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RESEARCH ON THE IMPLEMENTATION MECHANISM OF INDUSTRIAL CLUSTER INTEGRATED INNOVATION

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Abstract. *The process of integrated innovation involves different factors of innovation in the industrial cluster system. It must realize the inter-coordination of these elements of innovation. Multiple innovative subjects in industrial cluster collaborate by self-organization and form a dynamic network organization, which is the essence of integrated innovation system. The characteristics of organization are creative, fusible, systematic, innovative integrated effect of amplification. Based on the analysis of endogenous and exogenous motivation in integrated innovation system, we explain the dynamic mechanism with embeddedness perspective from the embeddedness of knowledge, relationship and structure.*
Keywords: Industrial cluster, Integrated innovation, Embeddedness of knowledge

1. **Introduction.** In recent years, along with economic globalization, industrial cluster is an important organization form to promote the development of regional economy, and it has drawn more attention by international organizations, as well as governments. Industrial cluster is a complexity dynamic economic system. In this system, disadvantages of bureaucracy organization and high transaction costs are nonexistent. Therefore, the process of integrated innovation in industrial cluster is a qualitative change process, which is not simply accumulation of innovation. It is an effect of $1 + 1 + 1 > 3$ that makes the system realize innovation of integrated amplification.

The process of integrated innovation involves different factors of innovation in the industrial cluster system, such as technology development, organizations, and management. The integration process will be affected by many factors, such as enterprise factors, relationship of enterprises in the industrial cluster and external environment. These factors make the integrated innovation effect complex and uncertain extremely. So, it has to be some kind of implementation mechanism to ensure the innovation ability of integrated innovation to be realized. In integrated innovation system, integrated innovation ability can be controlled based on explicit dynamic evolution path; thus, the holistic economic benefits of industrial cluster can be improved.

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2. **Relevant Studies Review.** The theoretical research of integration innovation began in the 1970s, when Dosi [7] did a lot of work on the comprehensive innovation of enterprise technology, organization, system, management and culture from the perspective of integration of internal technological innovation elements. They pointed out that the key to improving the efficiency of enterprise technology innovation lies in coordinating the matching relationship of the factors just mentioned. Since then, many foreign scholars have carried out comprehensive integrated innovation research in a wider range and gradually formed the following research perspectives.

2.1. **Technological integration and innovation perspectives.** Iansiti [1], a professor at Harvard Business School, puts forward "technology integration". He believes that "the application of resources, tools and problem-solving methods throughout organizational process is called technology integration, which provides a great impetus to improve the performance of R&D". His concept of "technology integration" focuses on the technological side of innovation.

2.2. **Product development perspective.** Through the research on the projects of American and British high-tech companies, Souder, Sherman and Davies-Cooper [2] put forward that under the condition of technology and market uncertainty, the integration of enterprise R&D and marketing activities, as well as the integration of R&D activities and customer demands, have played an important role in promoting the development of enterprises.

2.3. **Enterprise capability perspective.** Petroni [3] pointed out that the internal integration capability of an enterprise is equivalent to the construction capability, which corresponds to the design and manufacture of products, and the external integration capability of an enterprise is corresponding to the conceptual creation of products. On this basis, Petroni proposed the concept of "super-competent integration" and extended the perspective of strategic management based on dynamic capabilities.

2.4. **Management integration perspective.** Hardaker [8] studied the product development and management of European manufacturing enterprises, and then he divided the integrated innovation into technology level, management level and culture level. He introduced "management" as an integration element into the integration innovation system, and believed that integration innovation is the integration of multiple departments, multiple functions and multiple organizations, which inevitably involves the aggregation of multiple types of employees. Their attitudes to innovation, thinking modes and other differences exist, so integration of culture must be realized. There are differences in employees' attitude towards innovation. Therefore, enterprise culture integration must be involved.

3. The Connotations and the Characteristics of Integrated Innovation System in Industrial Cluster.

3.1. **The connotations of integrated innovation system in industrial cluster.** In the system theory, industrial cluster is a dynamic and complicated economic system and it can be further divided into many sub-systems from various aspects such as industrial patterns, organization structure and coordinated model. The aims of the integrated innovation system in industrial system are to improve the integrated innovation ability of the industrial cluster and to increase the key competitiveness. It takes the integrated innovation as the main innovation model, regards the technological enterprises in industrial cluster as the main force, views the higher education and science and research institutions are the source of the knowledge. Various exchange models such as technological exchanges, management services, financial cooperation and talent flow are combined and

the government supervision is accepted at the same time. In conclusion, the integrated innovation system in industrial cluster is a very complicated innovation system that is influenced by many factors in society. The nature is to take the advantage of many innovation entities that are internally linked with each other in industrial cluster and dynamic network organization that contains many linked entities is promoted. Different from the general innovation, integrated innovation includes many innovation entities and the dominance status among many entities is influenced by many factors and is changing all the time. This is to ensure the effectiveness of cooperation, the complete utilization of innovation vehicles and the adaptability to innovative environment. The process of integrated innovation is a process of effective integration between innovation entities and environment. This integrating process is not the simple accumulation of innovation factors, but the reaction from exchanges and communications of various organizations and it is the process of creating knowledge, conducting innovations and developing new products.

3.2. **The characteristics of integrated innovation system in industrial cluster.**

3.2.1. *Creativity.* Collecting many factors in system in a simple manner cannot be called the integration and merely combining the factors in a general way cannot produce creativity. If creative combination of factors can be generated in integrated innovation process, we call the whole process as integration. More importantly, this kind of innovation focuses more on entire innovation effect and the endurance of the competitiveness of the entire industry. In conclusion, the industrial cluster innovation means there are more creativities in industrial clustering process.

3.2.2. *Integration.* The integration is infused with creative thinking and it is the integration of creativity. It means that the innovation factors are optimized and matched by innovation entities and factors are combined in the most reasonable structure. In the specific area of industrial cluster, various stages, processes in innovation life cycle and innovation abilities, process, practices, resources and competitiveness of diversified innovation entities in industrial cluster are combined wisely, so that all the innovation factors and content can be complimentary to and match with each other. Finally, innovation mode with competitive advantages finally comes into being.

3.2.3. *Systematization.* Since innovation system in industrial cluster is an open system composed of many factors and sub-systems. It conducts large amount of information, material and energy exchanges with the outside and it has close links with the outside. The exchange and links make the factors and the relations of the factors keep changing, which leads to the reorganization of structure and relations and it shall be realized by innovative cluster. A reasonable, orderly and inter-connected organic entity can come into being through this innovative integration.

3.2.4. *Amplification of integrated innovation effect.* Integration amplification system is the result after combining the systematic features and the integrated features of integrated innovation. The reflection is that in the process of integration, the mutual combinations among various innovation factors are emphasized and the unification among innovation entities, innovation elements and innovation environment is focused. More importantly, reasonable optimization and matching are conducted actively among various elements. The most reasonable structure forms come into being, so as to create an organic entity made up of proper elements and the elements can be complimentary to each other and match each other. The whole structure of the innovation system and the whole function change reaches a qualitative leap and the enduring innovation ability and competitive edge can be formed. Through reasonably controlling the ratio of innovation components, the mutual connection, the changes of mutual effect, the structure of integrated innovation

entity can be optimized. As a result, the entire function of integrated innovation is amplified, creating the magnifying effect of integrated innovation.

4. Composing Elements of Integrated Innovation System in Industrial Cluster.

4.1. **Subject elements.** The formation of innovative system in industrial cluster relies on the network relation formed by the entities that joins the innovative activities. The subject elements mainly include governments, enterprises, higher institutions and scientific institutions. Enterprises are the main entities of technological innovation as well as the main entities of innovation investment, production and income. Theoretically, enterprises are also the core of innovation system in industrial cluster. Based on the real situations of industrial cluster, the majority of innovation entities in industrial cluster include governments and enterprises.

4.2. **Functional elements.** It refers to the connections and operating mechanism of behavior entities through taking advantage of innovation functions in the innovation process of the innovation entities in industrial cluster. The operating mechanisms include institutional innovation, technological innovation, management innovation and the mechanism and ability of service innovation. Two aspects have to be considered to make use of the functions of innovation system. First, there should be a complete internal operating mechanism for all entities. Secondly, there should be reasonable links among all the entities and the operations shall be highly efficient, so as to play their roles as main entities. The functions that are realized include the integration of regional innovation elements, the promotion of structural upgrade of regional industries, the acceleration of rapid development of regional economy, the improvement of economic quality, the activation of small and middle sized enterprises, the development of high-tech industries, the acceleration of transformation of traditional industries, the promotion of the transformation of technological transformation and the promotion of institutional and mechanism innovation. The functions of innovation system in industrial cluster evolve and improve gradually and the emphasis of functions in various phases is different.

4.3. **Environment elements.** It refers to the innovation environment of industrial cluster and it is the complete concentration of the limited innovation resources in the region. It is also combined with the innovative conditions. It reflects the foundation and potential of regional innovation in industrial cluster. The content of innovative environments is divided into four aspects: soft factors in social capital, including social institution, legal system, social customs, economic, culture and social network. Hard infrastructure in material technology and information infrastructure environment include hard factors such as regional resource, infrastructure, labor force, technology and economic stocks. The environment also refers to the institutional environment formed among the innovation system factors such as innovation entities, innovation function, innovation content and others in industrial cluster and the operational mechanism includes institutions, historical traditions, social atmosphere, business culture. The environment also refers to the components of innovation investment in the process of innovation system such as human resources, capitals, technological resources environment. It also refers to the environment of technological results such as products, industries, regional innovation in the innovation process.

5. Realization Mechanism for Integrated Innovation Capability in Industrial Cluster.

5.1. Motives formed in integrated cluster system.

5.1.1. *Internal motive.* The innovation system of industrial cluster takes advantage of its professionalism through the division and cooperation in organizations and it brings down the production cost. The innovation system also focuses on the core business of the organization and improves the core competitiveness of the organization. The innovation system in industrial cluster has the feature of network embeddedness and it is convenient to communicate owing to the advantages in geography and social relations, so as to reduce the information cost; the embeddedness of social capital is beneficial to the improvement of cooperation, so as to reduce the transaction cost and prevent the opportunism; stable social interactions and interpersonal relation leads to long-term coordination and the specificity of the assets. Complementation in resources can be formed because of the coordination and the gaming. As a result, the distribution efficiency of all the factors in the system can be further improved. Under the market economic conditions, the drive of economic profits promotes the relationship changes in the organization and the evolution of organization forms. Under the dominance of economic rules and ecological rules, the organization forms of the enterprises are not only driven by profits, but also have the characteristics of ecological evolution.

5.1.2. *External motive.* External motive is a very important motive. For example, the change of macroeconomic policy comes from the forcing and induction mechanism of the government, the press from the public, the new competition focus of green competitiveness and the global cloth-eating moth. The factors targeted at the individual enterprise also play the role in the ecology of industrial cluster. The informatization, networking, concentration and the ecology in industries improve the speed, depth and width of the evolution process of organizational forms in industrial cluster from the aspects such as technology, institution and ecology. In particular, the economy at the primary and industrialized stage accelerates the upgrading steps from traditional industries to ecological industries under the threat of economic globalization. The innovation in industrial cluster evolves from single enterprise to the region and the system, making the whole trend irreversible.

5.2. **The motive formation scheme of integrated innovation system: An "embeddedness" perspective.**

5.2.1. *The embeddedness of the knowledge.* Through large amount of coordination, an organization creates effective connections with other organizations in production knowledge. The embeddedness of the knowledge includes the following factors: complementation, compliance, tacitness, trust, protection and coordination. It is directly proportional to the compliance, trust and coordination and is inversely proportional to complementation, tacitness and protection. In the evolution process of the innovation system in industrial cluster, large amount of internal knowledge in regional network is accumulated among economic organizations in industrial cluster. That knowledge can be exemplified as: the consensus and understanding of environment and ecology, the common value in sustainable development, the common vision of integrated innovation system and the tacitness knowledge in the exchanges of related by-product. This knowledge is scatted in the daily exchanges in member enterprises and is penetrated into the working process and decision-making process of enterprises. The acquirement of this knowledge requires time and interaction experience.

5.2.2. *The embeddedness of relationship.* The embeddedness of relationship is an end product. It evolves from the understanding of certain behavior effectiveness and finally defuses strong debatable arguments in social relationship. Finally, a consensus is reached and it at last affects the behavior of the doer. This embeddedness is a help to the elimination of uncertainty and the enhancement of the trust among doers. As an economic resource with potential income, the linking relationship formed historically offers trust

foundation for the exchanges of member enterprises and reduces the information cost, thus creating a certain degree of tacit understanding. On the basis of the trust, information flows more smoothly and more emotional factors are integrated into the exchange activities, thus enhancing the depth, extensity and frequency of the cooperation. The close distance in special geography offers convenience for the development of integrated innovation system in industrial cluster. Longer interactions enhance the trust among the members and the same participation and mutually beneficial behavior solidifies the desire and motive for bilateral interactions. The enterprises cooperation in the industrial co-existing system expands in the aspects of scale, range and frequencies.

5.2.3. *The embeddedness of the structure.* The relationship among member enterprises in integrated innovation system of industrial cluster exceeds the relationship of industrial chain and it is a multi-perspective relationship structure. The self-organization process of integrated innovation system in industries is a process with constant desertification and complicated development of the system. In structure, it is reflected as the changes in material flow, energy flow, value flow and information flow among enterprises. On the basis of those medium, complicated exchange relationship among various enterprises is formed. The embeddedness enables the two sides in exchange to establish a reliable structure, which makes the transactions convenient. However, it may lead to more risks for two sides in transaction because the result of the transaction relies on the real behavior of the transactions parties.

As to the systematic process of the innovation in industrial cluster, the incentive of innovation and transformation comes from the pressure of macro environment. More importantly, it originates from the motives and directions of the reforms and innovations of the enterprises in its modeling and imitation process or in face of the external environment. The revision and changes of the external institutional transplantation are named as "institutional flexibility" by us. Secondly, it is the institutional adaptation. When those external institutions are successfully embedded in the local social structure, people's behavior can adapt to these institutions and the changing process of the rules gradually.

5.2.4. *A basic model of integrated innovation capability of industrial cluster enterprises.* This paper tries to use mathematical language to describe the static model of the integrated innovation ability of industrial cluster enterprises. It starts from the composition level, capability dimension and integrity of the ecological niche of enterprise integrated innovation. The capability of enterprise integration innovation can be represented as the capability of viability, development and competitiveness, and its mathematical model is:

$$C = F(A, X) \tag{1}$$

C is the level of enterprise integration innovation capability based on ecological niche, which is a function of A and X.

X is the viability, development and competitiveness level of enterprise integrated innovation, and the value from high to low indicates the performance or ownership level of the enterprise in such factors.

A is the crucial value of the characteristics of each constituent sub-element, and the value result from high to low indicates the importance of this factor to the formation of enterprise integrated innovation capability.

$$C = f\left(a_i^k, x_i^k\right) \tag{2}$$

k represents the main components of the enterprise's integrated innovation capability, and $k = 1$, 2 and 3 respectively represent the viability, development and competitiveness.

i represents all the sub-elements of an enterprise's integrated innovation capability component, $i = 1, 2, 3, \ldots, m$.

a_i^k indicates the importance of the class i sub-factors in the category k component of integrated innovation capability to enterprise integrated innovation capability.

x_i^k represents the level of sub-factors of category i in the k category of integration innovation capability factors of enterprises. For example, $x_1^2 = 1$ represents the level of sub-factors of category 1 in the development capacity of an enterprise as 1.

Thus, the enterprise's integrated innovation capability can be simply expressed as:

$$C = \sum \sum a_i^k x_i^k \tag{3}$$

where $i = 1, 2, 3, \ldots, m$; $k = 1, 2, 3$.

The above model is represented by matrix:

$$C = \sum A^{kT} X^k \quad k = 1, 2, 3 \tag{4}$$

where

$$A^{kT} = \left(a_1^k, a_2^k, \ldots, a_m^k\right) \tag{5}$$

$$X^k = \begin{bmatrix} x_{11}^k & x_{12}^k & \cdots & x_{1n}^k \\ x_{21}^k & x_{22}^k & \cdots & x_{2n}^k \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1}^k & x_{m2}^k & \cdots & x_{mn}^k \end{bmatrix} \tag{6}$$

$$C = C^1 + C^2 + C^3 \tag{7}$$

where enterprise integrated innovation viability level:

$$C^1 = A^{1T} X^1 \tag{8}$$

enterprise integrated innovation development level:

$$C^2 = A^{2T} X^2 \tag{9}$$

and enterprise integrated innovation competitiveness level:

$$C^3 = A^{3T} X^3 \tag{10}$$

6. **Conclusions.** Integrated innovation system in industrial cluster aims to realize the enterprise linkage and the reasonable distribution of the value chain through close division and cooperation among enterprises in the cluster. Industrial cluster is regarded as a comprehensive platform collecting all the resources for the enterprises. Under the entire coordination among management departments in industrial cluster, multiple parties can join the construction and management and the integrated innovation ability in industrial cluster can be improved through the coordination of various advantages and characteristics. Management department of industrial cluster shall offer good service environment for enterprises in industrial cluster, providing a guarantee for the innovation and development of industrial cluster. With the development of the integrated innovation capability, the industrial chain of industrial clusters has been gradually improved and the potential energy of the industry has been gradually strengthened.

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