# Knowledge Shift Model of Strategic Alliance Based on Prisoner's Dilemma and Snowdrift Game

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***Abstract***

*According to the development trend of the act of China's current strategic alliance, this paper elaborates the reason why the success rate of strategic alliance is not high from game theory. The mathematical model based on prisoner's dilemma game and snowdrifts game; synthesize the relevant factors of impacting the revenue sharing of enterprise knowledge alliance. Through analysis, it finds that the strategic alliance is a dynamic process of growth. In each stage of the process, because internal and external environment, business processes, customers, the market reaction and other external conditions as well as internal conditions, such as bearing and sharing mechanisms of the risks and benefits between alliance partners change, which brings enormous difficulties to maintain and develop strategic alliance . Due to the different strategic objectives, work efficiency, learning ability and other conditions, the alliance partners need to pay attention to coordination to make flexible and creative reforms.*

*Keywords: knowledge shift, prisoner's dilemma, snowdrift game, strategic alliance*

## 1. Introduction

With the rapid development of electronic information technology, a business valuation standard has the new content. Knowledge is regarded as a more and more important resource. As knowledge possesses the feature that it can not be easily copied by competitors, this considers knowledge as the root of maintaining the competitive advantage for enterprises.

In the 1980s, the strategic alliance as a new form of organization participates in the competition and cooperation of enterprises. Strategic alliance is beneficial for alliance members to enhance the core competitiveness of enterprises in many ways, including access to complementary resources, realization of economies of scale, sharing of knowledge and information. With the era of knowledge economy, knowledge has an increasingly significant impact on the development of the enterprises. Strategic alliance as a new strategic alliance has also become the of the focus in the field of business management and practice.

However, it is not easy to persuade companies to spread their knowledge. There are two reasons why companies are reluctant to spontaneously disseminate knowledge. One is the potential costs in the dissemination process, such as time, money, etc. The other is the losses of its own interests. it is usually considered that the valuable knowledge can ensure its core competitiveness. Emst & Young's report also pointed out that if people cannot get benefits, they would be reluctant to disseminate knowledge.

Only when companies clearly know what benefits they can get in the process of dissemination of knowledge and the benefits outweigh the costs, people are willing to spread knowledge. Typically, these benefits include improving the quality of work, promoting the work efficiency, avoiding duplication of previous errors, improving productivity and reducing labor capital [1]. Through considering the related factors impacting revenue sharing of enterprises' knowledge alliance and investigating comprehensively the dynamic process of knowledge sharing of strategic alliance, this paper is organized as follows. The second part focuses on the Prisoner's Dilemma of the strategic alliance knowledge sharing. The third part further explored enterprise knowledge sharing difficulties through snowdrifts game model. The fourth part contrastively analyses the reason of the occurrence of knowledge-sharing prisoner's dilemma

game and the snow game in the enterprise alliance and propose the most options. Finally it is the conclusion.

## 2. Prisoner's Dilemma of Knowledge Sharing in Strategic Alliance
### 2.1. Basic Assumptions

(1) There is a strategic alliance formed by firms A and B, which both have rational thinking in pursuit of profit maximization as the goal.

(2) Alliance enterprises A and B base on revenue sharing method to select the level of knowledge innovation.

(3) The output of strategic alliances is closely related to the level of enterprises A and B's knowledge innovation and capital inputs. Assume that the output of strategic alliances is a linear output $\pi = \mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 + \eta\phi$. Here $\alpha_1$ and $\alpha_2$ are respectively the coefficients of the level of enterprises A and B's knowledge innovation. $\mu_1\mu_2$ are respectively the coefficients of the level of enterprises A and B's knowledge innovation impact outputs, $\mu_1 > 0, \mu_2 > 0$. $\varepsilon_1$ and $\varepsilon_2$ are namely the coefficients enterprises A and B's capital investment amount influence outputs, $\varepsilon_1 > 0$, $\varepsilon_2 > 0$. $\beta_1$ and $\beta_2$ are namely enterprises A and B's capital investment amount [2]. $\phi$ is normally distributed random variable amount. It respects the market uncertainties and $\eta$ is the coefficient exogenous variables influence the output.

(4) Efforts costs of company A's knowledge innovation is $c_1(\alpha_1) = \dfrac{1}{2}k_1\alpha_1^2$, where $k_1$ is the effort cost coefficient of company A's knowledge innovation. Efforts costs of company B's knowledge innovation is $c_2(\alpha_2) = \dfrac{1}{2}k_2\alpha_2^2$, where $k_2$ is the effort cost coefficient of company B's knowledge innovation. And $k_1 > 0$, $k_2 > 0$. The larger $k_1$ $k_2$ are, the greater the disutility brought by the same level of effort.

(5) The revenue sharing form of companies A and B is the mode of sharing output. The revenue of company A is $z\pi$ and the revenue of company B is $(1 - z)\pi$. Besides, z is the revenue sharing coefficient of company A and $(1 - z)$ is the revenue sharing coefficient of company B; $0 \leq z \leq 1$.

### 2.2. Analysis of Game Model

(1) Case 1: Companies A and B choose the effort level both from the perspective of individual revenue maximization, and expected net income of company A is:

$$E(\pi_1) = z(\mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2) - \frac{1}{2}k_1\alpha_1^2 \tag{1}$$

Formula (1) first-order condition is:

$$\alpha_1^{(1)} = \frac{z\mu_1}{k_1} \tag{2}$$

Formula (2) refers to the optimal effort level choosing from the perspective of the individual income maximization by company A [3].

Similarly, the expected net income of company B is:

$$E(\pi_2) = (1 - z)(\mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2) - \frac{1}{2}k_2\alpha_2^2 \tag{3}$$

Formula (3) first-order condition is:

$$\alpha_2^{(1)} = \frac{(1-z)\mu_2}{k_2} \tag{4}$$

Formula (4) refers to the optimal effort level choosing from the perspective of the individual income maximization by company B.

Take the formula (2), (4) into Equation (1), and the expected net income of company A obtained is:

$$\pi_1^{(1)} = \frac{z^2\mu_1^2}{2k_1} + \frac{z(1-z)\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{5}$$

Take the formula (2), (4) into Equation (3), and the expected net income of company B obtained is:

$$\pi_2^{(1)} = \frac{z(1-z)\mu_1^2}{k_1} + \frac{(1-z)^2\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{6}$$

(2) Case 2: Companies A and B choose the effort level both from the perspective of alliance revenue maximization, and the optimization problem is:

$$\max_{\alpha_1,\alpha_2} E(\pi_T) = (\mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2)$$
$$- \frac{1}{2}k_1\alpha_1^2 - \frac{1}{2}k_2\alpha_2^2 \tag{7}$$

Formula (7) first-order condition is:

$$\alpha_1^{(2)} = \frac{\mu_1}{k_1} \tag{8}$$

$$\alpha_2^{(2)} = \frac{\mu_2}{k_2} \tag{9}$$

Formula (8) and (9) refer to the optimal effort levels choosing from the perspective of the alliance income maximization by company A and B.

Take the formula (8), (9) into Equation (3), and the expected net income of company A obtained is:

$$\pi_1^{(2)} = \frac{(2z-1)\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{10}$$

Take the formula (8), (9) into Equation (3), and the expected net income of company B obtained is:

$$\pi_2^{(2)} = \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{11}$$

(3) Case 3: Company A chooses the effort level both from the perspective of alliance revenue maximization and company B chooses the effort level both from the perspective of individual revenue maximization. Both the optimal effort levels are:

$$\alpha_1^{(3)} = \frac{\mu_1}{k_1} \tag{12}$$

$$\alpha_2^{(3)} = \frac{(1-z)\mu_2}{k_2} \tag{13}$$

Take the formula (12), (13) into equation (1), and the expected net income of company A obtained is:

$$\pi_1^{(3)} = \frac{(2z-1)\mu_1^2}{2k_1} + \frac{z(1-z)\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{14}$$

Take the formula (12), (13) into equation (3), and the expected net income of company B obtained is:

$$\pi_2^{(3)} = \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-z)^2\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{15}$$

(4) Case 4: Company A chooses the effort level both from the perspective of individual revenue maximization and company B chooses the effort level both from the perspective of alliance revenue maximization. Both the optimal effort levels are:

$$\alpha_1^{(4)} = \frac{z\mu_1}{k_1} \tag{16}$$

$$\alpha_2^{(4)} = \frac{\mu_2}{k_2} \tag{17}$$

Take the formula (16), (17) into Equation (3), and the expected net income of company B obtained is:

$$\pi_1^{(4)} = \frac{z^2\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{18}$$

Take the formula (16), (17) into Equation (3), and the expected net income of company B obtained is:

$$\pi_2^{(4)} = \frac{z(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \tag{19}$$

Table 1 shows that when company A selects the angle of alliance income, company B's optional choice is the angle of individual income. This is because:

$$\pi_2^{(3)} = \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-z)^2\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2)$$

$$\geq \pi_2^{(2)} = \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2)$$

Table 1. Shows the Loss Matrix of the Optimal Effort Level Game Selected by Companies A and Alliance B

| Company A / Company B | Individual Income Perspective $\alpha_1^{(1)} = \alpha_1^{(4)} = \dfrac{z\mu_1}{k_1}$ | Alliance Income Perspective $\alpha_1^{(2)} = \alpha_1^{(3)} = \dfrac{\mu_1}{k_1}$ |
|---|---|---|
| Individual Income Perspective $\alpha_2^{(1)} = \alpha_2^{(3)} = \dfrac{(1-z)\mu_2}{k_2}$ | $\begin{bmatrix} \dfrac{z^2\mu_1^2}{2k_1} + \dfrac{z(1-z)\mu_2^2}{k_2} \\ + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right), \\ \dfrac{z(1-z)\mu_1^2}{k_1} + \dfrac{(1-z)^2\mu_2^2}{2k_2} \\ + (1-z)\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right) \end{bmatrix}$ | $\begin{bmatrix} \dfrac{(2z-1)\mu_1^2}{2k_1} + \dfrac{z(1-z)\mu_2^2}{k_2} \\ + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right), \\ \dfrac{(1-z)\mu_1^2}{k_1} + \dfrac{(1-z)^2\mu_2^2}{2k_2} \\ + (1-z)\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right) \end{bmatrix}$ |
| Alliance Income Perspective $\alpha_2^{(2)} = \alpha_2^{(4)} = \dfrac{\lambda_2}{k_2}$ | $\begin{bmatrix} \dfrac{z^2\mu_1^2}{2k_1} + \dfrac{z\mu_2^2}{k_2} \\ + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right), \\ \dfrac{z(1-z)\mu_1^2}{k_1} + \dfrac{(1-2z)\mu_2^2}{2k_2} \\ + (1-z)\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right) \end{bmatrix}$ | $\begin{bmatrix} \dfrac{(2z-1)\mu_1^2}{2k_1} + \dfrac{z\mu_2^2}{k_2} \\ + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right), \\ \dfrac{(1-z)\mu_1^2}{k_1} + \dfrac{(1-2z)\mu_2^2}{2k_2} \\ + (1-z)\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right) \end{bmatrix}$ |

So whatever strategy company A selects, company B's optimal choice is always the individual income perspective [4]. This optimal strategy is called the dominant strategy of company B.

Conversely, when company B selects the angle of individual income, the optimal choice of company A should also be the angle of individual income. This is because:

$$\pi_1^{(1)} = \frac{z^2\lambda_1^2}{2k_1} + \frac{z(1-z)\lambda_2^2}{k_2} + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

$$\geq \pi_1^{(3)} = \frac{(2z-1)\lambda_1^2}{2k_1} + \frac{z(1-z)\lambda_2^2}{k_2} + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

When company B selects the angle of alliance income, the optimal choice of company A should also be the angle of individual income. This is because:

$$\pi_1^{(4)} = \frac{z^2\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

$$\geq \pi_1^{(2)} = \frac{(2z-1)\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z\left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

So whatever strategy company B selects, company A's optimal choice is always the individual income perspective. This optimal strategy is called the dominant strategy of company A.

When companies A and B are from the perspective of alliance income, the alliance's total revenue is:

$$\pi_{1联} + \pi_{2联} = \frac{\mu_1^2}{2k_1} + \frac{\mu_2^2}{2k_2} + \left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

When companies A and B are from the perspective of individual income, the alliance's total revenue is:

$$\pi_{1个} + \pi_{2个} = \frac{\left(2z - z^2\right)\mu_1^2}{2k_1} + \frac{\left(1 - z^2\right)\mu_2^2}{2k_2} + \left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

When companies A is from the perspective of alliance income and company B is from the perspective of individual income, the alliance's total revenue is:

$$\pi_{1联} + \pi_{2个} = \frac{\mu_1^2}{2k_1} + \frac{\left(1 - z^2\right)\mu_2^2}{2k_2} + \left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

When companies A is from the perspective of individual income and company B is from the perspective of alliance income, the alliance's total revenue is:

$$\pi_{1个} + \pi_{2联} = \frac{\left(2z - z^2\right)\mu_1^2}{2k_1} + \frac{\mu_2^2}{2k_2} + \left(\varepsilon_1\beta_1 + \varepsilon_2\beta_2\right)$$

It finds by comparison:

$$\pi_{1个} + \pi_{2个} \le \pi_{1联} + \pi_{2个}, \quad \pi_{1个} + \pi_{2联} \le \pi_{1联} + \pi_{2联},$$

That is can achieve total revenue maximization from the perspective of alliance revenues.

Therefore, the optimal effort level equilibrium of companies A and B is (individual, income) [5]. Since companies get into a prisoner's dilemma about revenue-sharing issue and in the conflicts of individual rationality and collective rationality,they do not reach the Pareto optimality (alliance income perspective, alliance income perspective).


## 3. Snow Game of Corporate Alliances Knowledge Sharing
### 3.1. Concept of Snow Game
Two persons drive in the reverse direction in winter, but a snow blocks them. Only when the snow is eradicated, they can pass. Assumed that the amount of labor required to eradicate the snowdrift to restore flow the road is c and both players' gain can be quantified as b, b> c. If both of them adopt a cooperative strategy, shoveling snow off together, both of their gains are R = b c / 2, and the amount of labor to pay is c / 2. if only one person shovels snow, although finally both sides can go home, the party without shoveling snow (traitor) avoids to pay the labor, whose revenue is T = b. And the party with shoveling snow away (collaborators) gets the gain S = b c. If the parties have taken the betrayal strategy, they both could not return home and both sides' gains are P = 0. So matrix of snowdrift game is:

$$\begin{pmatrix} b - \dfrac{c}{2} & b - c \\ b & 0 \end{pmatrix}$$

Assume that both sides are rational selfish individuals, then what strategy they will take? If one party takes betrayal strategy (do not shovel the snow), the best strategy for another party is to get off to shovel snow. This is because the gains of going home b-c are greater than gains of not shoveling snow 0. Conversely, if the opposite gets off to shovel snow, the best strategy at this time is betrayal, that does not shovel snow. So snowdrift game model is different from the prisoner's dilemma, in that it has two Nash equilibriums of (C, D) and (D, C).

The difference between snowdrift game and the prisoner's dilemma game is that the snowdrift game is more prone to snow cooperation [6]. If encountering a traitor, collaborator's income is greater than the gain of mutual betrayal. Therefore, the best strategy of one party depends on the opposite's strategy. If the opposite adopts cooperation, the betrayal is his best strategy. Conversely, cooperation is the best strategy for him. So the cooperative strategy will not disappear in such a system.

### 3.2. Model Analysis

In order to understand, apply assumption 1 and assumption 3 of prisoner's dilemma model in the previous text.

Table 2. The Loss Matrix of the Optimal Effort Level Game Chosen by Companies A and Alliance B

| Company B \ Company A | Individual Income Perspective | Alliance Income Perspective |
|---|---|---|
| Individual Income Perspective | $\left( \begin{array}{l} \dfrac{\mu_1^2}{k_1} + \dfrac{\mu_2^2}{k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2, \\ \dfrac{\mu_1^2}{k_1} + \dfrac{\mu_2^2}{k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 \end{array} \right)$ | $\left( \begin{array}{l} \dfrac{\mu_2^2}{2k_2} + \varepsilon_2\beta_2, \\ \dfrac{\mu_1^2}{2k_1} + \dfrac{\mu_2^2}{k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 \end{array} \right)$ |
| Alliance Income Perspective | $\left( \begin{array}{l} \dfrac{\mu_1^2}{k_1} + \dfrac{\mu_2^2}{2k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2, \\ \dfrac{\mu_1^2}{2k_1} + \varepsilon_1\beta_1 \end{array} \right)$ | $\left( \begin{array}{l} \dfrac{\mu_2^2}{2k_{21}} + \varepsilon_2\beta_2, \\ \dfrac{\mu_1^2}{2k_1} + \varepsilon_1\beta_1 \end{array} \right)$ |

(1) Case 1: If companies A and B are from the alliance perspective, the expected net income of companies A and B is:

$$E\left(\pi_1\right) = E\left(\pi_2\right) = \mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 - \frac{1}{2}\left( \frac{1}{2}k_1\alpha_1^2 + \frac{1}{2}k_2\alpha_2^2 \right) \quad (20)$$

Formula (20) first-order condition is:

$$\alpha_1 = \frac{2\mu_1}{k_1} \quad (21)$$

$$\alpha_2 = \frac{2\mu_2}{k_2} \quad (22)$$

Take the formula (21), (22) into Equation (20), and the expected net income of company A and B obtained is:

$$\pi^* = \frac{\mu_1^2}{k_1} + \frac{\mu_2^2}{k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2$$

(2) Case 2: If company A is from the alliance perspective and company B is from individual perspective, the expected net income of companies A and B is:

$$E(\pi_1^{**}) = \mu_1\alpha_1 + \varepsilon_1\beta_1 - \frac{1}{2}k_1\alpha_1^2 \tag{23}$$

Formula (23) first-order condition is:

$$\alpha_1 = \frac{\mu_1}{k_1} \tag{24}$$

Take the formula (24) into Equation (23), and the expected net income of company A obtained is:

$$\pi_1^{**} = \frac{\mu_1^2}{2k_1} + \varepsilon_1\beta_1 \tag{25}$$

The expected net income of company B  obtained is:

$$E(\pi_2^{**}) = \mu_1\alpha_1 + \mu_2\alpha_2 + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 - \frac{1}{2}k_2\alpha_2^2 \tag{26}$$

Formula (26) first-order condition is:

$$\alpha_2 = \frac{\mu_2}{k_2} \tag{27}$$

Take the formula (26) into Equation (27), and the expected net income of company B obtained is:

$$\pi_2^{**} = \frac{\mu_1^2}{k_1} + \frac{\mu_2^2}{2k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2 \tag{28}$$

(3) Case 3: If company A is from the individual perspective and company B is from alliance perspective, the expected net income of company A is:

$$\pi_1^{***} = \frac{\mu_1^2}{2k_1} + \frac{\mu_2^2}{k_2} + \varepsilon_1\beta_1 + \varepsilon_2\beta_2$$

The expected net income of company B  obtained is:

$$\pi_2^{**} = \frac{\mu_2^2}{2k_2} + \varepsilon_2\beta_2$$

(4) Case 4: If companies A and B are from the individual perspective, the expected net income of company A is:

$$\pi_1^{****} = \frac{\mu_1^2}{2k_1} + \varepsilon_1\beta_1$$

The expected net income of company B obtained is:

$$\pi_2^{****} = \frac{\mu_2^2}{2k_{21}} + \varepsilon_2\beta_2$$

Similarly, it can be seen that if company A selects cooperation, company B will choose betrayal [7-8]. When company A selects betrayal, company B will choose cooperation. When both companies A and B select cooperation, alliance gains is the largest.

## 4. Countermeasures

The second is the lack of an effective revenue-sharing mechanism which pushes the two sides to choose individual income to obey alliance earnings [9]. Thirdly, the vulnerability, dynamic and non-stability of strategic alliance itself as well as the relationship of competition and cooperation between alliances (Mo et al, 2003) make the alliance companies tend to focus on their own short-term gains and lack the enthusiasm from the perspective the alliance revenue. Fourthly, one party has no confidence in another's threatening choice, even if they sign a revenue-sharing agreement in the front of alliance. The agreement is invalid, because alliances companies with rational thinking do not positively comply with agreement to change prisoner's dilemma of the strategic alliance's revenue sharing.So we propose the following measure of establish the Nash bargaining model of revenue sharing.

Nash studied the problems of cooperation by two persons in 1951 (Sun Dongchuan et al, 2001; Ye Fei, 2003; Zheng Wenjun et al, 2001). we learn from this method to assume that it satisfies the reasonable conditions in Nash bargaining model, such as the individual rationality, combined rationality, linear, invariance and unrelated selection [10]. The above analysis is still an example. In order to ensure the achievement of the goal of alliance's optimal revenue sharing, from the perspective of alliance revenue, the expected net incomes of companies A and B are respectively.

$$\pi_1^{**} = \frac{(2z-1)\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2)$$

$$\pi_2^{**} = \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2)$$

Assume that the retained earnings of companies A and B are respectively M1, M2, and then Nash bargaining model of alliance knowledge sharing can be described as follows:

$$\max_z \left[\frac{(2z-1)\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) - M_1\right] \cdot \left[\frac{(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) - M_2\right]$$

$$s.t. \begin{cases} \frac{(2z-1)\mu_1^2}{2k_1} + \frac{z\mu_2^2}{k_2} + z(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \geq M_1 \\ \frac{(1-z)\mu_1^2}{k_1} + \frac{(1-2z)\mu_2^2}{2k_2} + (1-z)(\varepsilon_1\beta_1 + \varepsilon_2\beta_2) \geq M_2 \\ 0 \leq z \leq 1 \end{cases} \quad (20)$$

Solve the formula (20) and the revenue sharing coefficient of company A is:

$$z^* = \frac{3\mu_1^2 k_2 + \mu_1^2 k_1 + 2k_1 k_2 \left(M_1 - M_2 + \varepsilon_1 \beta_1 + \varepsilon_2 \beta_2\right)}{4\left(\mu_1^2 k_2 + \mu_2^2 k_1 + k_1 k_2 \varepsilon_1 \beta_1 + k_1 k_2 \varepsilon_2 \beta_2\right)} \tag{21}$$

The revenue sharing coefficient of company B is:

$$1 - z^* = \frac{3\mu_2^2 k_1 + \mu_1^2 k_2 + 2k_1 k_2 \left(M_2 - M_1 + \varepsilon_1 \beta_1 + \varepsilon_2 \beta_2\right)}{4\left(\mu_1^2 k_2 + \mu_2^2 k_1 + k_1 k_2 \varepsilon_1 \beta_1 + k_1 k_2 \varepsilon_2 \beta_2\right)} \tag{22}$$

Formula (21), (22) are respectively the revenue sharing factors of companies A and B from the perspective of alliance revenue [11]. According to these factors, setting up the appropriate strategic alliances' revenue sharing mechanism can guarantee that both sides are willing to accept the optimal revenue sharing program of Pareto.


## 5. Conclusion

The maintenance and development of strategic alliances are different from the general management of enterprise groups. With the growing number of strategic alliances, there are more and more cases of failure. Due to the different strategic objectives, work efficiency, learning ability and other conditions, the alliance partners need to pay attention to coordination to make flexible and creative changes. Strategic alliance is a dynamic process of growth [12]. At every stage of the process, because internal and external environment, business processes, reaction of customers and market and other external conditions change, the maintenance and development of strategic alliances have great difficulties. As the author has the limited capacity, this article only makes a simple analysis of the game between enterprises without the consideration of the external conditions impacting the course of the game and hope other researchers can continue to improve.

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