Study on Symbiotic Mechanism of the Industrial Clusters Ecosystem Based on City Innovation

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Abstract - In industrial ecosystem, the symbiotic relationship and mechanism of the various communities are the keys to normal operating such as natural ecosystems. In the process of industry innovation, the Community main bodies, such as enterprises, universities and research institutions, intermediary institutions and governments, play different roles. Under the symbiotic environment formed by city innovation system, the cooperation innovation in community main bodies is carried out to achieve the system functions.

Index Terms - city innovation, industrial cluster, ecosystem, symbiotic mechanism

"Symbiosis" was proposed by Anton De Bary —— German biologist in 1879。Symbiosis not only exists in the biosphere, also spreads out social systems. Over the last decade, symbiosis theory gradually extended to the field of economics and sociology. Thus the lessons could be drawn from the theory to study the industrial clusters ecosystem on city innovation.

1. Connotation and composition of the industrial clusters ecosystem on city innovation

Due to the variability and complexity of modern social, to advance the development of industrial clusters relies on the multilateral cooperation, such as enterprises, universities, research institutions, government and intermediaries. In the process of industrial innovation, they collaborate with their own advantages, and jointly advance scientific and technological innovating. Thus the industrial clusters ecosystem on city innovation is composed by these principal innovation bodies and their interaction relationships. By symbiosis theory, the symbiosis system is constituted by units, mode and environment. In three factors, the unit is a foundation, the environment is conditions and mode is the key factor.

A. The Definition of Symbiosis Unit

In Fig.1, as a result of the principal innovation bodies differently acting on and participating in the Industrial innovation, a hierarchy of symbiotic interfaces can be built in the industrial clusters ecosystem on city innovation, and different symbiotic units are formed, which comprise four kind of symbiotic units: enterprises, universities and research institutions, government and intermediary services (technology, social capital, etc.) . They are the fundamental units for symbiont to exchange matter and energy. And their characteristics can be described by a series of basic quality parameters, which reflect the internal properties of the symbiosis unit.

1) Enterprises is the most important symbiotic unit, the main body of investment and innovation activities, and also the most direct actor in the innovation added value. The enterprise-center symbiont is the key point and origin to study symbiotic system of industrial cluster. Its function mainly influences on forming the boundary of symbiotic system, allocating resource, improving of the symbiosis network, encouraging information and knowledge to flow, and so on.

2) Universities and research institutions are the main symbiotic units and the important sources of scientific research and innovation. As the primary creators and providers of knowledge and technology, universities and scientific research institutions not only directly involved in activities such as knowledge creating, disseminating and applying, but also participate in technological innovation activities by establishing businesses or enterprises and cooperating with other units.

3)Intermediary agencies，the main symbiotic units, are not directly involved in the creative process, and only plays a good role in assisting, communicating, coordinating and facilitating among government and universities, enterprises, society and market. And they also can provide financial support for other units.

4) Government also don't directly participate in innovation activities. But it plays an important role in promoting the function implementation of symbiotic system. It actively facilitate formation and development of the symbiosis network by building the industrial cluster symbiosis environment, and affects the entire innovation process by way of encouragement, guidance, coordination and protection .

B. Symbiotic Mode Selection

In the industrial cluster ecosystem, symbiosis model is the important way among symbiotic units to exchange information, energy and material, and is the decisive factor to influence the depth, breadth and cooperative forms among the main innovation bodies. Only benefiting from the system for their conducive developing, could the interdependence and cooperative relations be established among symbiotic units with their common goals, and be maintained sustainably and stably for a long time. To commonly developing and evolving, the symbiotic units select the corresponding symbiotic mode with the symbiotic goals and their own development needs, which includes of point symbiosis model, intermittent symbiosis model, continuous symbiosis model and integrated symbiosis model (As TABLE 1).

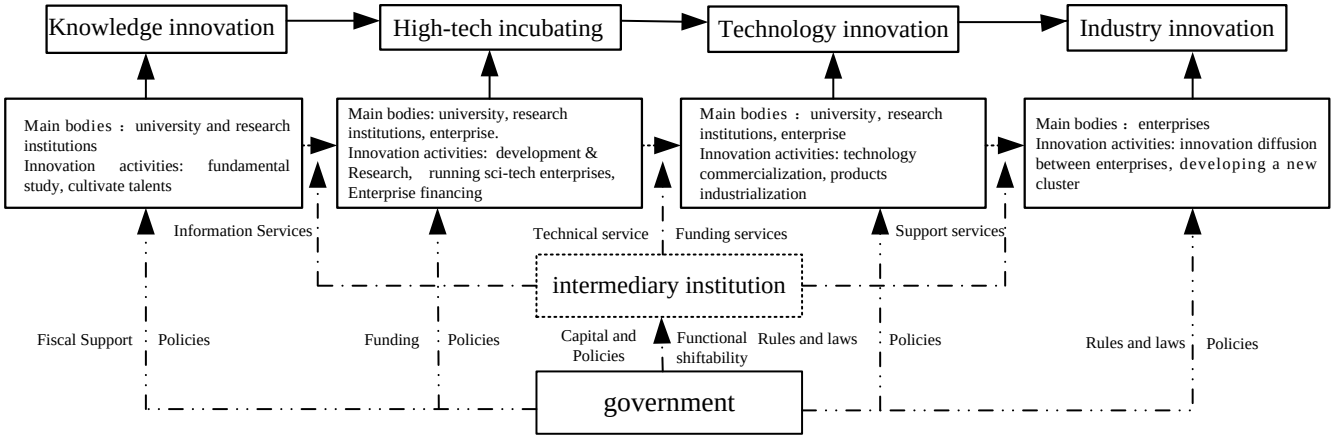

Fig.1 The industrial innovation process and its main participants

TABLE 1 The Classification of Cluster Ecosystem Symbiotic Model on Mineral Resources CityInnovation

Patterns	Implications	Symbiotic characteristics	Application mode
Point symbiosis	interacting once among symbiotic cells at a particular time	Opening strongly, strong random, poor stability, no symbiotic evolution	Technology transfer programs
Intermittent symbiosis	Under the condition of uncertainty and random, interacting multiple times among symbiotic cells	Strong open, poor stability, obviously evolving	Commissioned research programs joint research programs
Continuous symbiosis	Under more stable and inevitable condition, interacting multiple times continuously in several ways among symbiotic cells	Poorer openness, strong stability and specificity, more strongly evolving	Build scientific research bases through joint efforts
Integrated symbiosis	Under stable and inevitable condition, symbiont with independent nature and function being formulated among symbiotic cells	poor openness, strongest stability and specificity, most strongly evolving	Set up research and development entities and industrial technology alliance

C. Symbiosis Environment

The ideal symbiotic environment is positive for improving the industry cluster symbiosis ecosystem. Symbiotic environment can be defined from the macrocosm and microcosm, which determines the speed and efficiency of transmitting material and energy among the symbiotic units. The symbiotic environment makes an important influence on the emergence and development of the symbiotic relationship among symbiotic cells, which involves with policy, spatial geographical, network and social environments. Respectively, they could be separately measured with related indexes (As TABLE 2), such as policy support, the degree of spatial aggregation, complete information, and so on.

TABLE 2 The Classification and Measure System of Symbiotic Environment

Classification	Measuring index	Classification	Measuring index
Policy support	Innovation policy	The completeness of information	Symbiotic subject behavior
	Technology transfer policy		Technical characteristic
	Incentive system		Technology maturity
	Tax credit		Market maturity
	Financial subsidies	Clustering level	Number of research institutions
	Financial support		Number of enterprises
The degree of networking	Venture capital investment	Sincerity degree	Trust valuation on government
	Intermediary institutions		Trust valuation on intermediaries
	Information platform（database）		Trust valuation on symbionts

2. Analysis on symbiosis mechanism

A. Symbiosis Mechanism

In the industrial cluster ecosystem, the key to effectively establish a symbiotic relationship and sustained over a long period of time is whether a certain symbiosis interface is built up among symbiotic units. The symbiosis interface is not only the foundation of symbiotic mechanism, but also the prime prerequisite for symbiotic system surviving and developing. The symbiosis interfaces are the channels to transmit information, material and energy among enterprises, universities, research institutions, government and intermediaries. In different symbiosis environments, a variety of symbiotic interfaces can be produced among symbiotic cells (As TABLE 3). Generally, the more symbiotic interfaces and the greater contact surface are built, the better, the activities among symbiotic units and symbiotic effects are.

Tab. 3 The Analysis of Symbiosis Interface between Enterprises and Other Symbiotic Units in Cluster Ecosystem

Symbiotic units	Symbiotic interface	Symbiotic mode	New symbiotic energy	Enterprise's new symbiotic energy
University, Research institution	Professional	Output high-quality talents, provide on-the-job training	Promote university Popularity	Talents who can make money
	Programs	Participate in planning and consultation in many ways	Consulting fees, visibility	To solve the enterprise management problems
		cooperative project	Research funds, the number of published papers	To solve important technical issues, to increase production value
		To build research & development centre	Research funds	To achieve long-term development services, access to new product new technology
		University and local government jointly manage science and technology park	R & D funds	Business profits, phased conversion results for the mass production, training innovative talents
		Running enterprises	R & D funds ,transforming Scientific Results	Business profits
	Market	Transfer of achievement in science and technology With technology market	Technology transfer fee	Highly technical maturity, technological achievements bringing commercial profit potential
Intermediaries	Information	Technology and innovation information communication	Agency fees	Industry, government and technology information
	Technology	Integrate technology innovation resources and Promote application of technology	Technical service fee	Solve technical problem
	Training	Providing skills and management training	Technical training fee	Enhance staff skills and management ability
Government	Fiscal policy	Establish and perfect market system, build a competitive market environment	Tax, GDP, Regional rapid development, industrial competitiveness	Market competition environment, expand financing channels
		Improve system policy for enterprise technology innovation	Perfect system of systems and policies	Technical standards, risk management system, intellectual property system, etc., good social and cultural environment
		To strengthen the construction of technical market, optimize the innovation pattern, improve the efficiency of innovation.	Tax, industrial competitiveness	Technology channels
	Cooperation	Promote resource flow and enterprise cooperation, increase the investment dynamics, strengthen the international technology cooperation	Tax, industrial competitiveness, Industrial structure	Funds, human resources, technology

B. The Reaction Mechanism of Symbiotic Relationship

The symbiotic relationship can also be described by symbiosis-degree, and Symbiosis-coefficient.

1) Symbiosis-degree

If in the industrial cluster eco-system there are two symbiotic units: enterprise(E) and university (U), quality parameters Z_E 、Z_U are corresponded to them, thus the symbiosis-degree δ_{EU} could be defined:

$$\delta_{EU}=\frac{dZ_E/Z_E}{dZ_U/Z_U}=\frac{Z_U}{Z_E}\frac{dZ_E}{dZ_U} \qquad (dZ_U \neq 0)$$

δ_{EU} reports the change scope of correlation and the degree of interaction energy between Z_E and Z_U ,which is the most directly reflects the symbiotic nature and law of development. As playing a major role in symbiotic relationship, the main quality parameters are only discussed.

Assumes that Z_E is the main quality parameter of the symbiosis unit E and Z_U is the main quality parameter of the symbiosis unit E, then the characteristics of symbiotic degree can be defined as $\delta_{EU}^{m}=\delta_{EU:}$

$$\delta_{EU}^{m}=\frac{Z_{mE}}{Z_{mU}}\frac{dZ_{mE}}{dZ_{mU}}$$

δ_{EU}^{m} reflects the symbiosis characteristics of between Z_E and Z_U:

If $\delta_{EU}^{m}=\delta_{UE}^{m}>0$，they are the positive symmetric symbiotic relationship;

If $\delta_{EU}^{m}\neq\delta_{UE}^{m}>0$，they are non-symmetric positive symbiotic State;

If $\delta_{EU}^{m}=\delta_{UE}^{m}<0$, they are reverse symmetric symbiotic relationship

If $\delta_{EU}^{m}\neq\delta_{UE}^{m}<0$,they are asymmetric inverse symbiotic relationship.

Based on this analysis, a conclusion can be drawn that to improve innovation performance and promote innovation ability, a city must attract a variety of innovation subject and resources to build an ecological industry cluster innovation system to improve innovation performance and promote innovation ability. If to build a symbiotic relationship and then to achieve collaborative innovation and development, it is more important to Upgrade the Symbiosis degree among enterprises, universities, research institutions, media and government

2) Symbiotic relationships

If θ_m represents the symbiotic relationship between enterprise(E) and university(U), an equation can be given:

$$\begin{cases}\theta_{E}^{m}=\dfrac{\left|\delta_{EU}^{m}\right|}{\left|\delta_{EU}^{m}\right|+\left|\delta_{UE}^{m}\right|}\\ \theta_{U}^{m}=\dfrac{\left|\delta_{UE}^{m}\right|}{\left|\delta_{EU}^{m}\right|+\left|\delta_{UE}^{m}\right|}\end{cases}$$

Thus it can be seen that there is "$\theta_{E}^{m}+\theta_{U}^{m}=1$"，and if θ_m represents symmetric symbiotic relationship regardless of positive or negative symbiotic relationship, there always is "$\theta_{E}^{m}=\theta_{U}^{m}=0.5$".Thus the symbiotic relationship between U and E could be differentiated from the symbiotic coefficients.

If $\theta_{E}^{m}=0$, there is no any symbiotic relationship between them, for E don't have any effect on U;

If $\theta_{E}^{m}=1$, there is a parasitic relationship between them, for U don't have any effect on E, but E affects U;

If $0<\theta_{E}^{m}<0.5$, there is a partial symbiotic relationship between them, for U have more effects on E;

If $\theta_{E}^{m}=0.5$, there is a reciprocal relationship between them, for U have equivalent effect on E;

If $0.5<\theta_{E}^{m}<1$, there is a partial symbiotic relationship between them, for E have more effects on U.

C. Symbiotic Energy Regulation Mechanism

Symbiotic energy is the key to maintain and develop symbiotic relationships. In the industrial clusters ecosystem based on city innovation, symbiotic energy is released from interaction with enterprises, universities, research institutions, intermediaries and government in cluster. The new energy being constantly produced, can strengthen incentive actions on symbiotic units. Further, a virtuous symbiotic circle is come into being to continuously promote the optimization and development of the system. On the contrary, no enough symbiotic energy would gradually degenerate, even dying. Whether symbiosis energy could be generated depends on the total factor symbiotic degree(δ_s)in the system.

If there are m (m≥2) nodes (symbiotic units) in industrial cluster eco-system, and Z_i respectively represents the qualitative parameter of each node, the relation between Z_s与 Z_i can be indicated that"$Z_s=f(Z_1,Z_2,\ldots,Z_i,\ldots,Z_m)$".If there are the total factor symbiotic degree(δ_s) and the symbiotic damping coefficient(λ), then the relation between them can be indicated :

$$\delta_s=\frac{1}{\lambda}\sum_{i=1}^{m}\zeta_i \qquad (0<\lambda)$$

For the innovation symbionts in the industrial clusters ecosystem based on city innovation, there is a clear correspondence between symbiotic energy (E_s) and the total factor symbiotic degree (δ_s), of the symbiosis density (ρ_s) and symbiotic dimension (η_s). It can be indicated that:

$$E_s=f(\delta_s,\ \rho_s,\ \eta_s)$$

Therefore, in order to add value to system efficiency or benefit the value-added system or expand the scale of development systems, some appropriate measures on those subjects must be taken with the industrial clusters ecosystem.

1) Enhance the interaction efficiency of symbiotic interface. By enhancing their own qualities of symbiotic units and all elements, improving symbiotic interface functions and bettering symbiotic relationships, transaction costs would be reduced and the resistance between the symbiotic interfaces would also be diminished.

2) Advance the symbiosis symbiotic degree between the units. The δ_s can elucidate the internal reactions among symbiotic units, and it plays a key role in generating energy and speeding up. The bigger δ_s is, the greater symbiotic energy could be generated within the system.

3) Keep the symbiosis density (ρ_s) and symbiotic dimension (η_s) in a distance range. In symbiotic system, both symbiotic units size in a certain region (symbiosis density) should be controlled, and the number of the same category bodies in the same unit (symbiotic dimension) should be kept at a constant level. In the process of system developing, if each procedure of cooperative innovation processes wanted to achieve symbiotic effects maximization, the levels of symbiosis density and symbiotic dimension should be regulated gradually achieving equilibrium value and maintaining this level state.

3. Conclusions

In particular symbiotic environment of city innovation, the symbiotic relationships and symbiosis mechanism were formulated from interactions and interdependence among symbiotic cells. Further, these symbiotic units cooperate with industry innovation as the core content to achieve overall function of entire system by virtue of the symbiosis mechanism and mode.

References

[1] A.E. Douglas. Symbiotic Interactions. Oxford: Oxford University Press, 1994: 3.

[2] Yu Xizhan, Sui Yinghui. The Industrial Clusters Ecosystem Based on City Innovation. Science & Technology Progress and Policy, 2010(21): 56-60.

[3] Li Jianjun. Silicon Valley Model and Its University—industry Innovation System. Renmin University of China Doctoral Dissertation, 2000(6):50-51.

[4] Si Shangqi, Cao Zhenquan, Feng Feng. Research on the Cooperation Mechanism of Institutions and Enterprises----A Symbiotic Theory and Analytical Framework. Science of Science and Management of S & T, 2006(06): 15-19.