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Evolution Mechanism of Information Industry Ecological Security

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Abstract

The Information Industry Ecological Security is a combination of security and dynamic development. This paper analyzes the evolution mechanism of Information Industry Ecological Security from the perspective of evolution driving force, evolution process and so on using the theories and methods of Ecology and Synergetics systematically, and take China's Information Industry Ecological Security as an example of empirical research, then provided a range of effective policy suggestions for relevant Chinese government departments to control and guide China's Information Industry Ecological Security.

Keywords: *Information Industry Ecological Security, Evolution, Driving Force, Fluctuation, Order Parameter*

1. Introduction

The rapid development of economic globalization increases the competition of global industry through the globalization of trade. It not only makes many countries lose normal industrial chain and industrial ecology of economic development, but also lose the control on major industries and key technology related to the national economy. The industry security has become a core issue that restricts the development of national economy. Since the information industry is an important pillar industry of various countries, it has great significance to research how to protect the Information Industry Ecological Security in this context.

There is a lot of research about information industry both inside and outside the country, mainly in the following areas: ① Basic theoretical research, such as the definition and classification of the information industry [1-3]. ② Laws of development, which is the domestic and foreign latest hotspot [4-6]. ③ Crossover study, such as the contribution measurement of information industry to the national economy, etc. [7-9]. But generally speaking, there are still many problems about these research results. First, there are various research perspectives, and many scholars focus only on a part of information industry and ignore the integrity of information industry, so it is difficult to reflect the basic content of information industry, and can not reveal the basic evolution laws of information industry. Second, there is more qualitative research, while less quantitative research. Third, there is lack of in-depth research on the information industry, and analysis on the whole mechanism. Fourth, many research floats on the macro level, it is difficult to guide real practice.

However, the research on the information industry security both inside and outside at present is still in the exploratory stage, and has not yet formed a

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systematic theory. Therefore, we intend to study the issue of information industry ecological security from the perspective of Ecology, Synergetics, and other interdisciplinary using the theory and method of complex system. As a crossing research of Ecology and information science, we found that it is very effective to analyze and explain the evolution mechanism of information industry ecological security using Synergetics after analyzed its various characteristics. The co-evolution in information industry ecological security refers to the mutual adaptation and co-evolution between two or more interacting information industries and external environment in the formation and development process. Using the theory of Synergetics, we can well explain the reasons and process of this phenomenon, identify key variables and regulate them, thus promote the information industry ecological security develops towards a healthy, orderly, rapid and stable direction.

The organization of this paper is as follows. In Section 2, on the basis of defining the concept of general information industry security, we propose the concept of information industry ecological security and analyze its characteristics. Then, in Section 3, we study the evolution mechanism of information industry ecological security from the perspective of evolution driving force, evolution process and so on systematically. And finally in Section 4, we take China's information industry ecological security as an example of empirical research, and provided a range of effective policy suggestions for relevant Chinese government departments to control and guide China's information industry ecological security.

2. Information Industry Ecological Security

2.1. Concept of Information Industry Ecological Security

According to the definition of industry security given in the 'Research on the industrial security theory' [10], the information industry security refers to the state that the survival and development of information industry staying away from the threat, including survival security and development security of information industry. It is similar to the stability and dynamic development of Ecosystem of Information Industry, so we can define the information industry security from the perspective of Ecology. Reference the theory of Ecology, we define the information industry ecological security as an interactive and interdependent ecological functional unit that constitute by information industry and the relevant socio-economic environment factors at a certain time and in a relatively stable condition. In this functional unit, the structure and function of information industry is in a dynamic equilibrium of mutual accommodation and mutual coordination, and the material flow, energy flow, and information flow is in a self-regulated, orderly and stable state. It is a good status of information industry.

The Information Industry Ecological Security is a combination of security and dynamic development. It must be carried out under a relatively safe state if the information industry wants to maintain its own survival and promote healthy development. At the same time, the information industry ecological security is a kind of dynamic security, as shown in Figure 1. The Information Industry Ecological Security is not static. However, it has the characteristic of dynamic security development due to the function of positive and negative effects put on the information industry in the long run. So the dynamic security refers to that the relevant elements of information industry is evolving and changing, while its overall volume and performance is to maintain stable. Take the development process of information industry as an example. The amount of information industry in an area in a unit time is to maintain stable, and the development process of information industry is in line with the laws of certain functions. However, it doesn't mean that every individual doesn't have change, there are always companies to enter, and also has

companies exit. In other words, the security is global, while dynamic development and change is local.

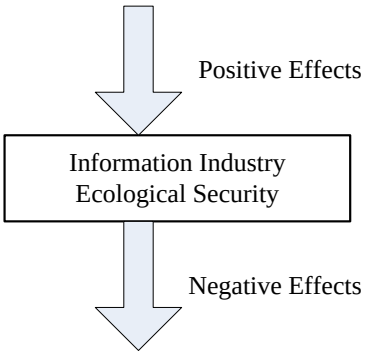

Figure 1. The Dynamic Ecological Security of Information Industry

2.2. Characteristics of Information Industry Ecological Security

The Information Industry Ecological Security has the following characteristics, shown as Figure 2.

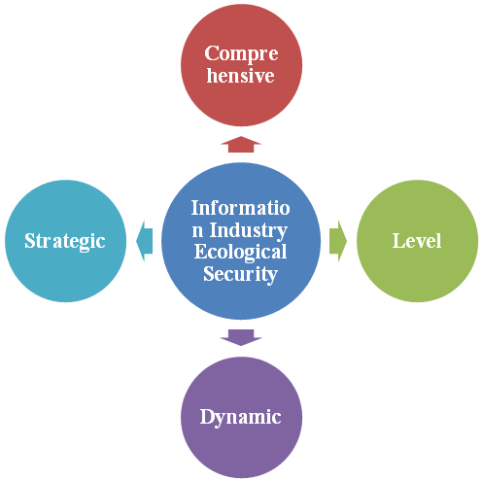

Figure 2. The Characteristics of Information Industry Ecological Security

(1) Strategic of Information Industry Ecological Security

As an important part of national economic security, the Information Industry Ecological Security is related to the national welfare and people's livelihood, as well as the long-term development of a country's economy, which relates to the economic interests and political status of a country. To make the national economic interests be not infringed and threatened, it is necessary to ensure the safety of information industry development in a country, and we must take the strategy of Information Industry Ecological Security into the consideration of national strategy, take it seriously and research the issue of Information Industry Ecological Security from a strategic and long-term perspective.

(2) Comprehensive of Information Industry Ecological Security

The Information Industry Ecological Security involves a wide range, which also has a strong correlation with other industries. When the information industry is threatened, the safety of other related industries will also be threatened directly or indirectly. In addition, the factors that affect the Information Industry Ecological Security is complex, including

political factors, economic factors, natural factors, social factors, information and technology, even including history, cultural factors, geographical conditions and human quality. It shows that the Information Industry Ecological Security has a high degree of complex and comprehensive features. Therefore, the means of maintaining Information Industry Ecological Security should also be complex and diverse.

(3) Level of Information Industry Ecological Security

The Information Industry Ecological Security includes the safety of one country's a certain information industry, the safety of information industry ecological chain, and the safety of information industry ecological group. There are relationships of parts and whole between all these three levels. It requires that we should deal with the relationship between different levels in information industry security properly in the process of maintaining Information Industry Ecological Security. The general principle is that we should take the security of information industry ecological chain and information industry ecological group in macro level as targets, take the security of some important pillar information industry as a support, and take the insecurity of local information industry as expense in order to get initiative in participating in the economic globalization and obtain maximum comparative benefits.

(4) Dynamic of Information Industry Ecological Security

The dynamic of Information Industry Ecological Security has two meanings: one is the problem of Information Industry Ecological Security is long-standing, but there are different industry security maintenance objects in different period, which is determined by the relative changes in economic development and international industrial competitiveness. Some industries are safe in a certain period, which do not need the government's regulations or intervention, while other industries may have a big risk, which need the regulation or protection of government. The second meaning is that the means and ways to realize the industrial security are in dynamic changes instead of immutable and frozen. The vast majority of industrial safety protection is not permanent, and the aim of government regulation is to provide a preparation period, so that the domestic industries can gain a firm foothold and gradually escalate after the transition period, then form a strong international competitiveness. The essence of government regulation is to promote the industrial upgrading and to improve the competitiveness in international market.

3. Analysis on the Evolution Mechanism of Information Industry Ecological Security

3.1. Evolution Driving Force of Information Industry Ecological Security

The evolution of Information Industry Ecological Security is affected by a variety of driving forces, such as the information technology, innovation, market demand, national policies, social environment, and so on. And according to their different natures and function ways, these driving forces can be divided into two types, namely the internal driving force and external driving force, as shown in Figure 3.

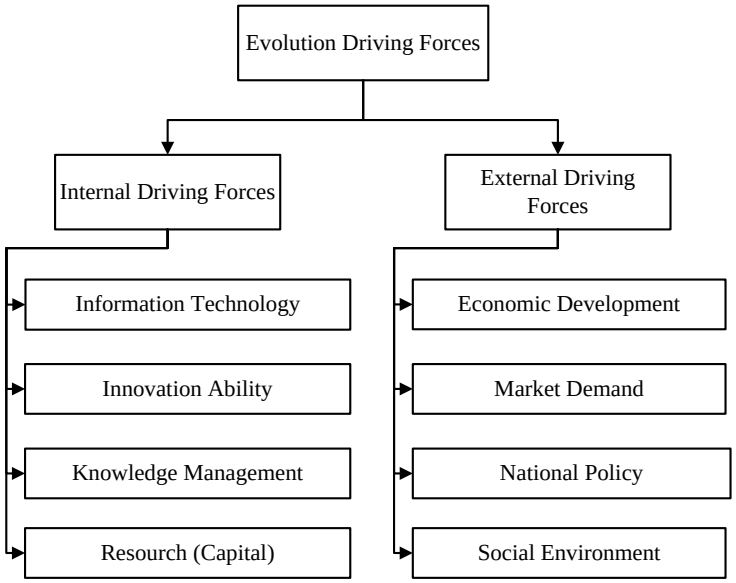

Figure 3. The Evolution Driving Force of Information Industry Ecological Security

The evolution of Information Industry Ecological Security depends on the joint function both of the internal and external driving forces, and the influence of internal and external driving forces is different in different states. The internal driving force is the main force within each development stage of information industry, while the influence of external force presents different emergence, shown as Figure 4 [11]. In the ecological security status, the information industry is relatively stable, so the influence of external force is smaller, while the influence of external force is bigger if in the non-security state. The internal and external driving force occurs mainly through the role of competition and cooperation during the evolution process of Information Industry Ecological Security. The competition of information industry tends to make the system unbalanced, and this is an important condition for the development of information industry. While the cooperation between the information industries amplifies some action of information industry in a non-equilibrium condition, and thus makes it take the dominant position, and control the overall evolution of Information Industry.

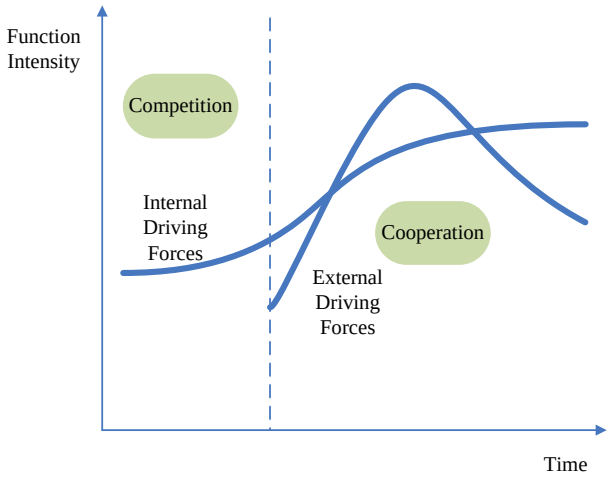

Figure 4. The Relationship between Internal and External Driving Force

3.2. Evolution Process of Information Industry Ecological Security

As an open complex giant system, the process is very complex for the information industry from non-security to security, since there are many possible ways of evolution before it forms an ordered structure or obtains perfect function. And the information industry would enter which branch or how to enter the branch is decided by the "fluctuation".

3.2.1. Fluctuation in the Evolution of Information Industry Ecological Security: The intricate interactions between the environment and the main body of the information industry cause the phenomena of fluctuation in the information industry, and also the complexity in the evolution process of Information Industry Ecological Security. In the evolution process of Information Industry Ecological Security, the fluctuation generally exists. According to the source of generation, it can be divided into two categories, namely internal fluctuation and external fluctuation. The internal fluctuation of Information Industry Ecological Security is generated by the main body of the information industry itself spontaneously, such as the emergence of a new information industry group, etc. While the external fluctuation of Information Industry Ecological Security is generated by the external driving force effect of the Information Industry Ecological Security evolution, such as the development of new information technology, etc. The largest influence on the Information Industry Ecological Security evolution is the fluctuation of science (information) technology, since the characteristics of the Internet determines that the appearance of a new information technology may lead to disruptive changes in internet social ecology system [12].

After the generation of some fluctuation in information industry, since there are always exchange of material, information and energy between the information industry and the natural and real social environment, if the complex nonlinear interaction within the information industry develops to the direction that in favor of the industry, the Information Industry Ecological Security is stable and safe. Otherwise, the industry can't make the fluctuation convergent and recursive and it will enlarge the fluctuation. Under the condition of positive and negative feedback mechanisms, the enlarged fluctuation caused by nonlinear interaction is likely to lead Information Industry Ecological Security into a qualitative change, which is called mutation, and then enter another security state, as shown in Figure 5.

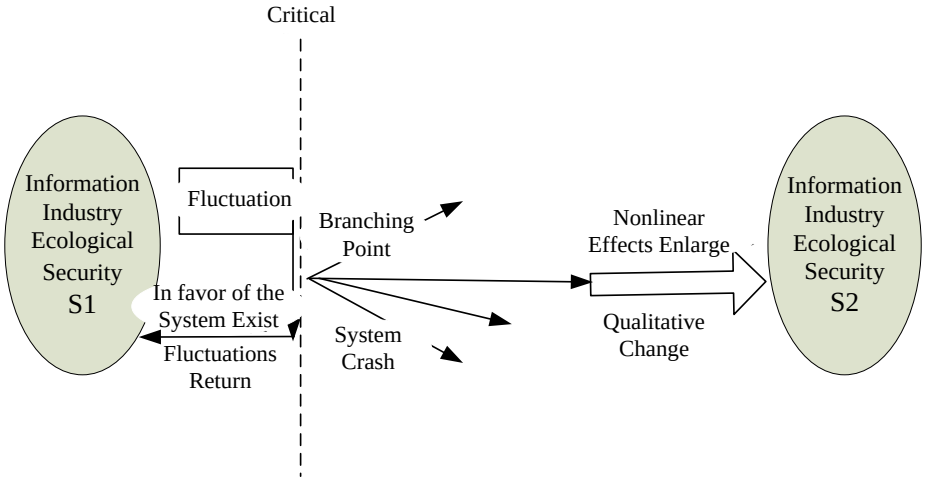

Figure 5. The Influence of Fluctuation on Information Industry Ecological Security

3.2.2. Fluctuation Leads to the Emergence of Order Parameter in the Evolution of Information Industry Ecological Security: The order parameter is a very important concept in Synergetics of Haken, and also the important reason to affect the evolution of Information Industry Ecological Security. It is a macro parameter, which dominates the synergistic manner and interoperability between the bodies that constitute the information industry, thus dominates the evolution of Information Industry Ecological Security. While the fluctuation is an important reason that generates the order parameter in the process of competition and collaboration between the bodies of Information Industry Ecological Security.

The order parameter has great promoting role for the evolution of Information Industry Ecological Security, and it has the following two characteristics.

(1) The order parameter is the product of the collective movement of the constituent body of information industry, and it's also the characterization and measurement of their competition and synergy. In the beginning of the formation, the information industry is often in the unsafe condition which means every part of the system acts independently. But when a leading power generates fluctuation, such as a network technology innovation, to drive the information industry far from equilibrium, independent acting of each part in information industry begins to associate with each other. Also, because of the presence of the fluctuation, interactions and environmental resources, input such as energy and information among the bodies together constitute the coupling relationship. In the effect of nonlinear positive feedback, its influence sphere is expanding. So the collaboration began to hold dominant position in contradiction of competition and cooperation, and ultimately leads to the generation of order parameter.

(2) The order parameter governs the behavior of all bodies in information industry, and dominates the process of evolution of Information Industry Ecological Security. According to the servo principle, although the order parameter is the product of the collective movement of the bodies of information industry, once it is formed, it has become an important reason for dominating the behavior of the bodies to make the bodies act according to the "instructions" of order parameter. Therefore, the order parameter is both the characterization and measurement of their cooperative effects, and a measure of the overall motion state of information industry.

4. Evolution Modeling of Information Industry Ecological Security and Empirical Research

4.1. Evolution Process Modeling of Information Industry Ecological Security

As a complex giant system, the status of information industry has to be described by using multiple variables, and it also has to depend on the state variable s of the system to analyze its evolution of ecological security. These state variables change over time according to their characteristics, and they can be divided into fast time-varying variables and slow time-varying variables. According to the Servo Principle of Haken, we can know that when the system changes, the evolution process and characteristics of the system are determined by the slow variables [13]. The evolution of the system is dominated by the slow variables, and the fast variables are servitude by the slow variables. Therefore, we can distinguish fast and slow variables by calculating, find the linear instability point, eliminate fast variables, and then obtain the order parameter equation which can be used to reveal the evolution process of Information Industry Ecological Security.

4.1.1. Model Assumptions: We give the following assumptions before constructing the model.

Assumption I: The self-growth rate of each individual of information industry is λ_i.

Assumption II: The evolution of Information Industry Ecological Security is related to its self-accumulation $q(t)$, and the higher the self-accumulation is, the safer the information industry is.

Assumption III: There are relationships of competition and cooperation between the information industries, and the interaction coefficients are α、β....

Assumption IV: There is mathematical sense of continuity with the evolution of Information Industry Ecological Security.

4.1.2. Model Construction: According to the Haken model, the interactions between different variables within the information industry that make the evolution process of ecological security occurred can be described in a mathematical form, shown as equation (1) [14].

$$q_i^* = -\lambda_i q_i + \sum_{j=1,...,i-1,i+1,...,n} \alpha q_i q_j, i = 1,2,...,n \tag{1}$$

Here, q_i is a state variable, α and λ_i are the control parameters. And α represents the intensity of competition and cooperation between different variables. If α is positive, then there will be inhibition between q_i and other variables. Otherwise, if α is negative, then there will be synergistic effect between these variables.

We can get the quantitative relationship between these variables through solving equation (1), and then identify the system order parameter.

We will only take two variables as an example to solve the equation. For ease of application, discrete the above equation into the following.

$$\begin{cases} q_1(t+1) = (1-\lambda_1) q_1(t) - \alpha q_1(t) q_2(t) \\ q_2(t+1) = (1-\lambda_2) q_2(t) + \beta q_1^2(t) \end{cases} \tag{2}$$

First put the original values of q_1 and q_2 into equation (2) and execute the regression analysis to get the control parameters values of α、β、λ_1、λ_2.Then put them into (1) which reflects the interaction between q_1 and q_2, and let $q_1^* = 0$ to get the solution using the method of adiabatic approximation.

$$q_2 \approx \beta / \lambda_2 \, q_1^2 \tag{3}$$

We can see from (3) that q_1 decides q_2, that is to say that the latter changes with the former, indicating that q_1 is the order parameter of the system. Then put (3) into (1) and get the order parameter equation.

$$q_1^* = -\lambda_1 q_1 - \alpha\beta / \lambda_2 \, q_1^3 \tag{4}$$

And then get the potential function by calculating its opposite number.

$$v = 0.5\lambda_1 q_1^2 + \alpha\beta / 4\lambda_2 \, q_1^4 \tag{5}$$

We can determine the convex and concave character of the potential function v by its second derivative d^2v/d, and then describe it graphically. The structural characteristics of the potential function can reflect the evolution mechanism of Information Industry Ecological Security intuitively, that is, when the state variables and control parameters change, the system potential function also changes, and the original stable state comes into an unstable state [15].

4.2. Empirical Research on China's Information Industry Ecological Security

The information industry has the characteristics of large R & D investment, long period and high risk. The traditional investment and credit capital are difficult to achieve effective support for innovation and entrepreneurship development, while the active venture capital and perfect multi-level capital market are the important supports for the healthy development of industry. Take US Silicon Valley and Wall Street as a representative. They formed a mutual linkage mechanism between high-tech industries, venture capital and capital market. The rapid expansion of some famous high-tech companies, such as Intel, Microsoft, apple, CISCO, Google, YAHOO, etc., in addition to technological advantages, are not separated from the credit of Wall Street. It helps the United States to achieve a new economic transformation by the wave of high tech that led by Silicon Valley and Wall Street. The positive interaction between technological innovation and capital market maintains the position of the United States with strong economic power. At the same time, the UK market, South Korea KOSDAQ market and the venture capital of these countries have become an important support for the development of their domestic industries. Therefore, we select two variables of technology innovation and capital investment to make analysis.

We can get the steady-state solution of China's Information Industry Ecological Security order parameter equation based on the formula (4), and there are two cases.

(1) If $\lambda_1 > 0$, then (4) has a unique stable solution $q_1 = 0$, and its potential function is shown as Figure 6.

(2) If $\lambda_1 < 0$, the (4) has three solutions, and they are $q_1^{\,1} = 0$, $q_1^{\,2} = \sqrt{-\lambda_1\lambda_2 / \alpha\beta}$ and $q_1^{\,3} = -\sqrt{-\lambda_1\lambda_2 / \alpha\beta}$. Here, only the second solution and the third solution is stable, as shown in Figure 7, which shows the information industry can enter into a new security status through mutation, and the change of q_1 would influence the change of whole information industry.

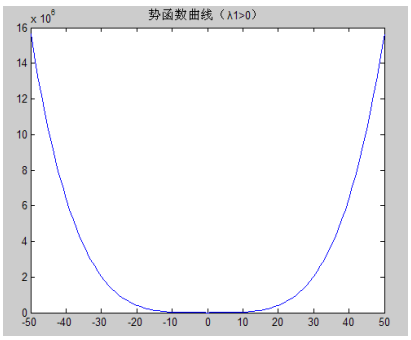

Figure 6 $\lambda_1 > 0$

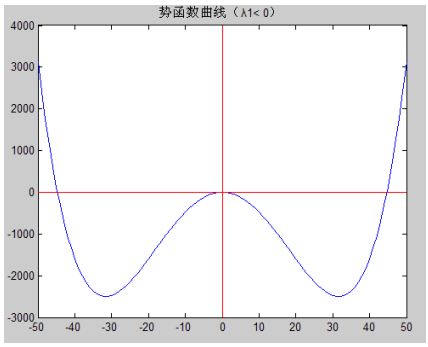

Figure 7 $\lambda_1 < 0$

(Obtained by substituting simulation data into Matlab, assuming $\lambda_2 = 1$, $\alpha\beta = 0.01$)

The evolution process of Information Industry Ecological Security can be represented by the potential function change of the information industry in Figure 8. When $\lambda_1 > 0$, the system potential function has only one minimum point, which is also the progressive safety point of information industry. At this point, although the information industry deviates from the safe point sometimes under the influence of random fluctuation force, it would soon return to the original location and maintain the safe state. When λ_1 gradually approaches zero, the curve of system potential function becomes flatter. And despite the potential function still has only one stable point, it will be very slow for the information

industry that departing from the safety point returns to its original state under the influence of random disturbance. That is "critical slowing down". The perturbed range is also growing, which is "critical fluctuation". When $\lambda_1 < 0$, the potential function has two minimum points, corresponding to the two stable points, and it is determined by the random fluctuation that the information industry would enter into which one safe state.

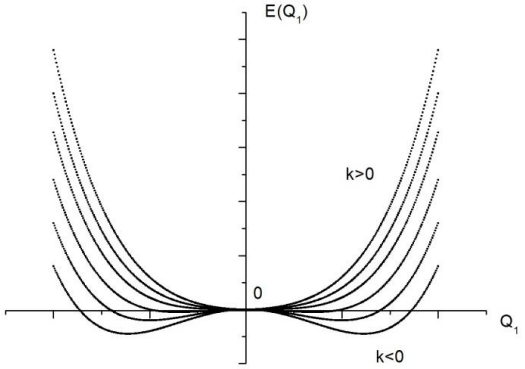

Figure 8. The Potential Function Change Diagram of the Information Industry

At present, the development of China's information industry generally faced with shortage of independent innovation and core technology situation and the industrial security is challenged. 92.3% of the global PC and 80.4% of the supercomputer use the Intel chip, 98% of the server core technology is in the hands of IBM and HP, and 89.7% of the database software is controlled by Oracle and Microsoft. As a important policy carrier, the capital market should make full use of its function, strengthen the enterprise independent innovation ability, improve the industrial whole technology level, and thus promote the optimization and transformation and upgrade of industrial structure.

In June this year, Xi Jinping, the general secretary, proposed in Academicians Congress to deploy the innovation chain around the industry chain and to improve the innovation chain around the capital chain. The breakthrough of any new technology and the formation of any new products are inseparable from the support of a lot of money. And the innovation of a product relies on the technological innovation and the business model innovation of all aspects in industry chain to achieve. Therefore, it needs accurately and reasonably investing money on different aspects of the industry chain and the innovation chain to improve the efficiency of innovation funds, realize independent innovation strategy, enhance the international competitiveness of industry, and promote the sustained and healthy development of China's economy. America's "Silicon Valley, Hollywood and Wall Street" mode, Shenzhen's "Tencent and BYD" mode and other cases are the typical representatives. It would integrate the spirit of equality, openness, sharing and free in Internet into every aspect of the industry chain to play an important role in the capital market, promote division and consolidation of industry chain, keep all sectors of the industry chain in control, promote competitive enterprises bigger and stronger, and thus protect industrial security.

5. Conclusions

The Information Industry Ecological Security is a combination of security and dynamic development, and its evolution depends on the joint function both of the internal and external driving forces, so it’s the key to improve the mechanism of competition and cooperation between information industries in order to guarantee the smooth evolution of Information Industry Ecological Security. During the evolution process of Information Industry Ecological Security, the technology

innovation is the fundamental driving force of the evolution. The government should coordinate the relationship between the interest-driven mechanism and ecological balance mechanism, take on comprehensive controlling measures, make sure there is no adverse evolution of Information Industry Ecological Security, so that the Information Industry Ecological Security can maintain coordinated, sustained and stable development.

Acknowledgements

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