

# Method and Empirical Research of the Relieve Non-Capital Functions based on Distance Collaborative Model

Dianru Ai

Beijing University of Posts and Telecommunications, Beijing 100083, China

1020267747@qq.com

**Abstract.** This paper focuses on the scientific evaluation of the degree of coordinated development of non capital function undertaking areas. We chose Caofeidian District as the research object under the background of non capital function relief. By improving the distance collaboration model, an evaluation method of Caofeidian is obtained. The collaboration within and among the subsystems of society, resources, economy and undertaking-non-capital-functions of the research object is also analyzed during 2017-2021. The empirical research results show that the development degree and comprehensive development degree of each subsystem in Caofeidian are obviously on the rise in general. The comprehensive development of Caofeidian has been greatly improved by undertaking the non capital functions of Beijing, especially the industrial transfer.

**Keywords:** Non-Capital Function; Distance Collaboration Model; Comprehensive Development; Caofeidian District.

## 1. Introduction

Previously, studies on the deconstruction of non-capital functions generally focused on a single aspect, such as infrastructure, industrial structure, public services, etc., and then made suggestions from the perspective of the government [1], which are usually one-sided and lack of persuasion. It is found that the evaluation method of regional coordinated development based on the grey correlation theory and distance coordination model [2, 3] can be used to scientifically evaluate the degree of undertaking non capital functions. This method modifies the distance collaboration model based on the gray correlation theory, and utilizes the ray correlation degree among subsystems to determine the pull factor among subsystems, and then obtain the ideal development degree and collaboration degree.

In this paper, Caofeidian is divided into four subsystems, namely, society, resources, economy, and UNCF (undertaking non capital functions) from the perspective of structure and function, to build an indicator system for evaluating the synergy of the composite system. Each subsystem provides guarantee for the development of other subsystems, and is also affected by other subsystems, so the relationship between which can accurately and completely reflect the development of Caofeidian. Based on the analysis of the development degree and synergy degree of each subsystem by using the optimized grey correlation model [4], the factors that affect the development degree of each subsystem and the improvement of the synergy degree of the composite system are found out. Finally, the countermeasures and suggestions to improve the synergy degree of the composite system are given.

## 2. Method Introduction & Index System Construction

### 2.1 Construction of Evaluation Model

In this paper, the distance synergy model improved by the grey relational theory is used for evaluation, and the synergy development degree is obtained by measuring the differences between the status quo and the ideal state of Caofeidian. We select four subsystems, namely society, resources, economy, and UNCF. The input is the value of each index of each subsystem over the years, and the output is the pull factor between each subsystem, the development degree and synergy degree of each

subsystem as well as the overall development degree, and the comprehensive collaborative development degree. The detailed calculation process is as follows.

(1) Normalization of evaluation indicators

The indicators selected in this paper are all positive indicators. The maximum value of each indicator over the years is taken as the normalization standard. The normalization conversion formula is as follows:

$$a_{ijt} = (x_{ijt} - \min_t x_{ijt}) / (\max_t x_{ijt} - \min_t x_{ijt}) \tag{1}$$

where  $x_{ijt}$  represents the j-th index of subsystem i in period t,  $a_{ijt}$  represents the normalized index.

(2) Determine the positive ideal point of each subsystem

The normalized value of each indicator is the result of comparison with the maximum value. The maximum value 1 is the positive ideal point, and the lower limit 0 is the negative ideal point.

(3) Calculate the distance between each subsystem and its positive ideal point, and then calculate the development degree

The distance between subsystem i and its positive or negative ideal points in period t is  $D_{it}^+$  and  $D_{it}^-$ , and the calculation formula is as follows:

$$D_{it}^+ = \sqrt{\sum_j (1 - a_{ijt})^2}, D_{it}^- = \sqrt{\sum_j a_{ijt}^2} \tag{2}$$

where  $a_{ij}^+$  and  $a_{ij}^-$  represent the j-th value of vector  $A^+$  and vector  $A^-$ , respectively. For each subsystem, its development degree is:

$$d_{it} = \frac{D_{it}^-}{D_{it}^- + D_{it}^+} \tag{3}$$

where  $0 < d_{it} < 1$ . The closer  $d_{it}$  is to 0, the lower the degree of development. For the whole system, the comprehensive development degree is:

$$d_t = \sum_i \omega_i d_{it} \tag{4}$$

here  $\omega_i$  represents the weight of the i-th subsystem, which is obtained by the analytic hierarchy process in this paper.

(4) Calculate the grey comprehensive correlation degree of each subsystem and determine the pull factor

Firstly, calculate the absolute correlation degree: set the initial row sequence  $X_i = (d_{i1}, d_{i2}, \dots, d_{it})$  and its normalized value is  $X_i^0 = (d_{i1} - d_{i1}, d_{i2} - d_{i1}, \dots, d_{it} - d_{i1}) = (d_{i1}^0, d_{i2}^0, \dots, d_{it}^0)$ . Set

$|s_i| = \left| \sum_{k=2}^t d_{ik}^0 - \frac{1}{2} d_{it}^0 \right|$  and  $|s_i - s_j| = \left| \sum_{k=2}^t (d_{ik}^0 - d_{jk}^0) - \frac{1}{2} (d_{it}^0 - d_{jt}^0) \right|$ . Then the absolute correlation between subsystems i and j is

$$\mu_{ij} = \frac{1 + |s_i| + |s_j|}{1 + |s_i| + |s_j| + |s_i - s_j|} \tag{5}$$

Then calculate the relative correlation degree and replace the initial sequence in the absolute correlation degree with  $X'_i = (\frac{d_{i1}}{d_{i1}}, \frac{d_{i2}}{d_{i1}}, \dots, \frac{d_{it}}{d_{i1}})$  to obtain the relative correlation degree between subsystems i and j. Finally, the comprehensive correlation degree  $\alpha_{ij} = \theta \mu_{ij} + (1 - \theta) \nu_{ij}$  is calculated, and the grey comprehensive correlation degree comprehensively represents the correlation degree among subsystems. As usual,  $\theta = 0.5$  is taken in this paper, which means equal attention is paid to the absolute quantity and change rate between subsystems.

(5) Calculate the ideal development degree  $d'_{it}$  and the synergy degree  $C_t$  of each subsystem

$$d'_{it} = \sum_{j=1}^k \omega_j \beta_{ij} d_{jt} \tag{6}$$

Where  $d'_{it}$  represents the development degree value when the i-th subsystem reaches the ideal state, and k represents the number of subsystems. Then calculate the collaboration degree of each subsystem:  $C_{it} = \frac{|d_{it}|}{|d_{it}| + |d_{it} - d'_{it}|}$ . Finally, calculate the collaboration degree of the whole system:

$$C_t = \sqrt[k]{\prod_i C_{it}}$$

(6) Calculate the comprehensive collaborative development degree of the whole system:

$$CD_t = \sqrt{C_t d_t} \tag{7}$$

### 2.2 Construction of Evaluating Indicator

A city is a social system with complex structure and diverse functions. Industry, market, environment, service and other functional structures interact and develop with each other to jointly promote the coordinated development of cities. In terms of structure and function, the indicator system of Caofeidian District's comprehensive development system is divided into four major parts: the social subsystem that reflects the level of social development, the resource subsystem that reflects the level of resource security, the economic subsystem that reflects the level of economic development, and the UNCF subsystem that undertakes the level of non-capital function relief in Beijing. These four subsystems interact and influence each other as inputs and outputs.

Based on the principles of systematicness, practicality, data availability, and combining the actual situation of Caofeidian, the following comprehensive development composite system evaluation index system of Caofeidian is constructed, as shown in Table 1.

**Table 1.** Evaluation index system of complex system in Caofeidian

First level	Second level	Third level
social subsystem	demographic indicator	urbanization rate of population
	quality of life	disposable income of residents
resource subsystem	public service facilities	general public budget expenditure
economic subsystem	ecological conditions	artificial afforestation area
	resource conditions	cargo throughput
UNCF subsystem	Consumption level	total retail sales of consumer goods
	trade level	total imports and exports
UNCF subsystem	economic structure	proportion of tertiary industry in GDP
	economic aggregate	GDP per capita
	production structure	investment in industrial upgrading
	production level	output value of emerging industries
UNCF subsystem	total investment	industrial transfer investment
	financial support capacity	bank deposit to loan ratio

### 3. Analysis of Data Results

The data of Caofeidian District from 2016 to 2021 were processed according to the above steps. The index values reflecting the collaborative development of Caofeidian over the years were obtained, including the pull factors among subsystems, the development degree and synergy degree of each subsystem and the whole, and the regional collaborative development degree. The results are shown in Table 2 and Table 3 and the name of each subsystem here is abbreviated

**Table 2.** Pull factor among subsystems

pull factor	social	resource	economic	UNCF
social	1.0000	0.6350	0.6932	1.3541
resource	1.5748	1.0000	1.7672	1.7316
economic	1.4425	0.5659	1.0000	1.1324
UNCF	0.7385	0.5775	0.8831	1.0000

**Table 3.** Development and synergy degree of each subsystem and the whole system

year	Development degree					Synergy degree					Synergy development degree
	social	resource	economic	UNCF	Caofeidian	social	resource	economic	UNCF	Caofeidian	
2017	0.303	0.500	0.110	0.144	0.168	0.709	0.685	0.602	0.987	.733	0.351
2018	0.355	0.242	0.216	0.293	0.275	0.887	0.521	0.703	0.881	.732	0.448
2019	0.457	0.329	0.586	0.558	0.544	0.765	0.354	0.977	0.914	.701	0.618
2020	0.544	0.658	0.669	0.676	0.659	0.752	0.589	0.927	0.909	.782	0.718
2021	0.777	0.750	0.892	0.531	0.670	0.894	0.663	0.847	0.880	.815	0.739

The pulling factors of UNCF system relative to the social, resource and economic subsystems are 1.3541, 1.7316 and 1.1324 respectively, which indicates that undertaking the non-capital function of Beijing has a significant pulling effect on other subsystems for Caofeidian.

From 2017 to 2021, the synergy degree and comprehensive coordination degree of all subsystems in Caofeidian District were relatively stable on the whole, but there was an obvious decline in 2020, mainly because the undertaking of industrial transfer significantly promoted the development of UNCF subsystem, while other subsystems did not keep up with the development speed of itself. Therefore, Caofeidian should pay attention to promoting the development of supporting systems such as society, environment and resources while striving to undertake the non-capital function relief, so as to improve the degree of comprehensive and coordinated development and realize the sustainable development of modernization.

#### 4. Summary

This paper combines TOPSIS thought and grey relational theory to improve the distance collaboration model, and constructs a new evaluation method for the degree of undertaking non capital functions. Taking Caofeidian District as an example, this paper conducts an empirical study to verify the practicability of the new method. The empirical results show that the synergy evaluation method based on the grey correlation theory and distance synergy model constructed in this paper can carry out the objective effective price for the actual situation, which is correct and operable. The regional system is complex and changeable, and its ideal planning value changes with the change of the regional development stage. How to find a scientific and universal method to determine the ideal planning value needs further research.

#### References

- [1] ZH H Y. A Study on the Functional Dissolution of Non-Capital Education. *Research on Innovative Education*, 2018, 6(2), 55-60.
- [2] LI G R, MA M N, et al. Analysis of evaluation and comparison about the regional economic development in China [J]. *Comprehensive Evaluation of Economy and Society with Statistical Science*, 2010, 16(9): 316-320.
- [3] VAN BEERS D, BISWAS W K. A regional synergy approach to energy recovery: the case of the kwinana industrial area, western Australia [J]. *Energy Conversion and Management*, 2008, 49(11): 3051-3062.
- [4] Li Haidong, Wang Shuai, Liu Yang. Evaluation method and demonstration of regional collaborative development Based on Grey Relational Theory and Distance collaborative model [J]. *Systems Engineering Theory & Practice*, 2014(7):1749-1755.