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Based on the Analysis and Prediction of the Current Situation of Higher Education in the Yangtze River Delta Region

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Abstract: The number of high-quality higher education resources and educational resources in the Yangtze River Delta region is at the leading level in the country, and changes in its education level often affect the development of education in the whole country, which makes it particularly important to study higher education in the Yangtze River Delta region. Therefore, this paper summarizes the development status of higher education in the Yangtze River Delta region through the university resources, first-class construction universities, the proportion of university strength, and the proportion of higher education capacity of four provinces and cities. The factors influencing the development of higher education are studied through the factor significance of the Logit model, the collected data are processed by U and ε, and the factors affecting the development of higher education are obtained through the significance analysis of Logit. At the same time, in order to effectively observe the development level and trend of higher education in the Yangtze River Delta, this paper establishes a comprehensive evaluation model of combined weights based on grey correlation analysis and entropy weight method.

1. Introduction

The scale of higher education and the number of high-quality higher education resources in the Yangtze River Delta region are among the best in China. At the same time, the Yangtze River Delta is also a region with strong economic strength, with about 1/6 of the country's population contributing about 1/4 of the country's GDP. In terms of higher education, among the four major university education clusters of Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong-Hong Kong-Macao, Sichuan-Chongqing and Shaanxi, the Yangtze River Delta region has the largest number and concentration of high-quality higher education resources. In terms of university quality: there are 35 “double first-class” universities and 41 “double-high plan” universities in the Yangtze River Delta region, accounting for 25.55% and 20.81% of the national total, respectively. According to the Times Higher Education World University Rankings 2021, six universities in the Yangtze River Delta region, University of Science and Technology of China, Zhejiang University, Nanjing

University, Fudan University, Shanghai Jiao Tong University and Tongji University have entered the world's top 500, accounting for 35.29% of the world's top 500 universities and ranking 35.29% of the world's top 500. However, when filling in the volunteer application, it is found that there is an imbalance in the development of higher education in the Yangtze River Delta region, so it is necessary to conduct quantitative analysis, focusing on analyzing the development status of higher education in the Yangtze River Delta region, studying the relationship between influencing factors and the development of higher education, and predicting the development of higher education in the Yangtze River Delta region in the next five years or more.

2. Development Status of Higher Education in the Yangtze River Delta Region

The level of higher education in the Yangtze River Delta region has always been the leader in the development of China's higher education, and its current higher education development status is obtained by studying its university resources, first-class construction universities, the proportion of university strength, and the higher education capacity of four provinces and cities.

The distribution of the number of universities in China's four major education regions is shown in Figure 1, the number of first-class universities in the Yangtze River Delta region is shown in Figure 2, the national proportion of universities in the Yangtze River Delta region is shown in Figure 4, the strength of universities in four provinces and cities in the Yangtze River Delta region is shown in Figure 4, and the university resources of four provinces and cities in the Yangtze River Delta region are shown in Figure 5.

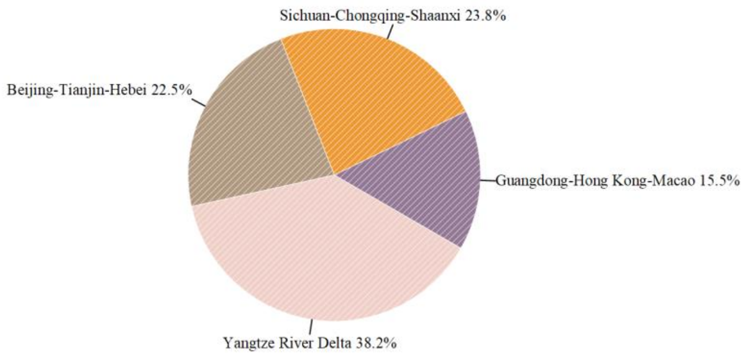

Figure 1: Number of Universities in the Four Major Education Districts

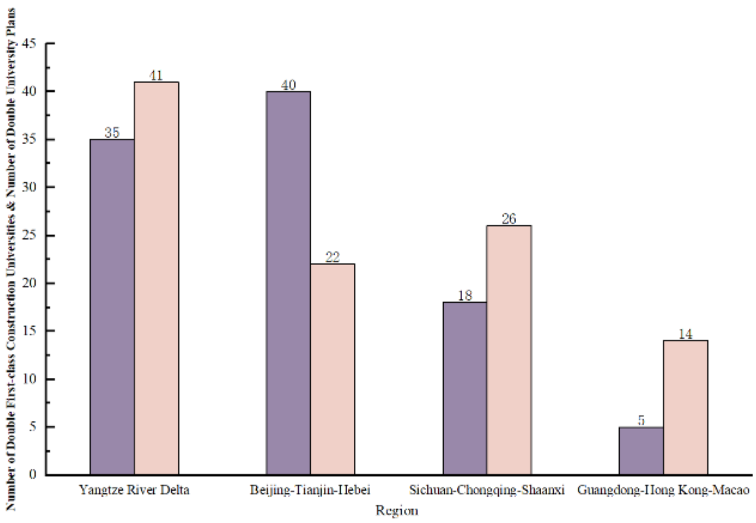

Figure 2: Number of First-Class Universities in the Four Major Education Regions

As can be seen from Figure 1, the number of universities in the Yangtze River Delta region is 459, accounting for 38.18% of the four major education areas, 186 in Guangdong, Hong Kong and Macao, accounting for 15.47%, 286 in Sichuan, Shaanxi and Yu, accounting for 23.79%, and 271 in the Beijing-Tianjin-Hebei region, accounting for 22.55%. Figure 2 shows that the number of double-first-class construction universities in the Yangtze River Delta region is 35, the double-high plan is 41, and the number of double-first-class construction universities in the Beijing-Tianjin-Hebei region is 40, and the double-high plan is 22. The number of double-first-class construction universities in Sichuan, Shaanxi and Yu is 18, and the number of double-high universities is 26. The number of double-first-class universities in Guangdong, Hong Kong and Macao is 5, and the number of double-high universities is 14. In summary, except for the number of double-first-class universities in the Yangtze River Delta region that is slightly lower than that in the Beijing-Tianjin-Hebei region, the number of other indicators is much higher than that of other regions.

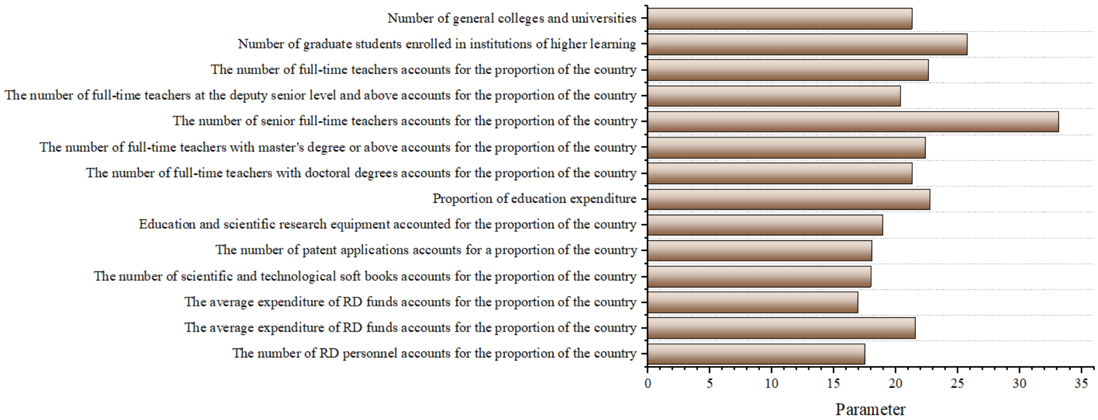

Figure 3: The Proportion of University Strength in the Yangtze River Delta Region

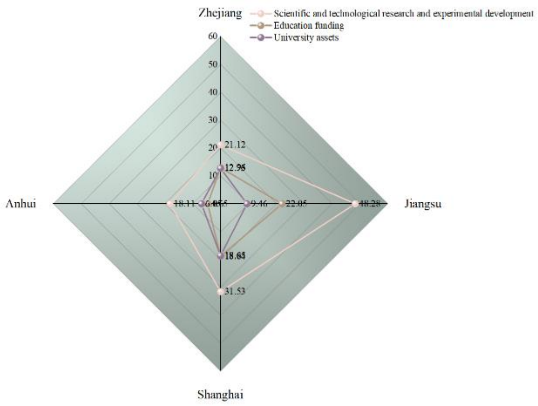

Figure 4: The Strength of Universities in Four Provinces and Cities

As can be seen from Figure 3, the number of ordinary colleges and universities in the Yangtze River Delta region accounts for 17.49% of the country, the number of graduate students in colleges and universities accounts for 21.57%, the number of full-time teachers accounts for 16.95, the number of full-time teachers of associate senior and above accounts for 17.97%, the number of full-time teachers of senior level accounts for 18.02% of the country, the number of full-time teachers with master's degree or above accounts for 18.91% of the country, and the number of full-time teachers with doctoral degrees accounts for 22.71% of the country. Education expenditure accounted for 21.30, education and scientific research equipment accounted for 22.37% of the country, the number of patent applications accounted for 33.11% of the country, the number of scientific and technological soft books accounted for 20.35% of the country, the number of scientific and technological papers accounted for 22.62% of the country, the average expenditure of RD funds accounted for 25.76 in the country, and the number of RD personnel accounted for 21.29% of the country.

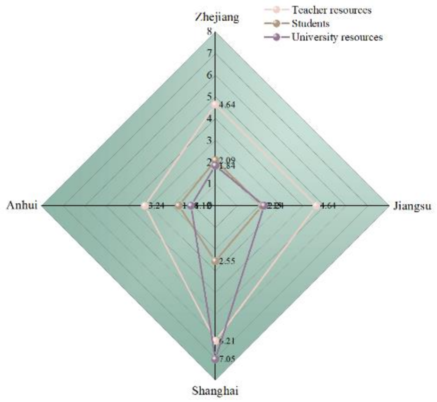

Figure 5: The Resources of Universities in Four Provinces and Cities

As can be seen from Figures 4 and 5, Jiangsu Province is higher than other provinces and cities in terms of the strength of universities, whether it is scientific research and experimental development, funding education or university assets, followed by Shanghai, Zhejiang Province and Anhui Province. In terms of teacher resources, students and university resources, Shanghai is higher than other provinces, followed by Jiangsu Province, Zhejiang Province and Anhui Province.

3. Model Building

3.1 Logit Model

In the study of what factors are related to the development of higher education in the Yangtze River Delta region, there are many influencing factors, so that the research model has a discrete type, after considering many models, finally the Logit model[0]-[0] is used to study the relationship between the influencing factors of the development of higher education, because the Logit model has the characteristics of discrete selection, and after scholar Marschark proved the consistency of the model with the maximum utility theory, the study determined the relationship between the form of the model and the distribution of non-deterministic terms of utility. It is proved that the Logit model can derive the influencing factors through saliency, so the Logit model of influencing factors of higher education in the Yangtze River Delta based on this problem is very applicable, and the specific modeling process is shown below.

In the Logit model, the random effect of the decision impact coefficient on educational development is first determined, and the determination formula is as follows:

$$U_{int} = \beta_i X_{int} + \varepsilon_{int} \tag{1}$$

In the formula: U_{int} is the utility function; β_i are the parameters to be estimated; X_{int} is the relevant attribute of the influencing factor; ε_{int} is a random term of the utility function, where ε_{int} obeys the Gengbel distribution. In order to better consider the differences between different factors, and these differences will lead to deviations between the estimated results of the parameters and the actual situation, in order to reduce this difference, the immediate influence distribution of my important variables is added, the β_i factors are assumed in the model, the influencing factors obey a certain distribution, and the difference parameters are introduced into the model, the formula is as follows:

$$f(\beta_i) = \frac{1}{\sqrt{2\Pi}\sigma_i} \exp\left[-\frac{(\beta_i - \overline{\beta_i})^2}{2\sigma_i^2}\right] \tag{2}$$

Where $\overline{\beta_i}$ is the mean of the β_i and the σ_i is the standard deviation of the β_i The influencing factor probabilities of each influencing factor are:

$$fP_{int} = \int \frac{\exp(\beta_i X_{int})}{\sum_i \exp(\beta_i X_{int})} f(\beta_i) d\beta_i \tag{3}$$

3.2 Combined Weighting Method

3.2.1 Grey Correlation Analysis

Grey correlation analysis is a method of multi-factor statistical analysis. Simply put, in a grey system, we want to understand the relative strength of one of the projects we care about that is affected by other factors[0]-[0].

Determine the comparison object and reference series according to the 3E system indicator system, and set the data set as matrix X, then:

$$X = \left(x_i{}^{(t)}\right)_{n\times T} = \begin{pmatrix} x_1{}^{(1)} x_1{}^{(2)} \cdots x_1{}^{(T)} \\ x_2{}^{(1)} x_2{}^{(2)} \cdots x_2{}^{(T)} \\ \vdots \quad \vdots \quad \vdots \\ x_n{}^{(1)} x_n{}^{(2)} \cdots x_n{}^{(T)} \end{pmatrix} \tag{4}$$

Select the optimal set of values for each indicator as a reference series:

$$X_0 = \min_t\{X\} = \left(x_0{}^{(1)} x_0{}^{(2)} \cdots x_0{}^{(T)}\right) \tag{5}$$

x_0 the reference series with dataset X according to the formula:

$$y_i{}^{(t)} = \frac{x_i{}^{(t)}}{x_0{}^{(t)}}, i = 0,1,2,\cdots,n \tag{6}$$

Through processing, the new data set and reference number columns are obtained:

$$Y = \left(y_i{}^{(t)}\right)_{n\times T}, I = 1,2,\cdots,n \tag{7}$$

$$y_0 = \left(x_0{}^{(t)}\right), t = 1,2,\cdots T \tag{8}$$

Calculate the grey correlation coefficient:

$$\xi_i{}^{(t)} = \frac{\min_i \min_t |y_0{}^{(t)} - y_i{}^{(t)}| + \rho \max_i \max_t |y_0{}^{(t)} - y_i{}^{(t)}|}{|y_0{}^{(t)} - y_i{}^{(t)}| + \rho \max_i \max_t |y_0{}^{(t)} - y_i{}^{(t)}|} \tag{9}$$

The above is the correlation coefficient of the data set to the reference number column on the t indicator. Thereinto, $\min_i \min_i \left|y_0^{(t)} - y_0^{(t)}\right|$, $\max_i \max_i \left|y_0^{(t)} - y_0^{(t)}\right|$ is the minimum difference of the two levels and the maximum difference of the two levels, $0 \leqslant \rho \leqslant 1$ is the sub-standard coefficient, and 0.5 is taken in this article ρ.

Calculate the weights of each index $W^{(1)} = (\omega_1{}^{(1)}, \omega_2{}^{(1)}, \ldots, \omega_n{}^{(1)})$, where:

$$\omega_i^{(1)} \frac{\xi_i^{(t)}}{\sum_{t=1}^{T} \xi_i^{(t)}}, i = 1,2,\cdots,n \tag{10}$$

3.2.2 Entropy Rights Act

Select n systems and m indicators, then it is the value of the ith x_{ij} system of the jth indicator, where, $i = 1,\ 2,\cdots,n, j = 1, 2,\cdots,m$.

Calculate the share of the ith system under indicator j:

$$p_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}, i = 1,2,\cdots,n, j = 1,2,\cdots,m \tag{11}$$

Calculate the entropy of indicator j:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{12}$$

Among them, $k > 0, k = \frac{1}{\ln(n)}, e_j \geq 0, k > 0, k = \frac{1}{\ln(n)}, e_j \geq 0$.

Calculate the coefficient of difference for indicator j:

$$g_j = \frac{1 - e_j}{m - E_e} \tag{13}$$

$$E_e = \sum_{j=1}^{m} e_j, 0 \leq g_i \leq 1, \sum_{j=1}^{m} g_j = 1 \tag{14}$$

Solve for entropy weights:

$$\omega_j^{(2)} = \frac{g_j}{\sum_{j=1}^{m} g_j}, j = 1,2,\cdots,m \tag{15}$$

The weights are $W^{(2)} = (\omega_1^{(2)}, \omega_2^{(2)}, \ldots, \omega_n^{(2)})$, where:

$$\omega_i^{(2)} = \theta\omega_i^{*} + (1 - \theta)\omega_i^{*}, i = 1,2,\cdots,n \tag{16}$$

where θ represents the degree of emphasis of the positive ideal solution.

3.2.3 Combined Weight Method

The combined weights based on grey correlation analysis and entropy weight method are[0-0]:

$$W = \alpha W^{(1)} + \beta W^{(2)} \tag{17}$$

Among them, the α and β are the importance coefficients of the weights, and $\alpha + \beta = 1$, the calculated $\alpha = 0.4815, \beta = 0.5185$. According to the weight given in Equation (17), the comprehensive development level of higher education is quantified according to Equation (18).

$$F = \sum_{j=1}^{N} \omega_j x \tag{18}$$

where x_i and N are the index values and the number of indicators of the higher education system, respectively, and w_j are the jth component of W in equation (18).

4. Example Verification

4.1 Logit Model Solution Results

Through the above formula, the influencing factor parameters in the model are solved by maximum likelihood estimation. Table 1 shows the parameters brought into the model after solving.

Table 1: Logit Model Data Processing

Tier 1 indicators	Explanatory variables	β coefficient	U coefficient
Government support	Financial support	0.42	0.49
	Policy help	0.62	0.49
School situation	Scientific research equipment	0.41	0.53
	Teacher resources	0.52	0.51
	Research policy	0.56	0.53
	Lesson plan	0.47	0.48
Other factors	Social help	0.36	0.67
	Student Origin	0.70	0.71

The correlation of the influence of each influencing factor is determined by the final utility function, and its calculation formula is shown below.

$$V_{ev} = \beta_0 + \beta_1 X_{f1} + \beta_2 X_p + \beta_3 X_{s1} + \beta_4 X_{t1} + \beta_5 X_{s2} + \beta_6 X_{t2} + \beta_7 X_{s3} + \beta_8 X_{s4}$$

V_{ev} as the extent to which higher education is affected; $\beta_i (i = 1,2 \ldots . n)$ as the corresponding coefficients, $X_{f1}, X_p, X_{s1}, X_{t1}, X_{s2}, X_{t2}, X_{s3}$,and X_{s4} were the impact factor parameters of financial support, policy assistance, scientific research equipment, teacher resources, scientific research policy, teaching plan, social assistance and student source, respectively.

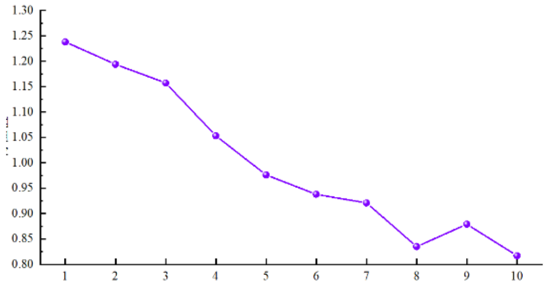

Figure 6: Stone Crushing Plot after B Coefficient Treatment

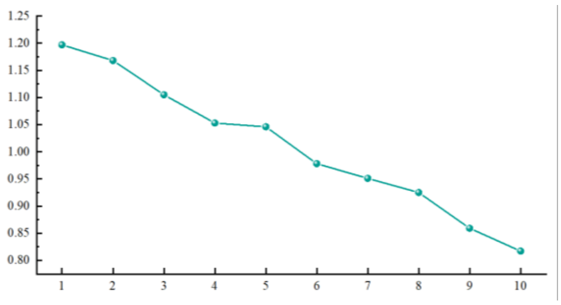

Figure 7: Gravel Plot after U-Coefficient Treatment

The coefficients processed by the β coefficients and U coefficients obtained from Fig. 6 and 7 can be very suitable for Logit data processing analysis, because its gravel plot tends to be stable after 10 iterations, and with the increase of the number of times, the eigenvalues gradually decrease, therefore, it is well suitable for the non-discreteness of the Logit model, and the model results calculated by Stata are shown in Table 2.

Table 2: Factors Affecting the Development of Higher Education in the Yangtze River Delta Region

Tier 1 indicators Government support	Explanatory variables	Coefficient	Chi-square calculation amount
Government support	Financial support	0.3617*	2.91
	Policy help	0.4452*	3.82
School situation	Scientific research equipment	0.2569**	3.12
	Teacher resources	0.4023**	2.43
	Research policy	0.2023**	2.18
	Lesson plan	0.5213*	1.37
Other factors	Social help	0.2132*	1.67
	Student Origin	0.2164	1.87

Note: ** and * indicate 1% and 5% significance levels, respectively

From Table 2, it can be seen that the influencing factors are financial support (0.3617), policy assistance (0.4452), scientific research equipment (0.2569*), teacher resources (0.4023), scientific research policy (0.2023), teaching plan (0.5213) and social assistance (0.2132), which are all significant at 1% and 5% significance levels. The chi-square calculation amount is greater than 1.50, which has good credibility, while the student source factor is not calculated as an influencing factor because it is not significant.

4.2 The Combined Weighting Method Solves the Result

4.2.1 Weight Calculation

The corresponding data of the higher education evaluation index system in the Yangtze River Delta region of China from 2019 to 2021 were collected, and the weight values of each index in the comprehensive evaluation model calculated using equations (10), 15 and (17) were obtained, and the results are shown in Table 3.

Table 3: Model Operation Results

Weight	Numerical calculation results											
$w^{(1)}$	0.093	0.090	0.081	0.097	0.072	0.093	0.092	0.101	0.074	0.068	0.066	0.068
$w^{(2)}$	0.096	0.111	0.104	0.103	0.080	0.102	0.103	0.034	0.061	0.079	0.067	0.055
w	0.094	0.100	0.092	0.100	0.076	0.097	0.098	0.067	0.068	0.074	0.067	0.062

4.2.2 Prediction and Evaluation

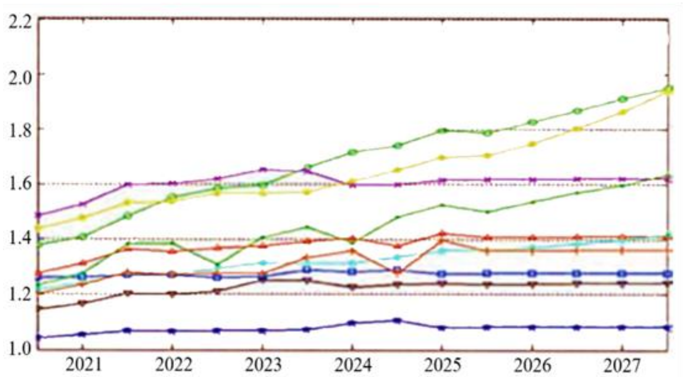

Figure 8: Forecast of Comprehensive Development Level

Based on the evaluation and analysis of the comprehensive development level of higher education in various regions, in this section, the ARMA time series model is used to forecast the data of each indicator in the next five years of 2021, and then the comprehensive development, indicators and sustainable development are predicted. The prediction process can be realized by writing a computer program using MATLAB software, and the calculation results are shown in Figure 8. It can be seen from the figure that the comprehensive development level of higher education in the Yangtze River Delta region is relatively flat and the level is low.

5. Conclusion

At present, the “championship” development model of higher education, which is characterized by a single region or a single university competing for excellence, is difficult to meet the requirements of the regionalized development of higher education for optimizing the allocation of higher education resources and improving the overall strength of regional higher education. The regional higher education cluster brand is an intangible asset shared by all affiliated universities in the region, which can not only enhance the visibility and recognition of universities, but also promote exchanges and cooperation between universities and improve the development level of regional higher education clusters. For some universities with relatively backward educational standards, the regional cluster brand of higher education is a strong endorsement.

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