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Study on Evolution Law and Optimization of Regional Industrial Structure Based on Theory of Stochastic Processes

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Abstract

Evolution process of regional industrial structure is a true random process subject to effects of such random variables as market demands, resources potential, technical advancement, flow of factors of production and policy orientation. The paper studies how the “cause” in the chain of “cause and effect" affects changes and rules of the effect. It attempts to discover thinking of control methods of changes of the "cause" affecting the "effect" established, studies essential rules of evolution process of regional industrial structure and proposes measures for optimizing regional industrial structure from the perspective of internal causes that affect regional industrial changes.

Keywords: Regional industrial structure, evolution rules, optimization measures, stochastic processes

Introduction

Industrial structure is the basis for economic growth not only in the past but also in the future and an important indicator for measuring both quality and standards of economic development (Jing, Qing-wu, & Juan, 2004). To a large extent, regional economic development depends on the rationality of regional industrial structure. Imbalance of industrial structure has a negative impact on normal, healthy and rapid development of regional economy. Therefore, industrial structure optimization is not only the main starting point for changing the mode of economic development but also the main line for promoting economic quality. Furthermore, it is the main drive for sustainable development of regional economy and the main approach to enhance regional economic strength. The paper analyzes how the "cause" in the chain of "cause and effect" affects changes and rules of the "effect." It attempts to discover thinking of control methods of changes of the "cause" affecting the "effect "established, studies essential rules of evolution process of regional industrial structure, proposes measures for optimizing regional industrial structure from the perspective of internal causes that affect regional industrial changes and discusses adjustment and optimization of regional industrial structure.

Evolution Mechanism of Regional Industrial Structure

Current technical progress, future market demands, energy and environment restrictions will affect capital and labor mobility, technical innovation, policy orientation, then affect industrial resources integration and production and operation mode change, and finally affects birth, growth, maturity and decline and fall of the industry, which in turn, determines state of industrial structure. Evolution mechanism of regional industrial structure is as shown in Figure 1.

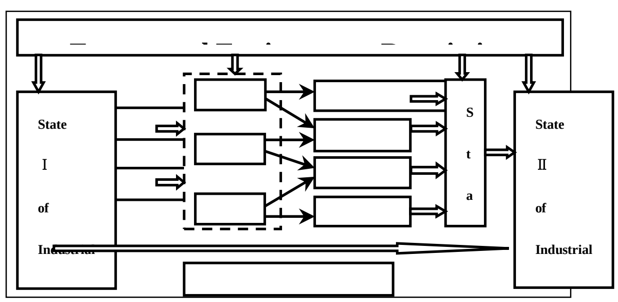

Figure 1: Evolution Mechanism

Nature of Evolution Processes of Regional Industrial Structure

Industrial system in one region consists of primary industry(including crop farming, animal husbandry, hunting, fishing and forestry), secondary industry(including mining and quarrying, manufacturing, construction, transport, telecommunications, power industry and gas industry), tertiary industry (including business, financial industry, catering industry as well as public administrative affairs such as science, health, culture, education, government, etc.). All these industries generate technical links and technical development of each industry directly or indirectly exert an impact on technical progress of other industries depending on economic relations between them.

Nature of Evolution Process of Regional Industrial Structure

Change in industrial structure is subject to both subjective factors and objective environment. It enables industrial structure to evolve in a constant manner under common actions of factors including resources endowments, population, technical progress, industrial policy, consumer demands, investment demands and international trade. In fact, regional industrial structure is a true random process subject to influences of random variables such as market demands, resources potential, technical progress and policy orientation (Ludeman, 2005).

Random Variables Set of Evolution Process of Regional Industrial Structure

Regional industrial system in a certain period is composed of several traditional and emerging industries. As the time passes and under influences of various factors, regional industrial structure evolves from one state to another, displaying the composition and change of proportions of industrial sectors in the industrial system, including formation of emerging industry and obsoleteness of declining industry. Capital and labor are two variables determining formation, development and decline of a certain industry, and are basic variables determining the state of a certain regional industrial structure. Both of them are random variables since they can increase or decrease and flow via market mechanism at any time. Where industrial capital and industrial labor is $X_K(t)$ and respectively $X_L(t)$.[3]

State Features of Random Evolution Process of Regional Industrial Structure

Convergence

Mathematic expectation of $\{X_{1,K}(t), X_{2,K}(t), X_{3,K}(t), \cdots, X_{i,K}(t), \cdots, X_{n,K}(t)\}$ of capital sequence $X_K(t)$ is $E[X_K(t)]$, when $\lim_{i\to\infty} E\left\{|X_{i,K}(t) - E[X_K(t)]|^2\right\} = 0$ and $X_{i,K}(t) \xrightarrow{m.s.} E[X_K(t)]$, then $X_K(t)$ converges to $E[X_K(t)]$. Mathematic expectation of $\{X_{1,L}(t), X_{2,L}(t), X_{3,L}(t), \cdots, X_{i,L}(t), \cdots, X_{n,L}(t)\}$ of labor sequence $X_L(t)$ is $E[X_L(t)]$, when $\lim_{i\to\infty} E\left\{|X_{i,L}(t) - E[X_L(t)]|^2\right\} = 0$ and $X_{i,L}(t) \xrightarrow{m.s.} E[X_L(t)]$,then $X_L(t)$ converges to $E[X_L(t)]$. Therefore, the evolution process of regional industrial structure determined by converging random variables capital $X_K(t)$ and labor $X_L(t)$ is featured by convergence.

Continuity

For capital $X_K(t)$, when $\lim_{\Delta t\to\infty} E\left\{|X_{i,K}(t+\Delta t) - E[X_{i,K}(t)]|^2\right\} = 0$, then $X_K(t)$ continues in the mean square at the moment of t. For labor $X_L(t)$, when $\lim_{\Delta t\to\infty} E\left\{|X_{i,L}(t+\Delta t) - E[X_{i,L}(t)]|^2\right\} = 0$, then $X_L(t)$ continues in the mean square at the moment of t. Therefore, the evolution process of regional industrial structure determined by continuous random variables capital $X_K(t)$ and labor $X_L(t)$ is featured by continuity.

Stationarity

For $X_K(t)$, any arbitrary integer $n \geq 1, t_1, t_2, t_3, \cdots t_n \epsilon T$和实数 π, when $t_1+\pi, t_2+\pi, \cdots, t_n+\pi \epsilon T$, $(X_K(t_1), X_K(t_2), \cdots, X_K(t_n))$与$(X_K(t_1+\pi), \cdots, X_K(t_n+\pi))$ has a joint distribution function, namely, $F_n(X_{1,K}, X_{2,K}, \cdots, X_{n,K}; t_1, t_2, \cdots, t_n) = F_n(X_{1,K}, X_{2,K}, \cdots, X_{n,K}; t_1+\pi, t_2+\pi, \cdots, t_n+\pi)$, then drift process of capital $X_K(t)$ has stationarity. For labor $X_L(t)$, any arbitrary integer $n \geq 1, t_1, t_2, t_3, \cdots t_n \epsilon T$和实数 π, when $t_1+\pi, t_2+\pi, \cdots, t_n+\pi \epsilon T$, $(X_L(t_1), X_L(t_2), \cdots, X_L(t_n))$与$(X_L(t_1+\pi), \cdots, X_L(t_n+\pi))$ has a joint distribution function, namely $F_n(X_{1,L}, X_{2,L}, \cdots, X_{n,L}; t_1, t_2, \cdots, t_n) = F_n(X_{1,L}, X_{2,L}, \cdots, X_{n,L}; t_1+\pi, t_2+\pi, \cdots, t_n+\pi)$, then drift process of labor $X_L(t)$ has stationarity. Therefore, the evolution process of regional industrial structure determined by drift process of stationary capital $X_K(t)$ and labor $X_L(t)$ is featured by stationarity.

Markov

For capital $X_K(t)$, spatial distribution $\{X_{1,K}(t), X_{2,K}(t), X_{3,K}(t), \cdots, X_{i,K}(t), \cdots, X_{n,K}(t)\}$ at the moment of t corresponds to any arbitrary $d_1, d_2, d_3, \cdots d_n \epsilon D$, D being state space, with $P\{X_{1,K}(t) = d_1, X_{2,K}(t) = d_2, \cdots, X_{n,K}(t) = d_n\} > 0$ and $P\{X_{(n+1),K}(t) = d_{n+1} | X_{1,K}(t) = d_1, \cdots, X_{n,K}(t) = d_n\} = P\{X_{(n+1),K}(t) = d_{n+1} | X_{n,K}(t) = d_n\}$, then $\{X_{1,K}(t), X_{2,K}(t), X_{3,K}(t), \cdots, X_{i,K}(t), \cdots, X_{n,K}(t)\}$ is Markov chain, that is, capital $X_K(t)$ has Markov. For labor $X_L(t)$, spatial distribution at the moment of t $\{X_{1,L}(t), X_{2,L}(t), X_{3,L}(t), \cdots, X_{i,L}(t), \cdots, X_{n,L}(t)\}$ corresponds to $d_1, d_2, d_3, \cdots d_n \epsilon D$, D being state space, with $P\{X_{1,L}(t) = d_1, X_{2,L}(t) = d_2, \cdots, X_{n,L}(t) = d_n\} > 0$ and

$\mathrm{P}\{X_{(n+1),L}(t) = d_{n+1} | X_{1,L}(t) = d_1, \cdots, X_{n,L}(t) = d_n\} = P\{X_{(n+1),L}(t) = d_{n+1} | X_{n,L}(t) = d_n\}$, then $\{X_{1,L}(t), X_{2,L}(t), X_{3,L}(t), \cdots, X_{i,L}(t), \cdots, X_{n,L}(t)\}$ is Markov chain, that is, labor $X_L(t)$ has Markov. Therefore, the evolution process of regional industrial structure determined by capital $X_K(t)$ and labor $X_L(t)$ with Markov characteristics is featured by Markov. This shows that state of industrial structure of a region at a certain period only relates to that at the former period.

Birth and death

Product market demands of some industries in regional economic system drops sharply due to the long-term technical backwardness, high material and energy consumption, high pollution and low profits. Influenced by market mechanism, environment and policy orientation, then these industries may exit market. Then out of scientific and technical innovation and market demands changes, there may emerge some new industries. Therefore, regional economy may survive or die in the course of development. Birth and death is a content of theory of stochastic processes. This kind of birth and death will inevitably result in great changes in regional industrial structure.

Transition Probability of Internal Cause Variables of Evolution Process of Regional Industrial Structure

Capital transition probability

Suppose the total capital in a certain industrial system at the period oft is $X_K(t)$, when distribution of the industrial system (including n industries): $\{X_{1,K}(t), X_{2,K}(t), X_{3,K}(t), \cdots, X_{i,K}(t), \cdots, X_{n,K}(t)\}$; at the period of t+1, the total capital in the regional industry is $X_K(t+1)$, when distribution of the industrial system (including m industries): $\{X_{1,K}(t+1), X_{2,K}(t+1), X_{3,K}(t+1), \cdots, X_{j,K}(t+1), \cdots, X_{m,K}(t+1)\}$. Obviously, during the time span of $t \to (t+1)$, capital completed its $X_K(t) \to X_K(t+1)$ transfer。 Therefore, the probability of $X_{i,K}(t) \to X_{j,K}(t+1)$ is: $P\{X_{i,K}(t) \to X_{j,K}(t+1)\} = P\{X_{j,K}(t+1)/X_{i,K}(t)\} = p_{K(j/i)}$, among which $1 \leq i \leq n, 1 \leq j \leq m$, $n \neq m$. This shows that capital $X_{i,K}(t)$ at the period of t be detained in i industry, while at t+1, transfer probability detained in j industry. When $r = \max(n, m)$, then R_1 is the emerging industry set at the period of t+1, R_2 is the continued industry set at the period of t+1, R_3 is the obsolete industrial set at the period of t+1. R_1, R_2 is the reducible state set, and its initial distribution is above zero at the period of t; R_3 is irreducible state set, and its initial distribution is above zero at the period of t. Hence, the matrix of transition probability:

$$P_K = \begin{array}{c} \\ R_{1K}(t) \\ R_{2K}(t) \\ R_{3K}(t) \end{array} \begin{array}{c} \begin{array}{ccc} R_{1K}(t+1) & R_{2K}(t+1) & R_{3K}(t+1) \end{array} \\ \begin{bmatrix} I & 0 & 0 \\ P_{KR_1} & P_{KR_2} & P_{KR_3} \\ 0 & 0 & I \end{bmatrix}_{3r \times 3r} \end{array} \qquad (1)$$

$$P_{KR_1} = \begin{array}{c} \\ R_{21,K}(t) \\ R_{22,K}(t) \\ \vdots \\ R_{2i,K}(t) \\ \vdots \\ R_{2n,K}(t) \end{array} \begin{array}{c} \begin{array}{ccccccc} R_{11,K}(t+1) & R_{12,K}(t+1) & \cdots & R_{1e,K}(t+1) & \cdots & R_{1u,K}(t+1) \end{array} \\ \begin{bmatrix} p_{K(R_{11}/R_{21})} & p_{K(R_{12}/R_{21})} & \cdots & p_{K(R_{1e}/R_{21})} & \cdots & p_{K(R_{1u}/R_{21})} \\ p_{K(R_{11}/R_{22})} & p_{K(R_{12}/R_{22})} & \cdots & p_{K(R_{1e}/R_{22})} & \cdots & p_{K(R_{1u}/R_{22})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{11}/R_{2i})} & p_{K(R_{12}/R_{2i})} & \cdots & p_{K(R_{1e}/R_{2i})} & \cdots & p_{K(R_{1u}/R_{2i})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{11}/R_{2n})} & p_{K(R_{12}/R_{2n})} & \cdots & p_{K(R_{1e}/R_{2n})} & \cdots & p_{K(R_{1u}/R_{2n})} \end{bmatrix} \end{array}$$

$p_{K(R_{1e}/R_{2i})}$ is the probability for continued i industrial capital at period of t to transit to emerging e industry at the period of t+1, $1 \leq e \leq u$. Since $e \ll n$, matrix P_{KR_1} needs adding several 0 arrays.

$$P_{KR_2} = \begin{array}{c} \\ R_{21,K}(t) \\ R_{22,K}(t) \\ \vdots \\ R_{2i,K}(t) \\ \vdots \\ R_{2n,K}(t) \end{array} \begin{array}{c} \begin{array}{cccccc} R_{21,K}(t+1) & R_{22,K}(t+1) & \cdots & R_{2j,K}(t+1) & \cdots & R_{2m,K}(t+1) \end{array} \\ \begin{bmatrix} p_{K(R_{21}/R_{21})} & p_{K(R_{22}/R_{21})} & \cdots & p_{K(R_{2j}/R_{21})} & \cdots & p_{K(R_{2m}/R_{21})} \\ p_{K(R_{21}/R_{22})} & p_{K(R_{22}/R_{22})} & \cdots & p_{K(R_{2j}/R_{22})} & \cdots & p_{K(R_{2m}/R_{22})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{21}/R_{2i})} & p_{K(R_{22}/R_{2i})} & \cdots & p_{K(R_{2j}/R_{2i})} & \cdots & p_{K(R_{2m}/R_{2i})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{21}/R_{2n})} & p_{K(R_{22}/R_{2n})} & \cdots & p_{K(R_{2j}/R_{2n})} & \cdots & p_{K(R_{2m}/R_{2n})} \end{bmatrix} \end{array}$$

When $n > m$, matrix P_{KR_2} increases to 0 array, and when $n < m$, matrix P_{KR_2} increases to 0 row.

$$P_{KR_3} = \begin{array}{c} \\ R_{21,K}(t) \\ R_{22,K}(t) \\ \vdots \\ R_{2i,K}(t) \\ \vdots \\ R_{2n,K}(t) \end{array} \begin{array}{c} \begin{array}{cccccc} R_{31,K}(t+1) & R_{32,K}(t+1) & \cdots & R_{3s,K}(t+1) & \cdots & R_{3v,K}(t+1) \end{array} \\ \begin{bmatrix} p_{K(R_{31}/R_{21})} & p_{K(R_{32}/R_{21})} & \cdots & p_{K(R_{3s}/R_{21})} & \cdots & p_{K(R_{3v}/R_{21})} \\ p_{K(R_{31}/R_{22})} & p_{K(R_{32}/R_{22})} & \cdots & p_{K(R_{3s}/R_{22})} & \cdots & p_{K(R_{3v}/R_{22})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{31}/R_{2i})} & p_{K(R_{32}/R_{2i})} & \cdots & p_{K(R_{3s}/R_{2i})} & \cdots & p_{K(R_{3v}/R_{2i})} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{K(R_{31}/R_{2n})} & p_{K(R_{32}/R_{2n})} & \cdots & p_{K(R_{3s}/R_{2n})} & \cdots & p_{K(R_{3v}/R_{2n})} \end{bmatrix} \end{array}$$

$p_{K(R_{3s}/R_{2i})}$ is the probability for continued i industrial capital at period of t transit to obsoleteness s industry at the period of t+1, $1 \leq s \leq v$. Since $s \ll n$, matrix P_{KR_3} needs adding several 0 rows. Therefore, the relationship between total industrial capital $X_K(t)$ at the period of t and that $X_K(t+1)$ at the period of t+1 is: $X_K(t+1) = X_K(t) + \Delta X_K(t \rightarrow t+1)$ （2）

In the formula, $\Delta X_K(t \rightarrow t+1)$ is the sum of increment of social capital invested and foreign direct investment (FDI) at the period in the industrial system of the region.

Labor Transition Probability

Suppose total labor $X_L(t)$ in the industrial system at the period of t in the region, and distribution in the industrial system is $\{X_{1,L}(t), X_{2,L}(t), X_{3,L}(t), \cdots, X_{i,L}(t), \cdots, X_{n,L}(t)\}$. Total labor

$X_L(t+1)$ in the industrial system at the period of t+1， and distribution in the industrial system is $\{X_{1,L}(t+1), X_{2,L}(t+1), X_{3,L}(t+1), \cdots, X_{j,L}(t+1), \cdots, X_{m,L}(t+1)\}$.

Obviously, during the time span of $t \to (t+1)$, labor change is $X_L(t) \to X_L(t+1)$, and during this process of transition, probability of $X_{i,L}(t) \to X_{j,L}(t+1)$ is $P\{X_{i,L}(t) \to X_{j,L}(t+1)\} = P\{X_{j,L}(t+1)/X_{i,L}(t)\} = p_{L(j/i)}$, among which $1 \le i \le n, 1 \le j \le m$, $n \ne m$. This shows the probability of labor $X_{i,L}(t)$ when detained in the i industry at the period of t, while at the period of t+1, transited and detained in j industry. When $r = \max(n, m)$, then R_1 is emerging industry set at the period of t+1， R_2 is continued industry set at the period of t+1 , R_3 is the obsolete industry set at the period of t+1. Hence the matrix of transition probability:

$$P_L = \begin{array}{c} \\ R_{1L}(t) \\ R_{2L}(t) \\ R_{3L}(t) \end{array} \begin{array}{c} \begin{array}{ccc} R_{1L}(t+1) & R_{2L}(t+1) & R_{3L}(t+1) \end{array} \\ \begin{bmatrix} I & 0 & 0 \\ P_{LR_1} & P_{LR_2} & P_{LR_3} \\ 0 & 0 & I \end{bmatrix}_{3r \times 3r} \end{array} \qquad (3)$$

$$P_{LR_1} = \begin{array}{c} \\ R_{21,L}(t) \\ R_{22,L}(t) \\ \vdots \\ R_{2i,L}(t) \\ \vdots \\ R_{2n,L}(t) \end{array} \begin{array}{c} \begin{array}{cccccc} R_{11,L}(t+1) & R_{12,L}(t+1) & \cdots & R_{1e,L}(t+1) & \cdots & R_{1u,L}(t+1) \end{array} \\ \begin{bmatrix} p_{L(R_{11}/R_{21})} & p_{L(R_{12}/R_{21})} & \cdots & p_{L(R_{1e}/R_{21})} & \cdots & p_{L(R_{1u}/R_{21})} \\ p_{L(R_{11}/R_{22})} & p_{L(R_{12}/R_{22})} & \cdots & p_{L(R_{1e}/R_{22})} & \cdots & p_{L(R_{1u}/R_{22})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{11}/R_{2i})} & p_{L(R_{12}/R_{2i})} & \cdots & p_{L(R_{1e}/R_{2i})} & \cdots & p_{L(R_{1u}/R_{2i})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{11}/R_{2n})} & p_{L(R_{12}/R_{2n})} & \cdots & p_{L(R_{1e}/R_{2n})} & \cdots & p_{L(R_{1u}/R_{2n})} \end{bmatrix} \end{array}$$

$p_{L(R_{1e}/R_{2i})}$ is the probability for continued i industrial labor at period of t to transit to emerging e industry at the period of t+1, $1 \le e \le u$. Since $e \ll n$, hence, matrix P_{LR_1} needs adding several.

$$P_{LR_2} = \begin{matrix} \\ R_{21,L}(t) \\ R_{22,L}(t) \\ \vdots \\ R_{2i,L}(t) \\ \vdots \\ R_{2n,L}(t) \end{matrix} \begin{matrix} R_{21,L}(t+1) & R_{22,L}(t+1) & \cdots & R_{2j,L}(t+1) & \cdots & R_{2m,L}(t+1) \\ \left[\begin{matrix} p_{L(R_{21}/R_{21})} & p_{L(R_{22}/R_{21})} & \cdots & p_{L(R_{2j}/R_{21})} & \cdots & p_{L(R_{2m}/R_{21})} \\ p_{L(R_{21}/R_{22})} & p_{L(R_{22}/R_{22})} & \cdots & p_{L(R_{2j}/R_{22})} & \cdots & p_{L(R_{2m}/R_{22})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{21}/R_{2i})} & p_{L(R_{22}/R_{2i})} & \cdots & p_{L(R_{2j}/R_{2i})} & \cdots & p_{L(R_{2m}/R_{2i})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{21}/R_{2n})} & p_{L(R_{22}/R_{2n})} & \cdots & p_{L(R_{2j}/R_{2n})} & \cdots & p_{L(R_{2m}/R_{2n})} \end{matrix}\right] \end{matrix}$$

When $n > m$, matrix P_{LR_2} increases 0 array, when $n < m$, matrix P_{LR_2} increases 0 row .

$$P_{LR_3} = \begin{matrix} \\ R_{21,L}(t) \\ R_{22,L}(t) \\ \vdots \\ R_{2i,L}(t) \\ \vdots \\ R_{2n,L}(t) \end{matrix} \begin{matrix} R_{31,L}(t+1) & R_{32,L}(t+1) & \cdots & R_{3s,L}(t+1) & \cdots & R_{3v,L}(t+1) \\ \left[\begin{matrix} p_{L(R_{31}/R_{21})} & p_{L(R_{32}/R_{21})} & \cdots & p_{L(R_{3s}/R_{21})} & \cdots & p_{L(R_{3v}/R_{21})} \\ p_{L(R_{31}/R_{22})} & p_{L(R_{32}/R_{22})} & \cdots & p_{L(R_{3s}/R_{22})} & \cdots & p_{L(R_{3v}/R_{22})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{31}/R_{2i})} & p_{L(R_{32}/R_{2i})} & \cdots & p_{L(R_{3s}/R_{2i})} & \cdots & p_{L(R_{3v}/R_{2i})} \\ \vdots & \vdots & \vdots\ \vdots & & \vdots\ \vdots & \\ p_{L(R_{31}/R_{2n})} & p_{L(R_{32}/R_{2n})} & \cdots & p_{L(R_{3s}/R_{2n})} & \cdots & p_{L(R_{3v}/R_{2n})} \end{matrix}\right] \end{matrix}$$

$p_{L(R_{3s}/R_{2i})}$ is the probability for continued i industrial capital at period of t to transit to the obsolete

s industry at the period of t+1, $1 \le s \le v$. Since $s \ll n$, hence, matrix P_{LR_s} needs adding several 0 arrays.

Relationship between total labor $X_K(t)$ at the period of t in the region and that $X_K(t+1)$ at the period of t+1 is $X_L(t+1) = X_L(t) + \Delta X_L(t \to t+1)$ （4）

In the formula, $\Delta X_L(t \to t+1)$ is the sum of increment of social labor invested and foreign labor input at the period in the industrial system of the region.

Rule of Evolution Processes of Regional Industrial Structure

Law of Capital Drift

Under market economy, equal capital requires equal profit. Or otherwise, profit-driven capital flows from low profit industry to high profit industry.

Suppose total industrial capital $X_K(t)$ at the period oft in the region is distributed in n industries as follows:

$$X_K(t) = [X_{1,K}(t) \quad X_{2,K}(t) \quad \cdots \quad X_{i,K}(t) \quad \cdots \quad X_{n,K}(t)] \qquad (5)$$

$$x_K(t) = \sum_{i=1}^{n} x_{i,K}(t) \qquad (6)$$

Total industrial capital distributed in each industry is as follows:

$$G_K(t) = [g_{1,K}(t) \quad g_{2,K}(t) \quad \cdots \quad g_{i,K}(t) \quad \cdots \quad g_{n,K}(t)] \qquad (7)$$

During the period of$t \to t+1$, capital transits from i industry to i or j industry based on capital transition probability $p_{K(j/i)}$ and transition probability matrix P_K. Therefore, the drift process of capital is $\{X_K(t) \xrightarrow{P_K} X_K(t+1), t\epsilon T, \Omega\}$, and drift law displayed during the process is

$$X_K(t+1) = X_K(t) * P_K + \Delta X_K(t+1) \qquad (8)$$

$\Delta X_K(t+1) = [\Delta X_{1,K}(t+1) \quad \Delta X_{2,K}(t+1) \quad \cdots \quad \Delta X_{j,K}(t+1) \quad \cdots \quad \Delta X_{m,K}(t+1)]$, $\Delta x_{j,K}(t+1)$ may be based on array $\{\Delta x_{j,K}(t-6), \cdots, \Delta x_{j,K}(t-1), \Delta x_{j,K}(t)\}$, to create GM（1,1）model $\frac{d(\Delta x_{j,K})^{(1)}}{dt} + a(\Delta X_{j,K})^{(1)} = u$ or $\widehat{(\Delta x_{j,K})}^{(0)}(t+1) = -a\left((\Delta x_{j,K})^{(0)}(1) - \frac{u}{a}\right)e^{-at}$, parameter in model $\begin{bmatrix} a \\ u \end{bmatrix} = (B^T B)^{-1} B^T Z_N$.

$$B = \begin{bmatrix} -\frac{1}{2}\left(\Delta X_{jK}^{(1)}(1) + \Delta X_{jK}^{(1)}(2)\right) & 1 \\ -\frac{1}{2}\left(\Delta X_{jK}^{(1)}(2) + \Delta X_{jK}^{(1)}(3)\right) & 1 \\ \cdots & \cdots \\ -\frac{1}{2}\left(\Delta X_{jK}^{(1)}(\mu-1) + \Delta X_{jK}^{(1)}(\mu)\right) & 1 \end{bmatrix}$$

M is the sequence: total data of $\{\Delta x_{j,K}(t-6), \cdots, \Delta x_{j,K}(t-1), \Delta x_{j,K}(t)\}$.

$$Z_N = \left[\Delta X_{jK}^{(0)}(2) \quad \Delta X_{jK}^{(0)}(3) \quad \cdots \quad \Delta X_{jK}^{(0)}(\mu)\right]^T$$

Change in distribution structure of industrial capital in different industries is $\left\{G_K(t) \xrightarrow{\tau,\theta} G_K(t+1), t\epsilon T, \Omega\right\}$. τ 、 θ represents market mechanism and industrial policy orientation respectively.

Suppose change in capital increase in the unit time is determined by $dK = \lambda K dt + \sigma_K K dz$, λ is the marginal propensity to saving, σ_K is the standard deviation of the process in the unit time, and dz is white noise.

According to C-D function， drift coefficient in the capital drift process is $\tilde{\varepsilon}_K = \left(\alpha\lambda + \frac{1}{2}\alpha(\alpha-1)\sigma_K^2\right)Y(t)$, and diffusion coefficient is $\breve{\varphi}_K = [\alpha\sigma_K Y(t)]^2$.[6]

Law of Labor Drift

With the establishment and improvement of labor market, labor transfers from low-profit industry to high-profit industry.

Suppose total labor $X_L(t)$ at the period of t distributed in n industrial sectors is as follows:

$$X_L(t) = [X_{1,L}(t) \quad X_{2,L}(t) \quad \cdots \quad X_{i,L}(t) \quad \cdots \quad X_{n,L}(t)] \qquad (11)$$

$$x_L(t) = \sum_{i=1}^{n} x_{i,L}(t) \qquad (12)$$

Total labor in industrial sectors is distributed as follows:

$$G_L(t) = [g_{1,L}(t) \quad g_{2,L}(t) \quad \cdots \quad g_{i,L}(t) \quad \cdots \quad g_{n,L}(t)] \qquad (13)$$

During the period of $t \to t+1$, labor transits from i industry to i or j industry based on transition probability $p_{ij,L}$ and transition probability matrix P_L. Therefore, the drift process of labor is $\left\{X_L(t) \overset{P_L}{\to} X_L(t+1), t\epsilon T, \Omega\right\}$, and the drift law displayed during the course is

$$X_L(t+1) = X_L(t) * P_L + \Delta X_L(t+1) \qquad (14)$$

$\Delta X_L(t+1) = [\Delta X_{1,L}(t+1) \quad \Delta X_{2,L}(t+1) \quad \cdots \quad \Delta X_{j,L}(t+1) \quad \cdots \quad \Delta X_{m,L}(t+1)]$, $\Delta x_{j,L}(t+1)$ can be based on array $\{\Delta x_{j,L}(t-6), \cdots, \Delta x_{j,L}(t-1), \Delta x_{j,L}(t)\}$, to create GM（1,1）model

$$\frac{d(\Delta x_{j,L})^{(1)}}{dt} + a(\Delta X_{j,L})^{(1)} = u$$

or $\left(\widehat{\Delta x_{j,L}}\right)^{(0)}(t+1) = -a\left(\left(\Delta x_{j,L}\right)^{(0)}(1) - \frac{u}{a}\right)e^{-at}$ 。

Change in distribution structure of total labor in different industries is $\left\{G_L(t) \overset{\tau,\theta}{\to} G_L(t+1), t\epsilon T, \Omega\right\}$。

Suppose behavior of labor increase is determined by $dL = \eta L dt + \sigma_L L dz$, η is the labor growth rate expected per unit time, σ_L is the standard deviation of the process per unit time, and dz is the white noise. According to C-D function，Drift coefficient in the process of labor drift is $\tilde{\varepsilon}_L = \eta\beta + \frac{1}{2}\beta(\beta-1)\sigma_L^2 Y(t)$,and diffusion coefficient is $\breve{\varphi}_L = [\beta\sigma_L Y(t)]^2$.

Law of Changes in Operating Mode of Industrial System

In market mechanism, the operating mode of industrial system Ω_i at the period of t depends on array mode of such variables as capital $X_{i,K}(t)$, labor $X_{i,L}(t)$, and technical progress $X_{i,A}(t)$ in the industrial system:

$f(X_{i,A}(t), X_{i,K}(t), X_{i,L}(t) / X_{i,A}(t), X_{i,K}(t), X_{i,L}(t) \in \Omega_i(t), t \in T)$

According to C-D function mode, the operating mode of industrial system Ω_i at the period of t should be:

$$Y_i(t) = X_{i,A}(t) * [X_{i,K}(t)]^{\alpha(t)} * [X_{i,L}(t)]^{\beta(t)} \quad (15)$$

In the formula, $\alpha(t)$ and $\beta(t)$ are elasticity of $X_K(t)$ and $X_L(t)$ to $Y_i(t)$. $(\alpha(t)+\beta(t))$ has the identification ability to the development trend of the industrial system. When $\alpha(t)+\beta(t)>1$, showing increasing returns to scale of i industry, and the technical progress can be speeded up and innovative and self-development ability can be strengthened. As a result, both capital and labor of other industries flow into this industry in the next period; when $\alpha(t)+\beta(t)<1$, showing decreasing returns to scale of i industry, and the technical progress can be lowered and innovative and self-development can be weakened, and its capital and labor will flow into the other industries in the next period; when $\alpha(t)+\beta(t)=1$, showing the same returns to scale of i industry, both its capital and labor will be detained at this industry for some time for waiting and seeing the development trend of the industry. Once conditions met, it will flow into other industries with higher profit.

During the period of $t \rightarrow$ "$t+1$" in the industrial system, change law of the operating model should be:

$$\left\{[f_t((X_A(t), X_K(t), X_L(t)), \Omega(t), T)] \xrightarrow{\tau,\ \theta} [f_{t+1}((X_A(t+1), X_K(t+1), X_L(t+1), \Omega(t+1), T))]\right\}$$

This changing process is materialized by factors such as capital, labor and technical progress based on established objectives in the common action and integrated influence of market mechanism and industrial policy orientation.

Management is the behavior process that enlarges industrial system functions. Consequently, both entrepreneur and managers attempt to change $\alpha(t)$, $\beta(t)$ and $X_A(t)$ by technical innovation, system innovation and market space cultivation and expansion so as to materialize $\alpha(t+1)$, $\beta(t+1)$ and $X_A(t+1)$, hence, the transition and change from $f_t(\cdot)$ to $f_{t+1}(\cdot)$.

Evolution Law of Regional Industrial Structure

The state of capital, labor and technical progress drifts along with the changes of market economy under common function and integrated influence of market mechanism and industrial policy. Therefore, regional industrial structure determined by capital and labor will inevitably yield to the evolution of random process.

Suppose there are n industries in the regional industrial system at the period of t, and the state of industrial structure $G_Y(t)$ is:

$$G_Y(t) = [g_{1,Y}(t) \quad g_{2,Y}(t) \quad \cdots \quad g_{i,Y}(t) \quad \cdots \quad g_{n,Y}(t)] \qquad (16)$$

The evolution process and law of regional industrial structure are $\left\{G_Y(t) \xrightarrow{X_K(t), X_L(t), X_A(t), \tau, \theta} G_Y(t+1)\right\}$.

Control of Evolution Processes of Regional Industrial Structure

Power Sources of Evolution of Regional Industrial Structure

Market demands are the external drive for regional industrial evolution

Any regional industrial structure is a resource converter by nature. It gathers factors of production and outputs products via transformation according to market demands. Obviously, changes in market demands will inevitably results in changes in production structure in the industrial system, hence, directly affecting changes in direction and degree of regional industrial structure.

Scientific and technological innovation is the direct drive for regional industrial structure evolution

State of regional industrial structure to some extent reflects corresponding technical levels. Scientific and technological innovation can not only promote regional industrial level but also diffuse itself into other industrial sectors. Besides, it substitutes and develops the leading industries or leading industrial groups, resulting development and changes in the leading industries in the region, hence the changes in regional industrial structure.

Process Control Methods of Evolution of Regional Industrial Structure

Controlling methods of capital drift process

In the course of regional industrial evolution, capital driven by certain profits drifts according to a certain transition probability. The profit is the higher returns produced by the former investment or expected benefits generated from profit rate on funds in the capital market. Opacity of capital operations and financial market leads to the blindness of capital drift, resulting in regional industrial structure unable to evolve as expected. In order to ensure capital to drift towards optimization objective beneficial to regional industrial structure, information opacity of capital market or financial market should be reduced while information identification ability and investment decision making ability of the investors be enhanced so as to effectively control transition probability of capital.

Controlling methods of labor drift process

In the course of regional industrial evolution, labor driven by certain profits drifts according to a certain transition probability. The profit is the expected benefits produced by higher returns of the former investment. Opacity of labor market leads to the blindness of labor drift, resulting in regional industrial structure unable to evolve as expected. In order to ensure labor to drift towards optimization objective beneficial to regional industrial structure, information opacity of labor market should be reduced while information identification ability and investment decision making ability of the investors be enhanced so as to effectively control transition probability of labor.

Controlling methods of changes in the operating mode of the industrial system

Changes in the operating mode of the industrial system depends on re-establishment of manufacturing processes, improvement of management and commercial modes, and enhancement of scientific and technological innovation and qualifications of entrepreneurs. In order to promote the input-output ability and ensure that the operating mode of the industrial system can evolve towards optimization objectives beneficial to regional industrial structure, technical factors and output elasticity of factors in C-D function model can be effectively controlled by strengthening scientific and technological innovation, improving quality of entrepreneurs, re-establishing manufacturing process and improving management and commercial modes.

Controlling and Optimization Application of Evolution Processes of Industrial Structure in Guangxi Province

Positive Analysis of Evolution Progress of Industrial Structure in Guangxi Province

30 experts were selected via Delphi method for consulting assessment based on statistics and transition probability matrix of industrial capital and labor among three industries in Guangxi Province in 2009 are as follows;

$$P_K(2009) = \begin{matrix} & 1 & 2 & 3 \\ 1 & 0.51 & 0.01 & 0.48 \\ 2 & 0.01 & 0.73 & 0.26 \\ 3 & 0.02 & 0.13 & 0.85 \end{matrix} \qquad P_L(2009) = \begin{matrix} & 1 & 2 & 3 \\ 1 & 0.90 & 0.01 & 0.09 \\ 2 & 0.13 & 0.67 & 0.20 \\ 3 & 0.12 & 0.25 & 0.63 \end{matrix}$$

Industrial capital in Guangxi Province in 2008 is RMB 272.59923 billion , and its distribution in three industries is as follows:

$$X_K(2008) = [100.7149 \quad 1426.8853 \quad 1198.3921], \quad G_K(2008) = [3.69\% \quad 52.35\% \quad 43.96\%]$$

Industrial labor is 27.99 million persons, and its distribution in three industries is as follows:

$X_L(2008)=[1528 \quad 424 \quad 847]$, $G_L(2008)=[54.59\% \quad 15.15\% \quad 30.26\%]$

Using GM（1,1）: $\widehat{\Delta X_K}(2009) = -a\left(\Delta X_K(2008) - \frac{u}{a}\right)e^{-at}$, To predict total capital increment in Guangxi Province in 2009 $\widehat{\Delta X_k}(2009) = 1619.6633$ (亿元), its vector quantity is $\widehat{\Delta X_K}(2009) = [39.4588 \quad 515.7838 \quad 1102.6930]$, total capital increment in three industries is distributed as $\widehat{\Delta G_K}(2009) = [2.38\% \quad 31.11\% \quad 66.51\%]$.

Creating GM（1,1）: $\widehat{\Delta X_L}(2009) = -a\left(\Delta X_L(2008) - \frac{u}{a}\right)e^{-at}$, to predict total labor increment in Guangxi Province in 2009 $\widehat{\Delta X_L}(2009) = 50.49$ (万人), its vector quantity is $\widehat{\Delta X_L}(2009) = [6.8061 \quad 28.7894 \quad 14.8946]$, total labor increment in three industries is distributed as $\widehat{\Delta G_L}(2009) = [13.48\% \quad 57.02\% \quad 29.50\%]$.

Therefore, industrial capital and labor in Guangxi Province in 2009 are distributed as follows:

$\widehat{G_K}(2009) = [0.0328 \quad 0.4397 \quad 0.5275]$, $\widehat{G_L}(2009) = [0.5473 \quad 0.1826 \quad 0.2701]$

Technical progress factor A, capital output elasticity α and labor output elasticity β of three industries measured via C-D model based on historical data are $A=[0.1863 \quad 0.3978 \quad 0.2286]$,

$\alpha=[0.3828 \quad 0.8632 \quad 0.6238]$ and $\beta=[0.8933 \quad 0.4283 \quad 0.5897]$.

Increment (RMB 0.1billion) of three industries in Guangxi Province in 2009 based on the formula of model (15) is:

$$\hat{Y}_{2009}=[1462.2421 \quad 3408.2785 \quad 2872.1836]$$

Industrial structure of the region predicted is: $\hat{G}_{2009}^{(Y)}=[18.89\% \quad 44.02\% \quad 37.09\%]$

Statistics show that actual increment (RMB 0.1 billion) of three industries in Guangxi Province in 2009 is:

$$Y_{2009} = \begin{bmatrix} 1458.49 & 3381.54 & 2919.13 \end{bmatrix}$$

Actual industrial structure is: $G_{2009}^{(Y)} = \begin{bmatrix} 18.80\% & 43.58\% & 37.62\% \end{bmatrix}$

Results of theoretical speculation $\hat{G}_{2009}^{(Y)}$ are very close to actual data $G_{2009}^{(Y)}$. Therefore, evolution process and law of regional industrial structure are studied based on theory and methods of stochastic process, and it is a good approach to observe and analyze them from the perspective of the changing nature of industrial structure.

Controlling and Optimization Methods of Industrial Structure in Guangxi Province

Formulate scientific industrial policy and guide rational flow of factors of production

Capital, labor and technical progress are the essential resources for industrial system development. The more resources the system owns and the higher the resources-bit is, the faster the industry develops and the larger the share in the regional industrial structure is or vice versa. Consequently, the government should formulate scientific industrial policy according to the changing trend in market demands, in both domestic and overseas industrial structure and the development strategy of local economy so as to correctly guide factors of production in and out the region flow towards targeted industrial system in a orderly manner, hence, the effective influence on transition probability of capital and labor.

Establish and improve trading market for factors of production and promote its rational flow

At a certain period, capital and labor flow among industries via capital market and labor market driven by profits. In order to ensure capital and labor to evolve towards our established optimization objectives beneficial to industrial structure in Guangxi Province, we should improve both capital and labor market, reduce grayscale of market information, enhance information identification ability and decision making ability of the investor and promote information adjustment ability and adaptability so as to effectively control capital and labor mobility.

Innovate and drive operating mode optimization of industrial system

Technical factor $X_{i,A}(t+1)$, output elasticity of factors $\alpha(t+1)$ and $\beta(t+1)$ are effectively controlled via technical innovation, promoting qualifications of industrial entrepreneurs, manufacturing process of recycled products, and improving management and commercial modes of enterprises. Therefore, regional industrial system operates according to the mode: $\dot{Y}_i(t+1) = \dot{X}_{i,A}(t+1) * [\dot{X}_{i,K}(t+1)]^{\dot{\alpha}(t+1)} * [\dot{X}_{i,L}(t+1)]^{\dot{\beta}(t+1)}$, with its results shown as follows:

Table for State Optimization of Regional Industrial Structure

Serial No.	Indicator Adjusted	Unit	Primary Industry	Secondary Industry	Tertiary Industry	Total
1	$\dot{X}_K(2009)$	RMB100m	126.0387	1710.6455	2547.2438	4383.9279
2	$\dot{X}_L(2009)$	Ten Thousand Persons	1441.1861	572.1094	836.1946	2849.4901
3	$\dot{\alpha}(2009)$		0.4028	0.8832	0.6438	------
4	$\dot{\beta}(2009)$		0.9133	0.4483	0.6097	------
5	$\dot{A}(2009)$		0.2500	0.4000	0.3500	------
6	$\dot{Y}(2009)$	RMB 100m	1345.4946	4940.4304	3300.8595	9586.7845
7	$\lambda(\dot{Y}\|Y)$	%	-7.75	46.10	13.08	23.55
8	$\dot{G}(2009)$	%	14.04	51.53	34.43	------

In 2009, the industrial structure in Guangxi Province is in fact “C, B, A（43.58%:37.62%:18.80%）” mode. Its output function realizes GDP RMB 776.916 billion. After adjustment of industrial structure, it is in “B, C, A（51.53%:34.43%:14.04%）” mode, the share of the primary industry in GDP decreased by 4.76%, while that of the secondary industry increased by 7.95%, with a GDP contribution of its output function being RMB 958.67845, an increase by 23.55%. It is clear that the industrial structure adjusted is more rational than the original with a higher output function.

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