Zán Tingquan

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Brief Introduction

This book discussed the theoretical foundation of industrial economic system analysis in detail, the general methods of classification of industrial economic systems and industries, as well as the basic characteristics of the industrial economic system and its three basic relations. It put forward the industrial resource-niche theory, the self-organization model of industrial structure evolution, the self-organizing institution and the hierarchical institution as well as the various combination of industrial policies, analyzed the systematic economic effects, put forward a new law of division of labor and elaborated the enterprise merger, economy of scale and system integration industries, etc. This book is suitable for college teachers and students who major in economics and management, or others working in government, enterprises and research institutions related.

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PREFACE

In scientific community, many people think that Theory of Relativity, Quantum Theory and Cybernetics are the three greatest scientific achievements in the first half of 20th century, which are the three great leaps of mankind to know and reform the world (Song Jian, 1996). In China, scientists usually divide the system science into two parts: the three old theories and the three new theories. The three old theories are cybernetics (Norbert Wiener, 1949), system theory (Bettalaffy, 1968) and information theory (Shannon, 1948); the three new theories are synergetics(Haken, 1977; 1983; 1987), theory of dissipative structures (G. Nicolis and I. Prigogine, 1977; 1987) and catastrophe theory (Tohm, 1988). The front edge of system science is on the research of non-linearity system; distinctive behaviors of non-linearity system are forks and chaos. In China, scientists who made outstanding contributions to system science are Qian Xuesen (1954, 1958, 1988), Wu Xuemou (1984, 1990), Deng Julong and Liao Shantao (1996), etc.

Internationally, it has been a long time for scientists to study with system science thought, and the most typical example and outstanding achievement is Wassily Leontief's input-output model, for which Wassily Leontief won the Nobel Prize in economics in 1973, and established International Input-Output Association. This association originates a famous magazine that has international influence: *Economic Systems Research*. Nearly all the articles published on *Economic Systems Research* used system method to study the economic problems. In 1987, Professor A. G. Fox and D. Miles of Edward's State University in the USA edited and published a collection of articles: *Systems Economics*: *Concept, Principle and Methodology*. There are two articles in the collection involving the problem of industrial economic system analysis. In 1987, M. Harris published *Dynamic Economic Analysis*. Professor Zou Zhizhuang, a Chinese American, published *The Analysis and Control of the Dynamic Economic System*. All of these are the early results of the combination of system science and economics.

In recent years, with the rapid development of the non-linearity system science, the effort to combine the system science and economics is also strengthening continuously, mainly concentrating on looking for the "economic attractor" and the research of the chaos behavior and the forks of macroscopic economic system (Chen Ping, 1988; Stutzer, 1980; Eeneckere and Pelikan, 1986). Moreover, from the works of industrial economics translated and published domestically nowadays, there is also much system science thought among them, such as J. Tirole's *Industrial Organization Theories* (People's Press, 1997) and *The New Problems of Industrial Economics* which is mainly edited by J. Cabourg (Chinese Tax Administration Press and Peking Tengtu Electronic Press, 2000)

In China, scientists tried to apply system method to economics since 1980s; representative works were: *The Regulation and Evolution of Dynamic Economic System* which is written by Deng Yingtao and He Weiling (1985), *Non-equilibrium System Economics Introduction* which is edited by Hu Chuanji and Zhou Baorong (1987), and so on. In China, the most successful scientist who applied system science to economics is Song Jian. He succeeded in constructing the cybernetics model of population development (Song Jian and Yu Jingyuan, 1985), and therefore acquired the blue ribbon of international modeling. Jiang Lu, Shi Long (1995) and Shen Huasong (1991) discussed the self-organization management theory and the self-organization theory of economic system with the

self-organization theory, respectively. Wu Jie published a lot of articles about constructing system economics from the aspect of philosophy in recent years (Wu Jie, 1998). Wu Xuemou also expounded the thought of economic system analysis in the related articles (Wu Xuemou, 1990; 1996). The author of this book has published series of articles about economic system analysis since 1980s, and tried to establish the quasi-axiom system of system economics (Zan Tingquan, 1988; 1990; 1995; 1996; 1997; 1998; 1999).

Although the combination of system science and economics becomes more and more close, and more and more "special subject researches" of economics with the system method appears, the "paradigm" of system analysis of the economics research has not formed so far. Thesis of the industrial system analysis can be found in "special subject research" related to economics, while we have not seen any research work on synthesizing different "special subject researches" together, and then put forward a basic frame of the industrial economic system analysis. This is the right consideration and basic motive of the research in this book. Based on the studies of forerunners, treating industrial economic system as the research object of industrial economics and industrial economic system analysis, this book adopts the methods of system science, qualitative analysis and qualitative researches, trying to establish primary academic foundation for the industrial economic system analysis, and provides a basic analytical frame. We can comprehend the significance of the study of industrial economic system from two aspects at least.

Firstly, the range of the research of industrial economics is badly in need of being expanded. With accelerated development of science and technology feedback and continuous improvement of social productivity, especially exchange of global knowledge and information made by science techniques, human activities especially the economic activities have already reached the scale and intensity that makes "the mankind have already become a kind of geology strength that have new huge influence." If it cannot be treated carefully, it will certainly cause a gradually lack of resources which support the subsistence and development of mankind, and then endanger the development of social economy and survival conditions of human being. The question of how to reflect this change in industrial economics, instead of treating it as the outside restriction of the inside theory, makes industrial economics face a revolution to expand the range of research. The concept of resource-niche put forward by this book is an important step toward this direction.

Secondly, the research method needs to be modernized. Because of the development of information business and transportation vehicles, the economic activities are gradually getting complicated; the whole world is becoming a village. The global economy becomes an inseparable and complicated system, in which the development of economy of each nation has to be brought into the track of international economic development. The research object of industrial economics is more and more complicated. How to analyze and operate the complicated industrial economic system effectively makes the industrial economics face a revolution on research method, requiring people to grope for a new research method, and develop a new analytic paradigm. The perspective that regards industrial economic system as the research object of industrial economic system analysis and industrial economics, and the practice that defines institution with the industrial economic system could be the first step to construct a new industrial economic analytic paradigm.

Under the dual backgrounds of both expanding research range and innovating study method of industrial economics, this book chooses the special subject of industrial economic system analysis, so its academic and practical significance is obvious.

Zan Tingquan

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ABSTRACT

The research on industrial economic system is a new direction in industrial economics study. This book tries to provide an academic foundation and a general analytic frame for industrial economic system on the base of the work made by people before.

This book includes eight chapters. In the preface, the history, actuality and significance of studies in industrial ecónomic system are discussed briefly. Analysis of industrial economic system begins from the first chapter. Here is a brief introduction according to the sequence of the content.

I

On the basis of traditional classification methods, this book provides a general method for industrial classification: relativity criteria (f, θ, D) (the first chapter), which is the foundation for analysis of industrial economic system. "Industry" is a basic concept in industrial economics. On the basis of "industry", the concepts of industrial organization, industrial structure and industrial economic system can be put forward. Moreover, ascertainment of industrial concept associates closely with classification of industries and the classification of industries can not be separated from industrial economic system. In order to open out the industrial economic system analysis, this chapter makes use of methods of systems economics to provide a formalized definition of industrial economic system, that is,

Industrial economic system = ({Industry (i) | $i = 2, \ldots, n$}, {The Relationship Between Industry (i) and Industry(j) | $i \neq j, i, j = 1, 2, \ldots, n$})

The so-called industrial structure mentioned above is the summation of relationships among different industries; and industrial organization refers to the summation of relationship of economic elements in industries. For enterprises, industrial organization is the summation of relationships among different enterprises.

Take the formalized definition of industrial economic system as the master line, I briefly narrate and comment some main industrial classification methods according to the time order, like Quesnay's *Economic Table*; Industrial classification theory of Max; Russian "agriculture, light, heavy" method of industrial classification; three-industry classification by A. G. D. Fisher and C. Clark from England; standard industrial classification method by U. N. and industrial classification method by Hoffman etc., as well as other industrial organization and industrial structure thought included. It indicates that the classification method should satisfy the following four standards: (1) intension; (2) completeness; (3) comparability; and (4) maneuverability. This chapter points out some limitation in "either this or that", "maturity" and "maneuverability", on the base of which, the general method of classification, that is, relativity criteria (f, θ, D) is raised. Here f is the initial economic relationship; θ is the classification criteria which is half-equivalence relation (tolerance relation) usually; operator D is the set of weight levels of f. The relativity criteria (f, θ, D) indicate that any change of any one of f, θ or D will lead to different industrial classifications.

In the last section of the first chapter, a thorough study on relativity criteria (f, θ, D) of industrial classification is made by Quasi-quotient topology method to form its topology model. Assume an economic system a, outside of it the approximation to appex (θ_1) is not

connective relative to half-equivalence operator θ_1. In other words, initial economic system is divided into two different industries in relative to θ_1. However, the approximation to appex (θ_2) may be connective in relative to the operator θ_2 for the same economic system. In other words, two different industries in relative to θ_1 turn to one industry in relative to θ_2. And this is a mathematical expression of the relativity of industrial classification. This chapter also points out the limitation and conditions for transmission of the relativity of industrial classification.

II

A thorough study on relativity criteria (f, θ, D) of classification and definition of industries naturally strengthens our cognition of industrial economic system which is the analytical object of industrial economics and industrial economic system. The analysis to the basic *characteristics* of industrial economic system *is* the foundation of the entire industrial economic system analysis. Various industrial economic systems have many characters and this book summarizes four basic characteristics of them: hierarchy and holography, Eigen-spatial and Eigen-temporal scales, nonlinear and non-equilibrium, self-organization and mechanism.

Hierarchy and holography are two important *characteritics* of industrial economic systems. The hierarchy of economic systems stresses on the diversity of an industrial economic system, and holography emphasizes particularly on the similarity. The former means that industrial economic system can be divided into several hierarchies according to relativity criteria (f, θ, D) of industrial classification, and they all have their own features and regularities; the latter points out that industrial system of different hierarchies or certain industrial economic system at different evolutional stages have similar nature and regularity. In view of philosophy, the hierarchy stresses on the particularity of an industrial economic system while holography stresses on the generality and these two make up of a pair of conjugate property.

In order to understand the hierarchy of economic systems exactly, we should discuss it under the background of global economic system. In relativity criteria (f, θ, D), if we make θ as the level of organization, the economic systems can be divided into six hierarchies: household economic system, enterprise economic system, industrial economic system, regional economic system, national economic system and global economic system, in which the global economic system is the highest hierarchy of these economic systems and the household economic system has the lowest organization level. In order to study the dynamic mechanism and variation rule of industrial economic system, we must go deeply into lower hierarchy, for example, household economic system, enterprise economic system. At the same time, it is dominated by high-level economic systems so it has to be analyzed under the background of the district, the state and the global economic system. There are two extreme *conditions* for hierarchy of industrial economic systems: (1) all the economic activities in many hierarchies belong to one industry; and (2) each unit (or enterprise) in economic system makes up a single industry.

The Eigen-spatial and Eigen-temporal scale of an economic system is intrinsic attribute of an economic system, which does not change with environment. We name the smallest time span which can embody the processes' character of the economic system Eigen-temporal scale and name the space range correspondent to the Eigen-temporal scale Eigen-spatial scale of an economic system. The Eigen-temporal scale and Eigen-spatial scale of the economic systems are called Eigen-spatial and Eigen-temporal scales. According to the hierarchy of industrial economic systems, each hierarchy has their own Eigen-spatial and temporal scales.

Generally, the Eigen-spatial and Eigen-temporal *scale of high-level economic system is* bigger than that of a low-level one.

Let L_{ij} (i = 1, 2, 3, 4, j = 1, 2,..., m) denote Eigen-temporal scales of big, medium, small and tiny items in "Standard industrial classification index of all economic activity", respectively, then

$$L_{i\,j} > L_{2j} > L_{3j} > L_{4j}$$

For industrial classification has character of relativity criteria (f, θ, D), Eigen scales L is also a function with parameters f, θ, D, then

$$L = L\,(f, \theta, \mathrm{D})$$

The value of Eigen scales accounted in this way is in theory and expressed by L_{theory}.

Essentially, the Eigen scales of industrial economical system is decided by its inherent attribute, that is to say, the Eigen scale is the empirical value or the experimental value indeed, expressed with $L_{\text{experiment}}$

L_{theory} should submit to $L_{\text{experiment}}$ which provides an indirect testing approach to the detection of relativity criteria (f, θ, D). Assume that,

$$L_{\text{theory}}\,(f, \theta, \mathrm{D}) = L_{\text{experiment}}$$

then θ and D chosen by classification criteria are appropriate for the problem worked on, and otherwise, unsuitable.

The nonlinear and non-equilibrium character of industrial economic system is the origin of diversity and complexity of industrial process and phenomenon. Non-equilibrium is the opposite of *equilibrium*; and non-linearity is the quantitative relation among the industrial elements. Traditional growth theory which excludes the factor of industrial structure as the source of growth is founded on the assumption of competitive *equilibrium* (Guo Zhenhua, 1996). In the state of competitive equilibrium, all industrial yield of element is equal to marginal productivity. If industrial economic system is in this state, the drive of resource transferring among different industries is diminished. Thus, the adjustment of equilibrium in industrial economic system is an ideal model which assumes potentially that the adjustment processes extremely slowly in order to satisfy that every state is equilibrium. Pasinetii (L. L. Pasinetii, 1981) ever pointed out the differences of labor and capital between *industries*. Thereby, the change of industrial structure is a process of non-equilibrium. The non-equilibrium stationary state is correspondent to equilibrium state of industrial economic system. Non-equilibrium stationary state refers to the stationary state in the restriction of non-equilibrium. Here non-equilibrium restriction means generalized resources change between industrial economic system and environment. In non-equilibrium stable state, the state variables are not changing with time.

Let X_i (i = 1, 2, ..., m) denote state variables of industrial economic system, then evolutionary equation can be written generally as:

$$\frac{\mathrm{d}X_i}{\mathrm{d}t} = F_i(\{X_i\}, r, t, \lambda)$$

where r and t represent Eigen-spatial variable and Eigen-temporal variable, λ is the control parameter, which reveals the non-equilibrium restriction. When the industrial economic system is in the non-equilibrium stable state,

$$F_i\,(\{X_i\}, \lambda) = 0.$$

This is a particular non-equilibrium state of industrial economic system.

When solving the evolutionary equation of economic system, nonlinearity plays an

important role. In the stable states far from balance, without the restriction of precise equilibrium condition, nonlinearity makes that the evolutionary equation of economic system has multiple solutions, and then engenders divergence and confusion. So non-equilibrium shows the potentiality hidden in nonlinearity, but when it is in or near equilibrium state, it still remains "latent". The thought provides a new approach for researching incentive mechanism and how to develop the latent ability and initiative of people.

The nonlinear and non-equilibrium character of industrial economic system determined its dynamics character and its representative behavior is stability. If we know the stability of economic system we can naturally know its instability and conditions for evolution, etc. The reason why industrial economic *system evolves* can be partly the "disturbance" from outside and partly the fluctuation inside the system. According to the despondence of economic system to these deviations, we studied on the diversified stability: Lyapunov stability, asymptotic stability, partial stability and whole stability. The possibility that industrial economic systems lose the stability under certain conditions shows the road which leads to the transition phenomena of the difference and complicated behavior within the economic system. At the same time, forks and symmetrical gaps seem to be precondition of industrial division.

The so-called mechanism of the industrial economic system refers to the relationship between the structure and function. In principle, the structure of the industrial economic system is the premise and guarantees to achieve a certain function, and the function is an external performance of the industrial economic system's internal structure. The mechanism of a certain industrial economic system or namely the relationship between structure and function is decided by concrete situation of the certain economic system. The purpose of consummating the function can be attained by changing the structure of the industrial economic system. Reformations of industrial structure that China practices now is to change the current structure of economy in the hope of bringing China's economy persisting increase. Vice versa, certain functions also benefit the constructing of new economic structure. In other words, keeping certain increasing rate can benefit the evolving of industry and construction of new industry.

Through the mechanism of itself, industrial economic system spontaneously constructs new industrial *structure* and attains the upgrading of industrial structure, which we call self-organization of industrial economic system. Self-organization and hierarchy which determine the operating manner and appropriate scope of industrial policy are two most important characters. When the behavior of industrial self-organization is in dominant status, only the inductive and indirect industrial policy can be taken. For example, the research of home electric appliance industry by Liu Shijin and Jiang Xiaojuan (1996) indicates that improper intervention of government must be of no use finally. The self-organization of industrial economic system has three characters:

(1) Every industry in industrial economic system organizes and adjusts by itself, there seems to be a hand which can not be seen manipulating these different industries; on the other hand, the cooperation of these industries is the reason for generating the hand which manipulates behaviors of every industry and forms an orderly industrial structure at last.

(2) The formation of new industrial structure or upgrading of old industrial structure is usually dominated by a few parameters. Though there are a great many parameters, surprisingly, at the critical state, just a few of them play important role. For example, the appearance of Internet brought an adjustment of industrial structure to world economy. Generally, there are many factors affecting the adjustment and update of industrial structure, but the effective ones were countable: adjustability, convenience and security of internet. This discovery has tremendous practical meaning: in view of mathematics, it allows us to deal with some high-dimension problem in the most economic way; at the aspect of economy, the

complicated industrial adjustment and update is simple essentially, and complicated industrial structure itself is determined by only a few parameters.

(3) In the appearance of new industrial structure or the critical point for adjustment of industrial structure, fluctuation functions as spring. Because at that moment industrial economic system is in the state of instability, any tiny fluctuation will be enlarged and then force industrial economic system to a state corresponding to new industrial structure.

III

The four essential characters and three essential relationships of industrial economic system make up the theory basis of industrial economic system analysis. And the three relationships are: whole-part Relation, causality relation and Shengke relation.

We put forward the analytical frame of economic structure, industrial structure and industrial organization, etc. in the third chapter of this book. And two propositions are obtained from mathematics:

Proposition 1: when each economic element of economic system constructs an industry, the structure of industry is equal to economic structure.

Proposition 2: when a whole economic system is an industry, economic structure is equal to industrial organization.

The three essential relationships in industrial economic system are three analytical modules of general frame mentioned above. In this book, three modules are discussed one by one and its corresponding mathematic descriptive method and operational rule are put forward, which constitute the foundation of whole industrial system analysis.

In order to establish a mathematic model of Whole-part Relation, causality relation and Shengke relation, we first construct a pan-weighted network model of industrial economic system. Let G denote the industrial economic system, then

$$G = (A, f),$$

where $A = \{A_i \mid i = 1, 2, \ldots, n\}$ is a set of different industries A_i, f are various relationships that are defined in A, which can be depicted as the direct product of the set:

$$f \in P(A^a \times W)$$

W is pan-weighted space, $P(\cdot)$ represents the power set, $a \in \{n, [n], *\}$, and A satisfy

$$A^{[n]} = A \cup A \cup \ldots \cup A^n$$

$$A^* = A \cup A^2 \cup \ldots$$

Make $f_i = A^i \times W$, we have $f = f_1 \cup f_2 \cup \ldots \subset A^* \times W$.

Specially, when $f = f_1 \cup f_2$, industrial economic system can be expressed with

$$G = (\{A_i \mid i = 1, 2, \ldots, n\}, \{f_1, f_2\})$$

And this is the *pan-weighted* network model of industrial economic system.

We could work on the Whole-part Relation of industrial economic system utilizing the mathematic descriptive form above. For universality, let economic system $S = (A, B)$, $B \subset A^n \times W$. If $A_i \subset A$ $(i = 1, 2 \ldots m)$, and $\cup A_i = A$, then $S_i = (A_i, B_i)$ is the subsystem of A_i, $B_i = B \cap (A_i^n \times W)$ It's easy to testify $\cup B_i = B$ can come to existence only under following conditions

(1) $B=\varnothing$, then $B_i=B_j=\varnothing(i=j=1,2,...,m)$

(2) $B\neq\varnothing$, but $B_i\cap B_j\neq\varnothing(i\neq j)$, namely there is no relationship between any two subsystems.

According to the definition of industrial economic system, there are connection and interaction between enterprises and subsystems, therefore, the two conditions above are contradicted with the definition of industrial economic systems. We can conclude that,

$$\cup B_i \neq B$$

especially, we have

$$\cup B_i \subset B$$

That is the mathematic description of "The whole is greater than the sum of all parts". The excessive part is the connection derived from subsystems S_i by software of economic system and this is the mathematic description of "effect of systematic economy" and industrial structure's contribution to economic increase.

In order to discuss the causality relation of industrial economic system, we suppose industrial economic system $S = (A, f),. f \subset A^* \times W$. Let $g{:}A\rightarrow g(A)$ is a mapping, namely causality relation, then S's resultant system under the effect of g is

$$S_g = (g(A), f_g)$$

where $f_g \subset [g(A)]^* \times W$, it is equal to the mapping from the software of S to the software of S_g, then

$$f_g = M_g(f) \subset [g(A)]^* \times W$$

If industrial economic system S and its subsystem S_g have different pan-weight space, that is,

$$M_{g,h} : A^* \times W \rightarrow g(A)^* \times W_g$$

which means, to $(X_1, X_2...)$, we have,

$$[g(X_1), g(X_2), ..., h(W)] \in [g(A)]^* \times W_g$$

At this time, the resultant system of industrial economic system S is

$$S_{g,h} = [g(A), M_{g,h}(f)]$$

The general analysis for causality relation of industrial economic system is discussed above. This book provides some idiographic conclusions and operational rules, such as the Causality-Shengke Principle, the Principle of Dynamic Key-order, the Principle of Causality Small Environment, High-efficient Condition Principle and High Price Conjunction Principle, etc.

Shengke relation is one of three essential relationships of industrial economic system. In order to exactly grasp the concept of Shengke, we first introduce the Shengke-relativity Principle of industrial economic system and then construct various mathematic models of industrial Shengke.

For industrial economic system $S = (A, B)$, in which A is a set of industries and B is generalized software, suppose $R = \Pi R_i$ is the generalized resource space, industrial economic relation $f \subset R \times A$. For $g_i \in A$, $f \circ g_i$ is the generalized resource utilized, taken up

and adjusted by g_i and the resource-niche mathematics model of economic system g_i. Suppose $g_i, g_j \in A$ $(i \neq j)$ are two different industries, the degree of inter-restraint of resource-niche between them is:

$$K(g_i, g_j) = f \circ g_i \cap f \circ g_j$$

$K(g_i, g_j)$ can be measured according to semi-order of R's power set $P(R)$.

Endue weight with the degree of inter-restraint of resource-niche between industries, we could get a confliction model of industrial economic system

$$K : A^2 \to P(R)$$

Suppose the weight $D \subset P(R)$, then $K \circ D \subset A^2$ represents industries between which the degree of inter-restraint is controlled. Suppose $D_i \subset P(R), i = 1, 2, 3, ..., m$ represent different degrees of conflict, and then $K \circ D_i \subset A^2 (i = 1, 2, 3, ..., m)$ represents industrial set of different degree of conflict.

In the text, the mathematics models of industrial Shengke we cover include: the Shengke model of generalized supply and demand, five basic elements Shengke model and industrial relation Shengke model, etc. Specially, in the industrial relation Shengke model, the degree of pan-weighted M_{ijk} could be used to describe the conflict degree in rationality, optimization, etc. in industrial structure which plays an extremely important part in industrial economics.

IV

The evolvement of industrial structure could be divided into self-evolvement and hierarchical evolvement. The hierarchical evolvement of industrial structure refers to an evolution process conduced by restriction and effect of high-level economic system and government, for example, industrial structure changes caused by industrial policy. And this problem will be discussed in next chapter in detail. This chapter will focus on evolvement of self-organization of industrial structure which refers to a result caused by reciprocity of different industries among which there are diversity in resource-niche and function, such as the self-change of resource collocation caused by difference in marginal income of industries. Pete-Klink law discusses the variation rule of industrial distribution of labor in different stages of economic growth.

In this chapter, we will first discuss the contributions to economic growth made by the change of industrial structure; then the theory of industrial resource-niche is recounted particularly in order to provide an all-sided basis of evolvement of industrial structure; at last, this chapter also constructs the self-organization mathematic model of the evolvement of industrial structure and discusses the character of it and points out Pete-Klink law is just a special condition of the model.

A common definition of industry niche is given as follows: in generalized resource space, the part that can be occupied, utilized or adapted to actually or potentially is called the niche of this industry. Let $G = \{g_i \mid i = 1, 2, ..., m\}$ be the set of different industries, $R = \prod R_i$ be the generalized resource space, which is the multi-dimension space propped up by generalized resource factors, economic relationship $f \subset R \times G$, so for the industry $g_i \in G$, $f \circ g_i$ is the niche mathematical model of niche of industry g_i. Other part of the generalized resource space which can not be occupied, utilized or adapted to actually or potentially by this industry is called the non-resource-niche of this industry.

According to the mathematical nature of niche, it can be divided into continuous niche and discrete niche; According to the quantity of dimension of resource niche, it can be

divided into 1-dimensional niche, 2-dimensional niche, 3-dimensional niche and multi-dimension niche, etc. In the text, we give a table of resource niche classification systems (Table 4-3) and method of estimation (Fig. 4-3), the equation of niche-element diversity (NED) and niche-element evenness (NEE). If niche-elements are consecutive, then we have:

$$\mathrm{NED}_d = -\sum_{i=1}^{n} P(x_i) \ln P(x_i)$$

where x_i denotes No. i niche-element, $P(x_i)$ represents the probability of niche-element x_i, and $\sum_{i=1}^{n} P(x_i) = 1$. As to AN, $P(x_i)$ denotes the probability that niche-element x_i can be utilized among n niche-elements. To PN or EN, $P(x_i)$ is the probability that the niche-element x_i happens.

The basic thought of calculating the NED of continuous niche ($\mathrm{NED_c}$) is similar to that of concrete niche. So, we have:

$$\mathrm{NED_c}\ (A) = -\int_a^b P(x) \ln(x) \mathrm{d}x$$

In equation above, a and b are respectively the bottom and top limit of niche, $P(x)$ is the probability density function of niche, $\int_a^b P(x)\, \mathrm{d}x = 1$. To AN, $P(x)$ is the probability density function that the industry utilizes the niche. To PN or EN, $P(x)$ is the probability density function that the niche happens.

The evenness of niche-element represents the evenness degree of probability of niche element (NEE) and the equation of estimation is:

$$\mathrm{NEE} = \mathrm{NED}/\mathrm{NED}_{\max}$$

In order to discuss the mechanism of industrial structure evolvement, we give niche quantity similarity (NQS) and niche quantity difference (NQD). The quality similarity of niche describes the quality similarity degree of niche among different industries, the measuring equation is,

$$\mathrm{NQS\ (AB)} = [\ \mathrm{NNE_{AB}} / \mathrm{Max}\ (\ \mathrm{NNE_A}, \mathrm{NNE_B}\ )] \times 100\%$$

The quantities of niche-element of G_1 and G_2 are respectively $\mathrm{NNE_A}$, $\mathrm{NNE_B}$, the quantity of the same niche-element of G_1 and G_2 is $\mathrm{NNE_{AB}}$.

The quantity difference of niche between industries G_1 and G_2 can be expressed as:

$$\mathrm{NQD\ (AB)} = \sum_{i=1}^{n} \mathrm{NEQ}_i\ (\mathrm{A}) - \sum_{j=1}^{m} \mathrm{NEQ}_j\ (\mathrm{B})$$

The theory of industrial resource-niche makes a firm foundation for research on industrial structure evolvement. Evolvement of self-organization of industrial which refers to a result caused by reciprocity of different industries among which there are diversity in resource niche and function. For example, the self-change of resource collocation is caused by difference in marginal income of industries. On the foundation of this theory, due to the nonlinear and non-equilibrium character of industrial economic system, we discuss the characteristics and structure method of the evolvement of self-organization of industrial mold; also we establish self-organization mathematics mold in view of the labor force's evolvement situations in the different industrial distribution.

$$\frac{dX_i}{dt} = \zeta \bullet PN_i \bullet (J_i - X_i)$$

$$\frac{d(PN_i)}{dt} = \lambda P - \frac{dX_i}{dt} + MG_i^{in} - MG_i^{out}$$

$$= \lambda P - \frac{dX_i}{dt} + k\sum_{j \neq i}(PN_j)\frac{V_{ij}}{\sum_k V_{kj}} - k\sum_{j \neq i}(PN_i)\frac{V_{ji}}{\sum_k V_{jk}}$$

$$\frac{dJ_i}{dt} = \rho J_i(1 - \frac{J_i}{M_i})$$

$$\frac{dM_i}{dt} = \eta t_i$$

The model can be considered as Pete-Klink law's general form.

V

The evolution of industrial structure can be divided into the self-organizing evolution and the hierarchical evolution. Based on resource-niche theory, the fourth chapter explains the basic character of the self-organizing evolution at some length, and formularize the self-organizing mathematic model which is about the evolutional rule of the labor forces in different industries. And then it focuses on the hierarchical evolution of the industrial structure from the aspects of industrial institution and industrial policy.

Firstly, it gives a brief survey of new institutional economics, and puts forward a general theory of institution: self-organizing economic institution and hierarchical economic institution. Then, it advances series of combinations of the policies which lead to the evolution of hierarchical industrial structure.

Upon the definition of institution in new institutional economics, it provides a generalization definition for the concept of institution as follows.

The institution means an organic whole which is composed of various kinds of restraints and influences on its economic elements and subsystems from the government or other economic systems (Zan Tingquan, 1996), as well as the relationship among these different kinds of restraints and influences. It can be formally shown as:

Institution = ({Restraints and influences on its economic elements and subsystems from the government or economic systems}, {Relationship among those different kinds of restraints and influences})

In this definition of institution above, the institution itself is a system. It is composed of parts: one is the various kinds of restraints and influences on its economic elements and subsystems from the economic system, which could be called the set of institutional elements; the other is the set composed of the relationship among these institutional elements. Usually, we regard the set composed of various kinds of institutional elements as the hardware of institution, while the set composed of the relationship among different elements as the software of institution. Thus, the institution can formally be shown as:

Institution = ({institutional elements}, {Relation among the different institutional elements}) = (hardware, software).

Through the simple comparing analysis, we can easily find that the definition of institution here covers all kinds of definitions about institutions in new institutional economics. According to the viewpoint of North that "the institution is some restraint terms that the mankind designs to regulate human interaction", and the viewpoint of Schultz that

"the institution is a set of a group of behavioral rules", their core contents all emphasize that the institution is some restraint terms of human behaviors, but these definitions are relatively general and non-hierarchy, so it is inconvenient for further investigation and refinement. Meanwhile, they don't clearly view the relationships among different constraint conditions and rules as an important content in the institutional study. The viewpoint of John R. Commons that "the institution is the control on individual behavior of the collective behavior" is relatively close to our definition. Comparing the individual with the collective, the collective is equivalent to the economic system, and the individual is equivalent to economic elements and subsystem of the economic system. Therefore, the definition of Commons belongs to the first part of ours.

Because of the hierarchy of economic systems, the institution can be defined as the organic whole which is composed of the various kinds of restraints and influences on its economic elements and subsystems from the government or other economic systems, as well as the relationships among these different kinds of restraints and influences, which itself has involved the hierarchy of institution. In the relativity criteria of industrial classification: (f, θ, D), if we regard the organizational level as the classification criterion θ of the economic system, the economic system can be divided into household economic system, enterprise's economic system, regional economic system, national economic system and global economic system. According to our definition of the institution, we can get household institution, enterprise's institution, regional institution, national institution and global institution correspondingly. If we regard industrial characteristic as classification criterion θ of the economic system, the economic system can be divided into agricultural economic system, industrial economic system and financial economic system, etc. We can correspondingly get agricultural institution, industrial institution and financial institution, etc.

In terms of the relations between individuals and institutions, from the perspective of property right economists, there are only individuals or single subjects, no classes or social forces made up of individuals (Huang Shao'an, 1996). According to the definition we provide, the institution includes not only the restraints and influences on single elements (individuals) from economic systems, but also the restraints and influences on the behavior of its subsystems and the relations between them. These subsystems mainly refer to the interest community composed of "the same interest relation", the interest stratum (class) and the interest group. To understand from this perspective, the relationship between individuals and institutions include not only the relation between individuals and institutions, but also "the relations between people in the class and institution" at the same time. This is just in accordance with the viewpoint of Marxism economics.

In terms of the relationships between the different level economic systems, the institution of high level economic system has decisive function on the institutional arrangement of the low level economic system. It regulates a basic range for the institutional arrangement of the low level economic system, or in other words, sets up a basic frame. Within the range of this frame, the low level economic system can choose and arrange economic institution freely, but it can't go beyond this frame, not to mention conflicting with this frame.

Generally speaking, compared with the high level economic institution, the low level economic institution is derivative, relative and diversified. Different low level economic systems with the same high level economic institution, or economic systems with the same institutional environment, can have different institutional arrangements according to different specific conditions.

According to the causes and the mechanism for implementing the institution, it can be divided into two parts: Self-organizing institution and hierarchical institution. The Self-organizing institution is an institution which is formed, organized and implemented by

the economic system itself. And hierarchical institution is a kind of institution that the institution arrangement is set directly by the government or the higher level economic system to the low level system and supervised by outer authority to complete.

So we can formally express institution as follows,

Institution = ({Self-organizing institution, hierarchical institution}, {the relationships between hierarchical institution and Self-organizing institution}, institutional environment)

In order to discuss the hierarchical institution in detail, we need to introduce the concept of economic system condition space. From the perspective of information theory, the so-called "now" state of economic system is the minimum information of "current" which must be known in order to assure the future state of economic system in the condition of all future environmental conditions given. In the economic system state space, the existence of the economic attractor divides the economic system condition space into two regions: One is economic attractor and its influenced range (I), the other is the region that the economic attractor can't impact (II). This constitution of the economic system state is called "comparing type" of economic systems. This objectively decides the mode and range of actions of the Hierarchical economic system. In the range (I), the self-organization must play the role to restrain and regulate the economic system and its subsystems; In the range (II), the high-level economic system or the government should directly set institution to do it. Moreover, even in the range (I), self-organizing institution is entirely possible to drive the economic system to a low efficient or inefficient state and trail. In this case, the higher level system or the government can indirectly restrain and regulate the economic state of the range (I) through setting institutional arrangements of impact attractor q_1, q_2, $q_3 \ldots q_n$.

The hierarchical evolution of the industrial structure is mainly decided by the direct restraint and control from the government or the high level economic system, which is performed by various kinds of industrial policies. According to the self-organizing institution and the hierarchical institution theory, we propose a clearer industrial policy combination that promotes the hierarchical evolution of the industrial structure to the goal which has been decided, namely

The industrial policy system = [(the industrial environment policy, the direct intervention policy, the indirect intervention policy, the inductive industrial policy, the industrial organization policy), (relations of the five policies above)]

Therefore, in the process of formularizing industrial policies, we should firstly take into account the five aspects above of the industrial policy, and meanwhile pay attention to the coordinated relationships between different industrial policies. Different combinations of these five industrial policies can achieve the different industrial policy goals and functions.

VI

Romer noted that the technology or knowledge as a commodity is unlike either the usual competitive goods or the public goods. Non-competitiveness and partial exclusiveness jointly portray the characteristics of the technology. The non-competitiveness of the technology can be performed as an enterprise or an individual could not prevent other people from using this technology at the same time, and the duplication cost of technology can be regarded as zero. The partial exclusiveness of technology has guaranteed that the enterprise doing research can benefit from the technical innovation.

The new growth theory points out that the inherent-decisive factor of the economic growth is the advancement of technology. According to the Kondratieff's business cycle theory, the present world economy is in the business cycle that the information industry is the leading industry. The important characteristic is that the knowledge and technology is more

important in the economical function than ever before, which can be called economy based on the knowledge, or knowledge economy for short. Thereupon, it has been a common view to take the accumulation and production of the knowledge seriously and attach importance to the invention and the innovation of technology. But the next problem is: how do we develop the invention and the innovation of technology, how does the enterprise choose the specific technical innovation project, which principles should the enterprise obey when choosing concrete innovation projects, and so on. The following technical innovation principle attempts to provide the partial answers to these problems.

Technical innovation principle: The economic system should choose such technical innovation project that the time criterion and the spatial scope involved should match with the Eigen-spatial and the Eigen-temporal scales of the economic system.

There are two keys for application of technology innovation principles: Firstly, we should define the Eigen-spatial and the Eigen-temporal scales of the system, which can be acquired through positive analysis according to the system economics principle. Secondly, we should determine the temporal scale and the spatial scope of the specific technological innovation project under the ideal conditions.

Technological innovation problems pertinent to every layer of economic systems have been elaborated in the main text. It also discusses the innovation system arrangement matching with the technological innovation. Especially, it has pointed out that there is little "originality" in our scientific research, which should be put special attention by the relevant departments.

VII

"The Systematic Economic Effect" is a core concept of the industrial economic system analysis, which is the scientific pattern and deepening of Aristotle's philosophy thought that "the whole is more powerful than the sum of the parts". Because of the development of systems science, especially computers and quantitative-controlling technology, the massive production in economic systems is transforming to de-massified economy. Toffler pointed out that it would lead to a conversion in producing process, even to the 'customized, one-by-one production'. Under the de-massified economy, the designation and production can be done according to various demands of different individuals, so as to increase the social welfare level of the economic system in the most economical way. The consequence of shifting from 'economy of scale' to 'de-massified economy' is to form the so-called economy of systems.

The economy of systems refers to the economic activities carried out in the economic system manner. Relative to the economic activities of non-economic system way, the economic activities through economic system way can generate a certain systematic economic effect. The so-call systematic economic effect means the economic activities carried out in an economic system manner could conform better to the three basic axioms of systems economics, including:

The generalized cost inclines to the possible minimum (the most economic principle of the world).

The level of Social welfare trends to the possible maximum (the social welfare principle).

The level of sustaining development never falls down (the sustainable development principle).

How to produce systematic economic effect? It is decided by the economic system's formation as well as the level of systematization. We can take the following steps to solve the question of economic system's formation: