Coupling Analysis of Regional Economic Structure System

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Abstract

Regional economic structure system is an exoteric self-organization system with dissipation structure and high-step, multi-variables, multi-loops and nonlinear feedback structure. On the basis of the qualitative analysis of coupling relations of subsystems in regional economic structure system, considering Heilongjiang province as the example, the paper establishes the model applying system dynamics method. By means of this model, the operating mechanism of regional economic structure system is studied. Some results have been concluded: the error is little between simulative value and true value, which means that the model could represent the performance of regional economic structure system and the obtained strategic conclusions can give reference to the future regulation.

1. Introduction

Based on the viewpoint of systematology research, the system is composed of many factors and the characteristic of system is decided by the characteristic of each component (subsystem), but there is new characteristic different from any partial one, which only belongs to the whole system. It could be described as "the whole is bigger than the sum of the parts", which manifests non-additive property and non-simple causality of the whole system. Regional economic structure system refers to an organic combination formed by the interrelation and dynamic interaction of regional economic elements (subsystems) to realize system function. Starting from the research goal of regional economic structure system, in the meantime taking account of system interior adjustability, the paper selects four subsystems including ownership structure, industry structure, urban and rural structure, investment structure to constitute essential factors set of regional economic structure system. There are the interdependence as well as the mutual input and output among these subsystems. According to the general qualitative analysis, an initial conclusion may be drawn that some relations exist among ownership structure, industry structure, urban and rural structure and investment structure[1][2]. But it is not clear whether there is a dynamic relevance of interaction, interdependence, intercoordination, as well as the mutual coupling in quantity among these subsystems. This need be proved by the characteristic data of regional economic structure subsystems applying quantitative test, which could confirm the former qualitative analysis.

2. Research methods

At present, the methods with which we study complicated economic system commonly are goal programming approach, input-output approach, econometric approach, system dynamics modeling approach, etc. Among them, the first three methods are based on linear algebra, so they are difficult to solve some dynamic problems such as technology changes and input-output analysis with time-delay. However, system dynamics modeling based on the information feedback mechanism could simulate systematic structure and function in reality, so as to provide people a method to solve problems.

System dynamics theory was first advanced by Professor Jay W. Forrester of American Massachusetts Institute of Technology. It is a science to analyze and research information feedback and the dialectical relationship of system structure, system function and the behavior. Taking system theory, information theory, cybernetics and computer technology as the foundation, system dynamics represents the dynamic performance of actual system according to the links such as system control and the feedback. By establishing simulation model, the simulation experiment is carried on with the aid of the computer. While studying and dealing with complicated system questions, system dynamics is good at periodic question, long-term question, relative data absence question and high-step, nonlinear, time-varying question. Meanwhile, it also could conduct long-term,

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dynamic, strategic quantitative research. System dynamics model is superior to regression prediction model, Markov's chain prediction model and linear programming model. It not only could carry on the dynamic analysis with time, but also take the interdepartmental coordination regulation[3]. By means of it, the interrelation and interaction of internal and external factors are manifested clearly and implicit feedback loops of the system are concealed in detail. Through setting kinds of controlling factors of the system, system behavior changes could be observed when controlling factors of inputs change, thus the dynamic simulation experiment will be carried out.

Because economic structure system is an exoteric self-organization system with dissipation structure and also is a feedback system with high-step, multi-variables, multi-loops and nonlinear structure, its system behaviors often have the characteristics of anti-intuition and insensitivity to the changes of internal parameters. It is difficult to deal with such system problems utilizing general statistical analysis method. But the advantage of system dynamics model lies in solving this kind of problem. System dynamics model focuses on the best goal of the whole system rather than the best goal of the subsystems only, which could contribute to the coordination of economical subsystems. By using first-order differential equations with delay and the dimensionless synthetic analysis, introducing the conception of input-output feedback loops, the model may handle the complicated nonlinear problems visually. Through man-machine conversation, model simulation with specialized software package, policy simulation and plan optimality, it may become the auxiliary system that the policy-maker participates directly.

3. Analysis of system structure

Regional economic structure system defined in this paper consists of ownership structure subsystem, industry structure subsystem, urban and rural structure subsystem, investment structure subsystem. According to system decomposition theory, each subsystem could be decomposed downward into certain essential parts (sub-subsystems), and then sub-subsystem could be further decomposed into many related function modules. Although the descriptive variables to economic structure system are numerous, system dynamics model is based on the leading parts principle to explore the leading feedback loops in regional economic structure system. Furthermore, by studying the properties of these leading feedback loops to deepen the understanding of system internal structure and dynamic characteristics, the system could be analyzed and simplified finally.

We should first choose those variables that can represent main aspects' changes of economic structure system. Meanwhile, in view of displaying mutual coupling function and meeting demands of data availability, high correlation degree variables are chosen to constitute feedback loops of economic structure system. From 41 influential variables that are selected, the main ones are determined by comparison, such as the proportion by type of industry, the proportion of state-owned economy and the level of urbanization and so on. Then together with auxiliary variables relevant with the main ones, the main circuits of economic structure system are formed. Graph of main causality is shown in Figure 1. In industry structure subsystem, GDP of three industries are taken as the level variables, which should be connected with industrial investment increment, and thus the relation with investment structure subsystem is established. At the same time, by connecting with the proportion of industries, industry structure subsystem also sets relation with ownership structure subsystem. In urban and rural structure subsystem, the level of urbanization is taken as the level variable, which makes urban and rural structure subsystem have interface with industry structure subsystem by connecting with the proportion of employment in industries. In addition, the representative variable of ownership structure subsystem is the proportion of state-owned economy, whose changes should influence the process of urbanization by developing multiple-owned economy, especially developing non-state-owned economy in town, which consequently make ownership structure subsystem have the negative effects on urban and rural structure subsystem.

4. Determination of system parameters

Equation parameters could support system performance. Two ways are adopted to determine the main parameters: 1.Trend extrapolation. Using historical data to decide the parameters, the approach could describe the relative stable trend of variables, such as the prediction of the increment of investment in three industries. 2.Regression fitting. In this model, some regression fittings are made to decide the relations of variables by SPSS software, such as the mutual effects between the level of urbanization and the increment of industrial GDP.

The main dynamic equations and the parameters of Heilongjiang economic structure system are as follows:

GDP of the first industry = INTEG (the increment of the first industry*GDP of the first industry, 377.23)

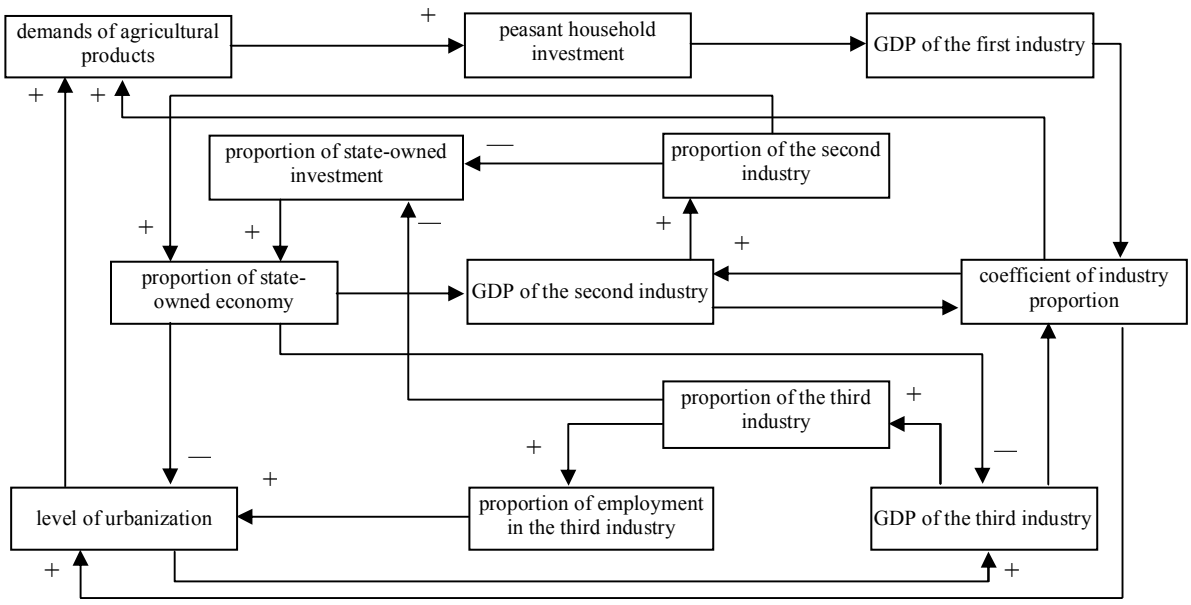

Figure1. Graph of main causality

the increment of the first industry =0.047+0.157*the increment of peasant household investment+0.251*the price of agricultural products

GDP of the second industry = INTEG (the increment of the second industry*GDP of the second industry, 1587.76)

the increment of the second industry = - 2.671+ 0.147*the increment of investment in the second industry-0.03*the productivity of the second Industry+5.262*the coefficient of industry proportion-1.768*the proportion of state-owned economy +0.007*time

GDP of the third industry = INTEG (the increment of the third industry* GDP of the second industry, 932.42)

the increment of the third industry = -1.316+0.38* the increment of investment in the third Industry+ 0.299*the productivity of the third industry+3.128* level of urbanization -2.065*Engel coefficient-0.102 *time

total GDP = GDP of the first industry +GDP of the second industry +GDP of the third industry

the coefficient of industry proportion = (the proportion of the second industry*0.3+the proportion of the third Industry*0.6)/SQRT((the proportion of the second industry^2+the proportion of the third industry^2) *0.45)

the productivity of the second industry = GDP of the second industry /jobholders of the second industry

the productivity of the third industry = GDP of the third industry /jobholders of the third industry

the level of urbanization = INTEG (the increment of urbanization* the level of urbanization, 0.5148)

the increment of urbanization = -0.251-0.014*the proportion of state-owned economy+0.788*the proportion of employment in the third industry+0.054*the coefficient of industry proportion-0.003* household registration policy

the proportion of state-owned economy = -0.601+ 1.02*the proportion of state-owned investment+1.535* the proportion of the second industry+0.011*time

the proportion of state-owned investment = IF THEN ELSE (Time=1999, 0.5763, 5.194 -5.28*the proportion of the second industry -5.085*the proportion of the third industry -0.029*reform policy of state-owned enterprises)

demands of agricultural products = IF THEN ELSE (Time=1999,0.010753,-6.6555+7.156*DELAY1(the level of urbanization,1)-3.709*DELAY1(Engel coefficient,1)-3.426 *DELAY1(disposable income of urban residents,1) +3.501*DELAY1(the coefficient of Indus-try proportion,1) +0.084*Time)

the increment of peasant household investment = 0.8298+0.95*DELAY1 (demands of agricultural products, 1) +3.173*the price of agricultural products + 2.235*the price of agricultural production goods+ 6.816*DELAY1 (net income of peasant household,1)-0.34*time

the proportion of employment in the third industry = 0.36-0.205*the proportion of the third industry -0.474* DELAY1 (the proportion of the third industry, 1) + 0.292* the level of urbanization

5. Verification of historical data

In this paper, system dynamics model for economic structure of Heilongjiang province is used to simulate the operation of industry structure subsystem, ownership structure subsystem, urban and rural structure subsystem and investment structure subsystem from 1999 to 2006. GDP of three industries and the coefficient of industry proportion are introduced to represent the basic situation of industry structure; the proportion of state-owned economy and the proportion of state-owned investment are drawn to display the basic condition of ownership structure; the level of urbanization is adopted to represent urban and rural structure; the change of investment in the first industry reflects the basic condition of investment structure. From the fitting data of the modules, we find that each sub-module has simulated the actual economic performance perfectly. Except individual years, the system errors are within ± 1%. Therefore, system dynamics model for economic structure system of Heilongjiang province established in this paper passes through the actual data testing, which means the model could reflect the actual running state of economic structure system and could serve as the foundation for study on operation of regional economic structure system, and it can provide theoretical supports for the choice of countermeasures of economic structure readjustment in the future.

6. Prediction of future trend

The running of economic structure system of Heilongjiang province from 2007 to 2010 could be simulated by use of system dynamics model established before. In the process, the initial exterior variables, containing the increment of peasant household investment, the increment of the second industry investment, the increment of the third industry investment, Engel coefficient, and the increment of agricultural products price, should be acquired from historical data. Following is the prediction of the changes of main economic structure indexes from 2007 to 2010 (Figure 2. to Figure 5.):

In the prediction of industrial GDP, the growth rate of three industries is different. The first industry almost presents a linear growth, and the second industry and the third industry look like the quadratic function growth approximately, thus the growth of GDP in the second industry and the third industry will be quicker. In the prediction of industry proportion and industry proportion coefficient (similarity coefficient), the proportion of the first industry should descend from 11.9% to 7.78% in 2007-2010, and the proportion of the second industry should decrease from 54.4% to 53.06%. However, the proportion of the third industry should increase from 33.7% to 39.15%. Simultaneously, the rise of coefficient of industry proportion means that industry structure will become reasonable. The prediction data of other structure subsystems show that the level of urbanization has a little advance, only from 53.56% to 53.75; the proportion of state-owned investment should drop greatly, from 45.24% to 21.74%; the proportion of state-owned economy effected by the change of state-owned investment should descend from 76.42% to 56.72%, which shows that ownership structure has a good tendency.

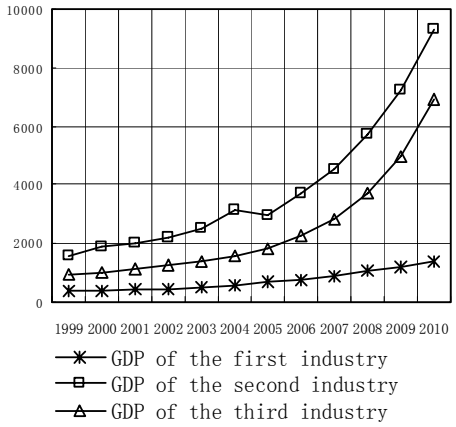

Figure2. Prediction of GDP by of industry.

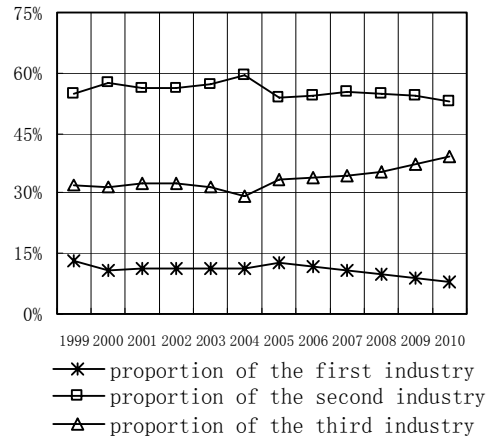

Figure3. Prediction of proportion by type of industry

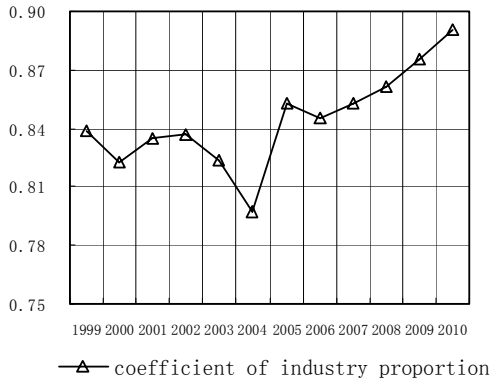

Figure4. Prediction of coefficient of industry proportion

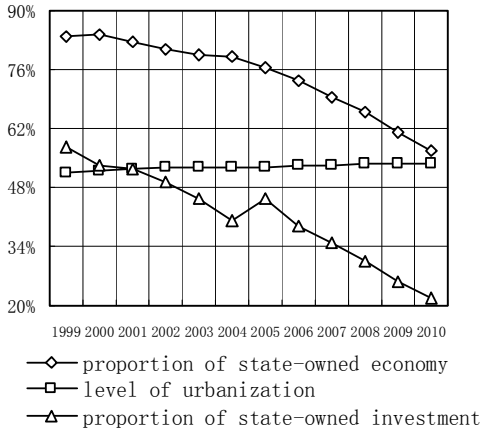

Figure5. Prediction of state-owned economy and urbanization

7. Conclusions

With the qualitative analysis of the intersystem coupling mechanism, system dynamics model for economic structure of Heilongjiang province is established in the light of the theory of system dynamics, which reflects the interactions among industry structure subsystem, ownership structure subsystem, urban and rural structure subsystem, and investment structure subsystem. Through parameters determination in dynamic model and system simulating using these model parameters, some conclusions could be drawn that the error is little between simulative value and true value in the main evaluation indexes of subsystems, and the model could reflect the overall changes of regional economic structure system of Heilongjiang province in recent years. Furthermore, the model is used to predict the performance of economic structure system in Heilongjiang province from 2007 to 2010. The trend and the interaction of subsystems shown in the prediction could be available for the regional economic structure adjustments in the future. The results indicate that there are the complex interrelations in regional economic structure subsystems, which could be described as "a hair pulls and the whole body moves". So when making the structural adjustment, we must adjust all elements in the system with interactive way, only by this, the whole adjustment goals of regional economic structure system could be realized.

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