International Journal of New Developments in Engineering and Society
ISSN 2522-3488 Vol. 3, Issue 2: 59-66, DOI: 10.25236/IJNDES.19209

Technology Innovation Cooperation Network Evolution Mechanism and Simulation

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ABSTRACT. *This article will complex network theory is introduced to the world's leading technology innovation cooperation network study, continue to deepen the theoretical study, by numerical simulation and empirical research on the method of combining technical innovation cooperation network to the evolution mechanism and its small world, scale-free characteristics were studied. First perfect the network modeling work decline period. Secondly, put forward the strategy of technology innovation diffusion, namely random selection, target selection and associated enterprises selection strategy, and compares the advantages and disadvantages of relationship between different strategies. Finally, combined the status quo of the cooperation technological innovation in our country, respectively from two levels to enterprises and government strengthen enterprise technical cooperation and improve enterprise technology innovation ability, and puts forward some Suggestions and countermeasures of technology innovation cooperation network further study is forecasted.*

Keywords: *technological innovation cooperation, scale-free, small-world, complex network, dynamic adaptation coefficient*

1.The basic characters of the small world and the scale-free network

The small world characteristic is described by the clustering coefficient and average path length. The clustering coefficient C describes the clustering phenomenon in the network node; it means compactness and collectivizes in the network node. This means the possibility that your two friends know each other much more than two persons at random. General speaking, it supposes that a node i connect with another node k_i ,this k_i is the neighbor of i. between the k_i , it has $k_i(k_i\text{-}1)/2$ sides at most. The ratio of the sides E_i between k_i and the most

sides $k_i(k_i\text{-}1)/2$ is defined the node I's clustering coefficient Ci:

$$C_i = \frac{2E_i}{k_i(k_i - 1)} \qquad (1)$$

The clustering coefficient in the network is the average value of all the clustering coefficient Ci:

$$C = \frac{1}{n}\sum_i C_i \qquad (2)$$

When C =0, it means there is no

character in the network, as well as the node in the network is an acnod.

When C =1, it means the network is GCM, any two nodes at random in the network are connected.

When the node N tends to infinity, the clustering coefficient C tends to a fixed number. At the same time, the raised nodes can't change the clustering coefficient. Clustering show the truth "birds of a feather flock together" in the network.

The description in the small world characteristic, the most important parameter is the average path length l. l means the shortest length between the two nodes. The average length in the network L is the average number between the nodes, it describes the degree of separation in the network nodes. As for the undirected network, the average length in the network nodes can be defined as:

$$l = \frac{1}{\frac{1}{2}n(n+1)}\sum_{i \geq j} d_{ij} \qquad (3)$$

Meanwhile, d_{ij} means the shortest distance between i to j.

scale-free has the features as following;

degree, degree distribution, power exponent.

The connected nodes number with i, we call it k_i .in World-Wide-Web, probability distribution of node degree falloff according to the power exponent γ :

$$p(k) \sim k^{-r} \qquad (4)$$

Power law distribution has no regular features, so it is also called scale-free distribution, the network is named scale-free network.

Hub-node

World-Wide-Web is connected by the high connection nodes. This one ten-thousandth nodes connect with more than 1000 nodes, so we call it hub-node. But more 80% negative number is less than 4. scale-free network is arranged by the hub-node, this is an important character for the scale-free network.

2.Technology Innovation Cooperation Network model

2.1 Phillips of Technology Innovation Cooperation Network evolution model.

To give every enterprise in the Technology Innovation Cooperation Network the sufficiency:

a. every enterprise's accommodation coefficient WM is a random number $N(0.5,0.01^2)$ according to the normal distribution.

b. accommodation coefficient function is done in computer imitation:

$$\eta_i = \mu + \mathrm{Sqrt}(\sigma^2) * \mathrm{R}(0,1) \quad (5)$$

μ is the average number, μ =0.5; σ is standard deviation; σ =0.01; R(0,1)is a random number between 0 and 1.

c. normal distribution. Is existing max maximum or min minimum, so the accommodation coefficient η_i must be in reasonable range.

If η_i <0, then η_i =0;

If η_i >1, then η_i =1;

Therefore, $0 \leqslant \eta_i \leqslant 1$.

Adaptation degree coefficient is introduced to solve the problem of selecting the best in the BA model. But the network is changing and developing, therefore, it is necessary to combine adaptation degree coefficient and the development of network.

d. Technology innovation cooperation probability

As mentioned above, the development of the network is change of the point and edge. For the technological innovation cooperation network, it is a new company to join, and to increase cooperative relations between new enterprises to join network and old enterprises. While this change will affect the characteristics of the network, an Important feature is that the change of parameter node degree. Conversely, the change of network node degree will eventually cause the innovation capability of enterprises to change. Therefore, Introducing the following calculation rules:

a. When any enterprise of network enters the network, the cooperative

relationship number is m_i, the number of edges of new nodes to be connected is m_i.Then η_i and m_i exists the following corresponding relationship, refer to table 1.

Table 1 relationship between the number and accommodation coefficient η_i

$\eta_i < 0.49196$	1
$0.49196 < \eta_i < 0.50804$	2
$\eta_i > 0.50804$	3

According to Normal distribution, we can know WM_i 30% probability less than 0.49196, 40% probability between 0.19196 and 0.50804, 30% probability more than 0.50804. this means, for the probability that a new node i can cooperate with 1,2,3 is 30%,40%,30%.

d. pulling into the cooperation probability. We know that when an enterprise chooses a partner, it focusses on not only the innovation from the partner, but also much more cooperation relationship. On the other way, most networks in the real world are open; they increase the new nodes and connect the used node to expend the network. At the same time, the probability about connecting with a new node is relating to the linear measure, the more nodes to be connected, the more chance to be chose, it is the "Matthew Effect". this illustrates that the accommodation coefficient and the node linear measure are very important requirements,

This generalized best connection can be ensured, if the accommodation ability is powerful, if some only new nodes can be connected as fast as possible. We have the point of view.

2.2 The algorithm of evolution mode

a. Assuming the initial status. Supposing there are N_0 nodes and m_0 sides($m_0 > N_0$)in the network, and there is a node connects with one side at least.

b. every time interval is t, adding to a new node. The new node judges the old node, then lead to the result M_{t+M_0+1}, it has the result that the probability between the new node and the old one, $\Pi = (\pi_1, \pi_2, \cdots, \pi_{t+m_0})$ including ;

$$\pi_i = \frac{M_i}{\sum_{i=1}^{t+m_0} M_i} \qquad k = 1, 2, \cdots, t + m_0 \qquad (6)$$

$$M_i = \eta_i * k_i \qquad (7)$$

k_i means linear measure of nodes. The new nodes connect according to this π_i.

2.3 Nonlinear evolution of growth model of technological innovation cooperation network

a. Corporate life cycle with multi-stage model

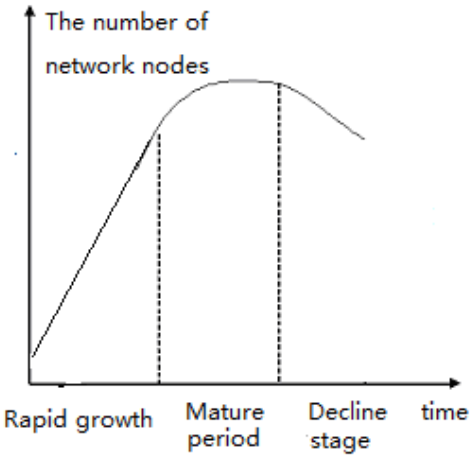

Figure 1 Network evolution cycle

The same for our technological innovation and cooperation networks, it also needs to be phased simulation. To this end, we will divide network evolution process into three phases, namely rapid growth, maturity and decline (see Figure 1). In the fast-growing period, the number of companies at a certain rate increases rapidly; In the mature period, the number of companies' increase has slowed down, but still maintain growth; In a recession, there are some companies out, so reducing the total number of companies. Therefore, in the technological innovation and cooperation network, the number of nodes grows in the nonlinear way.

b. Nonlinear evolution of growth model

Based on the BA model, fitness model, and previous studies [3~4], The growth of the network and choose the best mechanism to do the following expansion:

Network nodes grow cyclically. In the technological innovation and cooperation networks, Cooperative enterprises (node) of the increase is not uniform, but to comply with industry life cycle theory of nonlinear growth stages. Each new node with the number of edges can be associated with fitness. If an enterprise has strong technological innovation ability, then it can cooperate with more companies. In other words, a number of possible cooperation is affected by the business enterprise technology innovation or competitive.

That the number of edges m_i which each new node i can be connected between its fitness η_i as a function of:

$$m_i = f(\eta_i) \quad (8)$$

For this model, the specific function is shown in Table 1.

Prefered connection. According to the selection of best of BA model, nodes were connected to a large degree of broad large; this is not exactly in line with the actual technological innovation cooperation. Because, if a lot of enterprises maintain business and technology innovation partnership, then the company can make use of such cooperation resources to get more opportunities for technical cooperation. However, if a company has a strong technical innovation or unique core competencies (fitness), not only will the company's younger, less current technical cooperation (node degree is not big), there will be many companies chose to work with. Thus, a probability of node i is connected with the node degree k_i and the fitness η_i proportional to the product, namely:

$$\pi(k_i) = \frac{\eta_i k_i}{\sum_j \eta_j k_j} \quad (9)$$

This is a comprehensive merit-based connection rule proposed by fitness model.

Through technical innovation and cooperation network evolution simulation and empirical studies have been found that in addition to a smaller clustering coefficient C, the power law γ of evolution of the network, average path length L and other features similar to the actual network. Especially the power-law index γ, is generated by BA model of $\gamma = 3$ scale-free network. While this model is generated a $\gamma \approx 2$ scale-free network.

This suggests that the evolution model of this paper to build to better characterize the mechanism of realistic network evolution.

3. The summarizes the relationship of network characteristics and technology innovation diffusion

3.1 Technology innovation diffusion strategy

In the era of knowledge economy, the basic position and leading role of knowledge in the innovation activities is more than other economic elements. The innovation ability of the enterprise will be based on the accumulation and utilization of knowledge or effective information, and is no longer directly depending on quantity, scale and increment of the resource, capital and hardware technology. To acquire knowledge, technology and information, on one hand enterprises rely on their own R & D and innovation; on the other hand, they also should be good at cooperation, through technical cooperation network, the effective use of other innovations. Therefore, the enterprise must have the strategy choice of partner. Technology innovation diffusion strategy mainly include: random selection strategy; target selection strategy; affiliated enterprise selection strategy.

3.2 The relationship of technology innovation diffusion and the government and enterprises

According to the above research and analysis,this paper put forward the following recommendations about china's enterprises’s technology innovation cooperation: Adhere to the principle that the enterprise is the main body of technical innovation, enhance their technological innovation capability; Extensively carry out technology innovation cooperation, and constantly improve the learning capability and the competitive ability of enterprise organization; It is created a number of competitive advantage of core enterprise in China's high-tech industry. Strengthen the cooperation with the transnational enterprises about technology innovation; Actively promote Chinese enterprises to participate in the formulation of technical standard.

As new enterprises continue to join and cooperation of enterprises changes, technological innovation cooperation network is more complex. When the enterprises of network choose partners, this makes cooperation becomes more difficult and reduces the success rate of technical innovation cooperation because of the question of lacking relevant information, selecting blindly partners and etc. The government should build technical innovation collaboration service platform for enterprises to provide relevant information, in order to reduce the difficulty and cost of enterprises to obtain information, increase the possibilities of technology innovation cooperation among enterprises. This platform service functions includes: provide public technological services, guide the development of public service institutions; advance the market pace of the products of knowledge, build the social environment that enterprise use external information knowledge and technology; lead and support the crucial technology research and development.

In short, the government should set out from enhancing national power, promote the development of our country enterprise's technology innovation cooperation, promote the development of technology innovation cooperation network in the domestic industry by providing the corresponding public service, developing guiding policy and supporting the key enterprises, Thus create favorable conditions

for domestic enterprises more easily carry out technical innovation and cooperation.

References

[1]ZHANGLi-na, ZHAOWei-shuang(2004). The establishment of the fuzzy comprehensive appraising model of technical innovation spreading tnvironment. Shenyang Ligong University Journal, no.9, pp. 88-91.
[2] LU Xiao(2007). An analysis on formation of enterprise's technological innovation networks. XuChang Journal, no.3, pp. 60-64.
[3]LU Ming, DAI Shufen(2006). Construction on the technology innovation networks of small-and-medium-sized enterprises of our country. Science Technology an Industry, no.12, pp.19-21.
[4] Boccara N(2004). Modeling Complex system, Spinger.
[5]Hartmann Sonntag(2004). I Modeling self organization and innovation process in networks [Z]. arX IV: cond-mat/0406425v 1, 2004-06-18.
[6] QIAN Yanyun, Li Jing, LIU Juan, WEN Hongbo(2084).The empirical research on network characteristics of enterprise technology innovation cooperation. Science and Technology Management Research, no. 8, pp. 3-5.