Research on the Cooperation Relationship of the members of the Technology Alliance Based on Tightness and Pleasure Degree

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Abstract. The relationship of the members in the industrial technology innovation alliance is the key point of the improvement of the operational efficiency for the alliance. In this paper the cooperation relationship between the members in the alliance is studied by using the network analysis method because the alliance network belongs to a typcal network. The degrees of tightness and pleasure are used as the weights of the edges between the nodes. The cohesion sub-network is divided from the whole network by the tightness of cooperation between members. The result is that the structure of the whole alliance network is not tight enough while the one of the cohesion sub-network is very tight and the pleasure degree of the cohesion sub-network is also very high. So it is important to increase the scale of the cohesion sub-network rather than that of the whole scale.

Introduction

The competition between the enterprises in knowledge economics age is based on the resource of knowledge. The continuous acquisition of creative knowledge is the important foundation of improving core competitiveness. The industrial technology innovation alliance is the significant way for the enterprises to gain external knowledge and innovation ability. The industrial technology innovation alliance (for short, technological alliance) ,which organizes the core enterprises of the industry, scientific research institutions, medium organizations and governments, is a new cooperation mode of industry-university-research and also the innovation complex for the upstream and downstream firms to link up each other. From the 90's of last century, innovation alliances have emerged in a global context. For example, the government of Zhejiang province confirmed the first 15 alliances and provided financial assistance to them in 2010.

The construction of the innovation alliance is the important strategic measure of establishing innovative countries or regions. While the alliances usually have problems, such as low efficiency, difficulties of coordination, looseness of structure and so on. The research reports of the US consultancy McKinsey showed that only 40% alliance in the above 800 ones investigated from the 80s in the last century could hold up for more than 4 years and only 14% could cooperate for more than 10 years. The technological alliances are essentially focusing on knowledge and the exchange activities of technology and knowledge are the most basic cooperation relationship. So, the key of judging the efficiency of alliances is how to recognize the network structure of the alliances and analyze the relationship between the subjects.

The technology alliances in China are special because they are driven by the government. There are some differences in the operational process between these alliances and the ones formed naturally based on the market mechanism. Therefore, how to analyze the cooperation relationship among the subjects of the alliance network is the key point of understanding the efficiency.

Literature References

The Industrial Technology Alliance Providing New Competitiveness For The Enterprises.

As everyone knows, technology innovation is the original power of the development and industrial upgrading. The competition among the enterprises becomes the one of innovation capability instead of the ones of quality. Only the enterprises with more powerful creativity can survive and develop. While the pressure of the timeliness becomes heavier with the rapid development of technology, it is much more

difficult for a single enterprise to grasp all the knowledge for the innovation and to get all the resource for the innovation by itself. So there is a gap between the enterprise's ability to get the resource for the innovation and its strategic goals. The alliance can transfer the enterprises from technical self- sufficiency to technical cooperation to make up the gap by helping the enterprises and other ones, colleges and universities, even their competitors to organize the network of the alliance .

First, the alliance meets the demand of resource complementary of the enterprises. The technical innovation resource is configured unevenly among the innovation subjects. A single enterprise may lack for technical stuff, research capital, key technology or other innovation resource. If the enterprise resolve the problems on its own, it will spend much time or money on it. While the enterprises make an alliance to deploy the resource they own, they can learn each other and develop the technology together .

Second, the alliance intensifies the technological learning effect. The members in the alliance can often communicate to share the advancing technology or knowledge and increase the opportunity of learning each other. The continuous communication builds a favourable trust relationship between the members, also makes the partnership more open. The members probably share their sensitive information or tacit knowledge. This will be conducive to the knowledge spillovers in the alliance and promote the deep knowledge transferring.

Third, the alliance decreases the cost and risk of technology innovation. The activity of technology innovation is featured by high investment, high economic return and high risks. The enterprise suffers the pressure of high cost and risk of R&D (Research and Development) when bearing the larger pressure of innovation timeliness. The investment cost of a single enterprise can be reduced and the risk can be shared by the engaging the enterprises in the alliance in the innovation activity.

Forth, the alliance avoids the disorderly competition in the industry. The enterprises, colleges, universities and research institutes form the alliance to develop together and use the technological achievements together. Forming the alliance not only can avoid the disorderly competition in the industry but also can prevent other competitors to enter the industry by standardizing their technological achievements and making the technical barrier.

So, the technogilocal industrial alliance, a higher level organizational form of university-industry cooperation has been regarded as the first choice to resolve the industrial generic technology and promote competitiveness.

The Research About Cooperation Relationship Between The Members In The Alliance

The enterprises ask to join the alliance to get the innovative support for the benefits mentioned above. Sharing the technology and knowledge is needed, but the members are usually lack of common benefit target. The colleges and institutes are more interested in the degree of advancement of the research achievement while the enterprises are focus on the degree of industrialization. So the different value orientation of the subjects decreases cooperation enthusiasm to some extent and prevents the alliance's progress (Liang 2009). At the same time, there is opportunism in the alliance so that the members who own the core technology are reluctant to share the technology with others. The lack of trust also affects the degree of the exchange and sharing of technology and technology in the alliance that will make the direct influence on the innovation performance. The research results of Norman (2004) showed that the level of trust could make positive influence on the communication between the members. It proved that the trust could improve the innovation performance. The research of Zhu and Qi (2008) showed the reputation is important to the cooperation from the point of game relationship. For this reason, many scholars treat the choice of alliance partners or the alliance mode as the key of the success or failure of the alliance. Nil (1998) put forward three important conditions that were the potential of creation, common value and the circumstance for partners. Zhao (2010) used the AHP fuzzy evaluation to evaluate the innovation ability of the potential partners.

The technological alliance is a social network of multi subjects, whose operation is embedded in contact, trust and culture. So the research focus is shifted to the network structure of the alliance. Network analysis regards the social relationship of the units and organizations as a visual network. The complicated relationship can be represented as a network structure and analyzed by the method of graph theory and mathematic model. The performance of alliance can be judged by the analysis of the structure or behavior of the members on the basis of the method of network analysis. Sun and Wei (2011)

established the knowledge diffusion model of the high-tech alliance and found that the reduction of characteristic path length of the network, enlargement of Clustering coefficient and improvement of communication frequency were all the efficient methods for the knowledge diffusion and knowledge innovation. This result was similar to what Cowan and Jonard found in 2004. The location in the network might effect the performance of the innovation (Jiang, Sun, 2012). Kilduff etc. found that the network people could perceive showed greater small-world nature than the actual network., that meant the perceived network had higher clusting.

The Network Analysis Of The Industrial Technology Innovation Alliance

The complex network is the network which has all or some of the characters of self-orgnization, self-similarity, small-world and scale-free. The industrial technology innovation alliance possesses all the characters of this definition, so it belongs to the complex network. Network analysis is a set of norms and methods of analyzing the network structure and attributes. The main objects to analyze are the nodes and relations. The nodes represent the member of the alliance and the edges represent the interactions of the organizations. The network analysis method divides the network into individual and overall ones. If no structure with some member as the core exists, the network is called as overall network, otherwise individual network. The characteristic variables of the overall network include density, centrality, clustering coefficient, average shortest path, degree distribution and so on. These variables can be used to analyze the alliance network which possesses the characters of complex network. Generally, the lower the density, the lower efficiency of knowledge communication. But if the density is too high, the communication cost is also increased and the communication may lose its target.

The Network Model Of The Cooperation Relationship Of The Members In The Alliance

The Specificity Of The Network Of The Technical Alliance

Compared with the general complex network, the alliance network is a complete network, so its density is 1 and the average path is 1.

The size of the alliance network is small. The nodes of the network (every member in the alliance is regarded as a node) represent enterprises or universities or the research institutes. The alliance meets at least once a year so that the members know each other even if they have no virtual cooperation. Therefore, there is a line between every pair of nodes. The alliance network is complete and the density is 1 according to the expression of the density. Every member can get in touch with any other member without the introduction. So the average path is 1 too.

Obviously, there is no meaning of the research results if the variables are not adjusted. In our research, a new model is presented to measure the cooperation of the members in the alliance.

The Alliance Network and Cohesion Sub-Network

Definition 1 (Technological Alliance Network, TAN) The technological alliance network (TAN) is formed by m enterprises and n universities or research institutes. The edges in the network C_{ij}, $i, j = 1,2,\cdots,m+n$, represent the technological connects between any two members, such as the technological cooperation, technological communication and so on.

In the research of social theory, network cohesion is usually used to explain how a group reaches a consensus. High cohesion will enhance the realization of group goal and force the members to obey the rules. There are some members in a network who have common goals and sense of identity. The interaction frequency between them is higher than that of the whole complete network. Based on this, the cohesion sub-network is extracted.

Definition 2 (Technological Alliance Cohesion Sub-Network, TACSN) For some Technological Alliance Network (TAN), 0-10 is used to measure the tightness degree of cooperation, T_{ij}, $i, j = 1,2,\cdots,m+n$. The sub network formed by the edges which meet the norm of $T_{ij} \geq k, k \in [0,10],(i, j = 1,2,\cdots,m+n)$ is called K-degree technological alliance cohesion sub-network, in brief, TACSN.

From the Definition 2, only the members whose cooperation degree exceeds some value can be included as the nodes of the cohesion sub-network. Generally, we take k=5.

The Tightness Degree And The Pleasure Of The Cooperation

To reflect the tightness degree and the pleasure of the cooperation in the alliance, the reference system including perfect TAN and TACSN is needed.

Definition 3 (Perfect Technological Alliance Network, PTN) The technological alliance network (TAN) is formed by m enterprises and n universities or research institutes, in which any two members have edge of cooperation, C_{ij}, $i, j = 1, 2, \cdots, m + n$.

Definition 4 (Perfect Technological Alliance Cohesion Sub-Network, TACSN), For a K-degree technological alliance cohesion sub-network, any two members have edge of cooperation.

From the definition 3 and 4, the perfect network is a complete one.

Definition 5 (Tightness Degree of Cooperation of Network, TN) For the technological alliance network or cohesion network which contains m enterprises and n universities or research institutes, TN can be computed by the following Eq.1.

$$TN = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}T_{ij}}{10 \times \frac{(m+n)(m+n-1)}{2}} \tag{1}$$

$0 \leq T_{ij} \leq 10$, $i, j = 1, 2, \cdots, m + n$, this means that the number 0-10 is used to measure the tightness degree of cooperation. So, when TN=0, it indicates that there is no technological relation between the two nodes. When TN is above 5, the tightness degree is quite high.

Definition 6 (Pleasure Degree of Cooperation of Network, PN) For the technological alliance network or cohesion network which contains m enterprises and n universities or research institutes, TN can be computed by the following Eq.2.

$$PN = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}P_{ij}}{10 \times \left[\frac{(m+n)(m+n-1)}{2} - \frac{n(n-1)}{2} \right]} \tag{2}$$

$0 \leq P_{ij} \leq 10$, $i, j = 1, 2, \cdots, m + n$, this means that the number 0-10 is used to measure the pleasure degree of cooperation. PN=0 means that the two nodes have reached the opposite of the pleasure, the condition of dislike. So, PN=5 represents the condition of no pleasure or dislike. Only when the value of PN is above 7.5, we can think the pleasure degree of cooperation is quite high.

Empirical Analysis

Background

Zhejiang province has wonderful locational conditions and bundant marine resources. "The demonstration area project of marine economy development of Zhejiang Province" was officially approved by the State Council in March 11th, 2011. This means that the marine economy of Zhejiang province has been brought into the whole national marine economy development strategy. It is meaningful for the transformation and upgrading of marine economy in Zhejiang province. In August of the same year, the Science and Technology Agency of Zhejiang province also published some relevant policies. For example, a few technological innovation alliances were built in the support of local Science and Technology Bureau. The "shipbuilding industrial technological innovation alliance "was led by the Zhejiang Yangfan Ltd and the "aquatic products processing technological innovation alliance" was led by Zhejiang Xingye Ltd.

Compared with some alliances of traditional competitive industries, such as leather or low-voltage apparatus, the construction mode and operation mechanism of the alliances in marine strategic emerging

industry, such as marine equipment manufacturing, seawater utilization or marine biological medicine is obviously different. The emerging industry is in the primary stage of development. On the one hand, there are so few high-tech enterprises in the industry and the overall innovative ability is quite low. On the other hand, we should insist on preserving the ecological environment in the marine economy development. So, the enterprises in the marine industry must pay attention to the technology innovation to promote the technological level. There are many scientific research institutions of marine in Zhejiang province to provide intellectual support for the marine industry. It is very important to reinforce the communication between the enterprises, universities and institutes.

In our research, we chose two alliances in the marine industry to analyze and compare.

Alliance A: A technological alliance of shipbuilding industry, which was built in 2011 and a large enterprise acted the leading member. Now, there are 17 members in the alliance, including 8 universities or research institutes. In the industry chain, the 9 enterprises are all middle production ones and there are no cooperation of upstream and downstream between them.

Alliance B: A technological alliance of aquatic products processing industry, which was also built in 2011 and a large enterprise of aquatic products processing acted the leading member. Now, there are 15 members in the alliance, including 6 universities or research institutes. In the industry chain, the 9 enterprises are all middle production ones and there are no cooperation of upstream and downstream between them.

The Network Analysis Of Technological Alliance

The tightness degree between the members is the base for the operation efficiency of the alliance. So, the key point of our research is to find the tightness between the members. In this paper, the density is focused as an important index. As talked above, the alliance network is special for its small scale and the members in the alliance know each other without any cooperation. For this reason, the people who are responsible for the alliance in every enterprise are asked to mark the tightness and pleasure with other members in the questionnaire shown in the Table I. The score arranges from 0 to 10, 0 represents the most weak and 10 represents the most strong.

Table 1 the questionnaire

Degree / Unit	The Tightness	The Pleasure	Forms Of Cooperation
1			
2			
......			
17			

To extract the cohesion sub-network, we take K=5 as the Definition 2 and delete the edges whose value of tightness are less than 5. The cohesion sub-network of Alliance A is shown in Fig.1 and that of Alliance B is shown in Fig.2. The black circles represent the enterprises in the alliances and the white squares represent the universities or research institutes.
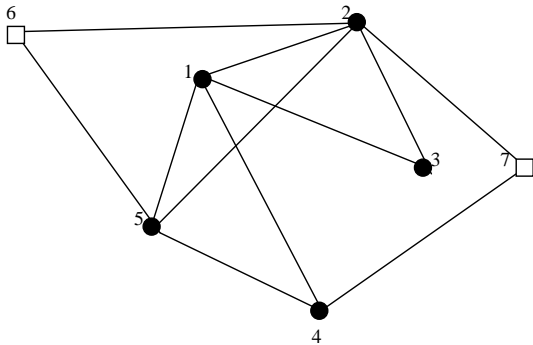

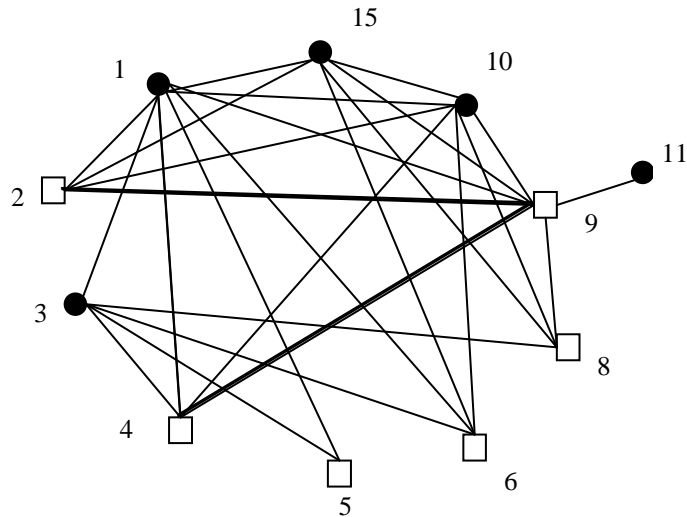
Fig.1 the 5-TACSN of Alliance A

Fig.2 the 5-TACSN of Alliance B

According Definition 5 and 6, the degrees of tightness and pleasure are separately computed and the results are shown in Table 2.

Table 2 the results of the degrees of tightness and pleasure

	Alliance A		Alliance B	
	TAN	TACSN	TAN	TACSN
The number of nodes, m	17	7	15	11
The number of nodes of universities and institutes, n	8	2	6	6
The number of edgs of the perfect network	136	36	105	55
The degree of tightness, TN	3.589	6.714	4.129	5.155
The degree of pleasure, PN	5.618	8.476	5.833	6.591

The Cooperation Analysis Based On The Network

From the Table 2, the cooperation tightness degree of Alliance A is not quite strong and is lower than that of Alliance B. The pleasure degree of Alliance B is also a little lower than that of Alliance B. But the cooperation tightness degree of the cohesion network of Alliance A is higher than that of Alliance B. This indicates that the cooperation tightness is unevenly distributed. Although the structure seems quite loosen as a whole, a tight cohesion network really exits. Like a formal organization, there is an informal group with frequent connections in it. Because of common goals or benefits or the pleasant cooperation experience, the cooperation relationship between the informal group will become stable. Thus, they may resist other member to join them. For example, if the cooperation relation between one enterprise and a university is very good, the enterprise will always seek help from the university and lose sight of other universities or research insititutes.

The pleasure degree of the cohesion sub-network of Alliance A or B is both higher than that of TAN. And the pleasure degree of TACSN of Alliance A is 8.476 that is much higher than that of Alliance B. This means the members in TACSN cooperate smoothly. Specially, it is not easy for the enterprises of the Alliance A, who are in the same industry, to cooperate so well. They can solve the technical problems together and achieve the goal for establishment of the alliance. From the interview, they also admitted that their innovation abilities were improved by the cooperation. The pleasure degree of TACSN is the

significant factor for the cooperation. It is important for the alliance to try to improve the pleasure degree between the members at same time of raising the cooperation tightness.

Summary

In this paper, a network method is used to analyze the relationship between the members of the technological alliance. The results further confirm that tightness and pleasure degree of cooperation of Network are key parameters of technological cooperation Alliance. The technical alliances are established mainly by government departments and they often take becoming bigger and stronger as goal. However it is easy to become bigger but difficult to be stronger. The challenge is how to strengthen the relationship between the members.

Therefore, just to pursue the scale of technology alliances is not a good way. To focus on considering how to promote the relationship between the alliance members is more important. In addition to regular league meetings held to promote understanding and communication among members, government departments should identify the Cohesion Sub-Network of Technological Alliance, and encourage cooperation between members. At the same time, the other members should be encouraged to find ways to integrate into the sub-network and share the technological achievements developed in sub-network by the policy such as subsidy.

From the concept of cohesion subnet, if multiple alliances sub-networks with high tightness and high pleasure degree of cooperation are formed in technology alliances, this situation is very helpful and valuable for the promotion of technological innovation.

Also to improve the members composition of the alliance can expand the scale of sub-network. In the technology alliances of the paper, the structure is not reasonable enough, the enterprise members are in same part of industrial value chain and the alliances are lack of the upstream and downstream enterprises of industrial chain. If upstream and downstream enterprises attend technology alliance, the tightness of cooperation will be greatly enhanced. The larger the scale of Cohesion sub-network, the wider the influence of radiation is to technology alliance.

In addition, the member outside the sub-network should try best to attend into sub-network. Such as in Alliance B, Member 11 belongs to condensed sub-network just by cooperating with Member 9, so that he can share some technology resource. Only into the sub-network, there may be substantial cooperation among members inside. Similarly as a breakthrough, the enterprise outside the technology alliance should establish contact with the subk-networ node to join the alliance.

Acknowledgement

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