The Dynamic Evolution Process of the Innovation Ecosystem Dominated Universities Based on LV-Logistic Model

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Abstract: The Establishment and cultivation of innovation ecosystem not only helps to enhance the competitiveness of the countries and regions, but also is the national and regional powerful thrusting and strategic objectives. Colleges in the regional innovation system as the core of ecological organization, it is also the source of original creation knowledge and technology, and provides mechanisms for diversification of the knowledge transfer. How to make the innovation ecosystem dominated in the perspective of regional development synergies and sustainable development has become an important issue. Based on this background, a synergetic evolution model of innovation ecosystem dominated by colleges and universities, named Lokata-Volterra, is put forward from ecological perspective. Through the mathematical analysis, the cooperative evolution law of all kinds of species in the innovative ecosystem is discussed. This paper takes Chongqing University National University Science Park and Beibei National University Science Park as the research object, and fuse Logistic mode to analyze the dynamic evolution process of innovation ecosystem. The results show that the innovation ecosystem, which is dominated by the University, needs to link the internal and external resources and the platform to realize the diversity of the main body of the ecosystem.

1. Introduction

With the advent of the global innovation 3.0 era, building a good symbiotic innovation ecosystem has gradually become an important way for each region to implement innovation development strategy. In 2016, the China's two sessions further strengthened that innovation is the first driving force to lead development, and proposed to accelerate and foster the creation of entrepreneurial innovation ecosystem. At the same time, the Chongqing Municipal Government has also promoted the establishment and cultivation of innovative ecological system to a regional core strategy, and clearly proposed that Chongqing should be built into a western innovation center during the 13th Five-Year Plan period. In this context, how to use limited resources to build a reasonable innovation ecosystem, and strengthen the collaborative innovation of industry, University and academic, has become the focus of promoting regional innovation capability.

Since the 1990s, scholars have gradually studied the systematic paradigm of innovation from the perspective of ecology. MOORE firstly applies innovation ecology to the level of enterprise development and management, and believes that innovation ecology is an economic consortium based on organizational interaction(Moore 1993).. ADNER defines the innovation ecosystem from the technical perspective as the enterprise realizes the contact with individuals or other actors, provides customer-oriented solutions and implements value output mechanism(Adner 2006). Chen Yun and others regard innovation ecosystem as a collaborative innovation system, and interpret the whole innovation activity as a process of social interaction(Chen 2013). Mei Liang summarized the origin, knowledge evolution and theoretical framework of the innovation ecosystem(Mei 2014).

Innovative ecosystems, analogous to natural ecosystems, evolve from random selection of factors into structured communities. At present, scholars have analyzed the elements of innovation

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ecosystem from the micro and macro levels. Zhang Weiwei believes that innovation ecosystem is composed of University and research institutions, venture capital, talent database, entrepreneurship, market service system, government policy, relationship network and GEM resource subsystems(Zhang 2015). Dong Jiajun distinguishes the relationship between micro-innovation ecosystem and enterprise innovation ecosystem, and re-divides the macro-innovation ecosystem, macro-innovation ecosystem and micro-innovation ecosystem(Dong 2017). Yang Rong analysis that innovation ecosystem is related to specific regional space and has hierarchy, which can be divided into national innovation ecosystem, regional innovation ecosystem and enterprise innovation ecosystem(Yang 2014).

From the research status at present, few scholars have conducted quantitative research on the dynamic evolution of innovation ecosystem based on the University-led perspective. This paper takes the innovation ecosystem dominated by Universities as a foothold, Chongqing University National University Science Park and Beibei National University Science Park ecosystem as the research object, carries on the empirical analogy analysis between the innovation ecosystem and the natural ecosystem, combines the Lokata-Volterra and Logistic model to study the dynamic evolution process of the ecosystem.

2. Dynamic evolution model framework of innovation ecosystem

The existing research results are mostly from the perspective of knowledge resources, ecological competition (enterprises) and specific industries to explore the innovation ecosystem. Based on the University-led perspective, the analysis of innovation ecosystem co-evolution model research results are less. Therefore, this paper puts forward a dynamic evolution model framework of regional innovation ecosystem dominated by universities, which is shown in Figure 1.

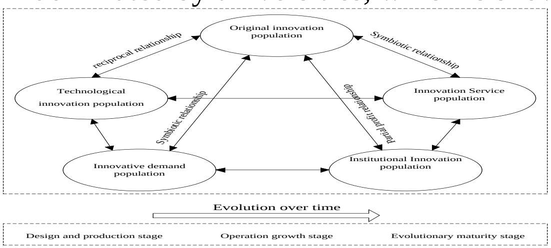

Fig. 1 the theoretical framework of the dynamic evolution model of innovation ecosystem

According to the characteristics of time sequence, from the perspective of technology and knowledge innovation evolution, the collaborative evolution process of regional innovation ecosystem dominated by universities can be divided into three stages: design stage, operation stage and evolution stage. In the design stage, the innovation ecosystem is mainly driven by the government-led system, and its innovation elements are not perfect. It mainly depends on the internal conditions of innovation resources formed by the system and subject attributes to attract the habitat preferences of the relevant ecological subjects. At the stage of operation , the innovation ecosystem develops gradually and forms a benign self-organizational cycle, that is, the basic elements and service organizations of the innovation ecosystem are already available, and the interaction (competition or cooperation) among the innovation population within the system is gradually formed, the flow of innovation resources represented by knowledge and information.

With the acceleration of the pace of knowledge diffusion, all kinds of innovative knowledge and technology are constantly emerging and looking for opportunities to achieve major breakthroughs and changes. At this time, the innovation ecosystem is gradually transformed from government-led to market participants cooperating with universities. In the mature stage, the regional innovation ecosystem generally has the ability of self-organizing evolution. Innovative products and services begin to export and produce benefits. New and more powerful hierarchical entities are emerging. Innovation population is self-debugging in the collision between market and society. As the number of innovation population in the system is increasing, eliminated and evolved, the heterogeneity and diversity in the system are increasing, and the innovation ecosystem is further evolving into more complex and orderly organizations.

3. The construction of the dynamic evolution model of innovation ecosystem

Considering the relationship and similarity between Regional Innovation Ecosystem and natural ecosystem, this paper combines the basic idea of Lokta-Volterra Model proposed by L.A. Lokta and other scholars(Zhao Guangfengg 2017) and constructs an Innovation Ecosystem Co-evolution Model based on ecological perspective, which mainly simulates some ecological phenomena and predation relationship between two populations. This paper presents the law of co-evolution among different species in the innovative ecosystem dominated by universities by mathematical analysis. At present, this model is mainly used in the field of industrial innovation. Hu Junyan (2011) used Lokta-Volterra model to analyze the competition relationship between industry-academic-research cooperation and internal research under limited R&D resource allocation. Chen Yu (2010) used Lokta-Volterra model and ecological theory to simulate the evolution path of China's photovoltaic industry ecological innovation system. Guo Yanzi (2013) used this model to study the mechanism of knowledge creation of industrial technology innovation network .

3.1 Model establishment

The ecological subject has different position of the ecological chain in the Regional Innovation Ecosystem. Universities and scientific institutions are the source and producer of innovative knowledge, while enterprises are the consumers and absorbers of innovative knowledge and technology. There are competition and cooperation relations among different ecological entities in the innovation ecosystem, they play different roles because of their different ecological niche sizes. As the producers of technology and knowledge, the original innovative population can provide knowledge and primitive technology for enterprises in the process of competition and upgrading. Enterprises, as adopter of knowledge and technology, they can apply the achievements provided by the original innovative population to the development and upgrading of its products and technologies, while the institutional innovative population represented by the government mainly plays a role of promotion and catalysis.

Based on the above ecology theory analysis, assumed that the innovation knowledge resources in the Regional Innovation Ecosystem are limited under the operation growth stage (t stage). In the innovation ecosystem dominated by universities, these two original innovation populations possess the innovation ability of X (t) and Y (t) respectively. The natural growth rate of innovation ability of the two populations are r1 and r2, and the coefficient of correlation competition between these two populations are a1 and a2 respectively. Restricted by innovative knowledge resources and market environment, the respected limit scale areK1 and K2. Taking the innovation ecosystem which composed of original innovation population, technological innovation population and related population as a benchmark perspective, the correlation coefficient is a1=1/a2. Among them, the influence of X on Y is expressed by a1, the influence of Y on X is expressed by a2. The Chongqing University National Science Park and Beibei National University Science Park’s Scale of innovation capability can satisfied the differential equations:

$$\begin{cases} X(t): \dfrac{dX}{dt} = r_1 X(1 - \dfrac{1}{K_1} X - \dfrac{a_1}{K_1} Y) \\ Y(t): \dfrac{dY}{dt} = r_2 Y(1 - \dfrac{1}{K_2} Y - \dfrac{a_2}{K_2} X) \end{cases}$$

Two straight lines representing population capacity are obtained:

$$\begin{cases} L_x: 1 - \dfrac{Y}{K_1} - a_1 \dfrac{X}{K_1} = 0 \\ L_y: 1 - \dfrac{Y}{K_2} - a_2 \dfrac{X}{K_2} = 0 \end{cases}$$

The upper form is the Lokta-Volterra model for two groups to acquire innovative knowledge under the constraint of innovation resources.

3.2 Analysis of dynamic evolution mechanism of model

The model shows that if the size of a population increases or decreases, the growth rate of the corresponding population will decrease or increase accordingly. By analyzing the equal slant between two populations. when $\frac{dX}{dt}=\frac{dY}{dt}=0$, the innovation ecosystem can achieve the corresponding equilibrium state, there are 4 equilibrium points, following are: Origin O(0,0)、P(K10) (intersection of line X=0 and $L_x: 1-\frac{Y}{K_1}-a_1\frac{X}{K_1}=0$ line)、Q(0 K2)(intersection of line Y=0 and $L_y: 1-\frac{Y}{K_2}-a_2\frac{X}{K_2}=0$ line) and the intersection of two straight (L_x and L_y) in the first quadrant.

Drawing two straight lines according to the equilibrium point. On the inner side of the line, the number of the population increases because $\frac{dX}{dt}$ and $\frac{dY}{dt}$ larger than zero; on the outer side of the line, the number of the population decreases because $\frac{dX}{dt}$ and $\frac{dY}{dt}$ smaller than zero. According to the intercept difference of the linear relationship obtained from the model equation and the numerical changes of K1、K2、a1 and a2, the following four kinds of position relations can be concluded:

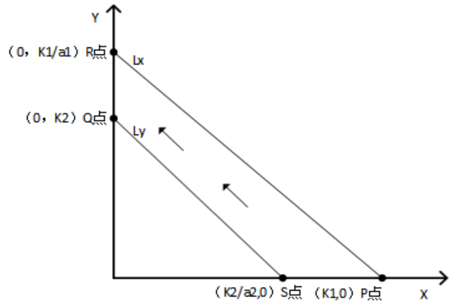

Fig. 2 fitting curve of model a X population wins

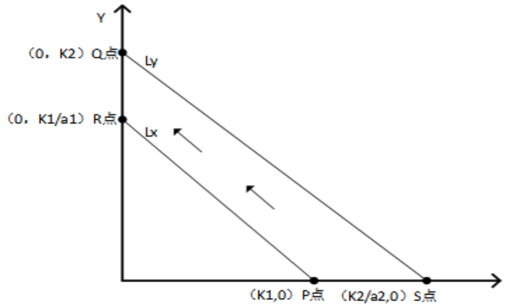

Fig. 3 fitting curve of model b Y population wins

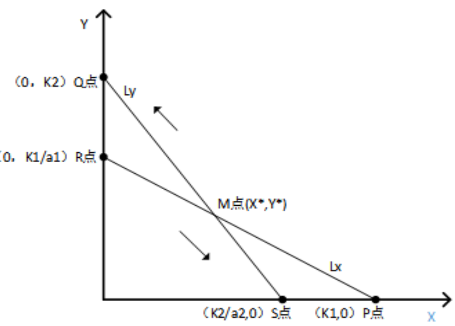

Fig. 4 fitting curve of model c Competition diffusion

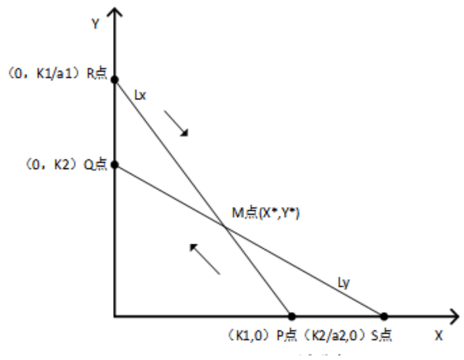

Fig. 5 fitting curve of model d Balance and symbiosis

As shown in figure 2, the intersection points of linear LX with abscissa are P(K1,0)and R(0, K1/a1),the intersection points of LY with abscissa are S(K2/a2,0) and Q(0, K2),among them, K1>K2/a2，K2<K1/a1. At this point, the capacity of the innovation population represented by line LY is less than that of LX. Therefore, in the region consisted of R point, Q point, S point and P point, the innovation population represented by LX has the space for continuous growth, while the innovation population represented by LY has reached the maximum capacity, and the final result is that the innovation population represented by LX wins and continues to grow. In figure 3, it can obtained the four points which are P(K1,0),R(0, K1/a1),S(K2/a2,0)and Q(0, K2), where K1<K2/a2，K2>K1/a1. In the region composed of R, Q, S and P points, the innovation population represented by LX has no possibility to continue to expand, while the innovation population represented by LY can maintain growth, and the final competition result is the innovation population represented by LY wins. In Figure 4, there is a relationship between the intersection point of line LX and line LY with abscissa and ordinate as follows: K2/a2>K1 and K1/a1>K2, these two lines intersect at point M(X*, Y*). In the triangle area made by M, S, P. Because of the above relationship between S point and P point value, the innovation population represented by LY can’t continue to grow, the capacity of innovation population represented by LX can continue to increase, the trend of development of these populations spread outward, the final competing result will depend on the initial capacity of the population and innovative environmental factors. K1<K2/a2，K2<K1/a1.

In figure 5, line LX intersects LY with point M(X*, Y*). In the region composed of M, P and S points, because dX/dt is greater than zero and dY/dt is less than zero, which indicates that the innovation population represented by LX can’t continue to grow, while the innovation population represented by linear LY can continue to grow, and the development is gradually closer to M point. The innovation population represented by LX and the innovation population represented by LY can achieve a competitive balance when LY is reached, both of them finally can reach co-existence state.

4. Case analysis of dynamic evolution process of innovation ecosystem

The National University Science Park of Chongqing University and the National University Science Park of Beibei are the key scientific bases for technological innovation and transformation of achievements in Chongqing. With the close cooperation of "industry-academic-research" and the effective integration of multi-resources, these two bases have initially formed the main force for the development and transfer of innovative knowledge. Taking the Regional Innovation Ecosystem as an example, this paper explore the dynamic evolution mechanism of innovation ecosystem dominated by universities.

4.1 Model parameter variable

From Schumpeter's writings of the connotation of innovation, it can see that any level of technological innovation capability in any link ultimately reflects on the economic output, while the economic output is concentrated in the independent operation of enterprises. Therefore, this paper chooses the accumulative graduating enterprises of these two Science Park as the core variables to measure the innovation level of technology and knowledge in the park. The number of incubating enterprises is an important manifestation of technology innovation transfer and development in Science Park, which is regarded as a variable of technology and knowledge innovation achievements in the park.

4.2 Population competition coefficient parameter

According to the above parameters, this article selects the data of China Torch Yearbook from 2008 to 2014, and uses SPSS22.0 to estimate the parameters of linear regression, quadratic, cubic and logistic models, to calculate the population competition coefficient. The result is as follows:

Table 1 model fitting and parameter estimation

Equation	Model Fitting					Estimates		
	R^2	F	df1	df2	Sig.	Constant	b1	b2
Quardratic1	0.940	23.660	2	3	0.015	44.100	2.525	-0.161
Quardratic2	0.932	20.491	2	3	0.018	38.700	9.532	-0.554

In the competition model of LV, the coexistence and competition between populations is mainly affected by their competition coefficients, so the competition coefficients in the LV model can be determined by the ratio of competition coefficients a1 to a2 in the equation, and the simulation and demonstration between populations can be carried out. According to the above LV coincidence model, the difference equation is:

$$\begin{cases} X_{(t+1)} - X_{(t)} = \gamma_1 X_{(t)} - \gamma_1 X_{(t)}^2 / K_1 - \gamma_1 a_1 X_{(t)} Y_{(t)} / K_1 \\ Y_{(t+1)} - Y_{(t)} = \gamma_2 Y_{(t)} - \gamma_2 Y_{(t)}^2 / K_2 - \gamma_2 a_2 Y_{(t)} X_{(t)} / K_2 \end{cases}$$

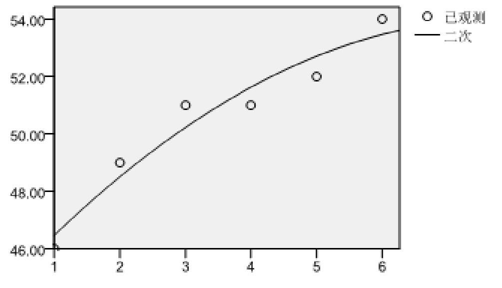

Fig.6 Model fitting curve of Chongqing University

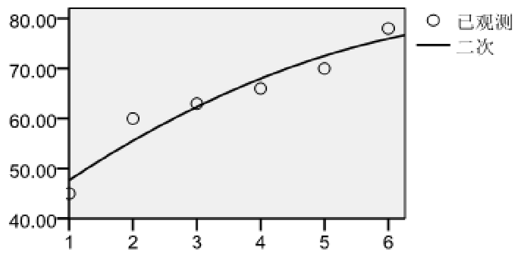

Fig.7 Model fitting curve of Beibei Science Park

Because of the X=a1Y relationship between the two populations, we can get them into the upper form:

$$\begin{cases} \Delta X = \gamma_1 a_1 Y - 2\gamma_1 a_1^2 Y^2 / K_1 \\ \Delta Y = \gamma_2 a_2 X - 2\gamma_2 a_2^2 X^2 / K_2 \end{cases}$$

Set $A_1 = \gamma_1 a_1$, $A_2 = -2\gamma_1 a_1^2 / K_1$, $A_3 = \gamma_2 a_2$, $A_4 = -2\gamma_2 a_2^2 / K_2$, the original formula can be simplified to:

$$\begin{cases} \Delta X = A_0 + A_1 Y_{(t)} + A_2 Y_{(t)}^2 + E_{(t)} \\ \Delta Y = A_0 + A_3 X_{(t)} + A_4 X_{(t)}^2 + E_{(t)} \end{cases}$$

If $K_1 = K_2$, then $A_2A_3 / A_1A_4 = a_1 / a_2$. In summary, the parameters obtained in this paper can be obtained:

$$A_2 = -2\gamma_1 a_1^2 / K_1 = -0.161 \quad A_3 = \gamma_2 a_2 = 9.532$$

$$A_1 = \gamma_1 a_1 = 2.525 \quad A_4 = -2\gamma_2 a_2^2 / K_2 = -0.554$$

Therefore, $\frac{a_1}{a_2} \times \frac{K_2}{K_1} = \frac{A_2A_3}{A_1A_4}$ =1.097. K1 and K2 are the ultimate scale (carrying capacity) of the innovative knowledge possessed by the two populations respectively. According to the incubator data, the K1 value of Chongqing University National University Science Park is 121, and the K2 value of Beibei National University Science Park is 96. So a1/a2=1.383, that is, the ratio of population competition coefficient is 1.383. Indicating that the role of Chongqing University National University Science Park on Beibei National University Science Park a1 is greater than Beibei National University Science Park on Chongqing University National University Science Park a2.

4.3 Natural growth rate of population and carrying capacity of innovation

As the number of incubators in the National University Science Parks which referred in paper conforms to the logistic model, the natural growth rates of the incubators can be deduced from the logistic model. shows that the overall fitting degree of the model is 0.952 and 0.933, the fitting effect is ideal. In addition, Table 3 shows that the significance level (P value) is 0.003 and 0.007 respectively through the analysis of variance of the logistic curve model. There was a statistically significant difference.

It can be obtained that the original model equation is effective which based on the above analysis. According to the logistic regression analysis results, the natural growth rates of knowledge quantity in National University Science Park of Chongqing University and National University Science Park of Beibei are r1=0.97 and r2=0.91respectively, the competition coefficient of the two populations is 1.383, and the ratio is a2=1,a1=1.383.

4.4 Simulation and prediction of population models

Through calculation, the parameters of LV model are as follows:

r1=0.97，r2=0.91，K1=121，K2=96，a1=1.383，a2=1

Put the parameters into the original equation, then it can get simulation results:

$$\frac{d_x}{d_t} = 0.97X - 0.00801653X^2 - 0.01108686XY$$

$$\frac{d_y}{d_t} = 0.91Y - 0.00947917Y^2 - 0.00947917XY$$

The formula (6) is simulated by Matlab7.0, and its simulation results are shown in Figure 8:

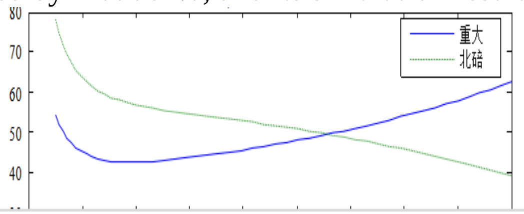

Fig 8 Numerical simulation results of two types of innovative ecological population

The simulation results show that the two models evolve at a stable rate after experiencing high-speed growth in an ideal external environment ecosystem. With the existing innovation capacity and scale, the development trend of Beibei National University Science Park may be gradually reduced, and its scale level will be equal to that of Chongqing University National University Science Park in a certain period of time. While, the Chongqing University National University Science Park rises steadily at a higher growth rate with its own strong innovation ability, and have the better evolution of the development speed.

This paper assumed that the" cumulative number of graduating enterprises" reflects the achievements and capabilities of technological and knowledge innovation in the park at certain extent, while the number of "incubating enterprises" represents the overall innovation and knowledge scale of the park and the richness of innovation subjects. According to the analysis of the data, Beibei National University Science Park, which combines the advantages of Southwest University, mainly focuses on agricultural and biological high-tech, and has a high conversion rate of research results. The number of graduating enterprises is slightly higher than Chongqing National University Science Park since 2009, while the number of incubating enterprises is slightly lower. While the Chongqing University National University Science Park is developing in multi- fields such as optoelectronics and communications, focusing on optoelectronic integration, electronic information, biomedicine, new materials and environmental protection technology. Its research scale is large and research cycle is relatively long. At the early establishment of this park, the number of incubators achieved peak, and still large-scale nowadays after the fierce competition.

In a word, there is not only cooperation but also competition among populations in the innovation ecosystem, competition and cooperation transform each other to promote the overall development. Innovation is the result of social interaction among multiple innovation stakeholders, and each innovation subject is interdependent in the process. As an important source of regional innovative knowledge and technology development, universities have formed knowledge transfer mechanisms such as project cooperation, enterprise creation and personnel support, which effectively promote the internal transfer of tacit knowledge in the innovation ecosystem .As two National University Science and Technology Parks affiliated to Chongqing Municipality, they should pay more attention to mutual cooperation and complement each other in terms of policy resources, talent elements and technological innovation, thus forming a win-win situation of competition and cooperation, and ultimately promoting the creation of the whole region.

5. Conclusions and recommendations

In this paper, we introduce the Lokta-Volterra model to simulate the dynamic evolution of the main groups. Combined with the demonstration of Chongqing University National University Science Park and Beibei National University Science Park. The main conclusions are as follows:

(1) Colleges as the leading innovative ecosystem should adhere to the academic support, and strive to form a collaborative ecological situation. At present, society is changing from "industrial economy" to "knowledge economy", enterprises and organizations should continue absorb knowledge innovation to gain competitive advantage. In addition to the traditional role of providing trained personnel and basic knowledge, universities are also the source of information, technology and regional development. Because universities have the function of knowledge creation and diffusion at the same time, it requires them to assume the role of supporting force for technological innovation and knowledge diffusion. The science and Technology Parks of the two national universities in Chongqing should make full use of the scientific research power and advanced experimental equipment, combine with their own advantageous industries to form the innovative source of radiation guidance and scientific development, so as to promote the industrial upgrading and structural adjustment of Chongqing and its surrounding areas.

(2) The national university science park should be an organic part of the innovation ecosystem, and should feed back to the University (as the main body of innovation). In general, the national university science park is not only to promote the incubation and transformation of high-tech achievements, but also to give play to the internal attraction of gathering talents and promote the cultivation of innovative students. Learning is the essence of innovation process, and education is more conducive to the interaction between individuals and the flow of tacit knowledge. When national university science park develops to a certain scale and level, universities should make use of its resource advantages to promote the integration of industry-academic-research collaboration, to feed back the successful experience and platform of incubating enterprises to the curriculum and teaching of universities, cultivate high-quality technical and managerial talents. The result of the model analysis shows that only when the key subject of innovative talents is enriched, diversified and hierarchical can more innovative resources and knowledge flow and development be promoted,

then, the National University Science Park can make sustained progress.

(3) The national university science park also should actively link up the external elements of innovation ecosystem, participate in regional, national and international network and exchange platform proactively, to provide more opportunities for enterprise development. capital operation, business services and public policies play an interdependent role in the formation and development of national university science park, therefore, external innovation resources and platforms can not be ignored for the stimulating innovation development of national university science parks. Meanwhile, the healthy national university science park and science business incubator will produce massive innovative knowledge, and spill over through enterprises, talents, technology and other ways. This requires national university science park should also actively link up the external innovation elements, thus intensifying the diffusion and flow of innovative knowledge, which has a great impetus to the regional innovation and economic development.

References

[1] ADNER R.,2006. Match your innovation strategy to your innovation ecosystem[J]. Harvard Business Review, 84(4),pp. 98-107.

[2] Yun, Chen, Yuanqiong, He, Zhenhong, Zhou, 2013. Research on the construction of regional innovation ecosystem dominated by Research Universities [J]. Scientific and technological progress and Countermeasures, 30(14), pp. 32-36.

[3] Kaijun, Dong,2017. Research on innovation ecosystem from microcosmic perspective: concept and definition [J]. Scientific and technological progress and Countermeasures, 34(8),pp. 9-14.

[4] Yanzi, Guo, Zhong, Wu,2012. Research on knowledge creation mechanism of industrial technology innovation network based on Lokta-Volterra model [J]. Information magazine, (6),pp. 139-143.

[5] MOORE J F.,1993. Predators and prey: a new ecology of com-petition[J]. Harvard Business Review, 71(3), pp.75.

[6] Liang, Mei, Jin, Chen, and Yang, Liu, 2014. Innovation Ecosystem: origin, knowledge evolution and theoretical framework [J]. Science Research, 32(12), pp. 1771-1780.

[7] Rong, Yang, 2014. Definition, characteristics and construction of innovation ecosystem [J]. science and management, (3),pp. 12-17.

[8] Weiwei, Zhang, Changliu, Wang, Yubin, Zhang ,2015. Creating innovative ecosystem and cultivating innovative firms -- Based on the survey of innovative enterprises in Nanjing [J]. Special Economic Zone, (11),pp. 40-43.

[9] Guangfeng, Zhao, Zhiqiang, Ma, Yongyue, Zhu , 2017. Construction and operation mechanism of innovation ecosystem in Colleges and Universities [J]. China Science and Technology Forum, (1),pp. 40-46.