# Stability Analysis Model of Eco Economic System based on Discrete Selection

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**Abstract: The internal structure of eco-economic system is relatively complex, and its stability is easily affected by external environmental factors such as region, which results in poor accuracy of the results of its analysis. Based on this, the stability analysis model of eco-economic system based on discrete selection is proposed. In order to improve the accuracy of eco-economic system analysis, the characteristics of discrete selection model are analyzed. Based on the principles of scientificity, practicability, regionality, operability and dynamic, and the comprehensive development of four sub-systems of economy, land, environment and society, the indexes of economy, land, environment and society are selected to build the stability evaluation of eco-economic system Price index system: through adjusting the structure of resource utilization, the indexes are selected hierarchically to truly reflect the structure of resource utilization. The weight of each index is obtained by AHP, and the component of each index in the evaluation system is reasonably divided. According to the theory of stochastic utility, the elements of discrete selection model are analyzed, and then the discrete selection model is constructed. By studying the close degree of each evaluation object and ideal solution, the stability analysis of ecological economic system is realized. The experimental results show that the influence of the proposed model on net income per unit is relatively stable at the positive and negative balance points, which is consistent with the actual situation, and the shortest analysis time is 1.2 min, which is feasible.**

**Keywords: Discrete selection; Ecosystem; Economic stability; AHP; Stochastic utility theory; Ideal solution**
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## 1. Introduction

Urbanization is an inevitable trend of the development of human society and the inevitable product of the continuous progress of economic technology, and it is the inevitable stage of social fire towards modernization. With the continuous growth of population, urbanization brings economic benefits to human society, but also brings many problems, especially a series of ecological environment problems to the city The basic problems of ecological environment are all land problems, which correspond to land ecological system and land economic system respectively. The two systems interact, permeate and interact with each other in a specific land space or section, forming a composite system with certain structure and function, i.e. land ecological economic system [1, 2]. Ecological economic system includes two aspects: ecological system and economic system. Only when they are in a stable and balanced state, can the level and ability of land resources development and utilization be continuously improved. Therefore, for the development and utilization of land, we should not blindly pursue economic interests, but also fully consider the impact on the ecological environment, carry out scientific and reasonable ecological consolidation, strengthen the construction and development of infrastructure, and improve the efficiency of resource utilization [3]. All activities of human development are carried out in this ecological economic system. Therefore, it is necessary to analyze the stability of land eco economic system scientifically. The contradiction between economic development and ecological environment has become increasingly prominent. How to coordinate the relationship between ecological environment stability and economic development has become a research frontier and hot issue.

Literature [4] explores the evaluation model and method of land eco economic system stability, constructs the analysis and evaluation system of land eco economic system stability, and establishes the evaluation standard of land eco economic system stability analysis. Through the analysis of the stability of Changchun land eco economic system, it is verified that the land eco economic system is in a stable state. This method can effectively evaluate the land ecological environment, but the operation process is complex and the evaluation process is easy to be interfered by external factors, resulting in the low accuracy of the evaluation.

In reference [5], the stability and Hopf bifurcation of a class of differential eco economic system with Allee effect are studied by using the theory and method of differential algebraic system. The system is discretized by using the Euler discretization method, and the step length is taken as the bifurcation parameter, This paper discusses the flip branch and the sacker Neimark branch of the system, discusses the stability of the equilibrium point of a differential eco economic system with Allee effect by using the theory of differential algebraic system, and realizes the stability analysis of the eco economic system. However, although this method studies the relationship between the soil

eco economic system and the sustainable utilization of resources, it studies the stability of the eco economic system There are few qualitative studies and some problems to be solved. In reference [6], the emergy theory and analysis method are used to establish the evaluation index system of the ecological economic system. Five main indexes, net emergy output rate, environmental bearing rate, system production dominance, system stability index and sustainable development performance index, are selected to evaluate the emergy input-output structure and sustainable development status of the cultivated land ecological economic system. The evaluation accuracy of this method for the stability of eco-economic system is high, but there is blind pursuit of economic benefits in the performance analysis of sustainable development, which increases the pressure on the ecological environment. Without the analysis of the evolution of the spatial-temporal pattern of the stability of eco-economic system, it is difficult to find out the evolution law of the stability of eco-economic system.

Based on the above problems, this paper puts forward the stability analysis model of eco-economic system based on discrete selection. It is a common decision-making technology for multi-objective decision-making analysis of limited schemes in system engineering. It can systematically analyze the gap between the stability of eco-economic system and the ideal state. This paper discusses the application of the model in the stability analysis of ecological economic system, and uses the comparative method to verify the results, in order to find a more suitable analysis method.

## 2. Analysis of Discrete Choice Model

The research of discrete choice model, which belongs to the field of micro econometrics, is a very effective and practical market research technology. Discrete choice model is widely used, not only in dealing with traffic problems, but also in education and career choice, consumer demand for goods, and residential location selection. The model is easy to estimate and the results are relatively accurate and reliable, so it is widely used. The discrete choice model describes the choices made by decision makers (individuals, families, enterprises or other decision-making units) among different options available [7-9]. The selection set is the summation of all the optional items, which has three properties:

A. Mutex: select one of the options, you can't select other options;

B. Completeness: all options must be included in the set;

C. Finiteness: the number of choices in the selection set must be limited.

The two points need to be further explained for the above properties:

Mutual exclusion and completeness are non limiting. By properly defining the options, we can ensure that the options are completely mutually exclusive and the selection set is completely [10, 11].

The limitation is limited. This condition is the definiteness of the discrete choice model, which can distinguish the application field of the discrete choice model from that of the regression model.

Discrete selection model, also known as quality response model, is

caused by the difference between continuous variables and discrete variables representing the set of choices [12]. The difference is expressed in quality. The discrete selection model cannot be used for quantity selection. The distinction between discrete variable and continuous variable is not always meaningful, so it cannot be used as the basis for researchers to decide whether to choose discrete selection model for research.

In view of the problems such as slow growth, increasing gap between urban and rural areas, backward industrial structure and management mode in the rapid development of eco-economic system, this paper measures the eco-economic system through the discrete choice model, and the research results can provide effective reference for the development and marketing of eco-economy, and finally realize the effective docking of resources, economy and market, and provide the behavior of eco-economic system Research methods provide reference [13].

## 3. Stability Analysis Model of Eco Economic System based on Discrete Selection

### 3.1. Construction of evaluation system

The eco economic system is formed by the coupling of eco system and economic system. Among them, the ecosystem is formed by the coupling of land system and ecological environment system; the economic system is formed by the coupling of economic and social system. Therefore, the eco economic system consists of four subsystems: economy, land, environment and society. Based on the principles of scientificity, practicability, regionality, operability and dynamic, the comprehensive development of the four subsystems of economy, land, environment and society is the starting point. The construction principles are as as shown in:

Comprehensive principle: It should be made clear that the research on the stability of eco-economic system is an organic whole, which is affected by many factors in the social environment. Among them, the change of any factor may lead to the change of system stability. Therefore, when building the stability evaluation index system, we should as shown in the comprehensive principle, fully consider the factors that affect the system, and control the ecological economic system as a whole.

Regional principle: Due to the heterogeneity of the eco economic system, we should as shown in the regional principle when building the index evaluation system, take the specific land use structure of the region as the starting point, fully consider the actual situation of its own development, and study the stability of different regional systems according to local conditions.

Dynamic principle: The stability of eco-economic system is relative. With the change of social and economic development and the transformation of human use structure, its stability will show different characteristics in different periods. Therefore, in the construction of evaluation index system, dynamic factors should be taken into account to avoid the situation that the evaluation results do not conform to the actual situation.

Operability principle: In the formulation of evaluation indexes, it should be combined with specific data and actual situation to ensure the

operability of the selected indexes, and be able to carry out vertical comparative analysis according to the elements embodied in the indexes, so as to avoid blind mouth drawing on the experience of other regions to formulate indexes [14].

In order to fully reflect the long-term coordinated development of the ecosystem and the economic system, five indicators from the four aspects of economy, land, environment and society are selected to build the evaluation index system of the stability of the ecological economic system, as shown in Table 1.

**Table 1 Evaluation index of economic system stability**

| Target layer | Criteria layer | Index layer |
|---|---|---|
| Ecology Economics System Stability | Economic factors | Per capita GDP / yuan |
| | | Urban per capita disposable income / yuan |
| | | Per capita net income of farmers / yuan |
| | | Proportion of total agricultural output value in GDP /% |
| | | Per capita fixed asset investment / yuan |
| | Land factor | Per capita Road area / $m^2$ |
| | | Per capita cultivated land area/$10^4$ $m^2$ |
| | | Per capita land area of urban residents/$m^2$ |
| | | Built up area/$km^4$ |
| | | Sown area of grain crops/km2 |
| | | Fertilizer application amount per unit cultivated land/(t/$10^4$ $m^2$) |
| | Environmental factor | Average temperature/℃ |
| | | Precipitation/mm |
| | | Forest coverage/% |
| | | Sewage treatment rate/% |
| | Social factors | Natural population growth rate/% |
| | | Urbanization level/% |
| | | the registered urban unemployment rate/% |
| | | Proportion of social security in financial expenditure/% |
| | | Population density / (person / $km^2$ ) |

On the basis of the above evaluation index selection, it is necessary to obtain the selected index weight, and then determine the proportion of each index in the ecological economic system, so as to improve the evaluation stability of the ecological economic system.

### 3.2. Index weight acquisition

The data of each index comes from the statistical yearbook and the bulletin of economic and social development statistics. Because there are differences in dimension, order of magnitude and magnitude of change among the evaluation indexes. Therefore, when analyzing the stability of eco economic system, it is necessary to standardize the current data to eliminate the differences.

By adjusting the structure of resource utilization, the utilization

efficiency is constantly improved to meet the demand for resources in economic production activities. According to the land use to achieve the ultimate goal as the basis of index selection, a complete index evaluation system is formed. The stability of ecological economic system requires the common stability of economy and ecosystem, the overall coordination of the relationship between them, and the promotion of sustainable utilization of resources. In the process of index selection, we must consider many factors comprehensively and select each index in a hierarchical way so that the selected index can truly reflect the problems existing in the utilization structure of the excavated land.

After the selection of evaluation indexes, we need to adopt scientific methods to determine the weight of each index, which is mainly to be able to reasonably divide the components of each index in the evaluation system, so as to conduct in-depth study on the system stability. Analytic hierarchy process [15] is a common evaluation method, which is suitable for the complex regional environment. It combines the qualitative and quantitative indicators, establishes the corresponding structural model according to the actual situation, and analyzes the weight of each indicator.

Z-score standardization method is adopted to process the data, and the processing formula is as shown in:

$$Q_{ij} = \frac{q_{ij} - \overline{q_i}}{s_i} \tag{1}$$

In the formula, $q_{ij}$ represents pre-standardized processing data; $Q_{ij}$ represents standardized processed data; $\overline{q_i}$ means of representation; $s_i$ represents the data standard deviation, the calculation formula of average value and data standard deviation is:

$$\overline{q_i} = \sum_{j=1}^{m} q_j \tag{2}$$

$$s_i = \sqrt{\frac{1}{m-1}\sum_{j=1}^{m}\left(q_j - \overline{q_i}\right)^2} \tag{3}$$

In the formula, $m$ represents the total amount of data.

The coefficient of variation of calculation index is:

$$\alpha_i = \frac{s_i}{q_i} \tag{4}$$

Therefore, the index weight is:

$$\omega_i = \frac{\alpha_i}{\sum_{i=1}^{m}\alpha_i} \tag{5}$$

### 3.3. Construction of stability analysis model based on discrete selection

#### 3.3.1. Determination of discrete selection model elements

The general principle of discrete choice model is stochastic utility theory, Suppose the chooser has $J$ options, corresponding to a certain utility $X$, the utility consists of two parts: fixed and random, Fixed utility V can be explained by certain observable elements, while random part represents unobservable utility and error. If the chooser's strategy is to select the option with the highest utility, then the probability that each option is selected is expressed as its fixed utility function:

$P = F(V)$, The concrete form of function depends on the distribution of random effect . In most model settings, utility $V$ is expressed as a linear combination of explanatory factors, namely: $V = \beta x$, $\beta$ is the coefficient, its value and significance level can be estimated from the observation data. Discrete selection model elements are shown in Figure 1 [16].

Decision maker: the subject who makes the choice behavior; Alternative scheme set: there are usually multiple schemes for decision makers to choose; Scheme attribute: each consideration is called an attribute; Decision criteria: different decision makers have different behavior criteria when they make a plan selection. Different decision criteria will lead to different selection results [17].

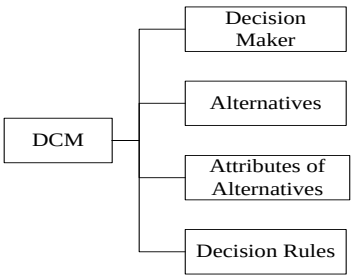


**Figure 1 Discrete selection model elements**

### 3.3.2. Stability analysis model of economic system

In this system, the elements of ecological and economic system have mutual influence and restriction, and they are not isolated. In the process of using resources, the ecological environment has also changed to some extent, and the continuous adjustment of the utilization structure has produced corresponding economic benefits, which cannot exist independently from the ecological benefits. Therefore, the eco economic system has the characteristics of integrity. For the study of its stability, we must put all the influencing factors into a complete system, and pay attention to the effect of each factor on the overall environment. The stability analysis model of ecological economic system is shown in Figure 2.

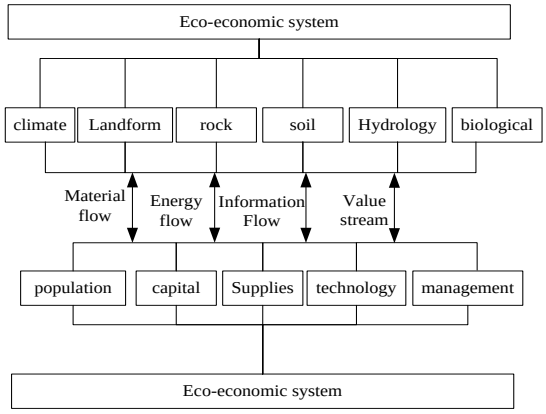


**Figure 2 Stability analysis model of eco economic system**

The discrete selection model is used to analyze the stability of the eco-economic system

Step 1: Determine the weighted normalized decision matrix $E$, namely:

$$E = \left| E_{ij} \right|_m = \left| \omega_i \times Y_{ij} \right|_m \quad (6)$$

In the formula, $Y_{ij}$ represents the index standardization decision matrix.

Step 2: Determine positive and negative ideal solutions.

The positive ideal solution is the best solution achieved by each attribute value, and the negative ideal solution is the worst solution achieved; The maximum value and the minimum value in the weighted normalized decision

matrix $E$ represent the positive ideal solution and the negative ideal solution, namely:

The positive ideal solution is:

$$E^{+}=\left[\max_{E_{ij}}\right],\left(j=1,2,L\ ,m\right) \tag{7}$$

The negative ideal solution is:

$$E^{-}=\left[\max_{E_{ij}}\right],\left(j=1,2,L\ ,m\right) \tag{8}$$

Step 3: calculate the distance from each evaluation object to positive ideal solution and negative ideal solution:

The distance from each evaluation object to the positive ideal solution is:

$$L_i^{+}=\sqrt{\sum_{i=1}^{m}\left(E_{ij}-E^{+}\right)^2} \tag{9}$$

The distance from each evaluation object to negative ideal solution is:

$$L_i^{-}=\sqrt{\sum_{i=1}^{m}\left(E_{ij}-E^{-}\right)^2} \tag{10}$$

In the formula, the smaller the distance from each evaluation object to the positive ideal solution, the closer the evaluation object is to the positive ideal solution, the more stable the ecological economic system is; the smaller the distance from each evaluation object to the negative ideal solution, the closer the evaluation object is to the negative ideal solution, the more unstable the ecological economic system is.

Step 4: Calculate closeness $\psi$. Closeness $\psi$ indicates how close each evaluation object is to the ideal solution, that is:

$$\psi_j=\frac{L_i^{-}}{\left(L_i^{+}+L_i^{-}\right)} \tag{11}$$

In the formula, the closeness degree is between 0 and 1, which can comprehensively reflect the distance index from each evaluation object to positive and negative ideal solution, and reflect the stable state of the evaluation object. Among them, Higher $\psi$ value，It shows that the closer the evaluation object is to the ideal solution, the better the stability of the ecological economic system is.

## 4. Experimental Analysis

### 4.1. Experimental environment

In order to verify the scientific validity of the proposed model, simulation experiments are carried out. The experiment is completed on MATLAB platform, windows 10 operating system is selected, its running memory is 4 GB, SPSS. 13.0 is used as the data statistical analysis software to analyze the index data.

### 4.2. Experimental parameters

The evaluation results of eco economic system are shown in Table 2.

The stability of eco-economic system changes with the change of parameters. When the harvest benefit increases to an important threshold, the system loses stability. Based on this, the analysis of the stability of the positive balance point to the net income per unit and the negative balance point to the net income per unit to the ecological economic system is shown in Figure 3 and Figure 4.

**Table 2 Evaluation results of eco economic system**

| Year | Ecosystem | | | Economic system | | | Ecological economic system | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal solution | Negative solution | Close degree | Normal solution | Negative solution | Close degree | Normal solution | Negative solution | Close degree |
| 2011 | 0.305 | 0.210 | 0.405 | 0.591 | 0.241 | 0.290 | 0.460 | 0.305 | 0.321 |
| 2012 | 0.248 | 0.245 | 0.501 | 0.505 | 0.260 | 0.320 | 0.581 | 0.320 | 0.351 |
| 2013 | 0.332 | 0.155 | 0.325 | 0.511 | 0.165 | 0.325 | 0.585 | 0.215 | 0.275 |
| 2014 | 0.298 | 0.175 | 0.358 | 0.429 | 0.280 | 0.390 | 0.485 | 0.352 | 0.401 |
| 2015 | 0.255 | 0.194 | 0.431 | 0.401 | 0.315 | 0.405 | 0.455 | 0.355 | 0.435 |
| 2016 | 0.221 | 0.320 | 0.518 | 0.412 | 0.325 | 0.454 | 0.404 | 0.380 | 0.450 |
| 2017 | 0.220 | 0.265 | 0.545 | 0.321 | 0.425 | 0.575 | 0.358 | 0.495 | 0.588 |
| 2018 | 0.158 | 0.342 | 0.691 | 0.297 | 0.520 | 0.641 | 0.691 | 0.615 | 0.676 |
| 2019 | 0.214 | 0.315 | 0.617 | 0.284 | 0.541 | 0.645 | 0.321 | 0.618 | 0.606 |

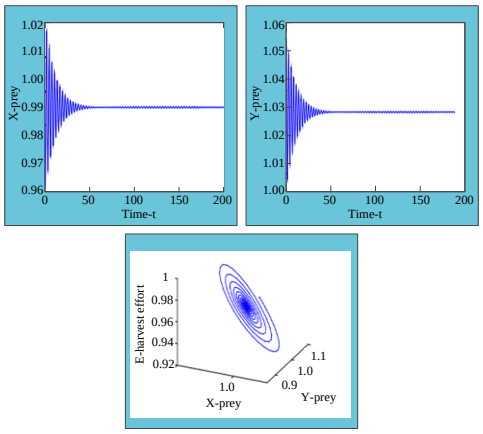


**Figure 3 positive balance point vs. net income per unit**

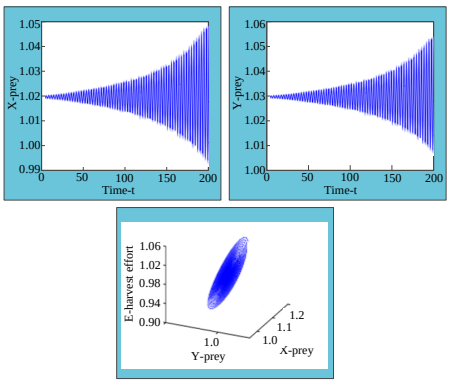


**Figure 4 negative balance point vs. net income per unit**

As can be seen in Figure 3, the positive balance point has a relatively stable impact on net income per unit, while the negative balance point in Figure 4 has an unstable impact on net income per unit.

### 4.3. Analysis of experimental results

#### 4.3.1. Analysis of the influence of different positive equilibrium points on net income per unit

In order to verify the scientific validity of the proposed model, the traditional model and the model in this paper analyze the impact of the positive balance point on the net income per unit. The experimental results are shown in Figure 5.

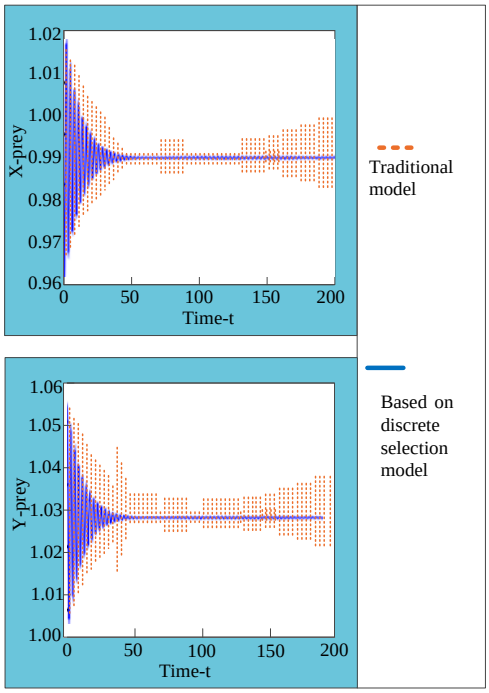


**Figure 5 Comparison of the influence of different model positive balance points on net income per unit**

Analysis of Figure 5 shows that under x-prey, with the increase of time, the positive balance point is relatively stable for each unit of net income in the early stage, and fluctuates in the later stage, and the fluctuation range is relatively large. It can be seen that the impact of the positive balance point of the traditional model on each unit of net income is relatively unstable. Using the discrete choice model under x-prey, the net income per unit of the positive equilibrium point is consistent with the actual situation and is in a stable state. Under the y-pre condition, with the increase of time, the positive equilibrium point is stable in the first 50 tons of net income per unit. Although it is more volatile than the actual situation, it is also basically stable. It is also relatively stable within 50-150 T, but it is quite different from the actual situation. The fluctuation range gradually increases from 150-200 T, which is seriously inconsistent with the actual situation. In this model, under y-prey, the positive equilibrium point is still consistent with the actual net income per unit. It is verified that under X-Pay and y-pay based on the discrete choice model, the positive balance point has a more stable impact on the net income per unit, which also shows that the model is more accurate for the stability analysis results of the ecological economic system.

#### 4.3.2. Analysis of the influence of different negative equilibrium points on net income per unit

Under the negative equilibrium point, the two models are compared and analyzed for the stability analysis results of the ecological economic system, and the experimental results are shown in Figure 6.

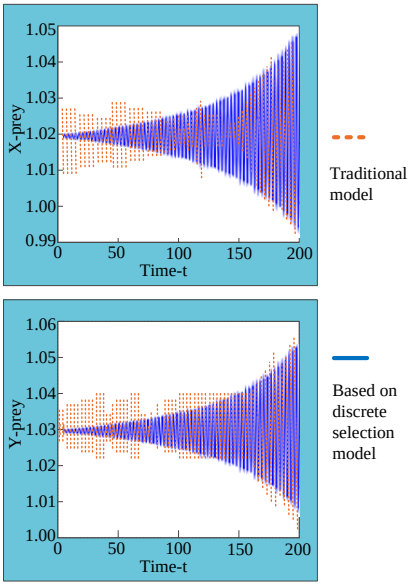


**Figure 6 Comparison of the influence of negative balance points of different models on net income per unit**

According to the analysis of Figure 6, under the conditions of X-Pay and y-pay, the negative balance point of traditional methods has an unstable impact on net income per unit, and there is a large fluctuation. Based on the discrete choice model, the negative equilibrium point is stable for each unit of net income.

It is verified that the negative equilibrium point is stable for each unit of net income under X-Pay and y-pay.

**4.3.3. Time consuming analysis of different models**

In order to further verify the feasibility of the proposed model, the experiment analyzes the time-consuming of this model and the traditional model in the stability analysis of the eco-economic system, and analyzes the influencing factors in the eco-economic system. Among them, the shortest time is used to prove that the effect of this model is better. The experimental comparison results are shown in Table 3:

**Table 3 Comparison of analysis time of different models (min)**

| Number of indicators | The model of this paper | Traditional model |
|---|---|---|
| 5 | 1.2 | 3.3 |
| 10 | 1.5 | 3.6 |
| 15 | 1.4 | 4.2 |
| 20 | 1.4 | 5.6 |

According to the data in Table 2, when the number of indicators in the analyzed eco economic system is 5. In this paper, the model time is 1.2 minutes, the traditional model time is 3.3 minutes, when the number of indicators in the analysis of the ecological economic system is 20. The time of this model is 1.4 min, and that of the traditional model is 5.6 min; through comparison, it can be seen that the time of this model analysis is the shortest, and the shortest is 1.2 min, while that of the traditional model is 3.3 min, which is about 2.1 min higher than that of the traditional model. The feasibility of the proposed model is verified.

**5. Conclusions**

In this paper, the stability analysis model of eco-economic system based on discrete selection is proposed, and the discrete selection model is introduced to analyze the four subsystems of eco-economic system and determine the influencing factors. Based on the basic concept of discrete selection model and the theoretical background of utility maximization, the general expression form of discrete selection model is derived, and it is pointed out that different discrete selection models are obtained by setting different density

functions of random error terms. At present, in the case of rapid development of eco-economic system and lack of statistical data, this method can be used to measure the stability of eco-economic system, and then targeted product development and differential marketing.

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