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## Review of High Technology Industrial Clusters Innovation Network

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**Abstract:** Innovation network is especially suitable to social science and its intercross disciplines. Therefore, applications and results of innovation network are introduced, such as innovation network structure, innovation performance, innovation network evolution and industrial upgrade from the perspective of high technology industry cluster. And further applications and research directions are discussed in detail.

**Key words:** Industrial clusters, innovation network, high technology industrial

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### INTRODUCTION

In 1890, A. Marshall proposed the industrial cluster idea in the famous book of Principles of Economics. In 1991, Research Policy firstly proposed the concept of innovation network in the research field of networks of innovation published in June 1991. Based on the relevant literature at home and abroad, this study only makes review and analysis on the research status of high-tech industrial cluster's innovation network in the related fields and discusses its future research directions. Researches on high-tech industrial cluster innovation network in relevant fields are as follows.

### RESEARCHES ON HIGH-TECH INDUSTRIAL CLUSTER INNOVATION NETWORK STRUCTURE

Research of high-tech industrial cluster innovation network structure mainly include measurement index and measure of innovation network's characteristics, network structure's influences on technology innovation and innovation and so on.

On the aspect of measurement index of innovation network's characteristics, Tichy and other learners described network characteristics with contents of transactions, strength of connection and structural features (Tichy *et al.*, 1979). In the measurement indexes, strength of connection uses strength, reciprocity, clarity of expectations, compound degree, etc. for measurement and structural features use scale, density, gregariousness, publicity, stability, accessibility, concentration, personal relationship and connections, bridges, gatekeepers and isolators for measurement. Knoke and some researchers used matrix manipulation to get some indicators to measure network, such as network cohesion, network centrality, network diversity, the network reputation of actors, self-network density of actors and so on

(Knoke and Kuklinski, 1982). Many scholars used complex network technology and combined theoretical model of empirical validation to analyze network structure's effects on innovation behaviors (Ferrary and Granovetter, 2009).

After the study, Phelps found that partners' technical differences enhanced the enterprise's exploratory innovation and network density increased the influences brought by the differences (Phelps, 2010). On the basis of considering to adopt the local network effect produced by individual interaction (Zhao *et al.*, 2011) applied microscopic diffusion model to research innovation diffusion. Complex social network structure, strength of local network effect and innovation adoption of individual heterogeneity jointly determine the process of innovation diffusion. Qing (2001) analyzed the production mode and management structure of modularization of silicon valley industrial cluster and believed that the hard-packed modularization of industrial cluster is more effective and Liu and Gao (2006) studied further the information system and cluster efficiency of high-tech industrial cluster on the above basis.

Many previous studies focused on describing the existing competitiveness by researching the structural characteristics of the cluster, while the latest research results tend to use "network in the cluster" to summarize these existing characteristics (Wang, 2009). In the development of clusters, all normal cluster members, such as "CEO Club", etc. have been become important objects of researchers.

### RESEARCHES ON PROMOTING INNOVATION PERFORMANCE OF HIGH-TECH INDUSTRIAL CLUSTER INNOVATION NETWORK

Projects related with innovation ability and performance of industrial cluster are always the hotspots in the research field of industrial cluster. In recent years,

researches about this problem have transitioned more and more from the overall levels of the cluster, such as scale economy, scope economy and other angles, to the micro-mechanism of action within the cluster.

Wei (2003) held that innovation and performance come from the knowledge spillover effect among the cluster members. Cai (2003) thought that as social network increases trust and contacts and promotes the flow of information and knowledge, industrial cluster innovation and performance are produced which are beneficial to the spread of implicit knowledge and sensitive information and have brought advantages of technology innovation. Having inspected research-intensive biotechnology company, Whittington and other researchers held that the enterprise's geographical location and its location of innovation network have different effects on innovation (Whittington *et al.*, 2009). Applying social network theory in new economic sociology and adopting appropriate regression method, Wang and Wang (2005) tested the effects of the cluster network structure to enterprises' innovation ability and finds that density and centrality has significant positive influence on innovation. Yang and Li (2010) analyzed the influences of the presented structural characteristics in the clusters transferred from advanced countries or regions and connection of their relations on cluster innovation activities. The study shows that innovation activities with different knowledge base need to construct different network relation combinations and network structure and network interactivity is developed in industries and between industries based on technology similarity and technology correlation. Engel and other researchers research the innovation dynamic relations between clusters (Engel and Del-Palacio, 2011). Huang (2007) thought that industrial cluster innovation network contains multiplier transmission and innovation mechanism, cooperative innovation mechanism and innovation motivation-increase mechanism to improve innovation performance. For the improvement of the cluster innovation ability, the existing research shows that not only the cluster's internal network ties, mutual cooperation, external economy, knowledge spillover, institutional environment and government's policy support are very important (Knorringer, 1999), the cluster's external associations, especially its associations with global behavior actors cannot be ignored (Whittington *et al.*, 2009). In terms of continuous innovation, Li *et al.* (2007), etc. divide key resources in high-tech industrial cluster innovation into industrial cluster, entrepreneurs, government, colleges and universities, financial support system, intermediary institutions, professional technology incubator and intangible resources and they think that the integration of these resources is the key of cluster continuous innovation. From the respective of synergetic, Xie and

Zeng (2008) researched the co-evolution mechanism, pattern and process of the continuous innovation system of high-tech industrial cluster and build cyclical evolution quantitative model of the continuous innovation system of high-tech industrial cluster and ability evaluation system of the continuous innovation system of high-tech industrial cluster which has guiding significance to explore the internal development of the continuous innovation system of high-tech industrial cluster. Winch and Courtney study the key role of innovation agent organization in the innovation process (Winch and Courtney, 2007). There are many scholars such as Paruchuri and Visser explore regional policies' influences on promoting network and innovation behavior (Paruchuri, 2010).

#### **EVOLUTION RESEARCHES ON HIGH-TECH INDUSTRIAL CLUSTER INNOVATION NETWORK**

The development and evolution of innovation network is the topic that researchers focus on. The emergence of innovation network is on the basis of resource complementarities and it often develops unbalancedly. Industrial differences, subdivision of market and government's support degree and method can cause great influence on the process of network evolution. Research of Powell, Cantner and Graf reveals that there are regional and industrial differences on any network formation (Cantner and Graf, 2006). Porter argues that clusters are in dynamic evolution after their creation and it probably because external threats and internal rigidity make clusters losing competitiveness (Porter, 1998). In reality, many clusters are gradually changed to "locked" and "rigid" systems under both internal and external influences which have lost the ability to deal with the external environment changes and fallen into new dilemma, even gone to declination or perishment.

Combining with cluster life cycle theory and in the evolution process of cluster network, many scholars make study on the variation of the number of cluster network nodes and relationship strength etc. with the process of clusters' formation, growth and maturation. On the basis of evolution theory, Ahokangas and other scholar analyzed the process and mechanism of industrial clusters' emergence, development and declination (Ahokangas *et al.*, 1999). By building dynamic and open system of industrial cluster network and breaking through the "locked" and rigid state in the specific stage of industrial cluster development, Zhang and Liu (2010) tried to realize the continuous innovation of industrial clusters and promote their sustainable development. Based on Complex Adaptive Systems theory and aiming at the evolution process of karyotype industrial cluster innovation network, Fu and Zhang (2011) constructed

echo model and simulated the model on Swarm platform which pointed that the bottleneck factor restricting the development of such kinds of innovation evolution process in our country is the low striping ratio of focal firm to the key basic components. Start with multiple network theory, Visser and other scholars analyzed the different functions of manufacturing network and R and D network to cluster technology innovation and product innovation and dissected the internal relations between the evolution of network system and evolution of cluster innovation (Visser and Atzema, 2008). Through such link relations as commercial relation, financial relation and R&D relations among innovation network nodes, Wang (2013) explored the evolution process of regional biomedical innovation network.

In the study of power of innovation evolution, the study of complex network theory has universality. Watts defined two different power of network evolution: dynamics of the network and dynamics on the network (Watts, 2003). They respectively expound network node and contact increase and decrease and the behavior change of network node. As the most basic power of network evolution, both the changes can be applied to dynamic researches of innovation network as theories.

#### **INNOVATION NETWORK AND INDUSTRIAL UPGRADING**

As for problem of industrial upgrading, many schools emphasize the important functions of local system, external economy and collective actions to cluster upgrade (Maskell and Malmberg, 1999). From the 1990s, many international scholars started studying the development and upgrading problems of industrial cluster from such aspects as external resources, cross-boarder connection and division of labor of value chain. Theory of new industrial district and global value chain theory have become important foundation of cluster upgrading research (Humphrey and Schmitz, 2002). Humphrey and Schmitz thought that cluster upgrading refers that clusters climb from the low value-added link of value chain to the high value-added link of value chain and achieve cluster upgrading through technological process upgrading, product upgrading, function upgrading and chain upgrading (Humphrey and Schmitz (2000). As a complex huge system, the influencing factors for the upgrade of the local industrial cluster under the global value chain are various, including the cluster internal innovative ability, the supporting effect of the external environment, the governance relationship of the value chain and the regional network environment (Shen and Wei, 2009). The feature of different clusters and the different types of the value chain also decide the upgrading measures of the cluster. In general, the upgrading measure of the industrial

cluster can be implemented from the internal cluster, value chain and external value chain (Wen and Zeng, 2005).

Based on the research perspective of global value chain, Meng and Cao (2009) holds that the improvement of the technology innovation ability in the cluster enterprise is the micro foundation and fundamental driving force of the upgrading of the industrial cluster. Cultivating a constant developing and evolving overall supporting system within the global open system is the key for the upgrading of the local electronic information industrial cluster. Ernst and Dieter analyze the information technology industry in Taiwan and hold that the learning ability is the key for the industrial upgrade (Ernst, 2010). The method of embedded global value chain will influence the upgrading prospect of the cluster and the inappropriate embedment can only lead to the "immiserising growth" of the cluster (Kaplinsky and Morris, 2005). Gereffi specially stresses the promotion effect of the dominant enterprises on the upgrade of the local industrial cluster (Gereffi, 1999). In the analysis of geographical and cultural factors on the cluster upgrade, Mei *et al.* (2005) proposes that under the global value chain environment, the basic connotation for the upgrade of the local industrial cluster shall include the contents in five aspects of technical ability, innovation ability, external association, social capital and regional innovation system. Humphrey and Schmitz think that the upgrading prospect of industrial cluster in the global value chain varies due to different embedded value chain types (Humphrey and Schmitz (2000). Through the empirical research on Pudong IC local industrial network embedded in the Zhun-ke-Ceng chain, Wen Hu and Zeng Gang also supplement and amend the opinion of Gereffi (Humphrey and Schmitz, 2000; Wen and Zeng, 2005) and hold that the promotion or block of the global leading companies on the upgrading of the local industrial network is decided by whether the upgrading behavior of the local industrial network violates the core competencies, rather than the upgrading type of the local industrial network.

At the early 2000s, some scholars at home and abroad try to start from the technical chain theory to research the industrial upgrade in the developing countries, thus providing a new perspective for the research of industrial upgrade in the developing country. Wang and Wang (2005) holds that the key for the industrial upgrade is the docking between the technology system of the local industry and the advanced technology system in the developed country, integrating into the global technology chain, constantly conducting the progressive technology innovation, accurately grasping the limit of industrial technology, timely researching the industrial substitute technology and realizing the upgrading among the industrial technology chains. Due to the spontaneity formed in the industrial cluster in our

country, no matter the traditional industrial cluster or the high-tech industrial cluster, the development also lies in the low level and it faces with the urgent upgrading issue (Lin *et al.*, 2010). The upgrade of the industrial cluster is the construction of innovation mechanism of the industrial cluster after all with the concentrated reflection of the formation and the role play of cluster innovation network.

### **DEVELOPMENT AND PROSPECT**

The research on the innovation network at the high-tech industrial chain mainly focuses on the network structure, innovation performance, network evolution and innovation mode of the innovation network. The research on the microstructure and dynamic feature of the innovation network is relatively weak, therefore, the research on the innovation network at the high-tech industrial cluster needs to be deepened.

Currently, the research on the formation and evolution mechanism of the industrial cluster mainly starts from the homogeneous enterprise. The research methods mainly adopt the economics, management, sociology and complex network theory (Liu, 2010). With the direct entry point of the heterogeneous focus enterprise, researching the microscopic mechanism of the cluster evolution, the construction and coupling mechanism between the industrial chain and innovation network are the research directions in the future with the non-equilibrium system self-organization theory.

The research from the perspective of industrial technology innovation and industrial structure evolution is mainly qualitative. The future research shall adopt the quantitative model analysis with the case analysis or empirical research to inspect and develop the theory of technology innovation network in the domestic environment.

The research on the high-tech industrial chain innovation ability and performance shall gradually transform from the scale economy and range economy of the overall cluster to the microscopic effect mechanism within the internal cluster members (20). Compared with the normative research, there are a few empirical researches and verifying the conclusion in the normative research with the empirical research method is a trend in recent years. Moreover, the research at home and abroad is theoretical analysis and empirical research on the innovation performance of the enterprise or the cluster aiming at the network structure feature and further research on the influence of network structure feature and relation feature on the spread of technology innovation and knowledge flow.

The current research on the relationship between the high-technology industry and industrial upgrade is mainly qualitative and there are only a few literatures conducting the quantitative analysis. It is worth mentioning that the research objects of industrial upgrade at home and abroad are mainly the traditional industries, such as textile, ceramics, clothing, toy, while there are a few researches on the high-tech industry. The research around the emerging industries of electronic information and biotechnology in the future shall be the valuable research direction.

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