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A PRIMARY EXPLORATION ON THE SUPER-NETWORK MODEL OF ECONOMIC DEVELOPMENT UNDER THE RESTRICTION OF RESOURCES AND ENVIRONMENT

Uma exploração primária no modelo de super-rede de desenvolvimento econômico sob restrição de recursos e meio ambiente

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ABSTRACT

With the theory of super-network and the variational inequality method, this paper establishes a super-network model of economic development in three aspects, builds a new indicator system for measuring economic development, and calculates the equilibrium conditions for the balance of economic development. Firstly, the economic development is divided into three parts: economic growth, ecological environment optimization and scientific and technological progress. Respectively, with the set of measuring indicators in three aspects as a point of super-network and the link between these indicators as a super edge, thus a super-network model is established. Secondly, the hierarchical variable clustering analysis method is used to analyze the tightness of the links among the nodes in the super-network; and the objective function is established by using the partial measurement index, which simplifies the model. Finally, the variational inequality and projection iterative algorithm are used to calculate the equilibrium condition of the whole model. The main conclusions in this paper are as follows: (1) The indicators of economic development are interrelated with each other. (2) It can contribute to the balanced development of the economy in satisfied certain conditions.

Keywords: Super-network. Economic development. Clustering analysis. Variational inequality. Equilibrium condition

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UMA EXPLORAÇÃO PRIMÁRIA NO MODELO DE SUPER-REDE DE DESENVOLVIMENTO ECONÔMICO SOB-RESTRIÇÃO DE RECURSOS E MEIO AMBIENTE

A Primary Exploration on the Super-network Model of Economic Development under the Restriction of Resources and Environment

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RESUMO

Com a teoria da super-rede e o método da desigualdade variacional, este artigo estabelece um modelo de super-rede de desenvolvimento econômico em três aspectos, constrói um novo sistema de indicadores para medir o desenvolvimento econômico e calcula as condições de equilíbrio para o equilíbrio do desenvolvimento econômico. Em primeiro lugar, o desenvolvimento econômico é dividido em três partes: crescimento econômico, otimização do ambiente ecológico e progresso científico e tecnológico. Respectivamente, com o conjunto de indicadores de medição em três aspectos como ponto de super-rede e o vínculo entre esses indicadores como super-borda, é estabelecido um modelo de super-rede. Em segundo lugar, o método de análise de agrupamento de variáveis hierárquicas é usado para analisar a rigidez dos links entre os nós na super-rede; e a função objetivo é estabelecida usando o índice de medição parcial, que simplifica o modelo. Finalmente, a desigualdade variacional e o algoritmo iterativo de projeção são usados para calcular a condição de equilíbrio de todo o modelo. As principais conclusões deste artigo são as seguintes: (1) Os indicadores de desenvolvimento econômico estão inter-relacionados. (2) Pode contribuir para o desenvolvimento equilibrado da economia em determinadas condições.
Palavras-Chave: Super-rede. Desenvolvimento Econômico. Análise de agrupamento. Desigualdade variacional. Condição de equilíbrio

INTRODUCTION

In the current information age, the application of super-network theory has spread to various fields, and the introduction of mathematical related calculation methods has made the research of super-network gradually change from qualitative to quantitative, making the established model more scientific. The topology of the super-network is hypergraph, proposed by Claude Berge in 1970. He established the theory of undirected hypergraph systematically and defined the super-network with hypergraph. The vertices v_1, v_2, ..., v_n of the hypergraph form the set V, and the non-empty set e_i is used to describe the edge of the hypergraph, that is, the super edge, and the set of the super side is E, then the binary relationship H=(V, E) forms a super map (Claude Berge,1973). In addition, how to divide the complex network and the advantages and disadvantages of variational inequality algorithms remain to be studied. And how to more closely simulate the construction of objective functions is one of the issues that must be considered when applying this theory.

Initially, in the United States, the Ministry of Commerce calculated the GDP per capita to measure economic development. Later, the American association for overseas development proposed to ignore income and use the actual quality of life index including infant mortality, life expectancy and basic literacy rates in the same weight, which is a great progress compared to only GDP per capita to measure economic development. However, the income is neglected by this index reflection some respects such as the availability of goods and services. Hence, the United Nations Development Program built a Human Development Index (HDI) that also includes income considering health, knowledge and income per capita as factors contributing to measure the country's economic development. HDI adjusts the income per capita of countries by ignoring high incomes to emphasize the diminishing marginal utility of high-income levels. It indicates that higher incomes are not necessarily associated with higher living standards (Office UHDR, 1998). However, the HDI measurement method includes the items and the manner they are given the same weight is not scientific, so it is not a perfect indicator.

In this paper, we focus on the three main aspects including economic growth, ecological environment optimization and scientific and technological progress in the various aspects of economic development, which have their own indicators. Since these indicators are closely interrelated to each other, the nesting relationship of the network could be analyzed by super-network theory. The purpose of this paper is to apply the super-network theory to the measurement of economic development, establish the index system and then use the variational inequality to study the equilibrium condition. The rest of the sections in this paper were organized as follows. Section II illustrates the model assumptions and descriptions. Section III describes the data and methodology. Section IV presents results of computation. Finally the paper is included in Section V.

1. MODEL ASSUMPTIONS AND DESCRIPTIONS

The interrelationship between the indicators that measure economic development can be described by the network. In all aspects of economic development, this paper selects three main aspects of economic growth, ecological environment optimization and scientific and technological cultural progress. These three aspects have their own measurement indicators, and each indicator is related to each other. The nested relationship of the network including the network can be analyzed by the super-network theory, that is, the theory of super-network is used to analyze the measurement of economic development, and the relationship between each measurement index is described, to comprehensively analyze economic development. Then, based on the model establishment, the variational inequality is used to study the equilibrium condition.

The scope of economic development includes economic growth, economic structure optimization, people's living standards, the gap between rich and poor, ecological environment, sustainable development, technological progress and the development of civilization and other aspects. This paper focuses on three aspects consist of the economic growth, ecological environment and science and technology culture to measure, while assuming that these aspects of economic development are the decisive factors. These indicators are discussed in detailed as the following.

1.1 Economic growth

Generally, a country's economic growth is defined as the long-term increase in the ability to provide a growing variety of economic commodities for people, that is, an increase in economic output capacity.

The output capacity of the economy is determined by the factors of production and production technology, thus the capital, manpower, technology used and natural resources are the direct influencing factors (Mankun, 2000). In macroeconomics, the total expenditure is divided into four parts by expenditure: consumption, investment, government purchases and net exports, in which consumption is determined by income, investment is determined by interest rates, government purchases depend on government policies, net exports are directly related to the exchange rate (Xiang Rongmei, 1996). Therefore, GDP per capita, interest rates, government policies, exchange rates, investments and foreign trade could be used as a measure of economic growth. On the other hand, economic growth depends on savings, population growth, and technological progress according to the economic growth model of Solow (Solow, 2004). In addition, the economic growth capacity is affected by the economic structure (Liu Wei, 2008), so the proportion of the three industries to GDP is also one of the indicators that reflect economic growth. From the analysis mentioned above, there are a lot of factors that affect economic growth in the study of national economic growth, often with a series of described indicators. The most important of which are GDP, urban registered unemployment rate, the consumer price index, import and export trade, foreign exchange reserves, the total investment in fixed assets, the tertiary industry added value, disposable income per capita and the natural population growth rate. These indicators are labeled as a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, the set of indicators is

$$A = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9\}.$$

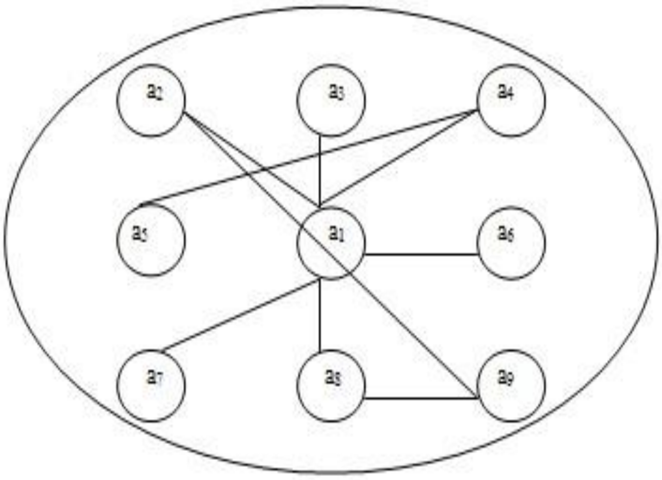

Figure 1 Indicator Network for Economic Growth

It is clearly shown that these indicators such as GDP, the natural growth rate of the population are not isolated but interrelated. Especially, there is a close relationship between the amount of import and export trade and foreign exchange reserves. In Okun's law, the change in GDP has a direct linear relationship with the unemployment rate. Concretely, the unemployment rate rises by one percentage point while the growth of the real GDP is generally reduced by 2%. These relationships could be used to simulate the diagram, in which indicators act as the edge nodes, and the link presents the relationship between them, as shown in Figure 1.

1.2 Eco-environment optimization

With economic growth, the ecological environment problems tend to be more and more. Some countries blindly pursue GDP growth at the high expense of the environment, but this kind of way is clearly unsustainable for the economic development. In case of economic growth and environmental protection, we should also pay attention to the ecological environment optimization problem in the economic development.

The energy consumption per unit of GDP is a very common measure of eco-environmental benefits, and the negative impacts of economic growth on the environment are also reflections of economic development, such as industrial waste water waste and emissions, the number of environmental pollution and damage every year (Li Yongkui, 2010). The results of environmental protection are also the vane of ecological environment optimization. The investment in environmental management is determined by the degree of environmental damage and the factors that determine environmental protection and effectiveness. The treatment efficiency of the industrial emission determines the quality of air quality; forest coverage is also a scale; the establishment of nature reserves has played a significant role in the protection of ecological diversity; the use of clean energy has significantly reduced the traditional industry the pollution.

The ecological environment optimization index system may be expressed by

$$B = \{b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8\}$$

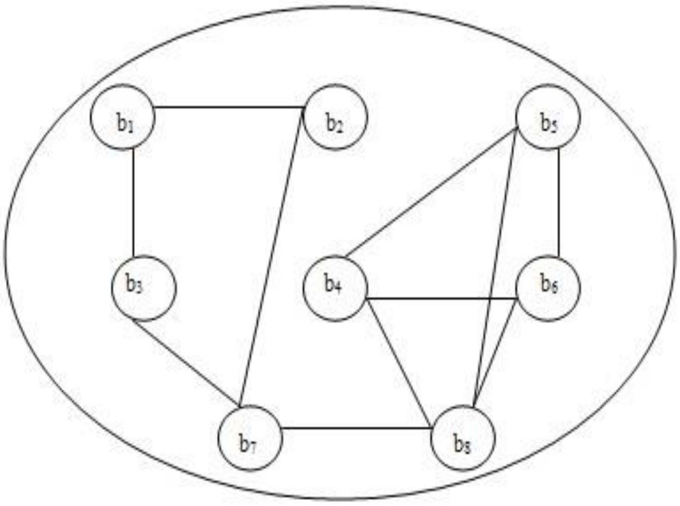

Figure 2 Eco-environment Optimization Indicators Network

Where b_1, b_2, b_3, b_4, b_5 , b_6, b_7, and b_8 are the total energy consumption per unit of GDP, the total amount of industrial exhaust emissions, the rate of industrial wastewater discharge and the total area of afforestation, the total area of nature reserves, the total investment in environmental pollution control, the investment of industrial pollution control and the number of environmental pollution and destruction, respectively. Similarly, the topology can be used to approximate this relationship, as shown in Figure 2.

1.3 Technological and cultural progress

The progress of science and technology is to bring people more convenient production and lifestyle. Therefore, the production efficiency continues to improve. Obviously, the use of new materials and technology to reduce environmental pollution is more efficient economic development. In addition, cultural progress is the improvement of the quality of social civilization, spiritual civilization and material civilization is equally important.

In the actual production, the progress of science and technology is often reflected in the emergence of new products (Li Zibiao, 2006). The output value of new products is higher and higher in the whole industrial production value which to a certain extent reflects the welfare the production process of technological progress for people. The proportion of research inputs in GDP has affected the number of research projects, and the innovations by scientific research determine the species and quantity of new products adopted. The proportion of new products reflects the speed of scientific and technological progress. Research and development projects (R&D) expenditure and the number of employees in R&D reflect the degree of attention on the pursuit of scientific research and development progress. From the aspect of cultural progress, education has a direct effect, so the proportion of cultural industries in GDP and the proportion of investment in education can be used to measure the development of culture Hence, the development of education is reflected in a series of indicators such as adult literacy rate, school-age children enrollment rate, the quality of enterprise employees, per capita education and etc. The collection of scientific and technological progress indicators as

$$C = \{c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9\},$$

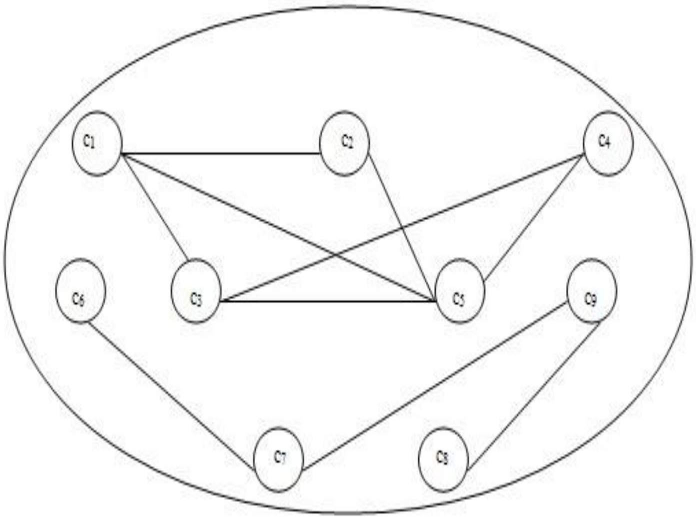

Figure 3. Scientific and Technological Progress Indicator Network

Where c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9 are the output value of new products, R&D funds internal expenses, R&D staff full-time equivalent, the technical market turnover, the number of scientific and technological achievements, cultural institutions, the total income of the performing arts group, school-age children net enrollment rate and education funding, respectively. The topological structure is shown in Figure 3.

1.4 Economic development super-network model

The measurement of economic development can be carried out mainly from three aspects: economic growth, ecological environment optimization and technological and cultural progress. These three aspects measure economic development from different angles and have a certain relationship between them and each other. The above three indicators are discussed separately, and these indicators and the linkages between them are now used to establish a super-network model for measuring economic development. As mentioned above, we discuss the three index systems, and we now use these indicators and the link between indicators to establish a super-network model to measure economic development.

From the perspective of economic development, this network could be used to construct a super-network. The economic development super network can be expressed as: G = (V, E), where V is the set of nodes, and V = {A is the set of nodes of economic growth index, B is the set of nodes of ecological environment optimization index, C is the set of nodes of scientific and technological progress indicators, E is the set of edges, and E = {E_{A-A}, E_{A-B}, E_{A-C}, E_{B-B}, E_{B-C}, E_{C-C}}. Topology of the super-network is called hypergraph. It can use a plan to simply simulate the hypergraph, as shown in Figure 4.

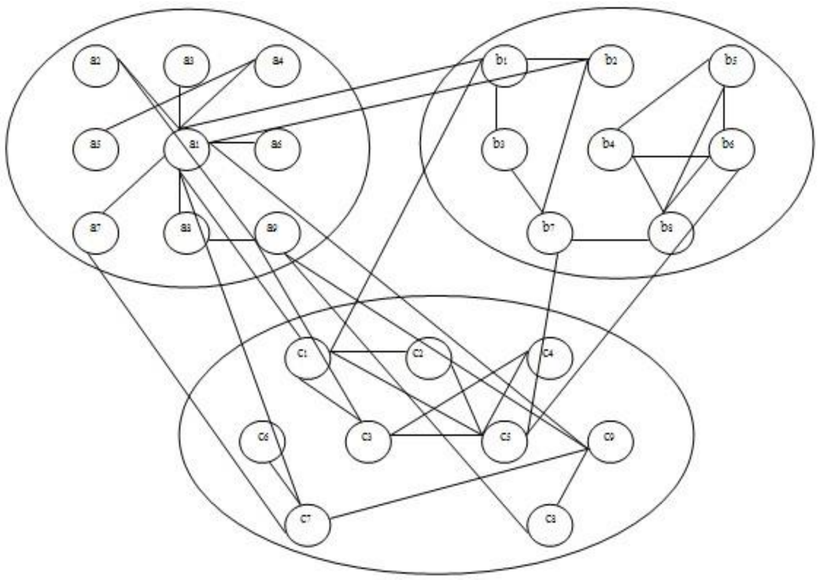

Figure 4. The Hypergraph Model Preliminarily Simulated of the Economic Development Index System

2. DATA AND METHODOLOGY

In the following, mathematical relations will be used to quantify the relationship between the strengths and weaknesses of these links in a more scientific way. Firstly, the quantitative analysis is carried out by using the statistical software to obtain the core indicators and the tightness of the links between the indicators, namely the cluster analysis. Then variational inequality is used to study the equilibrium conditions the model should meet.

2.1 Cluster analysis

There are total 26 indicators in the super-network model for economic development, and the degree of affinity among the indicators is different. When all the variables are taken into account to measure the economic development, the workload is too large and inefficient. Therefore, we can use cluster analysis method to select the core indicators with the tightness among indicators as a standard for further study. Cluster analysis is usually done by using statistical analysis software, thus, the SPSS software is used in this paper. With economic variables processed, they become indicators that can be compared to each other without a scale. To reflect the status of economic development fully, the annual growth rate index of each indicator is adopted. The calculation method is as follows: the index of this year's growth index = this year of the index value / index value of the previous year×100). The value of indicators from year 2004 to year 2015 can be found in the Chinese statistical yearbook. According to the calculation method above, the data can be processed to the growth index of 26 indicators in the ten years from 2005 to 2015, and then can use statistical software to analyze the data to achieve clustering.

From the third cluster analysis, it may be seen that the highest correlation between the other variables is the five variables in the first category as the following: a_1 (GDP index), a_3 (consumer price index), a_7 The three-industry added value index), a_8 (per capita disposable income index) and c_9 (education expenditure index), these variables are closely linked to each other, therefore, they are the most important indicators of economic development in the measurement; followed by higher correlation b_2 (total emissions of industrial emissions), c_4 (technical market turnover index), c_8 (net enrollment rate of school-age children) in category 2.

Table 1. The First Cluster

Cluster Membership

Case	3 Clusters
A1	1
A2	2
A3	1
A4	1
A5	1
A6	3
A7	1
A8	1
A9	3
B1	1
B2	1
B3	2
B4	2
B5	2
B6	1
B7	1
B8	3
C1	1
C2	3
C3	3
C4	1
C5	3
C6	1
C7	1
C8	1
C9	1

Table 2. The Second Cluster

Cluster Membership

Case	3 Clusters
A1	1
A3	1
A4	2
A5	2
A7	1
A8	1
B1	3
B2	1
B6	1
B7	2
C1	2
C4	1
C6	2
C7	1
C8	1
C9	1

Table 3. The Second Cluster

Cluster Membership

Case	3 Clusters
A1	1
A3	1
A7	1
A8	1
B2	2
B6	3
C4	2
C7	3
C8	2
C9	1

Table 4. Similarity Matrix for the Third Cluster

Proximity Matrix

Matrix File Input

Case	A1	A3	A7	A8	B2	B6	C4	C7	C8	C9
A1	.000	.423	.908	.740	.497	.237	.184	-.021	.515	.361
A3	.423	.000	.303	.829	.085	.617	.606	.180	.618	.515
A7	.908	.303	.000	.659	.402	.055	-.065	-.260	.288	.546
A8	.740	.829	.659	.000	.093	.623	.349	.139	.425	.644
B2	.497	.085	.402	.093	.000	-.019	.478	.282	.570	.139
B6	.237	.617	.055	.623	-.019	.000	.601	.654	.338	.456
C4	.184	.606	-.065	.349	.478	.601	.000	.656	.709	.269
C7	-.021	.180	-.260	.139	.282	.654	.656	.000	.357	.101
C8	.515	.618	.288	.425	.570	.338	.709	.357	.000	.100
C9	.361	.515	**.546**	.644	.139	.456	.269	.101	.100	.000

After the division of 26 indicators, it is possible to simplify the model. Namely, ignoring the indicators in Part III, we only consider the eight indicators in the part I and part II, and keep these important indicators as the core indicators of economic development.

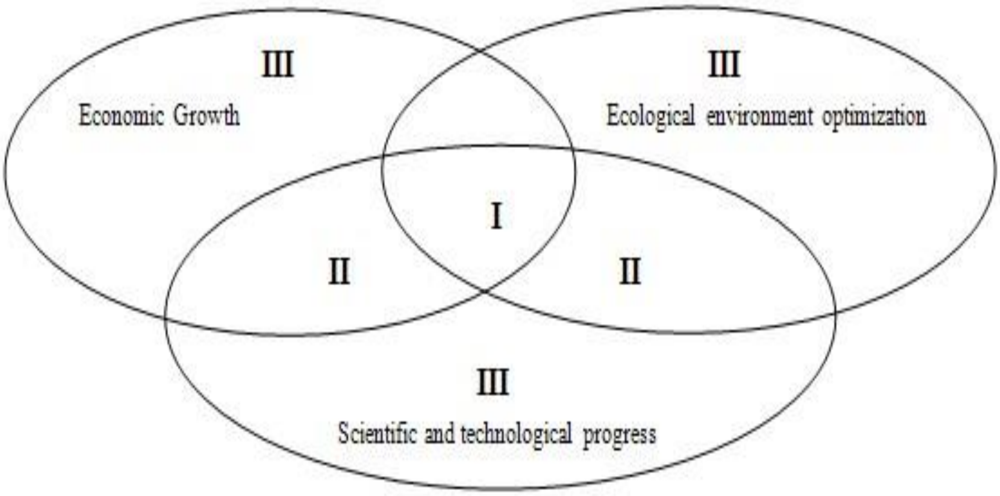

Figure 5. Simplified Model after Cluster Analysis

(Which I, including a_1, a_3, a_7, a_8, c_9 five indicators; II, including b_2, c_4, c_8 three indicators; III, including other indicators)

2.2 Objective function of the model

From the established super-network model of economic development measurement indicators, we can analyze the objectives of economic development from various indicator systems. When analyzing the objectives of economic development from three aspects: economic growth, ecological environment optimization, and scientific and technological cultural progress, each part should achieve coordinated development to achieve the optimization of the entire system, that is to achieve the most favorable economic development under the existing resource constraints while achieving the goal of optimizing their respective development by realizing the game trade-offs of economic growth, ecological environment and scientific and technological cultural progress. In the results of cluster analysis, the model is simplified to a system with only eight indicators by considering a_1, a_3, a_7, a_8 in economic growth, b_2 in the aspect of ecological environment optimization, and c_4, c_8, and c_9 in scientific and technological progress.

So we can get the objective function of the economic growth maximization as followed:

Max $fa\,(a_1, a_3 - p_0, a_7, a_8)$.

It can write the objective function to optimize the ecological environment: Min $g\,(b_2)$.

We can get the objective function to maximize the scientific and technological progress:

Max $h\,(c_4, c_8, c_9)$.

The objective function maximizing the economic development can be obtained by the objective function maximizing the three aspects above:

$$\text{Max } \lambda f\,(a_1,\ a_3 - p_0,\ a_7,\ a_8) - \mu g\,(b_2) + \eta h(c_4,\ c_8,\ c_9)$$

Which, λ, μ, η represent the weight of contributions the three parts making in the economic development.

The objective function maximizing the economic development obtained in the above could be transformed into the variational inequality form:

$$\left(\sum_{i=1,3,7,8} [\mu \frac{\partial g(b_2)}{\partial a_i} - \lambda \frac{\partial f(a_1,a_3-p_0,a_7,a_8)}{\partial a_i} - \eta \frac{\partial h(c_4,c_8,c_9)}{\partial a_i}] \times (a_i - a_i^*) \right.$$
$$+ \sum_{j=2} [\mu \frac{\partial g(b_2)}{\partial b_j} - \lambda \frac{\partial f(a_1,a_3-p_0,a_7,a_8)}{\partial b_j} - \eta \frac{\partial h(c_4,c_8,c_9)}{\partial b_j}] \times (b_j - b_j^*) \qquad (1)$$
$$\left. + \sum_{h=4,8,9} [\mu \frac{\partial g(b_2)}{\partial c_h} - \lambda \frac{\partial f(a_1,a_3-p_0,a_7,a_8)}{\partial c_h} - \eta \frac{\partial h(c_4,c_8,c_9)}{\partial c_h}] \times (c_h - c_h^*) \right) \geq 0$$

2.3 Projection iterative algorithm

At present, there are three main methods for solving the variational inequality. They are projection algorithm, non-smooth equations and smoothing method. The projection algorithm is a simple algorithm that relies mainly on the projection iteration $x^{k+1} = P_{\Omega k}(x^k - a_k d_k)$, which Ω_k is the convex set containing X, d_k is the search direction, $a_k > 0$ is the step, $P_{\Omega k}(\cdot)$ is the vector x to the projection on the set Ω_k, that is $P_{\Omega k}(x)$ = arg m in $\{\| x - y \|, y \in \Omega\}$.

A typical modified iterative method with an initial solution in a feasible domain is commanding $x^{k+1} = P_\Omega k (x^k - a F(\overline{X}^K))$, where $\overline{X}^K = P_{\Omega_K}(x^k - a F(x^k))$; α is a positive number.

We present the steps to solve the variational inequality by this method:

Step 1: Suppose $x^0 \in K$, and command $0 \leq a \leq \frac{1}{L}$, Where L is the Lipsets constant, k is the number of iterations, and k = 1

Step 2: Iterative calculations. First calculate $(a_1, a, a_3, a_7, a_8, b_2, c_4, c_8, c_9) \in K$, so that:

$$\left(\sum_{i=1,3,7,8} \overline{a}_i^k + \alpha[\mu \frac{\partial g(b_2^{k-1})}{\partial a_i} - \lambda \frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial a_i} - \eta \frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial a_i}] - a_i^{k-1}\} \times (a_i - \overline{a}_i^k) \right.$$
$$+ \sum_{j=2} \overline{b}_j^k + \alpha[\mu \frac{\partial g(b_2^{k-1})}{\partial b_j} - \lambda \frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial b_j} - \eta \frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial b_j}] - b_j^{k-1}\} \times (b_j - \overline{b}_j^k) \qquad (2)$$
$$\left. + \sum_{h=4,8,9} \overline{c}_h^k + \alpha[\mu \frac{\partial g(b_2^{k-1})}{\partial c_h} - \lambda \frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial c_h} - \eta \frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial c_h}] - c_h^{k-1}\} \times (c_h - \overline{c}_h^k) \right) \geq 0$$

And then through the iterative calculation $(a_1^k, a_3^k, a_7^k, a_8^k, b_2^k, c_4^k, c_8^k, c_9^k) \in K$, so that:

$$\left(\begin{aligned}&\sum_{i=1,3,7,8} a_i^{k}+\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial a_i}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial a_i}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial a_i}]-a_i^{k-1}\}\times(a_i-\bar{a}_i^{k})\\&+\\&\sum_{j=2} b_j^{k}+\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial b_j}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial b_j}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial b_j}]-b_j^{k-1}\}\times(b_j-\bar{b}_j^{k})\\&+\\&\sum_{h=4,8,9} c_h^{k}+\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial c_h}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial c_h}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial c_h}]-c_h^{k-1}\}\times(c_h-\bar{c}_h^{k})\end{aligned}\right)\geq 0 \quad (3)$$

Until the given $\varepsilon > 0$, *satisfies* $|a_i^k - a_i^{k-1}| \leq \varepsilon, |b_2^k - b_2^{k-1}| \leq \varepsilon, |c_j^k - c_j^{k-1}| \leq \varepsilon$,where i=1,3,7,8;j=2; h=4,8,9, The convergence of the solution of the variational inequality is achieved and the loop is exited; otherwise, let $k = k + 1$, return to step 2 to iterate.

3 RESULTS OF COMPUTATION

3.1 Solution of the model

The final solution of the model can be obtained by the existence of the uniqueness of the solution and the iterative algorithm that using to solve the variational inequality.

$$\bar{a}_i^{k}=a_i^{k-1}-\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial a_i}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial a_i}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial a_i}](i=1,3,7,8); \quad (4)$$

$$\bar{b}_2^{k}=b_2^{k-1}-\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial b_2}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial b_2}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial b_2}]; \quad (5)$$

$$\bar{c}_j^{k}=c_j^{k-1}-\alpha[\mu\frac{\partial g(b_2^{k-1})}{\partial c_j}-\lambda\frac{\partial f(a_1^{k-1},a_3^{k-1}-p_0,a_7^{k-1},a_8^{k-1})}{\partial c_j}-\eta\frac{\partial h(c_4^{k-1},c_8^{k-1},c_9^{k-1})}{\partial c_j}](j=4,8,9); \quad (6)$$

3.2 Description of the results

In the above mentioned, equation (4) is the condition that indicators of economic growth should solve, equation (5) is the condition that the indicators of the ecological environment should satisfy, and equation (6) is the condition that the indicators of science and technology culture should meet. While satisfying (4) (5) (6), we can achieve the goal of balanced development of the whole economy. In the equilibrium conditions obtained above, we can see that economic development should be balanced and optimized. The indicators must be coordinated with each other, which are the same as that envisaged before establishing the model objective function, and is consistent with the original intention of building the model on the basis of the interrelationship between indicators. This means that the maximization of the objective of the economic development objective determines that the purpose is not to maximize the economic growth, the optimization of the ecological environment, and the advancement of the culture of science and technology, but to maximize the coordination of the overall objective function, which may be contrary to the maximization of a particular aspect, but through the coordination of the overall optimization can be achieved, that is, some of the best is not necessarily the overall optimal, and the overall optimal is not necessarily which contains all the parts of the optimal.

3.3 Equilibrium in change

In (4) (5) (6) the formula is the balance conditions of optimal economic development, in fact, in these conditions it can also see how other indicators to change accordingly to achieve the new equilibrium when a particular indicator changes, that is, to achieve the balance problem in the changes of the model.

Consider the change in gross national product (a_1), assuming that the change of a_1 is m (the increase is positive and the decrease is negative, only the increase is considered, the decrease is the opposite trend, that is, m is greater than 0), a_3,a_7,a_8 will be a corresponding increase seen from the (4), b_2 will increase seen from the (5), c_4, c_8, c_9 will be a corresponding increase seen from (6), but the degree of increase due to the relevancy of a_1 in the index system respectively, the greater the impact of the indicators the greater the impact.

This means that the indicators of economic growth, ecological environment and science and technology coordinate with each other under the constraints of economic development optimization, and the degree of mutual influence between the indicators is determined by partial derivative of the function, that is, by the interconnection between the degrees of tightness of indicators.

Therefore, we can analyze the influence of mutual restraint or interrelations on other aspects when the policy affects one aspect based on this super-network model, and combine with the correlation matrix between the economic indicators obtained in the cluster analysis. It is also possible to analyze the conditions that must be met in all other aspects when a goal of a particular economic development is achieved. In addition, it can also analyze how the other indicators should be changed to ensure the ultimate achievement of economic development when an indicator changes.

CONCLUSION

In this paper, the super-network theory is applied to the measurement of economic development, to study the super-network model of economic development measure. Firstly, the complex system with multiple indexes is simplified by cluster analysis, and only important factors are studied. Secondly, the objective function is established according to the contribution degree of each index. Finally, the maximization problem of objective function is analyzed by variational inequality.

Theoretical contribution and practical significance of the conclusions: In theory, a measurement index system is established to improve the one-sided deficiencies of the single indicator with the application of super-network theory in the measurement of economic development, thereby further expanding its research field. Finally, the results of the model analysis are used to propose corresponding policy recommendations for macroeconomic operation. In reality, a new indicator system for measuring economic development is proposed. This is not a denial and substitution of GDP, but a promotion and improvement of it. It is to build a new indicator system to make up for the shortcomings and defects of the existing GDP. This is not only an inevitable requirement for the new era of ecological civilization and the construction of socialist ecological civilization, but also provides a new way for the government to evaluate economic development.

The super-network model of the economic development measure established in this paper is only preliminary, and there are still many aspects to be studied further in the future. Finally, how to give the weight more reasonable, that is the objective functions of this article, so that the objective function is more realistic economic life is also a problem to be solved.

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