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Study on Symbiotic Evolution Mechanism of Independent Innovation Ecosystem

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Abstract— *From linear innovation 1.0 to System Innovation 2.0 and then to ecosystem innovation 3.0, the innovation subject has gradually changed from a single enterprise to an innovation ecosystem centered on core enterprises. As a dynamic system, the innovation ecosystem is similar to the natural ecosystem and also has its evolution process. The units within the system will coexist and evolve with the changes of core enterprises. As the basic industry of China's economic construction, the independent innovation ability of agricultural enterprises is related to Chinese economic development. This paper studies the symbiotic evolution process of internal units of independent innovation ecosystem from the perspective of "center periphery", and explores the evolution law of four populations in the system by using logistic model and numerical simulation. The results show that the R&D population (R&D POP), enterprise population (enterprise POP), application population (application POP) and intermediary population (intermediary POP) of independent innovation ecosystem affect each other, And the mutually beneficial symbiosis model is the best direction of system evolution. Finally, the case of agricultural enterprise Yuan Longping Agricultural High Tech Co., Ltd. is described in detail, so as to provide reference for other agricultural enterprises.*

Keywords— *Innovation Ecosystem; Symbiosis Evolution; Independent Innovation; Numerical Simulation.*

I. Introduction

Innovation is the driving force of scientific and technological development. At present, China’s technological development has entered a new stage, which needs a new development pattern and innovative ideas. The "14th five year plan" and the outline of long-term goals for 2035 put forward that we should adhere to the core position of innovation in the overall situation of China’s modernization and take the self-improvement of science and technology as the strategic support for national development. On the one hand, since entering the 21st century, China has attached great importance to the important position of innovation in scientific and technological development, and has made considerable achievements. According to the data released by China’s Ministry of science and technology, China’s R&D investment in the whole society has increased from 1.42 trillion yuan in 2015 to about 2.4 trillion yuan in 2020, of which the basic research funds have nearly doubled over 2015. According to the "global innovation index" released by the world intellectual property organization, China’s ranking has jumped from 29th in 2015 to 14th in 2020, with R&D funds of 297.43 billion US dollars, Accounting for 17.5% of the world, laying the foundation for China to build an innovative country. On the other hand, there are still some shortcomings and weaknesses in the innovation and development of Chinese enterprises. First of all, China’s independent innovation ability is not strong, and the situation that key core technologies are controlled by others still needs to be solved urgently. The lesson of the "ZTE incident" tells us that only by mastering the core science and technology can we have a voice in the international community. Secondly, the supply of high-tech achievements is not perfect, the support for the supply chain and industrial chain is not enough, and the innovation ability of enterprises needs to be improved. Innovation requires a long cycle and large investment. Enterprises pursuing short-term profits often do not choose to make profits through innovation. Finally, the utility of the innovation system has not been maximized, and how enterprises, universities and scientific research institutions cooperate to achieve the maximum innovation output needs to be further studied. It can be seen that under the complex innovation environment, the innovation paradigm has gone through the stages of 1.0 (closed innovation, closed innovation, innovation sources are limited within the enterprise), 2.0 (open innovation, i.e. "non local invention", extensive access to innovation sources from outside the enterprise), and then 3.0(embedded innovation, embedded / symbiotic innovation, enterprise innovation behavior pays more attention to resource integration and symbiotic development) [1].

No. 1 central document pointed out that we should speed up the modernization of agriculture and rural areas, adhere to the independent and self strengthening of agricultural technology, and make up our minds to fight the seed industry and turn over the modern economy and modern food technology to support the grain security. In the two sessions of the NPC and CPPCC in 2021, the agriculture modernization was also pointed out in the same period in 2021.Seed is the key to food security. We should strengthen the protection and utilization of germplasm resources and the breeding and popularization of excellent varieties, and tackle key core agricultural technologies. We should solve the bottleneck problems of China’s agriculture, such as large but not strong, many but not worried, and weak competitiveness. We should promote agriculture from increasing production to improving quality, so as to achieve high-quality development. Agricultural enterprises are an important part of the innovation ecosystem. In order to compete for the limited resources in the system, the innovation units compete or cooperate with each other, which changes with the change of the symbiotic evolution of the system. Therefore, exploring the evolution process and the best evolution direction of the independent innovation ecosystem of agricultural enterprises is of great significance to improve the independent innovation ability of agricultural enterprises in China.

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II. Literature Review

The emergence of innovation ecosystem can be traced back to the concept of business ecosystem put forward by Moore [2] in the decline of competition, which considers the innovation environment of enterprises from the perspective of bionics. In 2004, the American Council on competitiveness took the lead in putting forward the concept of "innovation ecosystem", pointing out that " Innovation is not a linear process, but an ecosystem. There are many relationships in many aspects of this ecosystem... Enterprises, workers, government and researchers establish a relationship to form an innovation ecosystem." [3] since then, scholars have focused on the innovation ecosystem from its action mechanism [4] - [5], evaluation methods [6] - [7], structural evolution [8] and resource integration [9], value creation [10] - [11], knowledge diffusion [12], system creation process [13]. As a nonlinear and self-organizing dissipative structure, innovation ecosystem has similar characteristics to general biological ecosystem. Under the background of continuous optimization of innovation and entrepreneurship environment and continuous integration of heterogeneous resources, there are more and more studies on the symbiotic evolution of innovation ecosystem. Ou Zhonghui(2017) analyzed the evolution process of symbiotic units of core organizations and supporting organizations in the system [14]. Bao Yuhang (2018) constructed an evaluation system of symbiotic evolution strategy of enterprise innovation ecosystem based on the symbiotic evolution mechanism of innovation ecosystem [15]. Liu Pingfeng (2020) studied three populations (Research Group, development group and Application Group) in innovation ecosystem Symbiotic evolution model, and analyzed the symbiotic evolution relationship between species groups under different symbiotic relationships [16]. Zhang Xiaonan (2021) focused on strategic emerging industries, divided the population in the system into enterprise population, university scientific research institution population and socialized Internet user population, and revealed its evolution law [17]. Moore divides the evolution process of innovation ecosystem into four stages, namely, formation stage, expansion stage, maturity stage and transformation stage. In the early stage of system formation, the core symbiotic subjects first occupy a place in the system by virtue of their own innovation ability and innovation resources, and then attract other symbiotic units to join. The innovation ability of each symbiotic unit is different and will occupy a position after entering the system. With the same niche, the prototype of innovation ecosystem has been formed. On the one hand, the core enterprises in the expansion period follow the open concept, integrate more external resources, attract more symbiotic units, and realize the expansion of innovation boundary. On the other hand, with the development and expansion of symbiotic units, there will be niche overlap among symbiotic units, which will lead to competition. In the mature period. The symbiotic units of the system have increased sharply, the niche has become increasingly rich, and the system boundary has expanded to the maximum. The maturity of the system also increases the number of homogeneous species in the system, the system repels heterosexual thinking, becomes a "closed system", the positive entropy is increasing, and the system tends to "dead state "At this stage, the whole system needs to be innovated and transformed to establish an ecosystem that is completely opposite to the original system. On the whole, the symbiotic evolution process of the innovation ecosystem is a circular process of "disorder order disorder". Generally speaking, the population scale change of the innovation ecosystem in the evolution process is shown in the figure below.

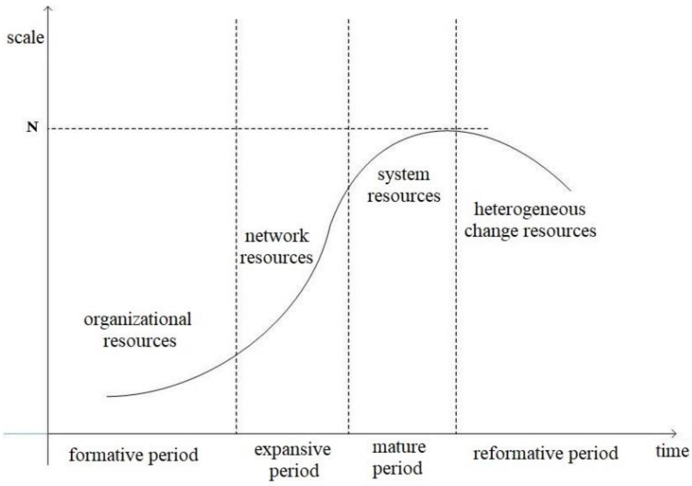

Fig. 1. Evolution process of innovation ecosystem

Under the background of the rapid development of information technologies such as the Internet, big data, cloud computing and artificial intelligence, independent innovation enterprises have a unique innovation ecosystem, which not only maintains the core position of enterprise knowledge production, but also evolves many collaborative innovation modules and symbiotic networks due to environmental changes such as the information revolution. Chen Jin (1994) first proposed independent innovation [18], it is considered that independent innovation includes three aspects: first, strengthen the original efforts to obtain more technology discovery and creation on this basis. Second, realize the integration of innovation and integrate various technologies to form products and markets with their own core competitiveness. Third, digest, absorb and re innovate on the basis of introducing foreign advanced technologies [19]. Chen Wei (2011) pointed out that the development of China's independent innovation capability can be promoted by building an internal and external support system for independent innovation [20]. Yan Yongcai (2015) studied the path of integrating heterogeneous resources in the system based on the innovation ecosystem, and constructed the enterprise innovation ecosystem and independent innovation model under the new economic normal [21]. Zhou Xuefeng (2020) based on the perspective of overseas M&A, it is pointed out that the evolution path of independent innovation management of enterprises is a process from extension innovation capability to endogenous innovation capability [22]. Chen Jin (2020) pointed out that in the face of "neck" technical problems, strategic guidance can be carried out through the strategic vision of "bottom line thinking + comprehensive independent innovation endogenous capability" [23].

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To sum up, there are many studies on the symbiotic evolution mechanism of independent innovation and innovation ecosystem at this stage, but few scholars study the symbiotic evolution mechanism of independent innovation ecosystem, and there are few studies on agricultural enterprises. Therefore, this paper mainly analyzes the symbiotic evolution process of independent innovation ecosystem, and constructs logistic model based on four population ecosystem model, discuss the equilibrium point and stable point in the symbiotic evolution model according to the Jacobian matrix, use Matlab for data simulation, try to explain the symbiotic evolution law of various groups in the independent innovation ecosystem under different symbiotic relationships, and make a case analysis through Yuan Longping Agricultural High Tech Co., Ltd., a typical representative of independent innovation, in order to open up the "black box" of ecosystem Symbiosis Evolution Law.

III. SYMBIOTIC EVOLUTION MODEL OF INDEPENDENT INNOVATION ECOSYSTEM

According to the symbiotic evolution theory, only by establishing a sustainable cooperative relationship of complementary resources can species form a favorable position in the population, and eventually realize the continuous evolution and development of the whole population [24]. The symbiotic evolution of population mainly includes three parts: symbiotic unit, symbiotic environment and symbiotic model. According to biological metaphor, these three parts are mainly reflected in the innovation ecosystem: symbiotic unit refers to various groups in the system, symbiotic environment refers to the external innovation environment, and symbiotic model refers to the form of interconnection between populations,[16] including mutually beneficial symbiosis, competitive symbiosis, beneficial symbiosis, harmful symbiosis and independent symbiosis. The change law between biological populations based on ecology can be described by logistic model, that is, biological populations will show exponential growth in a short time (Malthus model). However, with the continuous expansion of population size, the increase of coefficient is hindered, the growth rate of population slows down and gradually tends to equilibrium [25].

3.1 Composition of independent innovation ecosystem

The independent innovation ecosystem originates from the general innovation ecosystem and is different from the general innovation ecosystem. According to the characteristics of the independent innovation ecosystem, its center is the core innovation subject. With its own innovation advantages, the core subject attracts universities, scientific research institutions, platform enterprises, upstream and downstream suppliers, governments, etc., forming a network structure to realize capital, information and technology in this paper, the population in the system is divided into R&D population (universities and scientific research institutions), enterprise population (platform enterprises and high-tech enterprises), application population (customers, suppliers and dealers) and intermediary population (talent intermediary, science and technology intermediary and financial intermediary)Core enterprises and R&D groups are the main body of innovation output. Platform enterprises and high-tech enterprises give them additional technical support. These two groups play the role of "producer" in the system; application groups are responsible for putting innovation output into the market, obtaining returns and playing the role of "consumer" in the system. In addition, they are similar to the "decomposer" in the food chain, there are also intermediary species in the system. See the figure below for the specific composition.

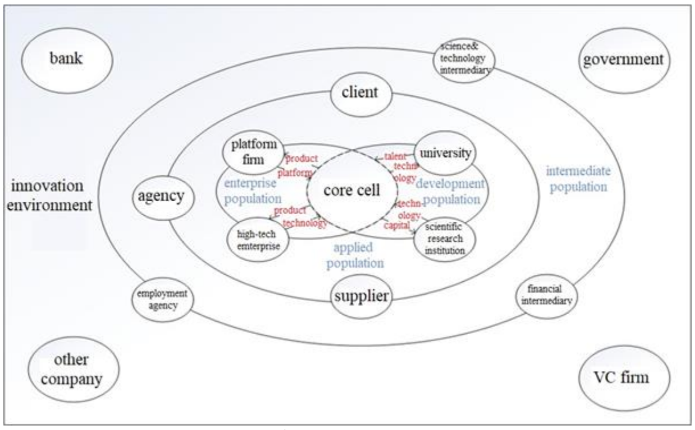

Fig. 2. Composition of independent innovation ecosystem

3.2 Model construction of symbiotic evolution

Based on the above analysis, this paper makes the following assumptions with the help of previous studies: Firstly, the number of individuals of the innovation population in the system is continuous without considering the difference in life span. Secondly, in the innovation resource environment, the maximum value of the population is n. when the maximum value is reached, the number of the population will not increase. Thirdly, in a certain innovation resource environment, the increase of the innovation population density has no lag on the growth rate. Fourthly, the scale of the main body in the system indicates the status of the ecosystem. When the scale of the main body expands, it indicates that the ecosystem is in good development. When the scale of the main body shrinks, it indicates that the ecosystem is in decline. Therefore, the symbiotic evolution model of the independent innovation ecosystem of the four populations is as follows:

$$\begin{aligned}
\frac{dy_1(t)}{dt} &= r_1 y_1 \left(1-\frac{y_1}{N_1}-m_{12}\frac{y_2}{N_2}-m_{13}\frac{y_3}{N_3}-m_{14}\frac{y_4}{N_4}\right)\\
\frac{dy_2(t)}{dt} &= r_2 y_2 \left(1-\frac{y_2}{N_2}-m_{21}\frac{y_1}{N_1}-m_{23}\frac{y_3}{N_3}-m_{24}\frac{y_4}{N_4}\right)\\
\frac{dy_3(t)}{dt} &= r_3 y_3 \left(1-\frac{y_3}{N_3}-m_{31}\frac{y_1}{N_1}-m_{32}\frac{y_2}{N_2}-m_{34}\frac{y_4}{N_4}\right)\\
\frac{dy_4(t)}{dt} &= r_4 y_4 \left(1-\frac{y_4}{N_4}-m_{41}\frac{y_1}{N_1}-m_{42}\frac{y_2}{N_2}-m_{43}\frac{y_3}{N_3}\right)
\end{aligned} \qquad (1)$$

$y_\alpha(0)=y_{\alpha 0}$ ，（α =1, 2, 3, 4）

Among them, y_1、y_2、y_3、y_4They are the scale of R&D population, enterprise population, application population and intermediary population, r_α is the growth rate within the population, N_α means the maximum carrying capacity of innovative resources and environment in the population, and the symbiosis degree $m_{\alpha\beta}$ for population β to population α .The size of symbiotic effect represents the strength of symbiotic

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relationship, and positive and negative represent different symbiotic modes. $y_{\alpha 0}$ represents the initial population size, $1-\frac{y_\alpha}{N_\alpha}$ based on the value of symbiosis degree, the symbiosis relationship table of four species independent innovation ecosystem is obtained.

TABLE 1. relationship between symbiosis coefficient and symbiosis mode

Relevant values of M	Symbiotic model	Characteristics among populations
$m_{\alpha\beta}=0$ ($\alpha,\beta=1,2,3,4$ 且 $\alpha\neq\beta$)	Independent symbiosis	The four species do not affect each other and are independent of each other
$m_{\alpha\beta}>0$, $m_{\beta\alpha}>0$	Competitive symbiosis	There is a competitive relationship among the four species, and the symbiosis coefficient is negative
$m_{\alpha\beta}>0$, $m_{\beta\alpha}<0$	Parasitic symbiosis	There are parasitic relationships among the four species, one species benefits and the other species suffers
$m_{\alpha\beta}>0$, $m_{\beta\alpha}=0$	Partial pest symbiosis	There are partial damage symbiotic relationships among the four species, one species is damaged and the other species has no impact
$m_{\alpha\beta}<0$, $m_{\beta\alpha}=0$	Partial benefit symbiosis	There is a symbiotic relationship of partial benefit among the four kinds of populations. One kind of population benefits and the other has no impact
$m_{\alpha\beta}<0$, $m_{\beta\alpha}<0$	Mutually beneficial symbiosis	There are mutually beneficial symbiotic relationships among the four species, and the symbiotic coefficient is positive

3.3 Stability analysis of symbiotic evolution

The symbiotic evolution process of independent innovation ecosystem is the process of dynamic game among the four populations. Due to the limited resources in the system, homogeneous innovation units may compete for scarce resources. On the other hand, in order to create new resources, complementary enterprises often realize through cooperation. The flow and integration of such resources and the generation of new resources are just the same. It is the source of the development of innovation ecosystem. Therefore, resources play an important role in the symbiotic relationship of symbiotic units of innovation ecosystem. In order to explore the dynamic evolution process between populations, the stability of equation group (1) is analyzed to obtain equation group (2).

$$\begin{cases} r_1y_1(1-\frac{y_1}{N_1}-m_{12}\frac{y_2}{N_2}-m_{13}\frac{y_3}{N_3}-m_{14}\frac{y_4}{N_4})=0 \\ r_2y_2(1-\frac{y_2}{N_2}-m_{21}\frac{y_1}{N_1}-m_{23}\frac{y_3}{N_3}-m_{24}\frac{y_4}{N_4})=0 \\ r_3y_3(1-\frac{y_3}{N_3}-m_{31}\frac{y_1}{N_1}-m_{32}\frac{y_2}{N_2}-m_{34}\frac{y_4}{N_4})=0 \\ r_4y_4(1-\frac{y_4}{N_4}-m_{41}\frac{y_1}{N_1}-m_{42}\frac{y_2}{N_2}-m_{43}\frac{y_3}{N_3})=0 \\ y_\alpha(0)=y_{\alpha 0},\ (\alpha=1,2,3,4) \end{cases} \quad (2)$$

By solving equation group (2), 16 equilibrium points of symbiotic evolution of independent innovation ecosystem can be obtained, which are $P_1(0,0,0,0)$, $P_2(N_1,0,0,0)$, $P_3(0,N_2,0,0)$, $P_4(0,0,N_3,0)$, $P_5(0,0,0,N_4)$, $P_6(0,0,\frac{N_3(1-m_{34})}{1-m_{43}m_{34}},\frac{N_4(1-m_{43})}{1-m_{43}m_{34}})$, $P_7(0,\frac{N_2(1-m_{24})}{1-m_{42}m_{24}},0,\frac{N_4(1-m_{42})}{1-m_{42}m_{24}})$, $P_8(0,\frac{N_2(1-m_{23})}{1-m_{32}m_{23}},\frac{N_3(1-m_{32})}{1-m_{32}m_{23}},0)$, $P_9(\frac{N_1(1-m_{14})}{1-m_{41}m_{14}},0,0,\frac{N_4(1-m_{41})}{1-m_{41}m_{14}})$, $P_{10}(\frac{N_1(1-m_{13})}{1-m_{31}m_{13}},0,\frac{N_3(1-m_{31})}{1-m_{31}m_{13}},0)$, $P_{11}(\frac{N_1(1-m_{12})}{1-m_{21}m_{12}},\frac{N_2(1-m_{21})}{1-m_{21}m_{12}},0,0)$, $P_{12}(0, p1, p2, p3)$, $P_{13}(p4, 0, p5, p6)$, $P_{14}(p7, p8, 0, p9)$, $P_{15}(p10, p11, p12, 0)$, $P_{16}(p13, p14, p15, p16)$. The Jacobian matrix of the system is:

$$\begin{pmatrix} r_1-\frac{2r_1y_1}{N_1}-m_{12}r_1\frac{y_2}{N_2}-m_{13}r_1\frac{y_3}{N_3}-m_{14}r_1\frac{y_4}{N_4} & -\frac{r_1y_1m_{12}}{N_2} & -\frac{r_1y_1m_{13}}{N_3} & -\frac{r_1y_1m_{14}}{N_4} \\ -\frac{r_2y_2m_{21}}{N_1} & r_2-\frac{2r_2y_2}{N_2}-m_{21}r_2\frac{y_1}{N_1}-m_{23}r_2\frac{y_3}{N_3}-m_{24}r_2\frac{y_4}{N_4} & -\frac{r_2y_2m_{23}}{N_3} & -\frac{r_2y_2m_{24}}{N_4} \\ -\frac{r_3y_3m_{31}}{N_1} & -\frac{r_3y_3m_{32}}{N_2} & r_3-\frac{2r_3y_3}{N_3}-m_{31}r_3\frac{y_1}{N_1}-m_{32}r_3\frac{y_2}{N_2}-m_{34}r_3\frac{y_4}{N_4} & -\frac{r_3y_3m_{34}}{N_4} \\ -\frac{r_4y_4m_{41}}{N_1} & -\frac{r_4y_4m_{42}}{N_2} & -\frac{r_4y_4m_{43}}{N_3} & r_4-\frac{2r_4y_4}{N_4}-m_{41}r_4\frac{y_1}{N_1}-m_{42}r_4\frac{y_2}{N_2}-m_{43}r_4\frac{y_3}{N_3} \end{pmatrix}$$

The stability points and stability conditions of the system are analyzed according to the characteristics of Jacobian matrix: if the eigenvalues of the coefficient matrix have at least one positive real number, it is not an equilibrium state; if all the eigenvalues are negative real parts, it is an equilibrium state. The equilibrium points and stability conditions of symbiotic evolution in the system are shown in the table below.

3.4 Numerical simulation

Through numerical simulation and image display, the change law and evolution process of symbiotic evolution mode of four populations can be more intuitively presented [16]. Based on MATLAB 2018, the evolution path between species and populations of four populations under different symbiotic modes is simulated. It is assumed that under the five symbiotic modes, the population can reach the maximum scale, the maximum scale is 1000, that is, N1 = N2 = N3 = N4 = 1000, and the initial scale is 100, that is, Y1(0)=y2(0)=y3(0)=y4(0)=100, the evolution cycle is 400, i.e. t = 400. The natural growth rate of various groups is determined according to the characteristics of various groups. Based on previous studies, the growth rate of various groups is controlled between 0-1. Due to the dominant R&D population in the independent innovation ecosystem and the auxiliary role of enterprise species, the natural growth rate is determined as 0.2

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and 0.15 respectively. As a more traditional symbiotic unit, its growth rate is lower than that of the emerging enterprise population, which is determined as 0.1. The intermediary population plays the smallest role in the independent innovation ecosystem and only plays the ability to provide some innovation resources for the innovation units in the system, so its natural growth rate is determined as 0.05, that is, $r_1 = 0.2$, $r_2 = 0.15$, $r_3 = 0.1$, $r_4 = 0.05$.

TABLE 2: stable points and conditions of system symbiotic evolution

Equilibrium point	characteristic value	Stability conditions
P1	All positive numbers	Not a stable point
P2	There is a negative value	m21>1,m31>1,m41>1
P3	There is a negative value	m12>1,m32>1,m42>1
P4	There is a negative value	m13>1,m23>1,m43>1
P5	There is a negative value	m14>1,m24>1,m34>1
P6	There is a positive value	Not a stable point
P7	There is a positive value	Not a stable point
P8	There is a positive value	Not a stable point
P9	There is a positive value	Not a stable point
P10	There is a positive value	Not a stable point
P11	There is a positive value	Not a stable point
P12	There is a negative value	$\begin{cases} \frac{(m_{42}+m_{43}+m_{23}m_{32}-m_{23}m_{42}-m_{32}m_{43}-1)}{m_{23}m_{32}+m_{24}m_{42}+m_{34}m_{43}-m_{23}m_{34}m_{42}-m_{24}m_{32}m_{43}-1}>0 \\ \frac{(m_{23}+m_{24}-m_{23}m_{34}-m_{24}m_{43}+m_{34}m_{43}-1)}{m_{23}m_{32}+m_{24}m_{42}+m_{34}m_{43}-m_{23}m_{34}m_{42}-m_{24}m_{32}m_{43}-1}>0 \\ \frac{(m_{32}+m_{34}-m_{24}m_{32}+m_{24}m_{42}-m_{34}m_{42}-1)}{m_{23}m_{32}+m_{24}m_{42}+m_{34}m_{43}-m_{23}m_{34}m_{42}-m_{24}m_{32}m_{43}-1}>0 \end{cases}$
P13	There is a negative value	$\begin{cases} \frac{(m_{41}+m_{43}+m_{13}m_{31}-m_{13}m_{41}-m_{31}m_{43}-1)}{m_{13}m_{31}+m_{14}m_{41}+m_{34}m_{43}-m_{13}m_{34}m_{41}-m_{14}m_{31}m_{43}-1}>0 \\ \frac{(m_{13}+m_{14}-m_{13}m_{34}-m_{14}m_{43}+m_{34}m_{43}-1)}{m_{13}m_{31}+m_{14}m_{41}+m_{34}m_{43}-m_{13}m_{34}m_{41}-m_{14}m_{31}m_{43}-1}>0 \\ \frac{(m_{31}+m_{34}-m_{14}m_{31}+m_{14}m_{41}-m_{34}m_{41}-1)}{m_{13}m_{31}+m_{14}m_{41}+m_{34}m_{43}-m_{13}m_{34}m_{41}-m_{14}m_{31}m_{43}}>0 \end{cases}$
P14	There is a negative value	$\begin{cases} \frac{(m_{41}+m_{42}+m_{12}m_{21}-m_{12}m_{41}-m_{21}m_{42}-1)}{m_{12}m_{21}+m_{14}m_{41}+m_{24}m_{42}-m_{12}m_{24}m_{41}-m_{14}m_{21}m_{42}-1}>0 \\ \frac{(m_{12}+m_{14}-m_{12}m_{24}-m_{14}m_{42}+m_{24}m_{42}-1)}{m_{12}m_{21}+m_{14}m_{41}+m_{24}m_{42}-m_{12}m_{24}m_{41}-m_{14}m_{21}m_{42}-1}>0 \\ \frac{(m_{21}+m_{24}-m_{14}m_{21}+m_{14}m_{41}-m_{24}m_{41}-1)}{m_{12}m_{21}+m_{14}m_{41}+m_{24}m_{42}-m_{12}m_{24}m_{41}-m_{14}m_{21}m_{42}-1}>0 \end{cases}$
P15	There is a negative value	$\begin{cases} \frac{(m_{12}+m_{13}-m_{12}m_{23}-m_{13}m_{32}+m_{23}m_{32}-1)}{m_{12}m_{21}+m_{13}m_{31}+m_{23}m_{32}-m_{12}m_{23}m_{31}-m_{13}m_{21}m_{32}-1}>0 \\ \frac{(m_{21}+m_{23}-m_{13}m_{21}+m_{13}m_{31}-m_{23}m_{31}-1)}{m_{12}m_{21}+m_{13}m_{31}+m_{23}m_{32}-m_{12}m_{23}m_{31}-m_{13}m_{21}m_{32}-1}>0 \\ \frac{(m_{31}+m_{32}+m_{12}m_{21}-m_{12}m_{31}-m_{21}m_{32}-1)}{m_{12}m_{21}+m_{13}m_{31}+m_{23}m_{32}-m_{12}m_{23}m_{31}-m_{13}m_{21}m_{32}-1}>0 \end{cases}$
P16	There is a negative value	-

（1）Independent symbiosis model. The symbiosis degree of R&D population, enterprise population, application population and intermediary population is zero, and their development does not affect each other. The development speed of each population is only related to the natural growth rate of the population itself. When the equilibrium state is reached, the four populations reach their maximum scale. This model does not exist and is only an ideal model in reality. The status is shown in Figure 3.

（2）Competitive symbiosis model. The competitive symbiosis model is divided into vicious competition model and equal competition model. Under the vicious competition model, as long as the symbiosis degree of any population to the other three populations is greater than 1. In the independent innovation ecosystem, the R&D population is dominated by the core enterprise.

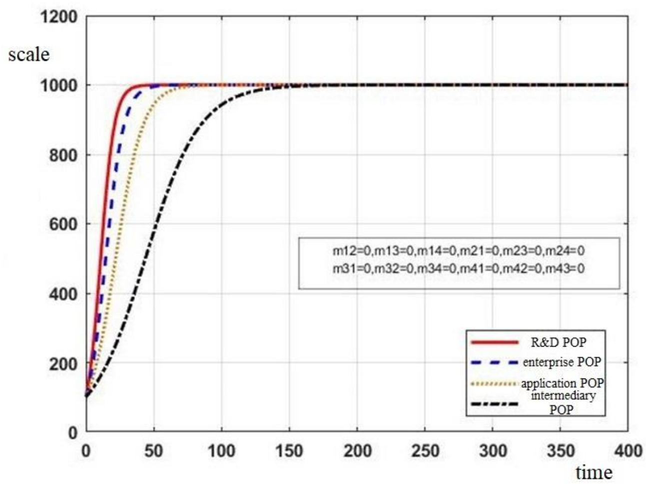

Fig. 3. Evolution process of independent symbiosis model system

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Due to the unique innovation advantages of R&D population, it gradually consumes the resources of other populations, leading to the decline of the other three kinds of populations, so that they can survive and develop and reach the maximum scale of the population, as shown in Figure 4. Under the equal competition mode, the symbiosis degree of the population is greater than zero and less than 1. The development of various groups in the system is not only affected by their own growth rate, but also threatened by the competition for resources by other populations. After the rapid development of R&D populations. Due to the consumption of innovation resources by the other three species, their development tends to be stable and does not reach the maximum scale of the population, as shown in Figure 5.

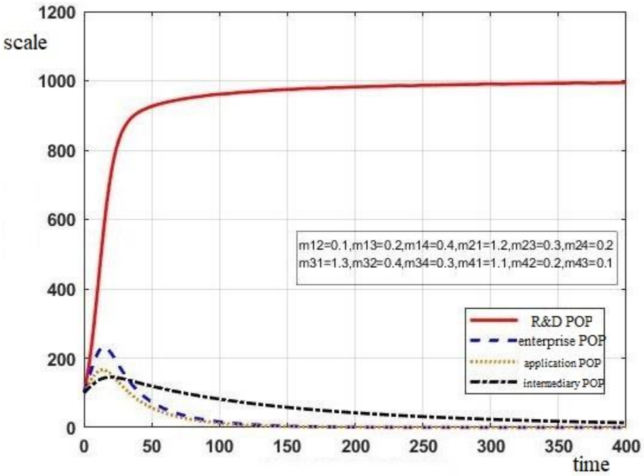

Fig. 4. Evolution process of vicious competition symbiosis model system

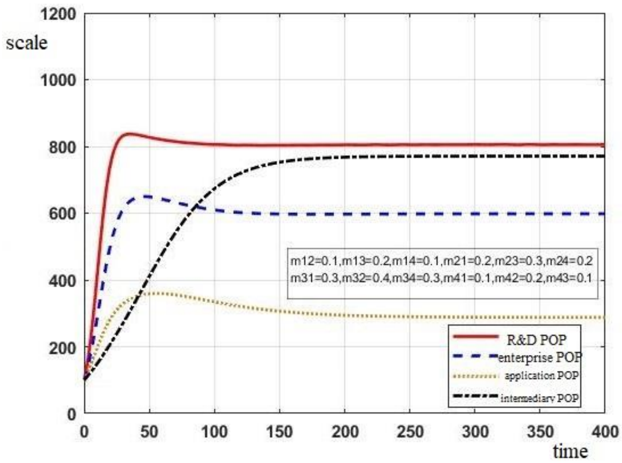

Fig. 5. System evolution process of symbiotic model of equal competition

（3）Parasitic symbiosis mode. In this mode, the symbiosis degree between any two populations is opposite to each other. Parasitic populations consume the resources of parasitic populations, making parasitic populations gradually decline. At this stage, with the rapid development of big data and artificial intelligence, independent innovation subjects need the help of mobile intelligence platforms in addition to system core enterprises and R&D populations. Platform enterprises and high-tech enterprises, the enterprise population dominated by science and technology enterprises is particularly important. As can be seen from Figure 6, after the R&D population develops rapidly and reaches the maximum population size, the enterprise population's possession of innovation resources gradually decreases and reaches stability.

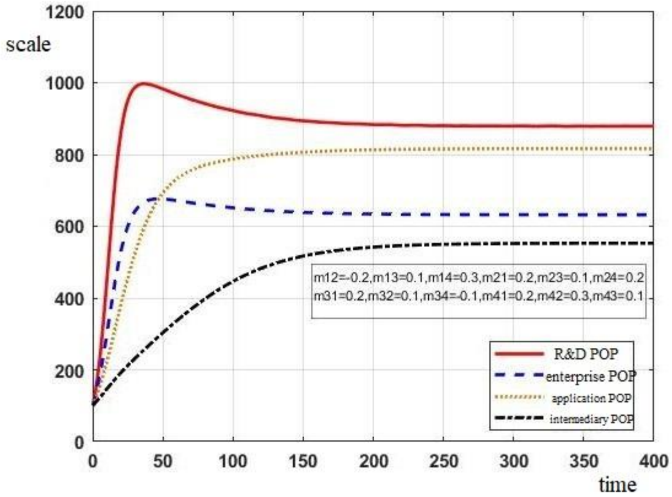

Fig. 6. Evolution process of parasitic symbiotic model system

（4）Partial symbiosis model. The partial symbiosis model is divided into partial benefit symbiosis and partial harm symbiosis. Under the partial benefit symbiosis model, the symbiosis degree of any two populations is equal to zero and less than zero. In the independent innovation ecosystem, the development of R&D population will inevitably drive the co evolution of enterprise population and application population. Due to the rapid development of the three populations, most innovation resources in the system are occupied. As shown in fig 7, the relatively weak intermediary population in the system develops slowly and gradually tends to be stable. The partial harm symbiosis model needs to meet the symbiosis degree of any two populations, one is zero and the other is greater than zero. Combined with fig 7 and fig 8, it can be seen that the intermediary population in the outer layer of the system has less competition for resources regardless of the partial benefit symbiosis or partial harm symbiosis model. It is weaker than the other three kinds of populations, and its population size is often much lower than the maximum population size.

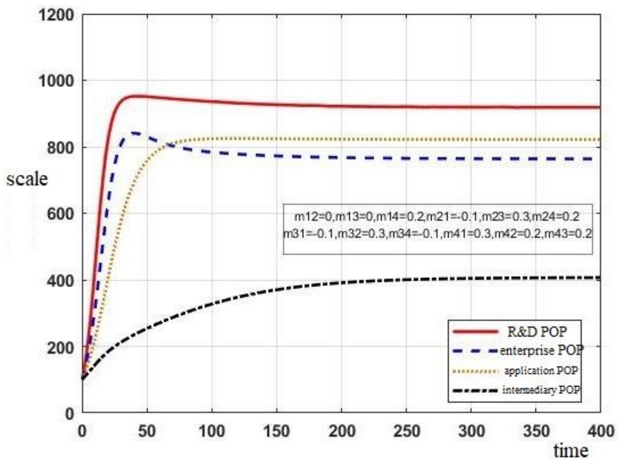

Fig. 7. Evolution process of the symbiotic model system

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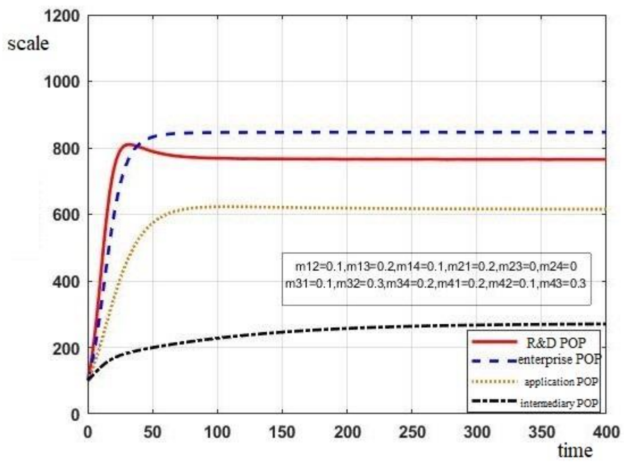

Fig. 8. Evolution process of partial pest symbiosis model system

(5) Mutually beneficial symbiosis model. Mutually beneficial symbiosis model is the best direction of symbiotic evolution of independent innovation ecosystem, and the symbiotic coefficients among various groups in the system are positive. In this mode, various groups break their own boundaries, realize the best integration of resources, co evolution and mutually beneficial symbiosis among populations. It can be seen from the figure that the four populations have achieved rapid development and are stable larger than the maximum scale of various populations under the independent symbiosis mode.

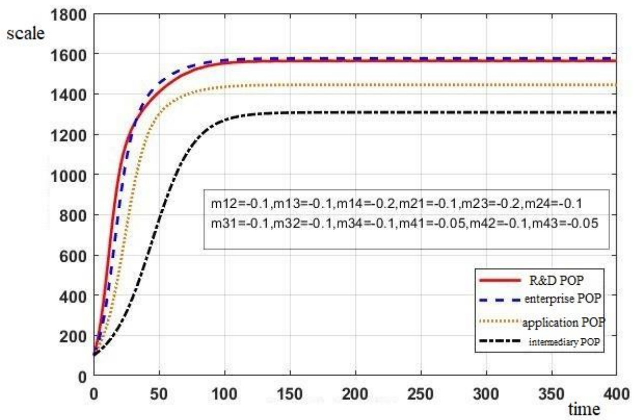

Fig. 9. Evolution process of mutually beneficial symbiosis model system

IV. CASE ANALYSIS

Case analysis can well supplement the results of computer simulation and make the research more practical. Taking Yuan Longping Agricultural High Tech Co., Ltd. as the core enterprise and Longping high tech park known as "seed Silicon Valley" as an example, this chapter further analyzes the symbiotic evolution model and process of innovation ecosystem.

Yuan Longping Agricultural High Tech Co., Ltd. was founded in 1999 by Hunan Academy of Agricultural Sciences, Hunan Hybrid Rice Research Center and Academician Yuan Longping. Combining modern agricultural technology with agricultural production, the enterprise has become a leader in China's agricultural enterprises in a short time. At the beginning of the establishment of the enterprise, Academician Yuan Longping established a professional agricultural technology innovation team, hoping to cultivate and innovate hybrid crops and vegetable crop seeds through technological innovation to improve yield [26].In 2004, Hunan Xindaxin enterprise transferred all state-owned equity of Longping high tech, making the enterprise a private holding group. In 2016, CITIC Group became the owner of Longping high tech, and the enterprise has become today's mixed ownership company. The concentration of scientific research institutes, state-owned capital and private capital makes the innovation environment of enterprises very complex. Longping high tech park was established in 1997 with 2506 enterprises. It aims to vigorously develop modern agriculture characterized by biological breeding. At the beginning of its establishment, the park has formed four pillar industries - modern agricultural enterprises represented by leading enterprises such as Longping high tech, electronic information industry represented by Hunan Guoke Photoelectric Technology Co., Ltd., biotechnology industry represented by Jingda biology, and new material industry represented by Hunan rare earth new material Co., Ltd. The core innovation unit of the system is Longping high tech. the R&D population includes more than 30 scientific research institutions such as subtropical Institute of Chinese Academy of Sciences, Hunan Agricultural University, Hunan Agricultural University, Provincial Academy of Agricultural Sciences and provincial Hybrid Rice Research Center. At the same time, relying on its own advantages, the park actively introduces e-commerce enterprises, platform enterprises and outsourcing enterprises, including Suning Tesco, SF express, Kangtong electronics, Aier Ophthalmology, xiangcha e-commerce, Jinsheng new media, ADICON medical laboratory Co., Ltd., Hunan Qinhai Digital Co., Ltd. and Hunan Jiajie Information Technology Co., Ltd., forming an enterprise population. The application population is composed of more than 200 upstream, middle and downstream enterprises in the biological seed industry chain, and the intermediary population composed of financial credit, Internet Finance and other intermediary companies effectively solves the problem of capital turnover of enterprises in the park.

Taking Longping high tech as the core of independent innovation promotes the mutual cooperation among various groups in the ecosystem, showing a symbiotic evolution model of mutually beneficial symbiosis. The evolution process of the system presents three stages. In each stage, there are different symbiotic relationships among R&D population, enterprise population and application population. The specific analysis is as follows:

1、initial stage of system development. Firstly, the core enterprises form cooperation with universities and scientific research institutions, and determine the industrial positioning of the system based on the innovation advantages and innovation resources of the core unit itself. Relying on the enterprise advantages of Longping high tech, it has attracted other enterprises by establishing a good image and incubated a large number of innovative small and medium-sized enterprises, which not only reduces the transaction cost, but also better realizes the communication between enterprises. R&D population is an important force of independent innovation. The scientific research projects participated by colleges and universities and scientific research institutions promote the transformation of innovation achievements, realize the flow of talents, technology, capital and other resources, and the innovation platform established by multi-party participation and cooperation provides an inexhaustible driving force for the development of high and new technology in seed industry. Due to the uniqueness of the independent innovation ecosystem, the R&D population dominates and occupies most of the innovation resources in the system at this stage. The development speed of the enterprise population is relatively slow. The traditional application population and intermediary population cannot become the leading force in the system due to the lack of core competitive advantage.

2、The system is in the middle stage of development. In the digital age with the rapid development of Internet big data, the participation of platform enterprises and high-tech enterprises makes the heterogeneous resources in the system richer, the independent innovation ability is strengthened day by day, the core innovation advantages of the system are gradually revealed, and the core units, R&D groups and enterprise groups in the system form a benign interaction. Enterprises represented by Suning Tesco and SF express have enriched the composition of the seed industry chain. In 2015, Qinhai digital with unique micro digital technology was introduced into the park. In 2016, more than 20 potential service outsourcing enterprises were introduced. The entry of a large number of outsourcing enterprises has also enriched the types of projects in the park, alleviated the conflict between enterprises occupying resources in the park, and formed the effects of knowledge sharing, information exchange, cooperation and mutual benefit among symbiotic units. At the same time, the establishment of core innovation advantages has attracted a large number of dealers, customers and suppliers to form an application population, improve the structure of the system and further promote the development of the system. At this stage, with the continuous evolution of the system, various heterogeneous units joined the system. Driven by big data informatization, the enterprise population dominated by platform enterprises sprung up, gradually surpassing the R&D population, occupying unique advantages and promoting the development of the system.

3、Later stage of system development. Due to the demand for capital, talents, technology and other resources in the innovation process, the intermediary population also develops rapidly and promotes the symbiotic evolution of the system. During this period, the development of R&D population and enterprise population was similar, and gradually tended to be stable. Longping high tech Park continues to promote the legalization of business environment, and actively creates a first-class business environment with less approval, smoother and more flexible system, higher efficiency and better supervision. In this regard, the park has formulated measures such as streamlining administration and decentralization, combining decentralization and management and optimizing services to improve policy transparency and accessibility, facilitate innovation and Entrepreneurship of enterprises in the park and stimulate innovation vitality. At the same time, the proximity of geographical location also makes the enterprises in the park establish a good trust and communication relationship and promote the symbiotic evolution of each symbiotic unit.

V. Conclusions and Suggestions

Based on the symbiosis theory, this paper studies the mechanism of population Symbiosis Evolution in the independent innovation ecosystem. According to the characteristics of independent innovation ecosystem and ecological chain, the population types are divided into R&D population, enterprise population, application population and intermediary population. Based on the logistic model, a dynamic model of four population Symbiosis Evolution is constructed and numerically simulated. The case of Longping high tech further illustrates the "black box" of symbiotic evolution among populations in the system. According to the research results, the following conclusions can be drawn: (1) the independent innovation ecosystem takes the core innovation enterprise as the center, presents the characteristics of "center periphery", and the populations in the system interact with each other, showing different symbiotic relationships. (2) The development of various populations is affected not only by their own natural growth rate, but also by the degree of symbiosis with other populations. When the symbiosis degree between populations is zero, various populations develop independently and do not affect each other; When the symbiosis degree is less than zero, the populations present a mutually beneficial symbiosis state, and the populations promote each other and develop together; When the symbiosis degree is greater than zero, the competition is dominant among the populations, and the highly competitive populations continue to consume the innovative resources in the system, forcing the less competitive party to decline gradually, and the system tends to be stable gradually.(3) Mutually beneficial symbiosis mode is the best direction for the evolution of independent innovation ecosystem. Under this mode, it can realize the best integration of resources, realize the mutual sharing of resources and information exchange among populations, and maximize the output of innovation achievements.(4) Based on the case study of Longping high tech, this paper summarizes the development process of symbiotic evolution of independent innovation ecosystem: firstly, the core symbiotic unit occupies a key position in the system with its own advantages, so as to attract other heterogeneous or homogeneous units to join. Secondly, each symbiotic unit realizes the unit set according to its own characteristics, forming R&D population, enterprise population, application population and intermediary population, so as to promote the flow of innovation resources in the system. Finally, in the process of resource flow, the symbiotic relationship between populations continues to evolve, helping the development of the system.

In view of the above conclusions, the following suggestions are given to enterprises: (1) continuously optimize the symbiotic evolution environment, enhance the trust between various groups in the system through policy support and government supervision, and strengthen the openness and transparency of information in the system, so as to provide an environmental basis for the evolution of the system towards the

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mutually beneficial symbiotic model.(2) Independent innovation ecosystem not only needs to pay attention to the symbiotic unit of innovation and R&D, but also mobilize other populations in the system to cooperate with it. Similar to the biological food chain, it is precisely because of the mutual constraints among producers, consumers and decomposers that the system can show a balanced state. The same is true of the independent innovation ecosystem. The R&D population, enterprise population, application population and intermediary population need to strengthen their cooperation to reduce the cost and resistance of symbiotic evolution, By continuously optimizing the symbiotic platform, attract more symbiotic units to join and promote system evolution and upgrading.(3) According to the characteristics of independent innovation ecosystem, grasp the evolution trend of the system, continuously improve the quality of symbiotic units in the population, pay attention to the coordinated development of various groups in the system centered on core enterprises, and promote the population to move towards the best evolution mode of mutually beneficial symbiosis. At the same time, pay attention to the talent training mechanism, promote the injection of heterogeneous resources into the system, and realize the best integration of resources, so as to reduce the transformation cycle of innovation achievements.

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