency before knowledge sharing between the enterprises, so we use the revenue "expectations" to measure the profit level of knowledge sharing and revenue expectations in this article come from the judgment on the total earnings of the two enterprises, which is the judgment on the revenue expectations of knowledge sharing.

Elasticity coefficient α and β for the cost of inputs being converted to the expected revenue. Because of the difference of hardware facilities, software, ability, strategic development direction, etc. between the enterprises, the revenue from the knowledge conversion of each enterprise are different, this leads to the different coefficients of elasticity. Assume that enterprise A is α , and the elasticity coefficient of enterprises B is β, then set $\alpha>0$ and $\beta>0$.

The maximum expected revenue λ. Same as expected revenue, saturation point also refers to the maximum expected return that the two enterprises reached. Expected revenue E is affected by knowledge sharing input cost D of the two enterprises, and E is the non-linear function of the input cost D (Samaddar & Kadilyala, 2006). With the D increases to a certain extent, E tends to saturation point and reach theoretical maximum value of expect revenue. Since it is assumed that elasticity coefficient α and β are greater than zero, then:

$$E_A=\lambda_A-D^{-\alpha}{}_A$$
$$E_B=\lambda_B-D^{-\beta}{}_B \quad (1)$$

Knowledge sharing safety factor S, and $0\leq S\leq 1$. Although this article is a judgment on the economy before the formation of knowledge-sharing, but still need to take into account the problem of shared risk, the risk needs to be incorporated into the judgment of the economy. Knowledge sharing safety factor refers to the risk coefficient because of the exit midway of member enterprises, stealing intellectual property, and knowledge sharing delay.

The income distribution ratio is X, and $0\leq X\leq 1$. If the profit sharing ratio of enterprise A is X, then the profit sharing ratio of enterprise B is $(1-X)$. Based on the optimal income core enterprise can adjust the proportion of the ratio to stimulate member enterprises into the knowledge-sharing, and willing to contribute their knowledge to the most degree.

Enterprise profit π through knowledge sharing. Enterprise knowledge sharing profit is equal to the expected revenue minus own knowledge sharing input cost, and makes the optimal revenue as the goal of knowledge sharing.

Based on the above basic assumptions and analysis, variable relationship can be obtained as follows:

$$E=E_A+E_B,$$
$$E_A=\lambda_A-D^{-\alpha}{}_A,$$
$$E_B=\lambda_B-D^{-\beta}{}_B,$$
$$\overline{E}=\overline{E}_A+\overline{E}_B, \quad (2)$$
$$\overline{E}_A=\overline{E}\times X\times S=X\times S\times[\lambda_A-D^{-\alpha}{}_A]+(\lambda_B-D^{-\beta}{}_B), \quad (3)$$
$$\pi_A=\overline{E}_A-D_A=X\times S\times[\lambda_A-D^{-\alpha}{}_A]+(\lambda_B-D^{-\beta}{}_B)-D_A, \quad (4)$$
$$\overline{E}_B=\overline{E}\times X\times S=(1-X)\times S[(\lambda_A-D^{-\alpha}{}_A)+(\lambda_B-D^{-\beta}{}_B)], \quad (5)$$
$$\pi_B=\overline{E}_B-D_B=(1-X)\times S\times[(\lambda_A-D^{-\alpha}{}_A)+(\lambda_B-D^{-\beta}{}_B)]-D_B, \quad (6)$$

2. EQUILIBRIUM SOLUTIONS

To achieve knowledge sharing between enterprises, both enterprises involved in the game model must develop a feasible and optimal strategic combination. To simplify analysis, the strategic portfolio includes input cost for knowledge sharing and the final knowledge achievement, this article will focus on the analysis of these two factors: the sharing input cost and the profit sharing ratio. According to game characteristics, basic assumptions, the backward inductive method is adopted to solve the Stackelberg equilibrium (Iijima& Sugawara, 2005) of the game model, specific ideas are as follows.

From the game model we can see, it is assumed that the enterprise A makes D_A as its knowledge sharing input cost based on their own actual strength and experience of innovation, according to D_A and the ability to convert knowledge into revenue, enterprise B may make the optimal choice strategy, put forward its own optimal investment cost for knowledge sharing, and feed back to enterprise A. After getting the information from enterprise B, enterprise A can make its optimal choice, weighing the allocation ratio, to stimulate enterprise B a more positive contribution to his own knowledge for knowledge sharing. At this point, the economic judgment of knowledge sharing comes to the end, and then the next type of game process will come, it is not the focus of this study, so the further discussion will not be made any longer. In accordance with the process of the game, firstly assumed enterprise A set its own input cost D_A, and then enterprise B begins to make the optimal decision that is how to maximize the profit π. Namely:

$$\max_{D_B\geq 0}\pi_B(D_A,D_B)=\max\left\{(1-X)\times S\times[(\lambda_A-D_A^{-\alpha})+(\lambda_B-D_B^{-\beta})]-D_B\right\}. \tag{7}$$

In Equation (7), the optimized first order condition is:

$$[\max_{D_B\geq 0}\pi_B(D_A,D_B)']=(1-X)S\beta D_B^{-\beta-1}-1=0. \tag{8}$$

After simplification:

$$D_B^*=[\beta S(1-X)]^{\frac{1}{\beta+1}}. \tag{9}$$

Now enterprise B has optimized its own profit through knowledge sharing between the two enterprises.

When enterprise A predicts that enterprise B will make D^*_B, namely $[\beta S(1-X)]^{\frac{1}{\beta+1}}$ as input cost for knowledge sharing, or enterprise B forwardly feeds back the input proportion to enterprise A, the problem of enterprise A in the first phase is:

$$\max_{D_A\geq 0}\pi_A(D_A,D_B)=\max\left\{X\times S\times[(\lambda_A-D_A^{-\alpha})+(\lambda_B-D_B^{-\beta})]-D_A\right\}. \tag{10}$$

So the optimal profit function of enterprise A can be obtained.

According to Formula (9) and (10):

$$\max_{D_A\geq 0}\pi_A(D_A,D_B)=\max\left\{\times S\times\{(\lambda_A-D_A^{-\alpha})+\lambda_B-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-D_A\right\}. \tag{11}$$

In Equation (11), the optimized first order condition is:

$$(\max_{D_A\geq 0}\pi_A(D_A,D_B))'=\alpha SXD_A^{-\alpha-1}-1=0. \tag{12}$$

After simplification:

$$D_A^*=(\alpha SX)^{\frac{1}{1+\alpha}}.$$

Right now, the Stackelberg balance between enterprises involved in the knowledge sharing can be reached, that is:

$$D_A^*=(\alpha SX)^{\frac{1}{1+\alpha}};\ D_B^*=[\beta S(1-X)]^{\frac{1}{\beta+1}}.$$

Let D^*_A and D^*_B be substituted into the profit function (4) and (6) separately, the optimal profit value of each enterprise can be obtained:

$$\pi_A^*=X\times S\times[(\lambda_A-D_A^{-\alpha})+(\lambda_B-D_B^{-\beta})]-D_A^*$$
$$=XS\{\lambda_A+\lambda_B-(\alpha SX)^{-\frac{\alpha}{1+\alpha}}-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-(\alpha SX)^{\frac{1}{1+\alpha}}.$$

Also known, the optimal profit function of enterprise B is:

$$\pi_B^*=(1-X)\times S\times[(\lambda_A-D_A^{-\alpha})+(\lambda_B-D_B^{-\beta})]\cdot D_B^*$$
$$=(1-X)S\{(\lambda_A+\lambda_B-(\alpha KX)^{-\frac{\alpha}{1+\alpha}}-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-[\beta S(1-X)]^{\frac{1}{\beta+1}}.$$

To sum up, based on the Stackelberg game model, the optimal proportion of input costs for knowledge sharing will be:

$$D_A^*=(\alpha SX)^{\frac{1}{1+\alpha}};\ D_B^*=[\beta S(1-X)]^{\frac{1}{\beta+1}}. \tag{13}$$

Now both sides can achieve the optimal profit, so the optimal profit functions of the two enterprises are:

$$\pi_A^*=XS\{\lambda_A+\lambda_B-(\alpha SX)^{-\frac{\alpha}{1+\alpha}}-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-(\alpha SX)^{\frac{1}{1+\alpha}}, \tag{14}$$

$$\pi_B^*=(1-X)S\{(\lambda_A+\lambda_B-(\alpha SX)^{-\frac{\alpha}{1+\alpha}}-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-[\beta S(1-X)]^{\frac{1}{\beta+1}}. \tag{15}$$

3. GAME RESULT AND DISCUSSION

It can be seen through the optimal profit functions of enterprise A and B that the value of enterprise profit is influenced by the knowledge of sharing safety factor S, the proportion X of revenue distribution, the expected revenue limit value λ, and the elastic coefficient α and β of expected revenue. Also note, the expected revenue limit value λ_A and λ_B can be regarded as constants because they will vary due to the field of logistics enterprises focus on different projects. At the same time, the coefficients of elasticity α and β for converting input costs to the expected revenue can also be regarded as constants (Zhang, 2004). Nevertheless, the safety factor S and the proportion of the distribution benefits X can be changed by adequate communication between the enterprises, which should become the focus of attention.

3.1 Knowledge Sharing Safety Factor S

Through Sackelberg game model analysis, there are four crucial factors to improve cooperative intention and profit level: knowledge sharing safety factor S, the distribution benefits proportion X, and the coefficients of elasticity α and β for converting input costs to the expected revenue. The elasticity coefficients will not change in a short period of time which can be regarded as constants. Through analysis of Stackelberg game model, the profit of enterprise A is:

$$\pi_A^*=XS\{\lambda_A+\lambda_B-(\alpha SX)^{-\frac{\alpha}{1+\alpha}}-[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}\}-(\alpha SX)^{\frac{1}{1+\alpha}}.$$

After the first derivation of safety factor S:

$$\frac{\partial(\pi_A^*)}{\partial S}=X\lambda_A+X\lambda_B-\frac{1}{1+\alpha}(\alpha S)^{-\frac{\alpha}{1+\alpha}}X^{\frac{1}{1+\alpha}}$$
$$-\frac{1}{1+\beta}(\beta S)^{-\frac{\beta}{1+\beta}}X(1-X)^{-\frac{\beta}{1+\beta}}-\frac{1}{1+\alpha}(\alpha X)^{\frac{1}{\alpha}}S^{-\frac{\alpha}{1+\alpha}}.$$

Then deform the above equation:

$$\frac{\partial(\pi_A^*)}{\partial S}=X[\lambda_A-\frac{1}{1+\alpha}(\alpha SX)^{-\frac{\alpha}{1+\alpha}}]+X[\lambda_B-\frac{1}{1+\beta}[\beta S(1-X)]^{-\frac{\beta}{1+\beta}}]$$
$$-\frac{1}{1+\alpha}(\alpha SX)^{\frac{1}{1+\alpha}}S^{-1}.$$

Put $D_A^* = (\alpha SX)^{\frac{1}{1+\alpha}}$, $D_B^* = [\beta S(1-X)]^{\frac{1}{\beta+1}}$ into the above equation:

$$\frac{\partial(\pi_A^*)}{\partial S} = X[\lambda_A - \frac{1}{1+\alpha}(D_A^*)^{-\alpha}] + X[\lambda_B - \frac{1}{1+\beta}(D_B^*)^{-\beta}] - \frac{1}{1+\alpha}D_A^* S^{-1}.$$

Hence $S\,\frac{\partial(\pi_A^*)}{\partial S} = SX[\lambda_A - \frac{1}{1+\alpha}(D_A^*)^{-\alpha}] + SX[\lambda_B - \frac{1}{1+\beta}(D_B^*)^{-\beta}] - \frac{1}{1+\alpha}D_A^*.$

Because $\pi_A^* = X\times S\times[(\lambda_A-(D_A^*)^{-\alpha})+(\lambda_B-(D_B^*)^{-\beta})]\text{-}D_A^* > 0,$

$$S\,\frac{\partial(\pi_A^*)}{\partial S} = SX[\lambda_A - \frac{1}{1+\alpha}(D_A^*)^{-\alpha}] + SX[\lambda_B - \frac{1}{1+\beta}(D_B^*)^{-\beta}] - \frac{1}{1+\alpha}D_A^* > 0.$$

Because of $S>0$, so $\frac{\partial(\pi_A^*)}{\partial S}>0$, the profit of enterprise A is in proportion to the safety factor S of knowledge sharing.

Likewise, the profit of enterprise B is also in proportion to the safety factor S. Obviously, it is necessary to improve the value of S for both enterprises to increase their profits through knowledge sharing.

3.2 Profit Distribution Proportion X

When the profit distribution proportion X tends to 1, from the perspective of enterprise A, it tends to occupy the largest proportion of the profit distribution. By formula (13), in terms of the input costs for the two enterprises, enterprise A will reach its maximum input cost $D^*_A = (\alpha S)^{\frac{1}{1+\alpha}}$, in addition, because (1-X)tends to 0, $D^*_B \approx 0$, this means that the knowledge sharing input of enterprise B is zero, making it impossible to bring out any knowledge sharing (Chen & Lin, 2005). On the contrary, when the profit distribution proportion X tends to 0, from the perspective of enterprise A, by formula (13), enterprise A will reach the minimum value of its own input cost, D^*_A tends to 0. For enterprise B, X tends to 0 means (1-X) tends to 1, then the knowledge sharing input will reach the maximum value, $D_B^* = (\beta S)^{\frac{1}{\beta+1}}$, so enterprise A will be reluctant to invest any money, manpower, hardware and software resources, knowledge sharing between the enterprises will fail.

According to fairness theory, it is undesirable whether the profit distribution proportion X is close to 0 or 1 (Ning & Fan, 2006). When it tends to 1, the sympathetic disutility of enterprise A will increase with the unfair distribution of profit, at the same time, the jealous disutility of enterprise B will increase. Conversely, when X tends to 0, because of the unfair profit distribution, the jealous disutility of enterprise A will increase, meanwhile, it will also lead to the increase of sympathy disutility of enterprise B . These two cases will both reduce the total utility of the two enterprises.

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