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Description	一般講演要旨

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Game Theoretical Analysis on High-tech Clustering in Information Age: Dilemma between open innovation and clustering in software industry of China

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ABSTRACT

In this paper, an important and intriguing aspect between open innovation and clustering is the conflict of knowledge acquisition（inflow）and knowledge spillovers (outflow). Firms will locate to maximize their net spillovers as a function of location's knowledge activity, their own capabilities, and competitor's anticipated actions. From the data of software industry of China from 2001 to 2007, we find that firms favor locations with different strategies. By using game theory to analyze the situation of two firms in clustering, we find the first mover in the model can create win-win relationship by sharing and recovering its investment.

INTRODUCTION

Software industry is the foundation of the revolution of the information technology (IT) and one important part of it. The rapid progress of the IT industry in Asia, especially in China and India, is going to repaint the economic map of the world. The software industry is now established in specific areas of specific countries, such as Bangalore in India, and Zhongguancun, Beijing in China. Actually, Zhongguancun's situation is similar with Silicon Valley's. In China, Zhongguancun Science and Technology Park as the headquarter of Chinese IT industry, which is famous for being a development base for software. It is a center for talented people, also is a high-density belt of knowledge. Because there are many famous universities gathering and government research organization in the place, where have been essential for Zhongguancun's development.

Specific geographical space serves as a cluster (accumulation) for specific industries. They come to have competitive advantages because face-to-face communication plays a big role in the formation of local accumulation of specific industries through knowledge creation, and technical innovation. In the age of IT revolution, geographical distance does not matter. All kinds of IT clusters can now be created between distant locations, which are often far apart geographically.

This paper examines a problem of dilemma between open innovations and clustering is the conflict of inflow and outflow of information. Firms will locate to maximize their net spillovers as a function of location's knowledge activity, their own capabilities, and competitor's anticipated actions. In the new uncertain competitive landscape that high-tech and other dynamic industries are facing today, it becomes essential for firms to be more flexible in their investment programs, allowing management to change the amount, rate, timing, or scale of investment in response to new, unexpected developments and competitive moves. Therefore, an exploratory methodology of option-game is applied to this problem. By using game theory to analyze the situation of two firms in clustering, we find the first mover in the model can create win-win relationship by sharing and recovering its investment.

SOFTWARE INDUSTRY IN CHINA

Impacted by the global economic crisis, while China's software industry still had developed well in the first three quarters of 2008, its industrial scale had gradually expanded, its market demand had increased steadily, its industrial structure and regional structure had been both improved continuously and its export had maintained a growth as well. The accumulative sales revenue of China's software industry was totaled at 576.47 billion Yuan in the first three quarters of 2008, up by 32.8% compared to the same period of 2007(CSIA, 2003). FIG1.1 illustrates the sales revenue of China's software industry from 2001 to 2007. During this period, IT software has increased rapidly.

China is highlighted as software development bases in the world. However, China's export of software is only 72.7billion Yuan in 2007. FIG1.2 and FIG 1.3 show us the situation about the amount of software export and the place of software industry in China respectively. From FIG1.2, we can find that the domestic demand is quite large. The center of Chinese software demand is domestic financial institutions. For this reason, domestic demand for software is considered to be almost infinite. Given that Japan, USA, Europe and Asia, all of them have offshore markets of China's software as illustrated in FIG 1.3.

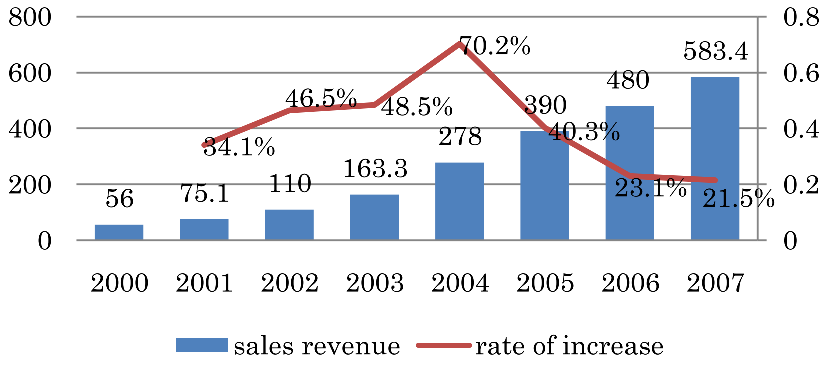


FIG1.1 sales revenue of software industry in China

(billion yuan)

Moreover, the Internet is booming in China, and it has given stimulus to the progress of the whole IT industry. A survey in the 20 big cities in China shows that the diffusion rate of the Internet is 11.7 %(7.9% in 1999), 14.9% for men and 8.5% for women. It turns out that the share of Shanghai (20.9%) and Beijing (12.9%) is dominant in the big 20 cities, with Tianjin (7.8%) and Guangzhou (6.8%) following (Tschang, 2003).

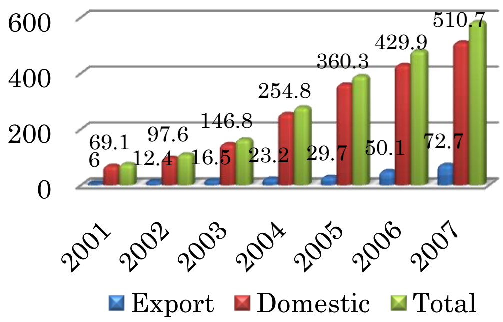


FIG 1.2 The comparison of software export in China from 2001 to 2007(billion Yuan)

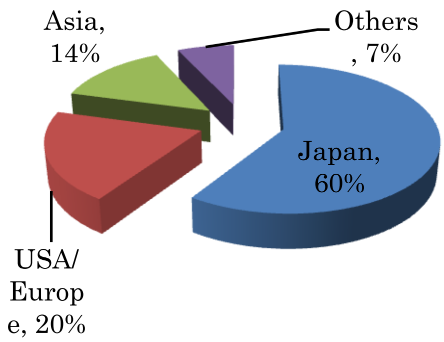


FIG 1.3 The place of software export in China in 2007(%)

COMPETITION AND COOPERATION IN CLUSTERING OF CHINA

The software industry is the most competitive industry, which can utilize intellectual property. Zhongguangcun of Beijing as one of IT headquarters, which has so far accumulated resources from universities and the government. There have other IT parks in Shanghai, Shenzhen or other big cities. However, as a leader, Beijing will greatly lead Shanghai and Shenzhen for the time being in software content. Currently, all of the IT parks in China attach great importance to cooperation each other during the process of development. The important factor is open communication and open resources for improving. However, they are also competing with each other for resources, talents and market.

Zhongguancun Park of Beijing—Center for R&D in software Development

Zhongguancun is located in the northwestern part of the city. There are more than 5,000 IT related companies are concentrated within 25 square kilometers, and more than 5,000 network and software development companies in Beijing. It is highly competitive environment. What's more, there are more than 70 schools here, including Tsinghua University and Beijing University. Furthermore, the government research institutes, such as Chinese Academy of Sciences (CAS), are also localized here. The function of universities and governmental research institutes is deciding factors for success of Zhongguancun's development, which as similar with Bangalore of India and Silicon Valley (Suttmeier, 2003). The numbers of enterprises in main cities of China and the sales revenue of these cities in 2004 are shown in FIG2.2 and FIG2.1 respectively. From the two of figures, it proves that Beijing is not only the center of culture and political function in China, but also the center for R&D in software development.

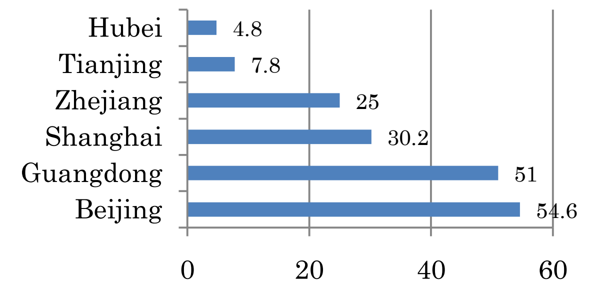


FIG 2.1 sales revenue of 2004 (billion yuan)

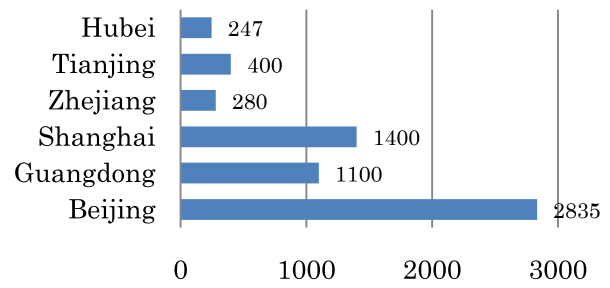


FIG 2.2 the numbers of companies in cities of 2004

Existing Problems in the Industrial Clustering of China

Although industrial clustering has received support and help from government and other institution, problems still exist. The existing problems are mainly as following:

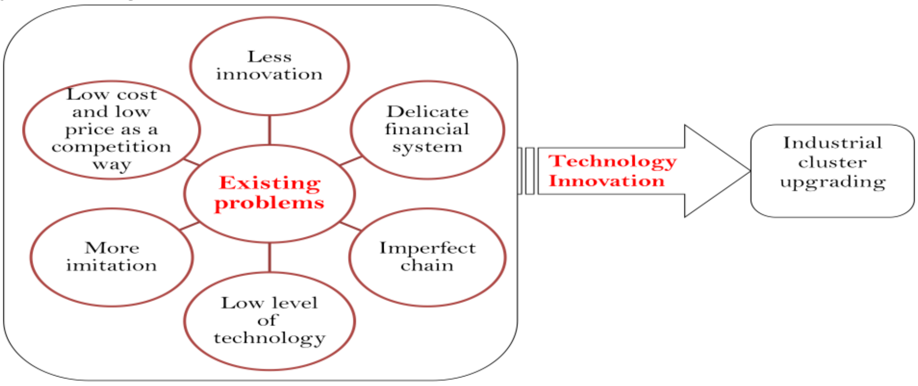


FIG 2.3 Existing problems in industrial clustering

Industrial Clustering Innovation Method

FIG 2.4 shows us industrial clustering innovation method. The industrial clustering innovation factors are made of two parts, which inner core factors and outer supporting factors. The first parts including: leading industry enterprise, competitive enterprise, relative enterprise, supply chain and client, which are the force of the core. The leading enterprise can promote the development of new product and innovation by comparing with competitive enterprise in the clustering, and then reduce time required to design a product or service. If leading enterprise cooperates with relative enterprises, it can promote their innovation and then bring along the entire industrial chain's development. Leading enterprise can strengthening of link with supplier and client to reduce cost by taking advantage of geography. The outer factors include university or research institution, agency and so on. They support some resources, infrastructure construction, technology, and human resource for inner core factors (Tschang, 2003).

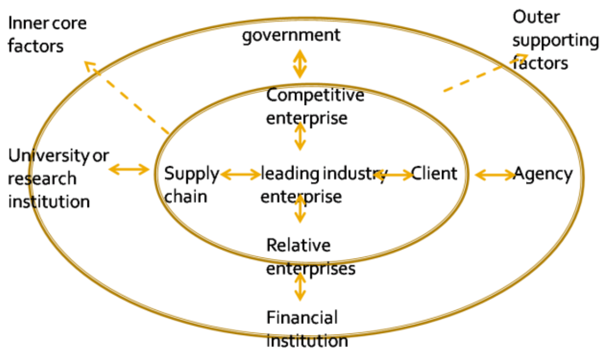
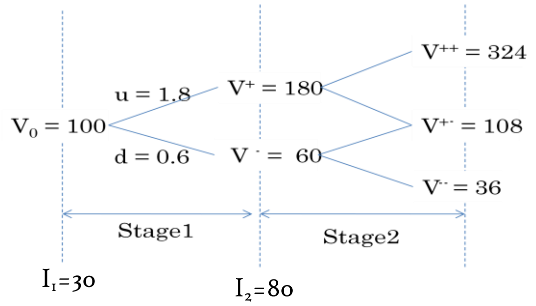


FIG 2.4 Industrial clustering innovation model

APPILCATION OF OPTION-GAME TO STRATEGIC PARTNERSHIP

Here it is assumed a two-player game between player A and B. first-stage strategic R&D investment I_1=30 (million Yuan), follow-up (second stage) commercialization investment I_2=80, up or down with binomial parameter u=1.8 and d=0.6, risk-adjusted discount rate k=0.20, risk free interest rate r_f =0.08, and original project value v_0 =100. If so, risk neutral probability will be given:

$$P = \frac{(1+r)V_0 - V^-}{V^+ - V^-} = 0.4 \qquad\qquad 1 - p = 0.6$$



Consider a two-stage game with endogenous competitive reactions in the second (production) stage among two otherwise similar competitors. The initial R&D investment for the first period I_1=30, the production investment for the second period I_2=80. When A and B make decision to invest, if they share investment by each firm, is half the total cost assumed in this case.
(I_A^2=1/2$\times$ 80 = 40 million).

<1>when competitor's reaction is contrarian, the payoffs of proprietary strategic investment:

		Firm B Wait	**Firm B** invest
Firm A	**Wait**	V^+ (81, 25) V^- **(10, 0)**	V^+ (0, 100) V^- (0, -20)
Firm A	**Invest**	V^+ (100, 0) V^- (-20, 0)	V^+ **(80, 20)** V^- (0, -20)

At V^+, when B invests, A waits: $NPV_A = 0$

When B waits, A invests: $NPV_A = 180 - 80 = 100$

When both leaders A (can occupy larger market share S_A =2/3) and follower B invest by sharing investment $I_{2:}$

$$NPV_A = \frac{2}{3} \times 180 - 40 = 80 \qquad NPV_B = \frac{1}{3} \times 180 - 40 = 20$$

If both of firms choose to wait, the competitive dynamics of the next-period subgames are as follows：
Firm A will get a big market share (S_A =2/3) at high demand (V^{++}=324), and preempts the full value at V^{+-}=108.
Both of them will delay investment at V^{--}=36. Hence, the value of option at V^+=180:

$$Option_A^+ = \frac{0.4\left(\frac{2}{3}\times 324 - 40\right) + 0.6(1\times 108 - 80)}{1.08} = 81 \qquad Option_B^+ = \frac{0.4\left(\frac{1}{3}\times 324 - 40\right) + 0.6\times 0}{1.08} \approx 25$$

The value of option at V^-=60 are:

$$Option_A^- = \frac{0.4(1\times 108 - 80) + 0.6\times 0}{1.08} = 10 \qquad Option_B^- = \frac{0.4\times 0 + 0.6\times 0}{1.08} = 0$$

<2>when competitor's reaction is reciprocating, the payoffs of proprietary strategic investment:
(Suppose that Firm A will get 2/3 of stage-2 total value through proprietary strategic investment, but it will invite a reaction by a reciprocating competitor, so the total market value will reduced by 1/4.)

		Firm B Wait	**Firm B** invest
Firm A	**Wait**	V^+ (61, 15) V^- **(10, 0)**	V^+ (0, 100) V^- (0, -20)
Firm A	**Invest**	V^+ (100, 0) V^- (-20, 0)	V^+ **(50, 5)** V^- (-10, -25)

At a strategic profile {Invest, Invest}:

$NPV_A^+ = \frac{2}{3} \times \left(\frac{3}{4} \times 180\right) - 40 = \frac{1}{2} \times 180 - 40 = 50$ $NPV_B^+ = \frac{1}{3} \times \left(\frac{3}{4} \times 180\right) - 40 = \frac{1}{4} \times 180 - 40 = 5$

$NPV_A^- = \frac{2}{3} \times \left(\frac{3}{4} \times 60\right) - 40 = -10$ $NPV_B^- = \frac{1}{3} \times \left(\frac{3}{4} \times 60\right) - 40 = -25$

At a strategic profile {Wait, Wait};

$Option_A^+ = \frac{0.4 \times \left(\frac{1}{2} \times 324 - 40\right) + 0.6 \times (1 \times 108 - 80)}{1.08} = 61$ $Option_B^+ = \frac{0.4 \times \left(\frac{1}{4} \times 324 - 40\right) + 0.6 \times (0)}{1.08} \approx 15$

<3> when competitor's reaction is contrarian, the payoffs of share strategic investment:

		Firm B: Wait	Firm B: invest
Firm A	**Wait**	V^+ (53,53) V^- **(5,5)**	V^+ (0,100) V^- (0, -20)
	Invest	V^+ (100, 0) V^- (-20, 0)	V^+ **(50, 50)** V^- (-10, -10)

The spillover effects (5/4 times market value increase) are changed by contrarian reaction.

Then at a strategic profile {Wait, Wait};

$Option_A^+ = \frac{0.4 \times \left(\frac{1}{2} \times 324 - 40\right) + 0.6 \times \left(\frac{1}{2} \times 108 - 40\right)}{1.08} = 53$ $Option_A^- = \frac{0.4 \times \left(\frac{1}{2} \times 108 - 40\right) + 0.6 \times (0)}{1.08} = 5$

At a strategic profile {Invest, Invest};

$NPV_A^+ = NPV_{\mathbf{B}}^+ = \frac{1}{2} \times 180 - 40 = 50$ $NPV_A^- = NPV_{\mathbf{B}}^- = \frac{1}{2} \times 60 - 40 = -10$

<4> when competitor's reaction is reciprocating, the payoffs of share strategic investment:

		Firm B: Wait	Firm B: invest
Firm A	**Wait**	V^+ (75,75) V^- **(10,10)**	V^+ (0,100) V^- (0, -20)
	Invest	V^+ (100, 0) V^- (-20, 0)	V^+ **(73,73)** V^- (-3,-3)

Each market value increases into 5/4 times by share strategy and reciprocating reaction.

Then at a strategic profile {Wait, Wait};

$Option_A^+ = \frac{0.4 \times \left(\frac{1}{2} \times \frac{5}{4} \times 324 - 40\right) + 0.6 \times \left(\frac{1}{2} \times \frac{5}{4} \times 108 - 40\right)}{1.08} = 75$ $Option_A^- = \frac{0.4 \times \left(\frac{1}{2} \times \frac{5}{4} \times 108 - 40\right) + 0.6 \times (0)}{1.08} = 10$

At a strategic profile {Invest, Invest};

$NPV_A^+ = NPV_{\mathbf{B}}^+ = \frac{1}{2} \times \left(\frac{5}{4} \times 180\right) - 40 = 73$ $NPV_A^- = NPV_{\mathbf{B}}^- = \frac{1}{2} \times \left(\frac{5}{4} \times 60\right) - 40 = -3$

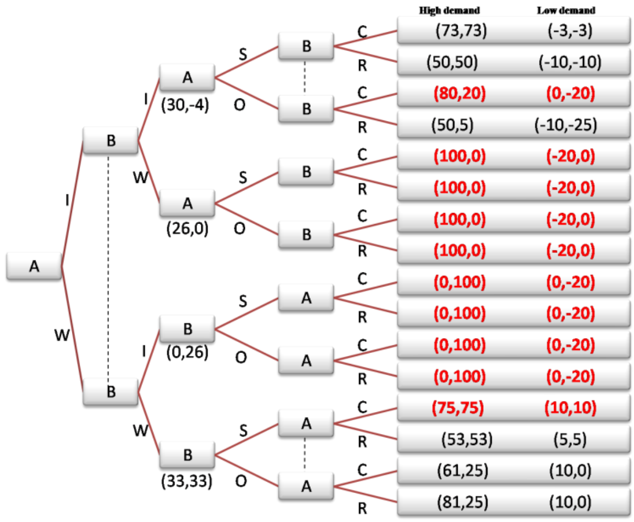
Calculate NPV:

$NPV_A(W, W) = \frac{0.4 \times 75 + 0.6 \times 10}{1.08} \approx 33$ $NPV_B(W, W) = \frac{0.4 \times 75 + 0.6 \times 10}{1.08} \approx 33$

$NPV_A(W, I) = \frac{0.4 \times 0 + 0.6 \times 0}{1.08} = 0$ $NPV_B(W, I) = \frac{0.4 \times 100 + 0.6 \times (-20)}{1.08} \approx 26$

$NPV_A(I, W) = \frac{0.4 \times 100 + 0.6 \times (-20)}{1.08} = 25.9259 \cdots \approx 26$ $NPV_B(I, W) = \frac{0.4 \times 0 + 0.6 \times 0}{1.08} = 0$

$NPV_A(I, I) = \frac{0.4 \times 80 + 0.6 \times 0}{1.08} = 29.6296 \cdots \approx 30$ $NPV_B(I, I) = \frac{0.4 \times 20 + 0.6 \times (-20)}{1.08} = -3.7037 \cdots \approx -4$



Notes:
I: Investment
W: wait
S: share
P: proprietary
C: contrarian
R: reciprocating

FIG3.1 The second stage development commercialization under different market structure

FIG 3.1 shows us that the second stage development commercialization under different market structure. It is just a simple game model about competition and cooperation, which introduce some strategies between two of firms in clustering. Both firms can choose strategies which fit for them simultaneously in this period by invest or wait. In this part, the model is divided into four different strategies as illustrated in Fig 3.1. The strategic profile are ｛Invest, Invest｝, ｛Invest, Wait｝, ｛Wait, Invest｝ and ｛Wait, Wait｝ respectively. In order to examine the results under different market structure, we assumed that firm A or firm B enters into the market as a pioneer, the firms decides to strategy (share or proprietary) according to competitor's reaction (contrarian or reciprocating). Of course, a possibility which the strategies are decided simultaneously also included in this model. There are different payoffs under different situations (high demand and low demand). From the last payoffs, the best choice of each strategy is shown in bold type. And then, the NPV are calculated by them.

If both firms invest simultaneously, and firm B's reaction is contrarian, proprietary is good strategy for firm A. If firm A invest, firm B wait, no matter what firm B choose, its payoff is zero. Identically, firm B invests, firm A wait, the result is opposites. When both firms wait and get the value of option, so share is the best strategy for firm B if firm A's reaction is contrarian. We recognized that an early strategy investment commitment may not only result in future commercialization or growth opportunities but may also influence the competitor's future behavior in desirable of potentially damaging ways (Smit, 2004). Moreover, as an industry cluster, they can unite to pursue a shared objective, sometimes. From the figure 3.1, we can find the strategic profile ｛Wait, Wait｝'s payoff (33,33) is Nash equilibrium. In order to get the Pareto optimal for clustering, both firms can observer the situation of the market first, and then make decision about invest or wait. If so, the payoff (33, 33) is correct. Only this case, there is the possibility that the research investment I_1=30.

CONCLUSION

A joint research venture enabling the firms to cooperate in R&D during the first stage may be a way to avoid the prisoners' dilemma. It can achieve the same research benefits with low costs by each firm, and it can make the cooperating firms to get the option value through wait or see under technology or demand to uncertainly to avoid competition pressures from innovation of market. In order to obtain these benefits, the firms may have to give up the possibility to gain a first-mover advantage on the other members of the alliance. Furthermore, joint R&D ventures may have a more positive strategy effect in high-tech industry.

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