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Investment Decision Model of Industrial Technologies and Innovation Strategic Alliance Regarding Conflict based on Plant Growth Simulation Algorithm

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Abstract: Conflict is the key factor to affect investment and benefits of the industry technologies and innovation strategic alliance. This paper constructs an investment decision model of industry technology innovation strategic alliance by discussing the influence of the conflict on the alliance generic technology investment and the impact of member benefits. The results suggest that maximize revenue optimization of alliance generic technology investment and members can be realized through a investment portfolio of alliance members. Moderate conflict would promote alliance innovation performance effectively.

Keywords: Industrial Technologies and Innovation Strategic Alliance, Plant Growth Simulation Algorithm, Moderate conflict, Investment decision-making

1 Introduction

Industrial Technologies and Innovation Strategic Alliance (ITISA) is based on the contractual relationship, aimed at breakthrough in industrial generic technology and/or establishing industrial standard. It emphasizes on co-contribution, benefit and risk sharing, large scale commercial application of technological achievements and long term stable cooperation between collaborative agents(Li Xinnan,2007,2009, Li Xueyong, 2010) [1,2,3]. Since 2007, ITISAs were developed rapidly in China, and more than one thousand ITISAs had been formed by the end of 2012. ITISA could promote knowledge innovation and enhance innovation performance. However, there are many instabilities which could stifle creativity, produce compliance, encourage free behavior and generate conflict(Jehn K A, Mannix E A,2001) [4]. From the structure, ITISA is an arrangement of several interest-group. There will be some conflict and contradiction between memberships.

Conflict is a phase transition behavior of management system. Any phase transition mutation is not out of thin air, but is in the long-term creep, through the process of the ebb and flow, turbulence, instability, reaches a critical state when a sudden shift happens(Chen Guangzhi,2002) [5]. The evolution of conflict is a dynamic process(Greer L. L. et al., 2008) [6]. In this process, the evolution of conflict is a time series of events(T homas K. W.,1992) [7]. ITISA is the process of producing new technology and knowledge. There will be all kinds of contradictions in the process of knowledge integration and transfer(Wall J. et al.,1995) [8]. These contradictions are perceived due to the differences or irreconcilable between the members, causing a series of conflicts(Wall J. et al.,1995) [8]. In the process of a series of conflicts, ITISAs investment decisions will change according to the conflict. ITISA conflict degree will directly affect the investment enthusiasm and effectiveness of the alliance participants. Accurately grasp of conflict degrees influence on ITISA performance will be conducive to league managers to make rational management decisions. This paper analyzes the portfolio decisions of members through constructing ITISA portfolio optimization model considering conflict, by discussing the influence of ITISA conflict degree on alliance generic technology investment and benefits.

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2 Research review of portfolio model of cooperation

Aspremont C., Jacquemin A.(1988) set up a two-stage game model to study R&D strategy, concluded that when the R&D spillover effect was big enough, cooperative R&D could achieve faster technology progress than competitive R&D [9]. Then some economists expanded this model from different angles. De Bondt R., Veugelers R. (1991) compared different R&D investment strategy existed overflow, discussed the choice of development strategy under different environment [10]. Suzumura K. (1992) expanded the model to two or more companies, maked more general hypothesis in the products demand function and cost function [11]. Choi J. P. (1993) analyzed the impact of uncertainty of innovation and marginal diminishing on development of earnings in the model [12]. Amir R. and Wooders J. (1999) abandoned the random spillover hypothesis and described the process of overflow with a binomial distribution, concluded that joint laboratory innovation always increased consumer welfare [13]. In the 21th century, many scholars, such as Bala V., Goyal S. (2000) [14], Kranton E, Minehart, D.F.(2001) [15], Goyal S., Moraga-Gonzalez J.(2001) [16], Goyal S., Joshi S.(2003) [17], focused on the R&D network and its influence on corporate R&D activities. Goyal S., Konovalov A., Moraga-Gonzalez J.(2003) [18] established a strategical game model integrated independent R&D, analysis the enterprise investment decision in mixed development mode. In this model the R&D activities of the enterprise could be divided into two parts, independent R&D and cooperative R&D. Cooperative project was mainly composed of one-to-one collaboration between enterprises alliance. The number of the alliance was not sure. Technical innovation activities were carried out through independent R&D of enterprises and cooperative R&D networks. Uncertainty of the number of enterprises in collaborative network was the general characteristics of enterprises to carry out the cooperative R&D activities. There are R&D investment repeated game under the condition, so as to make the development benefits maximization(Zeng Deming, Zhou Qing, 2005 [19], Zhou Qing, Zeng Deming, 2008 [20], Mao Chongfeng, Li Tong, Zhou Qing, 2012 [21]). But the existing research model didnt analyze alliance portfolio decisions in the perspective of indeterminacy environment, and never analyzed the influence of cooperation conflict to income uncertainty. Based on researches, this paper studied alliance members cooperative R&D investment decisions under conflict environment based on Plant Growth Simulation Algorithm to discuss ITISA optimal investment returns under different levels of conflict.

3 ITISA Portfolio Models regarding Conflict

In ITISA, conflict is inevitable. Conflict between members shows continuity. Under the action of conflict, investment decision-making of ITISA will be adjusted according to degree of conflict. Similarly, investment combination can also be changed. This paper use Plant Growth Simulation Algorithm to establish a two phase ITISA portfolio model of the conflict constraints.

3.1 ITISA Portfolio Decision regarding Conflict

In the process of alliance investment decisions, union enterprise's decision-making process can draw lessons from Goyal S. et al. (2003) [18]. Assume $N = \{1......n\}(n \geq 2)$is a set of enterprises on the market. There are $\lambda \in \{1,2,...n\}$ alliance member in g. x_{ig} is the R&D investment in . Independent R&D investment is x_{ii}. Suppose there are conflict between members of g, $k \in [0,1]$ is the conflict level. The conflict of the alliance has extrusion effect with generic technology investment. kx_{ig} is degree of extrusion. kx_{ig} will be totally used to its own independent R&D investment. Under the conflict, the investment of union members in ITISA will be $(1-k)x_{ig}$. The independent R&D investment of union members will be $x_{ii}+kx_{ig}$.

Production function of R&D investment is determined by $f(R)$, $f'(R) > 0; f''(R) < 0$, R is the effective R&D investment of the enterprise. That is, if other enterprises do nor invest R&D, in order to achieve the same cost reduction, it must be invest independently. Independent R&D investment returns of enterprise i is:

$$f_{ii}(x) = f(x_{ii}+kx_{ig}) \tag{1}$$

In ITISA, cooperative R&D investment returns of enterprise i is:

$$f_{ig}(x) = f\left(\sum_{i\in g}(1-k)x_{ig}\right) \tag{2}$$

Total loss of production cost obtained by carrying out technology development activities of enterprise i is:

$$f_i(x) = f\left(\sum_{i\in g}(1-k)x_{ig}\right) + f(x_{ii}+kx_{ig}) \tag{3}$$

So per unit cost of production of enterprise i is:

$$c_i(g,x) = \bar{c} - f_i(x) \tag{4}$$

$\bar{c}$ is per unit cost of production of enterprise i before technology development.

Consider cost $c_i(g,x)$, enterprise choose a certain output $q_i(g,x)$ to participate in product market Cournot competition. Assume that product demand inverse function of enterprise i is in symmetric linear form in symmetrical ITISA(Similar to the mesh type of alliance, every enterprise invest in R&D in the same way in the league), so:

$$p = a-(1+\lambda\varepsilon-\varepsilon)q_i(g,x) \tag{5}$$

p is equilibrium price, $q_i(g,x)$ is equilibrium quantity, a is the intercept of demand function. ε is the product substitution coefficient($\varepsilon \in [0,1]$). In the similar products market which supply exceeds demand, equilibrium quantity of enterprise i (Bala V., Goyal S., 2000 [14], Kranton E, Minehart D. F., 2001 [15], Goyal S., Konovalov A., Goyal S., Joshi S., 2003 [17], Moraga-Gonzalez J., 2003 [18], etc) is:

$$q_i(g,x) = \frac{(2-\varepsilon)a - [(n-\lambda-1)\varepsilon+2]c_i(g,x)}{(n\varepsilon-\varepsilon+2)(2-\varepsilon)} \tag{6}$$

Cournot benefit is:

$$\pi_i(g,x) = [q_i(g,x)]^2 - x_{ig} - x_{ii} \tag{7}$$

In investment decision-making of ITISA, alliance members will face a double decisions. From the perspective of the alliance (industry) overall interests, generic technology investment should be ensured to maximize to break through the bottleneck of the industry and promote the competitiveness of the industry. Enterprise benefit maximization is the goal of an enterprises key consideration. So in the investment decision-making of ITISA, alliance members will face a bi-level programming problem. In the investment decision-making of ITISA, maximize the investment of generic technology will be the first level of goal programming. The second level of the goal should be the individual utility maximization, so build portfolio optimization model of ITISA considering conflict.

$$\max_{x_{ig}} \mathrm{T} = \sum_{i\in g} [(1-k)x_{ig} + \sigma(x_{ii} + kx_{ig})]$$

$$s.\,t.\; x_{ii} + x_{ig} \leq \theta$$

$$0 < x_{ii} < (1-\rho)\theta$$

$$x_{ig} \text{ is solution of the following question} \tag{8}$$

$$\max \pi_i(g,x)$$

$$s.\,t.\; \rho\theta < x_{ig} < \theta$$

$$f_i(x) < \bar{c}$$

$$f_i'(x) > 0$$

$$f_i''(x) < 0$$

ρ is proportion of R&D investment agreement of i to join the alliance, θ is the total amount of R&D investment,$\theta = x_{ii} + x_{ig}$. σ is the diffusion coefficient of core knowledge. T is total generic technology investment of alliance.

3.2 Plant Growth Simulation Algorithm Optimized Analysis of Alliance portfolio

To solve bi-level programming problem above, it use Plant Growth Simulation Algorithm to build model and solve. Plant Growth Simulation Algorithm(P GSA)is an intelligence algorithm with the theory of the plant phototropism as heuristic rules. It establishes deductive way plant system on the basis of the growth rules and probability of growth model on the basis of plant phototropism(Li Tong, Wang Chunfeng, 2005 [22], Li Tong, Wang Zhongtuo, 2010 [23], Li Tong, Wang Zhongtuo, 2010 [24]). Optimization model formed by the combination of deductive methods and growth model is the whole process from simulating plant in the solution space of optimization problems from initial state to the final state. By PGSA, a better portfolio can be achieved (Mao Chongfeng, Li Tong, Zhou Qing, 2012 [25], Li Tong, Chen Chouyong, 2012 [26]], Li Tong, Chen Chouyong, Su Weiling, 2012 [27]). The introduction of bi-level programming to solve the decision-making process by PGSA is as follows:

Step1: In the upper decision variable solution space T choose k initial plant growing point($S_1, S_2, \ldots, S_k$).

Step2: Choose plant growing point $T_j(S_i) \in M_x(S_i)$ in the lower decision variable solution space $\pi_i(g,x)$ in S_i respective reasonable response sets. Connect S_i and $T_j(S_i)$ to form trunk. The length of the trunk is $F(S_i, T_j(S_i))$; $M_x(S_i)$ is reaction sets of lower level programming problem to the given value of the upper S_i.

Step3: calculate $(S_1, S_2, \ldots, S_k)$ morpheme concentration:

$$P_i = \frac{\mathrm{F(S_i,T_j(S_i))}}{\sum_{i=1}^{k} \mathrm{F(S_i,T_j(S_i))}}$$

Step4: $P_{i+1} \leftarrow P_{i+1} + P_i, P_i \leftarrow P_i/P_k$;

Step5: if $P_i < random[0,1] < P_{i+1}, H \leftarrow S_i$ (see the following table 1)

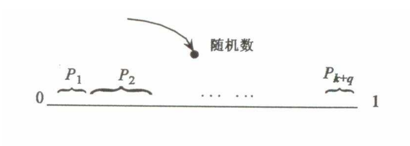

Fig. 1: the concentration of morpheme state-space

Step6: The upper variable initial states:H
rotation angle: $\delta = 90°$
*The growth rule: $F \to F[-F][+F]F$
The new growing point: $S_i(1), S_i(2), \ldots, S_i(2n)$,
n is upper planning decision variable dimension.

*Note: The growth rule is $L-$Systematic grammar established by A.Lindenmayer. Asumme (H, α) is the current state of the plant growing point. H is location of the coordinates. α is growing direction of the point. The length of the section is d, angle increment of top is δ. [is to record current information, save the information of the point(bifurcation point), and draw the first branch .] is to take the information of last point out, and draw the second branch in this point. F is to grow length d in current direction. + is to contra rotate δ, -is to clockwise rotate δ.

Step7:

$$\begin{aligned} S_i \leftarrow \min\{&F(S_i, T_j(S_i)),\\ &F(S_i(1), T_j(S_i)),\\ &F(S_i(2), T_j(S_i)),\\ &\ldots\ldots\\ &F(S_i(2n), T_j(S_i))\};\end{aligned}$$

Step8: The lower variable initial states:L
rotation angle: $\delta = 90^\circ$
*The growth rule: $F \rightarrow F[-F][+F]F$
New growing point: $T_{j1}(S_i), T_{j2}(S_i), \ldots, T_{j2m}(S_i)$, n is lower planning decision variable dimension.

Step9:

$$\begin{aligned} T_j(S_i) \leftarrow \min\{&F(S_i, T_j(S_i)) + f(S_i, T_j(S_i)),\\ &F(S_i, T_{j1}(S_i)) + f(S_i, T_{j1}(S_i)),\\ &F(S_i, T_{j2}(S_i)) + f(S_i, T_{j2}(S_i)),\\ &\ldots\ldots\\ &F(S_i, T_{j2m}(S_i)) + f(S_i, T_{j2m}(S_i))\};\end{aligned}$$

Step10: if iterate for n times continuously and no new branch growth, plant growth ends, or back to Step3.

Step3-Step9 is a growing process of trunk $S_i - T_j(S_i)$ in respective neighborhood after the trunk is formed by upper plant growing point chosen by probability of phototropism mechanism and lower growth point in corresponding reaction sets.

4 ITISA portfolio simulation analysis considering the conflict

4.1 Portfolio optimization analysis considering the conflict

Assume the market have 15 enterprises to participate in product market Cournot competition. There are 10 enterprises to carry out technology development activities through technical alliance. The biggest investment ratio of each enterprise technology alliance in is 0.3. In Cournot market, potential market demand for total 100 units, substitution coefficient of the enterprises product is 0.25. Investment of enterprises to invest in a technology R&D is 80 unit in budget. Technology diffusion coefficient in the technology market is 0.2. Corporate R&D investment returns is $f(R) = 0.5\sqrt{R}$, that is $n = 15$, $\lambda = 10$, $a = 100$, $\bar{c} = 10$, $\theta = 80$, $\varepsilon = 0.3$, $\rho = 0.25$, $\sigma = 0.2$. In the competition, Cournot returns and R&D returns of the 10 enterprises in technological alliance are influenced by both alliance portfolio and investment outside the alliance. The relationship between n alliance members are both cooperation and competition.

$$\max_{x_{ig}} \; T = 2x_{ii} + 6x_{ig}$$

$$s.t. \; x_{ii} + x_{ig} \le 80$$
$$0 < x_{ii} < 60$$

where x_{ig} is the solution of the following question

$$\max \; \pi_i(g, x) = \left[\frac{138 + 1.6(\sqrt{5x_{ig}} + \sqrt{x_{ii} + 0.5x_{ig}})}{10.54}\right]^2 - x_{ig} - x_{ii}$$

$$s.t. \; 20 < x_{ig} < 80$$

PGSA is programmed by Matlab, run on Windows XP. The hardware of computer is Celeron(R) CPU 3.06GHz,1.00GBRAM. PGSA iterates for 500000 times in each test, and calculates for 15 times. Error value between the best and worst result is no more than 0.001%. The result is quite stability. Through the test data 1 globally optimal solution and 4 locally optimal solution is available. As list in table 1.

Table 1: Optimal solution of PGSA

Optimal solution	x_{ig}	x_{ii}	T	π
globally optimal solution	79.4490	0.5500	477.7940	424.6702
locally optimal solution 1	65.8440	5.9440	406.9520	415.8122
locally optimal solution 2	60.0000	20.0000	400.0000	439.5393
locally optimal solution 3	40.0000	40.0000	320.0000	448.3475
locally optimal solution 4	44.6240	24.6240	316.9920	424.1039

According to table 1, in conflict maximization investment of alliance generic technology and investment profit optimization goal of members can reach an agreement. Optimization of the investment scheme can make the two goals to achieve synergy effectively. This can provide decision-making basis and reference value for the construction and run of industrial technology innovation strategy alliance and run ITISA, also can make further exploration of the investment behavior of union members.

Firstly, for globally optimal solution, cooperative R&D investment of members in the alliance is much more greater than the independent R&D investment. Thus, maximization goal of investment on alliance generic technology depends on the investment of members on alliance. Only when the alliance members make concerted cooperation R&D investment, it is more conducive to carry out alliance generic technology R&D. In fact, managers should pay more attention and guide the alliance members investment pattern. Members should understand the generic technology R&D is not only a key for technological breakthroughs, but also make sure that alliance members could get a better development benefits. Revenue and alliance members benefit must be based on a win-win basis.

Secondly, in table 1, with one aim that optimize T value of alliance generic technology investment, members cooperative R&D investment and independent R&D investment can be adjusted according to the alliance members expected return. But investment amount of members in not positive related to expected return. This means alliance members have more power to maximize revenue by retain its own technology. The result will make individual income increase, but generic technology investment be severely damaged. For instance, locally optimal solution can increase returns by 5.6% than globally optimal solution, but generic technology investment will decrease for 33.0%.

4.2 Impact of Conflict degree on the alliance generic technology and members investment profit

Further, when conflict degree varies in [0,1], ITISA generic technology investment T and individual income can be obtained through different conflict degree calculated in the former formula mode. This paper uses step length 0.03 and 0.04 to choose 30 point in [0,1] as simulation samples of conflict degree, calculates generic technology investment and individual income increase separately. With these values, the tendency chart of T, change along with conflict degree can be drawn.

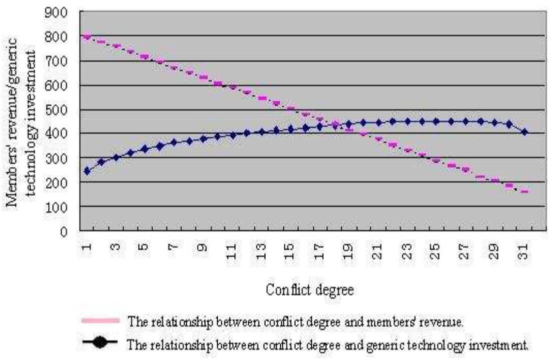

Fig. 2: The relationship between conflict degree and members' revenue, generic technology investment

From table 2, conflict degree between members has a reverse U relationship with individual revenue. That is to say, conflict is not only in the role of the influencing and discouraging members earnings in the traditional sense, but can also enhance members revenue. This is because conflict can simulate members innovation thinking, especially when they don't see eye to eye on a task. Different views and opinions conflict with each other will produce innovative path and prospect to complete tasks. Similar to brainstorming, fierce conflict and integration of thought will result in innovation. But conflict cannot be too great, it will hamper revenue when it is too big. Conflict management in the process of the alliance, the league managers need to moderate management conflict, to inspire members innovation power by conflict, increase alliance members revenue.

From table 2, there is a negative correlation between members conflict degree and alliance generic technology investment T. When conflict degree increase, members will be a conservative in generic technology investment. Enthusiasm in generic technology investment will be weaken. This fits normal rules. When conflict exists in members, it will influent the enthusiasm of investment. For alliance members, too much conflict will make more technology loss and investment in danger. Harmony of members of the alliance is the guarantee of reliable investment. So League managers need to build a harmonious win-win cooperation platform, to boost members confidence of the general technology and investment.

So to manage ITISA, managers should have a right attitude and cognition towards conflict between alliance members. They should not try to avoid conflict, but to use them to push innovation. From table 2, when conflict is not so big, alliance generic technology investment will decrease with the increase of conflict, members revenue increase. When conflict degree exceeds a certain degree, alliance generic technology investment will decrease with the increase of conflict, members revenue decrease. Alliance manager should determine the appropriate conflict environment to guide the members innovation activities. Members investment cannot cost the generic technology investment. It requires full consideration of alliance members. Moderate conflict control will be plays an important role to improve innovation performance in alliance innovation.

5 Countermeasure for promoting alliance innovation by moderate conflict

Conflicts have a certain impact on the ITISA. Chinese traditional culture advocate moderation and approach-avoidance a lot. For a long time, the role of conflict in innovation has been ignored or not been valued. In ITISA, conflict is inevitable, also hard to avoid, but can ease and be used. In the face of the conflict in the process of ITISA, alliance managers should be able to use conflict, by taking advantage of promote alliance innovation performance.

Firstly, by giving full play to the role of the market to guide the ITISA conflict in a moderate level, alliance innovation performance can be promoted. Market is the key for testing success of alliance, also is the inner motive power of alliance innovation performance improvement. Alliance manager should make full use of market to lead a alliances development. The choice of alliance member can be compared and selected through the market. Members management can also be adjusted by market means. In the running of alliance, market competition lead to conflict, also is an important means of mediation. Managers should make the league conflict management measures according to degree of competition in the market. When competition is severe, managers can ease the conflict by means of resolving the main conflict. When market is stable, managers should be good at using the conflict between members to promote the innovation in members.

Secondly, to guide the alliance conflict in a moderate level, managers need to build the perfect information sharing mechanism, develop a variety of communication methods, and open communication channels. Members could issue their work contents, schedules and plans to information communication platform immediately. On the platform, members can understand the technology development progress and which support they need on time. They can adjust their own technical development progress according to members requirement. The smooth running of information communication platform is not only a benefit to create a good atmosphere of mutual trust between alliance members, inhibit opportunism, but also play the role of the buffer when conflict degree is too high. Good communication can promote the mutual trust and synergy between alliance members. When conflict is very fierce, communication can set up the cooperative engagement, and establish fully trust in partner strategy conception. Making effective offer can maintain this trust and cooperative relations between alliance members, and ensure that the conflict between alliance members is in a moderate level.

Finally, in the process of conflict moderation, government policies will play a key role. Because ITISA is free of cooperation and the main body is enterprise, members conflict may be produced and broken out at any time, and even beyond the league managers’ control. At this time, government’s attention and guidance will play an important role. The guiding role of the government will mainly displays in guiding alliances run as a third party. Through the government’s credibility to mediate or ease the conflict, make sure conflict in alliance keeping in a moderate level. Especially when the alliance members have conflicts in some key aspects such as resource acquisition, government can integrate and optimize resources configuration mode, and boost the confidence of the members of alliance innovation. It will be relatively easy to guide the alliance conflict developing at a moderate level.

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