

The Analysis of Network Structure Model and Innovation Network Characteristics for Industrial Cluster: using Complicated Network Perspective

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ABSTRACT: Industry cluster is a new feature under the background of globalization, informationization and integration. Along with the development of science and technology, the competition between industry clusters is gradually changed from the traditional cost competition into the innovation ability. The ability of innovation is not only concerned with single enterprise or institution's ability but also concerned with the relationship built up by the enterprises in the industry cluster and the innovation environment around them. This article analyzed network structure and evolution of innovation networks on the basis of complicated network theory. According to the construction principle of complex network, we simulated the evolution process of innovation network structure of different types. And, we also analyzed the features and differences of two typical complex networks. The conclusion will provide suggestions for industry cluster to build up innovation system and upgrade the competition ability.

Categories and Subject Descriptors:

C.2 [Computer-Communication Networks]: Data Communications K.1 [Computer Industry]

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1. Introduction

Foreign innovative research of industrial clusters can be

traced back Marshall, published in 1890, "*Principles of Economics*". In China, Ciaran put forward in the industrial area of inter-firm relationships are built on mutual trust, interdependence and mutual cooperation based on, which will benefit a variety of innovative ideas in technology and rapid communication between enterprises and application [1]. By Mai Laite behalf of the European GREMI group theory from the perspective of environmental innovation cluster members to study, combined with the amount of clusters in various parts of Europe, the development of empirical analysis, the regional environment for innovation theory, And put the "innovation environment" extends the concept applied to members of the cluster level. Mytelka appoint that the core mechanism of the regional innovation environment and logo feature is the "group learning behavior" [2]. Broadly speaking, innovation refers to a cluster environment where the local social and cultural environment, which is generally specific to the local cluster to promote innovation in the various systems, regulations, practices, etc. constitute the sum of the system.

Innovation environment is constantly adjusting and changing the process of synthesis. Porter made in his monograph, these processes mainly by the internal mechanism of interaction and learning mechanism of the drive, which depends on the internal mechanisms of interaction within the cluster main innovation - the capacity for cooperation and business inter-dependencies in the innovation network, is relying on them in the development of relationships built up in the capital. With the adoption of group learning can promote the creation of new know-how and technology to promote cooperation between enterprises and the balance between competition and make it easier to find new ways to solve problems, etc., so the learning mechanism is mainly through the influence

and change the cluster Member companies in the technology and market environment in behavior to achieve the development of new projects and creating new resources.

Ge Chaoyang studies suggest that, in the innovation area, the innovator of concentration in a specific area, a good environment for the common use of local characteristics of the enterprise gather so that we can share a single enterprise can not achieve large-scale production and technology, organization and the benefits of innovation [3].

Mancusi analysis of industrial cooperation between enterprises within the cluster model to study the typical barriers to business cooperation, to explore how to overcome the negative impact of culture on cooperation, and finally put forward by the business cooperation to create an innovative environment, thereby enhancing the innovative capability of industry clusters and competitive edge channels [4].

2. The network topology model of innovation

The most common complex network model consists of small-world network model, scale-free network model and the local-world evolving network.

2.1 The small-world network model of innovation

Between small-world network model is completely regular network model with random topology between the network model, a smaller average path length and high clustering coefficient. Small-world network model assumes the same number of nodes in the network, to completely rule based on nearest-neighbor coupled network, the network connection between the nodes connected by a certain probability. Even under heavy small-world networks can be divided into different rules WS .NW small-world networks or small world networks. Which WS small-world

networks based on the probability of re-connecting the network nodes. And NW small-world network is based on the original network, to increase the probability of random nodes Side. Whether it is a small world network or WS NW small-world networks, two nodes are at most only one side exists. Although constructed in different ways, NW small-world networks and WS small-world networks have common mathematical characteristics, and when the number of nodes within the network and the probability is sufficiently large enough, NW model is essentially equivalent to the WS model.

According to above-mentioned regulation, simulation of industrial clusters in small-world network model of the building process innovation.

Assumptions: there have N cluster in the industrial innovation in individuals, where each individual node with two adjacent innovative partnership.

Link rule: According to the NW small-world network construction rules, any pair of randomly selected individuals involved in innovation, to the probability of occurrence of partnership with $p = p_0$.

Repeat the steps above i times, innovation and industrial clusters can be small-world network topology model.

Small-world network is a network exists and the reality is very close to the network, from the characteristics in terms of physical distance, the cluster has a space on the main innovation in the proximity, between the various companies can achieve a shorter path through the association; from the starting mechanism of the formation of clusters, each cluster innovation network enterprises are launched around a particular value chain innovation, technically vertical or horizontal relationship, so all companies have to shorten the distance between network nodes innovation subjective views of for cluster innovation networks have small-world

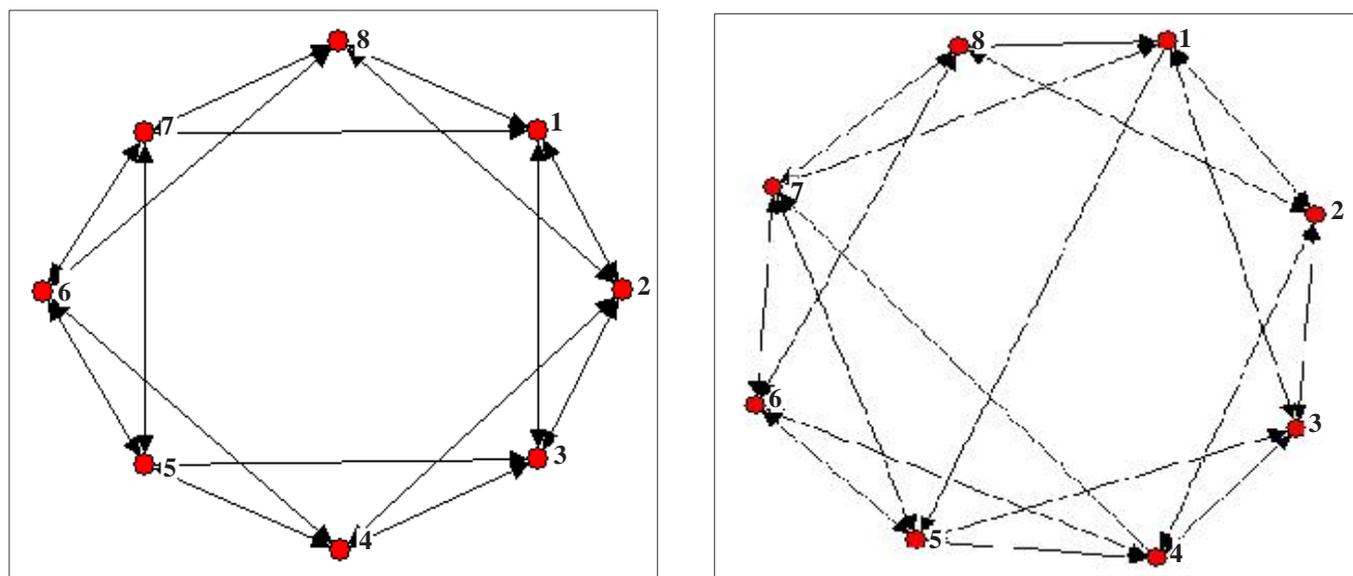


Figure 1. NW small-world network illustration

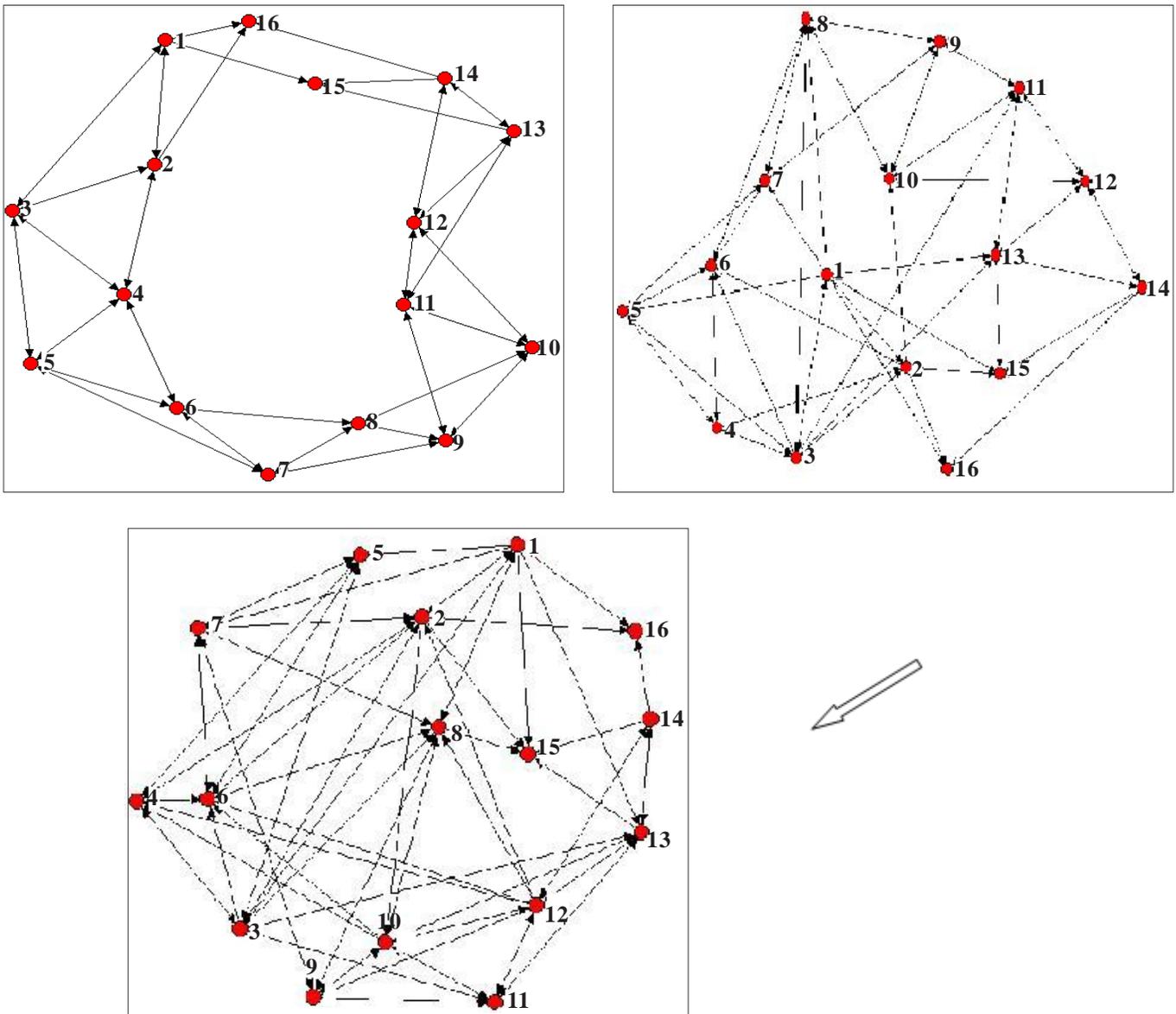


Figure 2. Small-world innovation network illustration

network characteristics to provide a realistic possibility.

Brown and Duguid have Silicon Valley companies on innovative ways to study that, everywhere in Silicon Valley, a similar occupational groups “*network of practice*” is the same or very similar to those engaged in the work of the people, through professional associations or informal groups and link. Practice network of people, while not all of the same company or employer, but they have the same practice, often encounter the same or similar issues, share in the mutual exchange of knowledge and skills within the industry, new ideas in this case in accordance with the transmission of smaller resistance.

2.2 Innovation network’s Scale-free Network model

Small-world network is one of the main features of the network connection degree distribution can be approximated by the Poisson distribution to indicate that the network was approximately evenly distributed. In recent

years, the Internet, metabolic networks, networks of research, found that many of the actual network connectivity degree distribution is not a Poisson distribution, but close to the power-law distribution, that is scale-free network.

Complex network of power-law distribution has two significant features:

2.2.1 Increasing

Small-world networks with fixed nodes; scale-free network is a growing network that is continuously joined by a new node, the network size in a constantly changing.

2.2.2 Priority connectivity

The new node tends to connect with a high degree of central node is connected.

Therefore, the scale-free network topology modeling, and

small-world networks are very different. It is not based on a natural network, but from a start-node network with n_0 , constantly introducing new nodes and connections in accordance with the laws of priority, according to a certain probability, and each node connected.

Simulation of industrial clusters in accordance with the rules of innovation in scale-free network growth model.

Assuming the initial time t_0 moment, there is innovation network n_0 nodes connected randomly between them, constitute a preliminary network of innovation.

Link rule: Each time after τ time, there will be a new nodal point that joins this creative network; it will select m node cooperation.

For each selected node i , to establish the probability of innovation and partnership was $p = \frac{k_i}{\sum_j k_j}$, in which k was

the connectivity of nodes i , and $\sum_j k_j$ is beyond the degree of all nodes i and connections. The newly added node is connected with the original node, depending on the connection probability depends on the original node i degree.

Continuous introduction of a node with n_t , you can get the scale-free network time-evolution with τ of innovation models.

3. Innovative features of network structure and function

Topology of the network to bring resources to the different integration effect at the same time, there are also negative effects, the enterprise may be locked in unproductive relationship, or to prevent firms seeking more effective partner to bring the risk of cluster development. The

structural properties of the cluster to the cluster network has brought the risk of impact in three areas: small-world network properties may lead to fragmented distribution of resources, the overall resources of the network control weakened, but the network itself has a certain ability to resist risks. Scale-free feature makes the cluster network of anti-risk ability both robustness and fragility of a double feature.

Information dissemination in complex networks, the transmission robustness is one of the important properties of communication networks. In a complex network, removing a small amount if the vast majority of nodes in the network node is still connected, may be considered the connectivity of the network node failure robust. In this definition, the robustness of the network that the innovation diffusion in the process of innovation diffusion, spread out any individual node, other nodes involved in the spread between the average path lengths has little effect.

According to Albert, Jeong and Barabási random network of ER and BA scale-free network robustness studies, that different network robustness under node failures there is a huge difference in scale-free networks to random node failure is highly robustness [5]. This robustness comes from the network degree distribution of the extreme non-uniformity, that the vast majority are relatively small-degree nodes, while a small number of nodes were significantly higher than other nodes.

According to innovation diffusion line, in the cluster innovation networks, innovation networks can be classified as divergent, straight, and network type. Which divergent innovation networks with degree distribution similar scale-free network: the network degree distribution in the extreme non-uniform, a large number of nodes is low, a high degree of individual nodes. The network-based innovation network degree distribution is close to the ER random network, each node within the network that the degree distribution is relatively uniform; there is no tide in the central node.

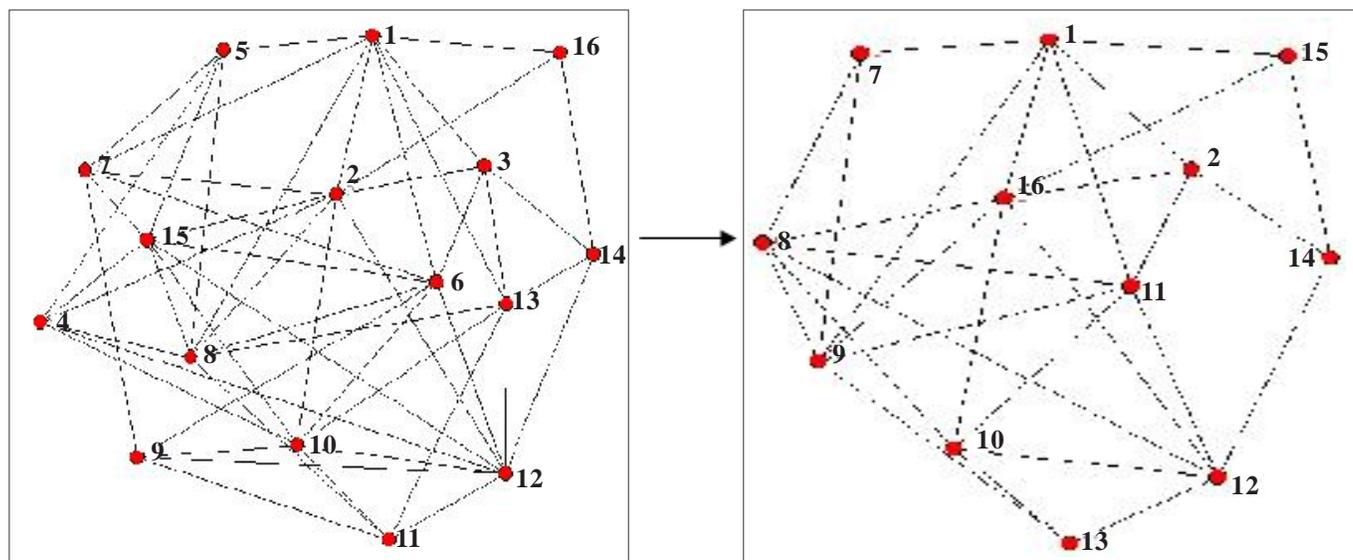


Figure 3. Illustration of robust character in network innovation network

Divergent innovation network technology innovations by one or more of the technical requirements of the main source to many other technology transfer, technology and the main source and demand nodes associated with it became common to engage in innovation networks, technology sources that this network high coefficient of the central node. The proliferation of different nodes of the network has a different role. When the network node in the low exit, on the other node is relatively small, the overall network efficiency and the spread of innovation has not been a huge influence, only in the node directly associated with the node. Conversely, if the central node to exit, then the spread of innovation has a huge hit Attack, and even the spread of innovation networks in part to stop. Therefore, divergent innovation network, nurture and protect the source of the central node in technology is important to ensure the efficiency of network communication means.

In the network-based innovation networks, innovation can be transferred several times, to be transferred in the recipient's innovative technology, not only their own use, but on the basis of the transformation of innovation can be transferred again to a third party, transfer diffusion model of the diffusion process reticular-type form, Each equal to participant since is a recipient as well is a new creative propagation divergence source. In the network organization, the role of each node on the proliferation of similar, there is no over-concentration of nodes. Thus, each node exits, the numbers of nodes are affected, but will not lead to proliferation of large-scale network failures. On the other hand, because there is no central node, expand Scattered in the direction and paths are difficult to predict [6].

Robust phase-corresponding with another feature of the complex network that the network vulnerability. Network vulnerability refers to the network in any attack can be used as a prerequisite features. Based on ER random networks and scale-free network research has shown that scale-free networks more vulnerable to deliberate attack have serious barriers to connectivity, and less robust in

the ER random network showing a more deliberate attack strong anti-aggressive.

Different complex networks show different vulnerability is due to the different network structures determined. Scale-free network of non-uniformity of distribution on the one hand resulted in a random network of nodes removed showed a strong robustness, but also the deliberate attack on the other hand, when the network is very fragile state, once the center of the node under attack, the spread of the network would be a huge blow to [7]. The ER random network node degree distribution as the average, there is no central node is hit phenomenon. So, although less robust scale-free networks, but in a planned attack, than the scale-free network more resistant to attack.

In the divergent innovation network, once the divergence of the source position in the spread of the central node fails, the Innovation Network has been great diminished. In the divergent innovation network, due to a more balanced degree distribution network, so even if individual nodes fail or withdraw from the overall network capabilities and will not cause a huge impact. Therefore, divergent innovation network, the innovative capability of maintaining the central node, the node to maintain the outward spread of innovation will be able to smooth the path to enhance efforts to spread innovation across the network. In the network-based innovation network, the importance of each node fairly and fully tap the innovative capability of each node, a network of convenient Propagation path, will improve the overall efficiency of the network of innovation spread. Overall, the divergent innovation networks, innovation centers to maintain by maintaining the individual wishes of the node-based innovation and dissemination; in network-based innovation networks, innovation and cooperation to improve efficiency is by all the nodes ability to innovate, improve network to improve communication within the environment.

With typical model of 128 industries in the high way hole tax gather cluster for instance, can fully explain divergent innovation network robustness.

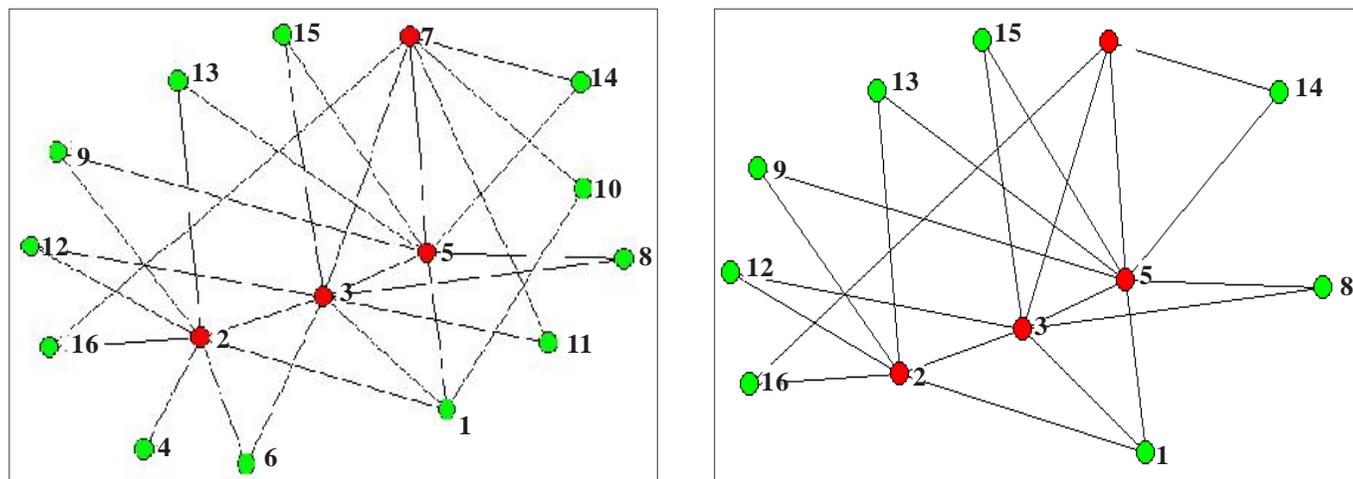


Figure 4. Illustration of robust character in divergent innovation network

50's in 20th century, the U.S. Route 128 region rely on government funding and military orders, the electronics industry has become a gathering area, various types of electronic industrial enterprises have mushroomed in the emergence of gathering thousands of companies and research institutions. 60 years, the region to strengthen cooperation between enterprises, innovative activities, active, endless invention. Such as transistors, semiconductor chips, computers are the results of this period. 70 years, after continuous development, Route 128 region has become the world center of innovation in the electronics industry, their innovative capacity and economic growth to become the world's attention.

However, since the 80's, Route 128 area of innovation capability is a serious downturn, many major companies have moved out of the area, Route 128 development of the region began to decline, the global electronics industry of Silicon Valley innovation and the status of being replaced. Summary Route 128 region in the development of industrial clusters by the gloom and doom for the following reasons: network-intensive high-Route 128 area of rapid development, so that business partners are located within the cluster. Center high degree, which is one of the most important reason, because Route 128 area of long term military orders, companies must pay attention to confidentiality, which resulted in several supply chain Close cooperation between business and less with other companies. This small group of cluster innovation network structure, due to density, although to a certain extent, is conducive to inter-firm learning and innovation, but if left unchecked will result of new information difficult to cluster into innovation networks within the group caused by the rigid, fragile structure. Route 128 region of the cluster innovation network is a consistent scale-free characteristics of the structure of innovation networks that many small businesses around the large enterprises to cooperate, this network structure caused by the vulnerability of the network, once the large enterprises have reduced ability to innovate or crisis, the overall structure of innovation networks will occur Loose, or even collapse.

4. Conclusion

Industry cluster is a special, between individual enterprises and the overall market between the regional organizations. Industry cluster innovation network topology describes the innovation network in the relationship between each node and geometry, and the network brought the network characteristics.

A characteristic from the network, the small-world network is based on innovation and the number of fixed nodes, or random by random to establish cooperative partnership and the formation of innovative reconfigurable network. Scale-free network is growing innovative network structure, adding innovative new network will give priority to cooperation by the individual characteristics and a certain number of individuals within the network have established

co-innovation relationship.

Small-world network is a homogeneous network of innovation, which individuals involved in innovation cooperation within the network number, is closer to each individual to enjoy the network resources more evenly.

Without scale innovation network is a non-uniform network, the network of individuals in the center of memory, and innovative partnerships happened many individuals. This results in network resources within the uneven distribution of innovation, on the one hand a small number of centers within the network nodes to control most of the resources, effective deployment and use of resources. On the other hand, the centralized network will result in small individuals tend to reduce the share of resources. In general, the traditional low-tech manufacturing industry cluster innovation network within the multi-show small-world network characteristics, and need to use a lot of resources for innovation activities in the new technology emerged in industrial clusters are mostly Scale-free characteristics of innovation networks.

Therefore, to enhance the high-tech industry in innovation and scale-free network of innovation process, should focus on two aspects of the upgrade, one central node within the network to enhance the quantity and quality, give full play to its "rich club" features; two, A more convenient platform for cooperation, to improve cooperation and exchange opportunities for Small and Medium Enterprises to promote the dissemination of knowledge within the network, Promote whole innovation of network further development capability.

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