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Evolution mechanism of the strategic emerging industry on the basis of haken model

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ABSTRACT

This paper studies the strategic emerging industry system, which includes market demand systems, innovation systems, government systems and resources to support the endowment of four subsystems. On the basis of Haken self-organized synergetic theory, order parameter needs to be found to dominate the evolution of the whole system, and has established the strategic emerging industry system evolution model and the solution is to set up and solve the order parameter equation. The collected data from 29 provinces and municipalities and autonomous regions such as Beijing, Tianjin for empirical research has established the evolution trend of the strategic emerging industries function, and it is concluded that the innovation of scientific and technological achievements conversion is a key factor affecting the evolution of strategic emerging industries. Order parameter of innovation input intensity is important in the evolution of the strategic emerging industry system.

KEYWORDS

Strategic emerging industry; Order parameter; Evolution.

INTRODUCTION

Full understanding of the connotation of strategic emerging industries calls for two prepositions: “strategic” and “emerging”. From the perspective of major, long-term and overall situation and the future, “strategic” refers to the healthy development of national economy and has a long-term effect the pillar of national security; for the adjustment of industrial structure and transformation of economic development, it plays a decisive guiding role. "Emerging" refers to the burgeoning relative to the current economic development stage. Technology and industry are both emerging and being deeply integrated. "Emerging" represents the most advanced productivity. Strategic emerging industries in the economic development of a specific phase affect the national economy overall and long-term development, and the strategic emerging industry is less consumption of material resources, large potential market guiding, pillar, good industry[1].

Seen from its connotation, the strategic emerging industry is a dynamic concept. Its development is affected by the factors from internal and external environment. Its innovation ability and market demand, which are uncertain, are the key factors to promote the development, among other factors, so the extent of the effect is not the same. The development and evolution of the strategic emerging industries is a complex system. Self-organization theory and method can be used to explore the laws of its development and evolution.

CHARACTERISTICS OF THE STRATEGIC EMERGING INDUSTRIES SELF-ORGANIZATION EVOLUTION

The concept of self-organization first proposed in philosophy by modern German philosopher Kant is the most important. He considers the self-organization of the parts which exist in other parts also allows the existence of the other parts; the parts interact with each other and thus come into being, so the causal links between them produce a whole[2]. The idea of "self-organization" by Haken, founder of the "synergetic", is accepted: "If a system gets no specific interference from outside in the process of obtaining the structure of space, time, or function, the system is a self-organization. Here the word 'specific' implies that the kind of structure or function of the system is not imposed from the outside, and that the outside world acts on the system in a non-specific way"[3]. The self-organization theory is a group theory, and studies a collection of the self-organizing phenomenon and regularity of the doctrine, though not yet a unified theory. It is mainly composed of the dissipative structure theory by which to solve the problem of self-organization conditions, the synergetic theory by which to solve the problem of self-organization dynamics, the catastrophe theory by which to solve the problem of path, and the super circulation theory by which to solve the combination and formation problem, etc. In short, the self-organization theory basically requires the system to be open, nonlinear and non-balanced. When the external control parameter reaches a certain threshold, through the fluctuation of mutations to form a new more orderly structure.

Because the innovation ability and the market demand of the strategic emerging industry system are uncertain, with the constant change of time, space and environment, a new system of strategic emerging industries is formed with a new system structure and the new industry associations[4]. In this paper, the strategic emerging industry is studied with the essentials of self-organizing system, specifically as follows:

(1) Open

The external environment of the strategic emerging industry system includes all related factors, such as market conditions, economic development, and the development of other related industries as well as other relevant factors. Each subsystem of strategic emerging industry system not only obtains information, energy and resources from the outside environment, but also outputs information, energy and resources to the outside world. So the strategic emerging industry system is open.

(2) Non-balanced

Under the balanced state, strategic emerging industry system does not change with time, space, or any changes in the environment. But the openness of strategic emerging industry determines the competition mechanism, which plays a leading role in its operation process. The competition throws the system off balance, but always maintains a dynamic balance. The system consists of multiple subsystems, which obtain information and resource through competition resulting from the external environment and market demand in different ways. Thus the rate of interest obtained in the economy is different, and a non-balanced trend of the development of strategic emerging industry system is formed.

(3) Nonlinear

The nonlinearity and the stochastic fluctuation within a nonlinear system are the intrinsic motivation to promote the orderly evolution. In a non-balanced state, the elements of strategic emerging industry system and the state variables are non-linear. The interaction between them is not a simple supraposition. It constitutes a new nature and function of the system as a whole.

(4) Fluctuating

Fluctuations are a phenomenon that the system state parameters spontaneously deviate from a certain average, which is a nonlinear interaction between components within the system, combined with random disturbance from external factors. The evolution of strategic emerging industry system is the result of the nonlinear effect of the industry system and the interaction of the external environmental factors. The fluctuations of the strategic emerging industry system play the role of spontaneous adjustment, and form one of the prerequisites of the self-organization of the strategic emerging industries system. According to the self-organizing characteristics of strategic emerging industries, it is shown that Haken model can be used to analyze the evolutionary mechanism.

THE CONSTRUCTION OF HAKEN MODEL

The purpose of self-organization of Haken Synergetics is "to establish a unified view to deal with the concept and method of complex system"[5]. An important point of Synergetics is: the self-organization system is usually determined by a small amount of order parameters and the "fluctuations" play a key role in the process of the evolution of the system. The main line of the Synergetics Theory Research is based on the loss of stability, followed by the export control principles, setting up and solving the order parameter equation.

The non-balanced characteristics of strategic emerging industries system are demonstrated as a state of instability. The difference and the imbalance of the decisive control parameter determine the belongingness of the speed parameter and the slow parameter. The slow parameter dominates the evolution process of strategic emerging industry system, and governs the behavior of the fast parameter. After pushing the system beyond the linear instability point, strategic emerging industries system will form a new structure and remain stable. At this point, the slow parameter will form the order parameter of a new structure. The strategic emerging industries system consists of multiple subsystems. To simplify the model analysis, first it is assumed that the strategic emerging industry system is composed of two systems: Subsystem Ⅰ and Subsystem Ⅱ respectively representing State Variables q_1 and q_2. According to the principle of Haken model, the basic relations between the state variables of the two sub-systems are as follows:[6]

$$\dot{q}_1 = -\lambda_1 q_1 - a q_1 q_2 \quad (1)$$

$$\dot{q}_2 = -\lambda_2 q_2 + b q_1^2 \quad (2)$$

Type: λ_1, λ_2 for damping coefficient; $a.b$ as the control parameter, reflecting the strength of the interaction of q_1 and q_2. The Formula (1), (2) is discretized[7]

$$q_1(k+1) = (1-\lambda_1)q_1(k) - aq_1(k)q_2(k) \quad \textbf{(3)}$$

$$q_2(k+1) = (1-\lambda_2)q_2(k) + bq_1(k)q_1(k) \quad \textbf{(4)}$$

Type : k as a benchmark in the time, is the benchmark general state after the discretization processing of the subsystem state variables. At this point, the strategic emerging industry system has a steady-state solution for $q_1 = q_2 = 0$. Using[8-9] adiabatic elimination method, the order parameter is determined. Assume $q_2 = 0$, then the approximate solutions can be obtained[10].

$$q_2(k) \approx \frac{b}{\lambda_2} q_1^{\,2}(k) \quad \textbf{(5)}$$

Type (5) shows that the variable q_2 is decided by q_1. Namely, Subsystem II changes with the change of Subsystem I. Namely the damping of q_1, which is the order parameter, is small, long-life, and determines the direction of the evolution of the strategic emerging industry system. the order parameter equation[11] and the evolution trend function[12] respectively are:

$$\dot{q}_1 = -\lambda_1 q_1 - \frac{ab}{\lambda_2} q_1^3 \quad \textbf{(6)}$$

$$F = 0.5\lambda_1 q_1^2 + \frac{ab}{4\lambda_2} q_1^4 \quad \textbf{(7)}$$

The structure characteristics of the potential function can represent the behavior of the system evolution, which depends primarily on the control parameters λ_1, when λ_1>0, the equation (6) has the only stable solution $q_1 = 0$ (as shown in Figure 2) The system has not established a non-zero function, a new structure is not formed. When λ_1<0, the equation (6), there are three solutions, $q_{11}=0$, $q_{13} = -\sqrt{-\frac{\lambda_1\lambda_2}{ab}}$, $q_{12} = \sqrt{-\frac{\lambda_1\lambda_2}{ab}}$, the first one of the three solutions is unstable, while the latter two are stable (See Figure 3). It shows that a new stable state is formed through mutation system. q_1 is the order parameter, whose change is related to the change of the whole system.

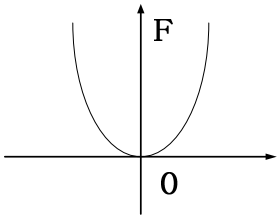

Figure 1 : λ_1> 0

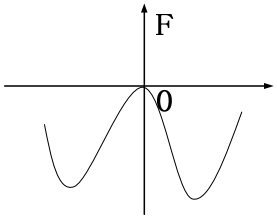

Figure 2 : λ_1<0

THE SELECTION AND THE BASIS OF VARIABLES

According to the aforementioned Haken Synergetics, the state variables affecting the self-organization evolution of strategic emerging industries system are many, but the author thinks that, among the many variables, the innovation ability and the market demand are the two key state variables, and can be selected to analyze the evolution process of strategic emerging industry system. The main reason is as follows:

(1) R is innovation input intensity. The major scientific and technological innovation is the basis for the development of strategic emerging industries. Science and technology innovation requires high-quality scientific research team and a lot of money. A large number of funds are mainly used in the research and development (R&D). The ratio of the funds into the R&D of the strategic emerging industries and the funds brought about by the added value of input intensity is the intensity of the input of the innovation ability, which is used to represent innovation subsystem. From the strategic emerging industry system evolution mechanism, technology innovation should go in succession through R&D, design, trial production, commercialization of products and so on. So the breakthrough of this part of the R&D will break the original balance. Technology innovation will cause the uncertainty of market demand, the corresponding policy support and resources endowment, which also produces a series of changes. These changes throw the system off balance. In order to eliminate this imbalance technology innovation will be promoted. Thus, the R&D in strategic emerging industries constantly produces new imbalance in the system. In the new imbalance, especially R&D not only causes the system to depart from balance but also makes the system suffer from creative destruction.

The R&D is a prerequisite of innovation as well as an important part of the innovation mechanism. The investment intensity of innovation ability of the R&D can directly reflect the innovation input, and reflect the characteristics of innovation system. Therefore, Variable R represents the innovation capacity development and technical innovation as a variable in the model.

(2) Variable *P* is the conversion rate of scientific and technological innovation achievements. It is used to represent the market demand subsystem of strategic emerging industries system. In computing Variable *P*, the index of the new product development project is used to represent the actual application in the production and innovation ability, which reflects the characteristics of the evolution of strategic emerging industry system. So this Variable *P* will be selected to represent the innovation ability and transformation of the technological achievements as another variable model. The two variables R and *P* are selected and analyzed to determine which variable is the more obvious variable on the strategic emerging industries and the more crucial to promoting and facilitating the evolution of the system.

Assume the order parameter R. Namely R is q_1, and *P* is q_2. According to Equations (3) and (4), the evolution model type of the strategic emerging industry system is obtained:

$$R(K+1) = (1-\lambda_1)R(K) - aP(K)R(K) \quad \textbf{(9)}$$

$$P(K+1) = (1-\lambda_2)P(K) + bR(K)R(K) \quad \textbf{(10)}$$

Among them, Variable R is the innovation input intensity, on behalf of the innovation system. Variable p is the conversion rate of the innovation of scientific and technological achievements, on behalf of the market system. a, b, λ_1 and λ_2 as the control parameters reflect the interaction of these two subsystems. *K* is the time variable. The original R and p are substituted into Equation (9) and (10), and the regression calculation is made to get the value of the control parameters of a, b, λ_1 and λ_2 which are plugged in (9), and (10), and the simultaneous differential equations of the interaction of *R* and *P* are obtained.

To ensure the validity of the results, a collection of data from the high technology industries (because the strategic emerging industry data are rare, the high technology industry data is used) in 29 provinces and municipalities and autonomous regions in China in 2009 and 2010 are selected to make the calculation to get the Variables *R* and *P*. the selected data include the internal expenditures of the R&D funds, the added value of the innovation ability, the number of the scientific research items, and the number of new product development, which is shown in Table 1:

TABLE 1 : 2009 and 2010, China's high technology industry R&D expenses within budget TAB

Province	R		P		Province	R		P	
	2009 year	2010 year	2009 year	2010 year		2009 year	2010 year	2009 year	2010 year
Beijing	0.086	0.086	0.715	0.612	Henan	0.026	0.033	0.636	0.597
Tianjin	0.029	0.034	0.778	0.738	Hubei	0.035	0.030	0.516	0.468
Hebe	0.029	0.034	0.778	0.528	Hunan	0.036	0.048	0.575	0.550
Shanxi	0.005	0.011	0.827	0.564	Guangdong	0.064	0.047	0.657	0.648
Inner Mongolia,	0.001	0.001	0.375	0.714	Guangxi	0.027	0.017	0.455	0.581
Liaoning	0.060	0.044	0.240	0.544	Hainan	0.007	0.020	0.900	0.546
Jilin	0.014	0.020	0.679	0.719	Chongqing	0.064	0.071	0.791	0.750
Heilongjiang	0.098	0.104	0.591	0.179	Sichuan	0.030	0.049	0.623	0.921
Shanghai	0.060	0.047	0.844	0.835	Guizot	0.038	0.038	0.668	0.771
Jiangsu	0.026	0.019	0.670	0.673	Yunnan	0.026	0.017	0.713	0.721
Zhejiang	0.024	0.039	0.6477	0.705	Shanxi	0.122	0.136	0.615	0.648
Anhui	0.057	0.081	0.838	0.824	Gansu	0.038	0.041	0.801	0.778
Fujian	0.023	0.029	0.783	0.451	Qinghai	0.031	0.006	0.941	0.455
Jiangxi	0.018	0.039	0.720	0.8050	Ningxia	0.047	0.069	0.250	0.461
Shandong	0.070	0.050	0.530	0.722					

Data sources: according to the high technology industry 2011 yearbook data sorted

Using the data from the computed R and p, the software Eviews5.0 is applied to make the regressed calculation:

$$R(K+1) = 0.9616R(K) + 0.1056R(K)P(K) \quad \textbf{(11)}$$

$(4.4522)***$ (0.3184)

$R^2 = 0.8101$ $AdjustedR^2 = 0.8031$ $F = 115.1683$

Among them, the figures in the brackets below the regression equation are the test value of *t* (the same below). The symbol "＊＊＊" means that it has gone through the test of significance of 1%.

$$P(K+1) = 0.9095P(K) + 3.3731R(K)R(K) \quad \textbf{(12)}$$

$(13.7499)***$ (0.3043)

$R^2 = -0.6472$

Seen either from the goodness-of-fit R^2, or F test, the regression equation (11) means the regression fitting effect is very good. The adjusted R^2 has reached 0.8031. The goodness-of-fit of Equation (12) is a negative value. The main reason is that there is no constant term in the regression

equation, and the square value of R is relatively low, influencing the regression results. The coefficients of the two formulas are obtained in the following ways:

$1-\lambda_1 = 0.9616$, so $\lambda_1 = 0.0384$;

$1-\lambda_2 = 0.9095$, so $\lambda_2 = 0.0905$.

Since λ_1 and λ_1 are damping coefficients, $\lambda_2 >> \lambda_1$, and $\lambda_2 > 0$, it indicates the state variables P is the rapidly attenuating fast variable. The damping of the order parameter R, which is consistent with the hypothesis, is small. At this time, $a = -0.1056$; $b = 3.3731$. The two control parameters, a and b, reflect the effect of the interaction of R and p. The value of λ_1, λ_2, a and b are substituted into Equations (1) and (2). q_1. and q_2 are R and p respectively.

$$\dot{R} = -0.0384R + 0.1056RP \quad \textbf{(13)}$$

$$\dot{P} = 0.0905P + 3.3731R^2 \quad \textbf{(14)}$$

According to the formula (5), assume $\dot{P} = 0$, $P \approx 37.2718R^2$. When the value of p is plugged into the formula (13), the order parameter equation is obtained.

$$\dot{R} = -0.0384R + 0.1056R \times 37.2718R^2$$

$$= -0.0384R + 3.9345R^3 \quad \textbf{(15)}$$

Because $\lambda_1 > 0$, according to Equation (6) and Figure 1, order parameter equation shows the steady state solution. Assume $\dot{R} = 0$. Namely, $R = \pm\sqrt{\frac{0.0384}{3.9345}} = \pm 0.0988$

When $R > 0$, there is only one steady state solution. When $R = 0.0988$, the values of λ_1, λ_2, a, and b are plugged into the Equation (7):

$$F = 0.0192R^2 + 0.9836R^4 \quad \textbf{(16)}$$

The second derivative of the potential function (16):

$$\frac{d^2F}{d(R)^2} = 0.0384 - 11.8035R^2 \quad \textbf{(17)}$$

$R = 0.0988$ plugged in (17), $\frac{d^2F}{d(R)^2} = -0.0768 < 0$

When $R = 0.0988$, this shows that the potential function has great value, and the shape of the potential function can be obtained according to Figure 2 and Figure 3:

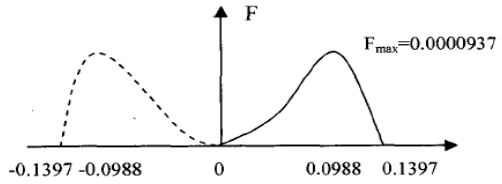

Figure 3 : The potential function of curve evolution of strategic emerging industries system

Strategic emerging industry system evolution potential function curve A structure characteristic of the potential function reflects the strategic emerging industry system evolution mechanism. When the state parameter (q_1, q_2) and the control parameters $(\lambda_1, \lambda_2, a, b)$ change, the potential function of the system will also change from the original stable state to an unstable state

CONCLUSION

Through the above analysis, the evolution rule of the strategic emerging industry system is clearly revealed. The input intensity variable of the innovation ability is the decisive factor in the process of the growth of strategic emerging industry system, which gives direction to the growth of strategic emerging industry system.

(1) The innovation input intensity is the order parameter in the growth process of strategic emerging industries. By formula (3) and (4), the evolution equations of Haken, the strategic emerging industry evolution equations (9) and (10) are obtained. At the critical point of the evolution process of the strategic emerging industry system, the order parameter innovation input intensity *R* dominates the system evolution. When the system produces a new ordered structure, a new steady-state solution $R = 0.0988$ is formed. The respective R values from many regions, which are calculated from the table, show that the current strategic emerging industries of the major areas have not yet reached the critical state. Therefore, practical measures have to be taken to increase the R&D investment, with special emphasis on the constructive role of the R&D and technological innovation, and the creation of the precondition of non-zero effect, which changes the variables. Great importance has to be attached to the R&D and technology innovation fluctuation factors.

(2) The innovation ability, market demand, government support policies and resource endowment are the decisive factors to promote the fast growth of strategic emerging industries. The synergy of the four elements determines the speed and scale of the evolution of strategic emerging industry system.

(1) The control parameter a is negative, reflecting the innovation capacity subsystems and market demand subsystem have a synergistic effect and a collaborative development.

(2) b is positive, reflecting the innovation input intensity will promote the market demand. It indicates that these two variables promote each other, and at the same time improve the strategic emerging industry evolution, which can continue to be a benign cycle.

(3)The availability of the innovation ability of the R&D funds is to be improved. This parameter $\lambda_1 = 0.0384$ is positive, indicating that positive feedback mechanism within the system is not perfect. In order to establish a sound system of positive feedback mechanism, on the one hand, the total investment in the R&D expenses is to be increased. On the other hand, attention should be paid to its economic efficiency. And finally the efficiency of the use of the R&D funds is to be improved. At present, the collected data show that the total amount of the R&D input in strategic emerging industries is not enough. So the R&D input is to be increased, which is very important to the development of strategic emerging industries.

(4) The acceleration of the innovation achievements conversion rate promotes the formation of the system synergy mechanism. The parameter λ_2 is positive, which indicates that market demand within the strategic emerging industries system is low, and also suggests that it is hard to make people recognize and accept the new products, thus to further improve the innovation ability of scientific and technological achievements conversion rate. Strategic emerging industries represent the advanced productive forces, which are derived from the innovation ability of transformation of scientific and technological achievements. Today, both the central and local governments are further perfecting the innovation research results into public service platforms. This initiative will improve the market demand of China's strategic emerging industry system, speed up the conversion of scientific research innovation ability, and thus promotes the formation of the synergy mechanism and the evolution of the system.

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