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A Dynamic Comprehensive Evaluation Model Based on the Niche Theory

Weiwei Liu

School of Economics and Management, Harbin Engineering University, Harbin 150001 P. R. China

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Abstract: The paper conducts a research on dynamic comprehensive evaluation model from a view of syncretizing the state and the trend of evaluated objects based on the niche theory. The approach adopted in the paper is a quantitative technique based on use of mathematical modeling; the state evaluation is used for describing development state of evaluated objects from a view of integral, while the trend evaluation is used for describing development trend from a view of considering change speed of evaluated objects. On this basis, a dynamic comprehensive evaluation model is constructed, in which the state and the trend of evaluated objects are syncretized. Finally, a calculation example is pulled into to illustrate the feasibility and availability of dynamic comprehensive evaluation model from the empirical perspective.

Keywords: Dynamic comprehensive evaluation, the niche theory, the state, the trend

1. Introduction

For comprehensive evaluation, not only it is necessary to consider the state of evaluated objects, but also regard the trend of evaluated objects. At present, there are intensive studies on evaluation method, however, studies on evaluation is more static evaluation [1–6], about dynamic evaluation are few. The development of objects is a continuous process with dynamic development and incessant improvement. The gaps of different objects gradually form, develop and expand with time changing, while some laps reduce and even disappear with time changing. Therefore, it's necessary to make a dynamic comprehensive evaluation for evaluated objects considering the state and the trend. The niche theory is a great research achievement of ecological development. This study proposes a dynamic comprehensive evaluation model that integrates the state and the trend of evaluated objects based on the niche ecostate-ecorole theory. Through dynamic comprehensive evaluation, we can analyze overall development situation of evaluated objects in continuous multi periods and recognize dynamic development status of evaluated objects. This method provides a valuable reference for managers to correctly identify and evaluate the overall development trend of evaluated objects and take some steps to manage and control accordingly.

2. The Basic Principles of the Niche Theory

The niche ecostate-ecorole theory is one of the ecological theories which not only is widely used in natural ecosystems, but also has important meaning for the social and economic ecosystem .The niche ecostate-ecorole theory thinks that, any biological unit has the property of two aspects, namely "ecostate" and "ecorole". The "ecostate" of the biological unit is the accumulated result of growth and development, learning, socio-economical development and the interacting with surrounding environment in the past. The "ecorole" is the current effect on the environments, such as the rate of energy and matter exchange, productivity, growth rate, economic development rate and expanding rate for new space etc[7, 8]. The niche is a description of the relative position and role formed by an organism unit in a particular ecosystem and environmental interaction, and also a synthesis of the "ecostate" and the "ecorole"[9]. Here, the "ecostate" indicates the state of evaluated objects, while the "ecorole" indicates the trend of evaluated objects. So, when making comprehensive evaluation for objects, the state and the trend of evaluated objects should be regarded synthetically.

* Corresponding author e-mail: heulww@163.com

3. Dynamic Comprehensive Evaluation Model

There are some achievements on dynamic evaluation[10–16] which concentrate upon multi-period information integration. Objects are changing and developing, therefore, dynamic comprehensive evaluation result of evaluated objects can be synthetically reflected when the development state and the development trend of evaluated objects are both considered. This paper puts forward a dynamic comprehensive evaluation model that integrates the state and the trend of evaluated objects in order to obtain multi-period information integration evaluation results of evaluated objects.

3.1. The State Evaluation

In a certain interval, it is supposed that the object U_i $(i = 1,2,\ldots,m)$ change equably in this interval, multi-period information aggregation model of objects state is shown in Figure 1.

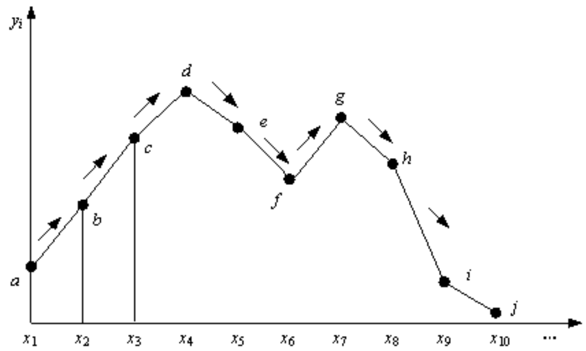

Figure 1 Multi-period information aggregation model of objects stat

Connect the state values y_{ij} with $y_{i,j+1}$ which locate in two adjacent time intervals $([T_j,T_{j+1}], j = 1,2,,n-1)$ on X axis, then the connecting lines between y_{ij} and $y_{i,j+1}$ denote sport tracks of objects state[17,18]. The area which is surrounded by $x_j y_{ij} y_{i,j+1} x_{j+1}$ and X axis reflects overall situation of objects state in $[T_j,T_{j+1}]$. The state of evaluated objects can be denoted as a form of integral of $s_i(x_j,x_{j+1})$.

$$s_i(x_j,x_{j+1}) = \int_{x_j}^{x_{j+1}} [y_{ij} + (x-x_j)(y_{i,j+1} - y_{ij})/(x_{j+1} - x_j)\, dx \quad (1)$$

The integral area of objects state of U_i equals to trapezoid area, namely

$$s_i(x_j,x_{j+1}) = \left(y_{i,j+1} + y_{ij}\right)\left(x_{j+1} - x_j\right)/2 \quad (2)$$

3.2. The Trend Evaluation

Suppose that v_{ij} denotes change speed of U_i in $[T_j,T_{j+1}]$, $v_{ij} = (y_{i,j+1} - y_{ij})/(x_{j+1} - x_j)$, β is the function about v_{ij}, according to the need of objects development trend, the function of β is constructed as follows.

$$\beta(v_{ij}) = \frac{\phi}{1+e^{v_{ij}}} \quad (3)$$

Set when $v_{ij} = 0$, $\beta(v_{ij}) = 1$, it denotes that there is no trend stimulation for the phase without the change of the state value, so we can obtain $\lambda = 2$.

When $v_{ij} = 0$, $\beta(v_{ij}) = \frac{2}{1+e^{v_{ij}}} = 1$, nothing will be done to the state of evaluated objects with a even trend when the state value is multiplied by the coefficient 1;

When $v_{ij} > 0$, $\beta(v_{ij}) = \frac{2}{1+e^{v_{ij}}} > 1$, reward will be given to the state of evaluated objects with a ascending trend when the state value is multiplied by the coefficient that is more than 1;

When $v_{ij} < 0$, $\beta(v_{ij}) = \frac{2}{1+e^{v_{ij}}} < 1$, punishment will be given to the state of evaluated objects with a descending trend when the state value is multiplied by the coefficient that is less than 1.

3.3. Dynamic Comprehensive Evaluation

According to Newton's Second Law of classical mechanics:

$$\sum F = kma \quad (4)$$

F denotes force, m denotes quality, k denotes coefficient and a denotes acceleration.

The dynamic comprehensive evaluation result of evaluated objects can be expressed as follows:

$$Y_j = k_j \cdot s_i(x_j,x_{j+1}) \cdot \beta(v_{ij}) \quad (j = 1,2,\ldots,n-1) \quad (5)$$

$s_i(x_j,x_{j+1})$ represents the "quality" of evaluated objects, namely the state of evaluated objects; $\beta(v_{ij})$ represents the speed of evaluated objects, namely the trend of evaluated objects; k_j represents coefficient, its set that $k_j = 1$.

Dynamic comprehensive evaluation value of U_i in $[T_j,T_{j+1}]$ is obtained as follows:

$$Y_j = s_i^o(x_j,x_{j+1}) = \beta(v_{ij}) \cdot \int_{x_j}^{x_{j+1}} [y_{ij} + (x-x_j) \cdot (y_{i,j+1} - y_{ij})/(x_{j+1} - x_j)]\, dx \quad (6)$$

The total dynamic comprehensive evaluation value of U_i in $[T_j,T_{j+1}]$ can be obtained as follows:

$$s_i^{\pm o} = \sum_{j=1}^{n-1} s_i^{\pm *}(x_j,x_{j+1}) \quad (7)$$

4. Method Application

This paper takes 5 enterprises as calculation study to make a dynamic evaluation of technical innovation capability in 2006-2011. Improved normalization method is adopted to standardize raw data, the subjective and objective weight method that combines AHP and entropy method is used to determine weight. The evaluation results of technical innovation capability of 5 enterprises in 2006-2011, as shown in Table 1.

Table 1 The evaluation results of technical innovation capability

Time / Enterprise	T_1	T_2	T_3	T_4	T_5	T_6
A	0.641	0.643	0.648	0.654	0.658	0.665
B	0.632	0.641	0.663	0.672	0.683	0.696
C	0.523	0.549	0.558	0.566	0.572	0.581
D	0.554	0.552	0.551	0.561	0.555	0.552
E	0.796	0.777	0.785	0.779	0.776	0.779

(1) Technical innovation capability state evaluation of 5 enterprises. According to the formula (2), $s_i(x_j, x_{j+1})$ in $[T_j, T_{j+1}]$ $(j = 1, 2, ...5)$ of 5 enterprises, as shown in Table 2.

Table 2 Technical innovation capability state evaluation results

Time / Enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$
A	0.6420	0.6455	0.6510	0.6560	0.6615
B	0.6365	0.6520	0.6675	0.6775	0.6895
C	0.5360	0.5535	0.5620	0.5690	0.5765
D	0.5530	0.5515	0.5560	0.5580	0.5535
E	0.7865	0.7810	0.7820	0.7775	0.7775

(2) Technical innovation capability trend evaluation of 5 enterprises. According to the formula (3), $\beta(v_{ij})$ in $[T_j, T_{j+1}]$ $(j = 1, 2, ...5)$ of 5 enterprises, as shown in Table 3.

Table 3 Technical innovation capability trend evaluation results

Time / Enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$
A	1.0010	1.0025	1.0030	1.0020	1.0035
B	1.0045	1.0110	1.0045	1.0055	1.0065
C	1.0130	1.0045	1.0040	1.0030	1.0045
D	0.9990	0.9995	1.0050	0.9970	0.9985
E	0.9905	1.0040	0.9970	0.9985	1.0015

(3) Dynamic comprehensive evaluation of technical innovation capability of 5 enterprises. According to the formula (6) and (7), dynamic comprehensive evaluation results of technical innovation capability of 5 enterprises, as shown in Table 4.

Table 4 Dynamic comprehensive evaluation results of technical innovation capability

Time / Enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$	$[T_1, T_6]$
A	0.643	0.647	0.653	0.657	0.664	3.264
B	0.639	0.659	0.671	0.681	0.694	3.344
C	0.543	0.556	0.564	0.571	0.579	2.813
D	0.552	0.551	0.559	0.556	0.553	2.771
E	0.779	0.784	0.780	0.776	0.779	3.898

5. Evaluation results analysis

(1) In 2006-2011, the order of dynamic comprehensive evaluation of 5 enterprises is: $E > B > A > C > D$. The result considers both technical innovation capability state and technical innovation capability trend in each period.

(2) In 2006, the order of technical innovation capability of 5 enterprises is: $E > A > B > D > C$, in 2011, the order is: $E > B > A > C > D$, the order between Enterprise A and Enterprise B has changed, and the order between Enterprise C and Enterprise D has changed. It can be found that the technical innovation capability trend of Enterprise A and Enterprise B are all ascending, however, the increase speed of Enterprise B is faster than Enterprise A, therefore, dynamic comprehensive evaluation value of technical innovation capability of Enterprise B is higher than Enterprise A. It can be found that most of technical innovation capability trends of Enterprise C are ascending; most of technical innovation capability trends of Enterprise D are descending, therefore, dynamic comprehensive evaluation value of technical innovation capability of Enterprise C is higher than Enterprise D.

(3) From dynamic comprehensive evaluation results of technical innovation capability of 5 enterprises, it can be seen that the state and the trend of technical innovation capability are equally important for an enterprise.

6. Conclusion

This paper makes a dynamic comprehensive evaluation study from the perspective of the niche ecostate-ecorole theory, introduces the state evaluation model and the trend evaluation model, on this basis, a dynamic comprehensive evaluation model that synthesizes the state and the trend is proposed. The method can observe comprehensive development situation of evaluated objects, accordingly analyze and master dynamic development trend of evaluated objects. Finally, this paper takes 5 enterprises as calculation example in order to illustrate the feasibility and availability of dynamic comprehensive evaluation model from the empirical perspective. In further dynamic comprehensive evaluation study, the state and the trend of change speed of evaluated objects can be integrated in order to make a dynamic comprehensive evaluation of change speed for evaluated objects and further analyze how fast evaluated objects change.

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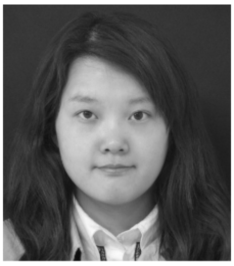

Weiwei Liu received the MS degree in Education Economics and Management from Harbin Institute of Technology in 2007, and the PhD degree in Enterprise Management from the department of Business Administration, Harbin Institute of Technology in 2011. She is currently a lecturer in Harbin Engineering University. Her research interests are in the areas of dynamic evaluation method, cost engineering, and knowledge innovation.