

Research on Sustainable Development of Competitive Sports in China based on PSR and DEA Model

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Abstract

This paper evaluates the sustainable development of China's competitive sports by using PSG model, principal component analysis, entropy method, coupling coordination degree model and grey correlation model. Sports development in the area of the sample and take the PSG model, principal component analysis (PCA) and entropy method to evaluate various provinces and cities and regions in the development of competitive sports scores, the PSR model coupling coordination degree evaluation of parts of the development of the coordination degree between the three systems, and finally build obstacle factor analysis model of gray correlation analysis to find the obstructive factors for the development of competitive sports. Confirmatory analysis by quantitative research method shows that the eastern region has the highest score in sustainability evaluation and the highest coupling coordination degree. It is suggested that in order to promote the sustainable development of competitive sports, all regions should increase the expenditure of sports development and the number of sports talents reserve.

Keywords

PSR Model; Principal Component Analysis Entropy Method Coupling Coordination; Disorder Factor Analysis; Grey Relational Data Envelope Analysis.

1. Introduction

With the rapid development of society, there are many standards to measure the development level of a country, among which competitive sports is one of them. From the previous Olympic Games China has made a number of achievements, China's competitive sports has risen to a new level, at the same time, in the next upcoming Tokyo Olympic Games and winter Olympics will also become the focus of global attention.

PSR model is a theoretical model for ecological environmental index projects. It mainly adopts the logical relationship of "cause-effect - response" to construct the advantages of the index system, and also covers four major elements of economy, society, environment and policy. As the competitive sports system is similar to the ecological environment system, it has the characteristics of openness, complexity, dynamic balance and so on, so the PSR theoretical model can also be strongly applied to the field of competitive sports.

Because of its own characteristics, competitive sports can continue to play an inspiring role, which is of great significance to the development of a country. However, competitive sports belong to a huge system, once the internal system is affected by external impact or internal adaptability decline, the whole system will stagnate or collapse, thus affecting the sustainable development of competitive sports. Therefore, we should construct a sustainable development comprehensive evaluation model on the quality of competitive sports system, and study and analyze the influencing factors that hinder the sustainable development of competitive sports.

Competitive sports system is an important symbol to measure the level of development of a country, which is of great significance to the development of a country. At the same time, competitive sports are also closely related to our daily life, especially its role of rallying people and inspiring spirit. Therefore, it is conducive to the sustainable development of China's competitive sports by constructing a comprehensive evaluation model for sustainable development of competitive sports in China and conducting research and analysis on it. Thus conducive to the cultivation of national patriotism, promote the country's economic growth, promote the level of national development.

2. Research Review and Hypotheses

2.1. Research Review.

Li Chunyu [1] In 2016, the principal component analysis method of PRS model was used to empirically analyze the performance of atmospheric environmental governance. The application of PSR model shows the coordinated development of atmospheric environmental governance from the relationship of "pressure-state-response", which provides some ideas for solving the sustainable coordinated development of competitive sports in China.

Yi Ping, Fang Shiming [2] In 2014, the coupling coordination degree of socio-economic and ecological benefits of geoparks was studied. Firstly, the evaluation index system is constructed, then the evaluation index data is standardized according to the constructed system, and the weight of each index is determined. Finally, the coupling coordination degree model is established. The establishment of the coupling coordination degree model provides help for solving the third question in this paper.

Geng Songtao, Yang Jingjing et al [3] In 2020, the performance evaluation of listed companies is studied, in which the diagnostic analysis model of obstacle factors is used, and the conclusion is drawn that the main obstacle factors of enterprise development are respectively the growth rate of operating income, fixed asset turnover rate and total asset turnover rate. The analysis method of hindrance factor diagnosis can be used for reference in solving the fourth question of text from the perspective of practical application.

2.2. Research Hypotheses

It is assumed that the data collected about competitive sports in various provinces are true and reliable. It is assumed that the model established by us can reasonably evaluate the development of competitive sports in various provinces. Assume that our model is built according to accurate steps and there is no human error. Assume that the analytical indicators of competitive sports selected by us have practical significance. It is assumed that the error of the model can be controlled within a reasonable range, and the influence on the analysis result is limited.

3. Research Design

3.1. Principal Component Analysis Model Construction

3.1.1. The Establishment of Principal Component Analysis Model.

Principal component analysis (PCA) is a statistical method of dimensionality reduction. It converts the original random vector with its component correlation into a new random vector with its component irrelevance, which points to p orthogonal directions with the most open distribution of sample points, and then transforms the multidimensional variable system into a low-dimensional variable system by dimensionality reduction. Specific modeling steps are as follows:

Standardized processing of the original data. Suppose there are m index variables for principal component analysis, which are a total of N evaluation objects, and the value of the JTH index of the i th evaluation object is $x_1, x_2, \dots, x_m$. a_{ij} Convert the index values into standardized index values, and a_{ij} and $\bar{a}_{ij}$.

$$\bar{a}_{ij} = \frac{a_{ij} - u_j}{s_j}, \quad i = 1, 2, \dots, n; j = 1, 2, \dots, m,$$

Where are the sample mean and sample standard deviation of the JTH indicator?

$$u_j = \frac{1}{n} \sum_{i=1}^n a_{ij}; s_j = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (a_{ij} - u_j)^2}, j = 1, 2, \dots, m, u_j, s_j$$

Correspondingly, called:

$$\bar{x}_j = \frac{x_j - u_j}{s_j}, \quad j = 1, 2, \dots, m,$$

3.1.2. Is Standardized Index Variable.

Calculate the correlation coefficient matrix R . The correlation coefficient matrix is as follow:

$$R = (r_{ij})_{m \times m}, \quad r_{ij} = \frac{\sum_{k=1}^n \bar{a}_{ki} \cdot \bar{a}_{kj}}{n-1}, i, j = 1, 2, \dots, m,$$

Where, $r_{ii} = 1, r_{ij} = r_{ji}, r_{ij}$ is the correlation coefficient between the i th index and the JTH index. Calculate eigenvalues and eigenvectors. The eigenvalues of the correlation coefficient matrix R and the corresponding eigenvectors are calculated. Among them, m new index variables are composed of the eigenvectors $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_m \geq 0$ $u_1, u_2, \dots, u_m$ $u_j = [u_{1j}, u_{2j}, \dots, u_{mj}]^T$.

$$\begin{aligned} y_1 &= u_{11} \bar{x}_1 + u_{21} \bar{x}_2 + \dots + u_{m1} \bar{x}_m, \\ y_2 &= u_{12} \bar{x}_1 + u_{22} \bar{x}_2 + \dots + u_{m2} \bar{x}_m, \\ &\vdots \\ y_m &= u_{1m} \bar{x}_1 + u_{2m} \bar{x}_2 + \dots + u_{mm} \bar{x}_m, \end{aligned}$$

Where, y_1, y_2 is the first principal component, $\dots$; y_m is the second principal component, and is the MTH principal component.

P ($P \leq m$) principal components were selected to calculate the comprehensive evaluation value. Calculate the information contribution rate and cumulative contribution rate of eigenvalues. $\lambda_j (j = 1, 2, \dots, m)$ According to:

$$b_j = \frac{\lambda_j}{\sum_{k=1}^m \lambda_k}, j = 1, 2, \dots, m$$

The information contribution rate of the main component, meanwhile, has y_j :

$$\alpha_p = \frac{\sum_{k=1}^p \lambda_k}{\sum_{k=1}^m \lambda_k}$$

Cumulative contribution of major components. $y_1, y_2, \dots, y_p$ When it is close to 1 (generally, the first P index variables are selected as P principal components to replace the original M index variables, so that comprehensive analysis of P principal components can be carried out. α_p $y_1, y_2, \dots, y_p$.

Calculate the comprehensive score:

$$Z = \sum_{j=1}^p b_j y_j$$

Where, is the information contribution rate of the JTH principal component, which can be evaluated according to the comprehensive score value. b_j .

The establishment of entropy weight method model.

Entropy method is a mathematical method used to judge the dispersion degree of an index. If the dispersion degree of an index is larger, the influence of the index on the comprehensive evaluation is greater, and the dispersion degree of an index can be judged by entropy value.

Data standardization

Suppose k indices are given, where. $X_1, X_2 \dots X_n$ $X_i = \{x_{1,i}, x_{2,i} \dots x_{n,i}\}$ Assuming that the standardized value of each indicator is, the expression of Y can be obtained as follows: $Y_1, Y_2 \dots, Y_K$.

$$Y_{ij} = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)}$$

Calculate the information entropy of each indicator.

According to the definition of information entropy in information theory, the information entropy of a group of data can be obtained:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^n p_{ij} \ln p_{ij}$$

Where, if, is defined. $p_{ij} = Y_{ij} / \sum_{i=1}^n Y_{ij}$ $P_{ij} = 0 \lim_{p_{ij} \rightarrow 0} p_{ij} \ln p_{ij} = 0$.

Determine the weight of each indicator.

According to the calculation formula of information entropy, the information entropy of each indicator is calculated, and then the weight of each indicator is calculated $E_1, E_2 \cdots E_k$.

$$W_i = \frac{1 - E_i}{k - \sum E_i} (i = 1, 2 \cdots k)$$

3.1.3. Solution of the Model

We first conducted model test on 20 indicators of the model by KMO and Bartlett test, and the test results are shown in Table 1. It can be seen from the test results that the significance level of the 20 indicators of the model is relatively high, so each indicator has passed the significance test of the model, indicating that the indicators of the model can be further analyzed.

Table 1. KMO and Bartlett tests.

KMO sampling suitability quantity.		0.601
Bartlett sphericity test	The approximate chi-square	606.653
	Degrees of freedom	190
	significant	0

We twenty indicators for the numerical calculation of the total variance explained (shown in Table 2), among them, the component composition of 1 to 5 cumulative variance explained 81.348%, says 20 ingredients, the first five principal components can explain 81.348% of the total variance, therefore, from the point of the results of the total variance explained table, we can extract the first five principal components as indices of dimension reduction process.

Table 2. Total variance interpretation table.

composition	Initial eigenvalue			Extract the sum of squares of loads		
	A total of	Percentage of variance	Cumulative %	A total of	Percentage of variance	Cumulative %
1	8.920	44.598	44.598	8.920	44.598	44.598
2	3.330	16.652	61.250	3.330	16.652	61.250
3	1.683	8.413	69.663	1.683	8.413	69.663
4	1.296	6.479	76.142	1.296	6.479	76.142
5	1.041	5.206	81.348	1.041	5.206	81.348
6	0.729	3.643	84.991	—	—	—
7	0.640	3.198	88.190	—	—	—
8	0.528	2.637	90.827	—	—	—
9	0.410	2.049	92.876	—	—	—
10	0.361	1.804	94.680	—	—	—
11	0.296	1.481	96.160	—	—	—
12	0.235	1.174	97.334	—	—	—
13	0.153	0.762	98.097	—	—	—
14	0.117	0.587	98.684	—	—	—
15	0.090	0.450	99.134	—	—	—
16	0.069	0.343	99.477	—	—	—
17	0.064	0.318	99.795	—	—	—
18	0.025	0.123	99.918	—	—	—
19	0.010	0.048	99.965	—	—	—
20	0.007	0.035	100.000	—	—	—

Table 3. Component score coefficient matrix.

component indicators		P1	P2	P3	P4	P5	P6	S1	S2	S3
composition	1	0.21	0.1986	0.2386	0.0743	0.1374	0.1042	0.241	0.295	0.2938
	2	0.3546	0.4007	0.3334	0.261	0.04	0.3803	0.0831	0.0139	0.0146
	3	0.1461	0.0218	0.1446	0.4659	0.0666	0.2638	0.1784	0.0601	0.1374
	4	0.0537	0.0352	0.0036	0.2523	0.6294	0.1292	0.1148	0.1406	0.0916
	5	0.23	0.0529	0.0361	0.0695	0.2441	0.1344	0.4736	0.2573	0.0235
component indicators		R2	R3	R4	R5	R6	R7	R8	R9	R10
composition	1	0.2825	0.3037	0.2807	0.2479	0.1545	0.2131	0.2941	0.1094	0.2723
	2	0.1234	0.0295	0.1064	0.1222	0.2005	0.1046	0.167	0.446	0.2201
	3	0.2098	0.0725	0.154	0.199	0.1552	0.0785	0.0367	0.0336	0.0457
	4	0.1868	0.0087	0.1125	0.1415	0.3422	0.1431	0.0776	0.0264	0.0258
	5	0.1927	0.1144	0.2228	0.1449	0.2919	0.5218	0.037	0.0162	0.1554

After determining the five main principal component indicators, MATLAB was used to calculate the weight of the five indicators by using the entropy method, and the results are shown as Table 4.

Table 4. Weight calculation results of entropy method.

item	Information entropy e	Information effect value D	Weight coefficient W
CSP	0.8732	0.1256	37.29%
CSR	0.9442	0.0558	16.41%
CSC	0.9469	0.0531	15.61%
CST	0.9403	0.0597	17.54%
CSB	0.9553	0.0447	13.14%

3.1.4. Data Description

According to this result, we can know that entropy value is a physical unit of measurement. Meanwhile, the larger the entropy value is, the more chaotic the data is, the less information the data carries, the smaller the utility value, and therefore the smaller its weight. Furthermore, entropy rule is a research method to determine the weight by combining the information value provided by entropy value. This method describes the basic principle and analysis process of entropy value, conducts in-depth description and analysis for the final weight value, and finally summarizes the analysis results to draw a conclusion. We through the five level indicators: pressure (CSP) of competitive sports, competitive sports achievements (CSR), cost (CSC) of competitive sports, competitive sports talent (CST), the weight of competitive sports benefit (the CSB) integrate, finally got to evaluate China's regional sustainable development of competitive sports, the mathematical model of comprehensive evaluation are as follows:

$$CSS = 0.3729CSP + 0.1641CSR + 0.1561CSC + 0.1754CST + 0.1314CSB.$$

Among them, CSS is the comprehensive evaluation index of sustainable development of China's regional competitive sports, and CSP, CSR, CSC, CST and CSB are five indexes.

3.2. \Model Construction

According to the comprehensive evaluation model of China's regional competitive sports in Question 1, the expression is as follows:

$$CSS = 0.3729CSP + 0.1641CSR + 0.1561CSC + 0.1754CST + 0.1314CSB$$

Among them, CSS is the comprehensive evaluation index of sustainable development of Regional competitive sports in China, and CSP, CSR, CSC, CST and CSB are the five indexes of competitive sports pressure, competitive sports achievement, competitive sports cost, competitive sports talent and competitive sports benefit respectively.

The standardized data of all provinces are brought into the comprehensive evaluation model of China's regional competitive sports to obtain the comprehensive scores of all provinces, and the sustainable development level of competitive sports of all provinces is ranked according to the scores, thus obtaining the following results shown in Table 5.

Table 5. Comprehensive evaluation score and ranking table of each region and province.

area	provinces	Comprehensive evaluation score	ranking	area	provinces	Comprehensive evaluation score	ranking
The eastern region	guangdong	95.468	1	In the western region	sichuan	61.321	1
	Shanghai	85.158	2		Shanxi	54.213	2
	jiangsu	82.272	3		Mongolia	53.323	3
	Beijing	75.904	4		chongqing	49.587	4
	shandong	72.184	5		guangxi	47.796	5
	zhejiang	70.623	6		yunnan	47.664	6
	tianjin	60.706	7		gansu	46.794	7
	fujian	57.59	8		xinjiang	46.083	8
	hebei	54.792	9		ningxia	42.474	9
	hainan	43.159	10		guizhou	41.905	10
The central region	hubei	61.059	1	In the northeast	qinghai	41.01	11
	hunan	55.268	2		Tibet	38.648	12
	henan	54.268	3		liaoning	63.229	1
	shanxi	51.689	4		heilongjiang	56.737	2
	anhui	50.631	5		Ji Lin	52.099	3
	jiangxi	47.763	6		—	—	—

As can be seen from the chart above, guangdong has the highest comprehensive score of competitive sports among all provinces in eastern China, with a score of 95.468. Among the provinces in western China, Sichuan has the highest comprehensive score of competitive sports, with a score of 61.321. Among the provinces in central China, Hubei province has the highest comprehensive score of competitive sports, with a score of 61.059. Among the provinces in northeast China, Liaoning has the highest comprehensive score of competitive sports, with a score of 63.299. In addition, by comparing the scores of provinces in each region, it can be found that the scores of provinces in the eastern region have a great advantage in the overall trend, while there is little difference among provinces in the other three regions. Further research on

the reasons behind it is mainly due to the differences in economic development level, environmental factors and geographical location of each region.

3.3. Coupling Coordination Degree Model.

Assuming m indicators describing the coordinated development level of competitive sports system in a province, the comprehensive evaluation function of the coordinated development level of competitive sports system in a province is: $x_1, x_2, \dots, x_m$.

$$F(x) = \sum_{i=1}^m \lambda_i X_i$$

Where $F(x)$ is the comprehensive development level index of competitive sports system coordination in a province; M is the number of comprehensive evaluation indexes of competitive sports; λ_i is the weight of the i th evaluation index of the competitive sports system; X_i is the standardized value of the i index of the competitive sports system.

3.3.1. Solution of the Model

Assuming n indicators describing the coordinated development level of competitive sports system in a certain province, the comprehensive evaluation function of the coordinated development level of competitive sports system in a certain province is: $y_1, y_2, \dots, y_n$.

$$G(y) = \sum_{j=1}^m \lambda_j Y_j$$

In the formula, $G(y)$ is the comprehensive development level index of competitive sports system coordination in a province; N Number of comprehensive evaluation indexes of competitive sports; λ_j is the weight of the j th evaluation index of the competitive sports system; Y_j The standardized value of the j th index in competitive sports system.

Assuming p indicators describing the coordinated development level of competitive sports system in a certain province, the comprehensive evaluation function of the coordinated development level of competitive sports system in a certain province is: $z_1, z_2, \dots, z_p$.

$$G(Z) = \sum_{q=1}^m \lambda_q Z_q$$

In the formula, $G(Z)$ is the comprehensive development level index of competitive sports system coordination in a province; P Number of comprehensive evaluation indexes of competitive sports; λ_q is the weight of the q evaluation index of competitive sports system; Z_q Standardized value of q index in competitive sports system.

Referring to the Capacitive Coupling definition and coefficient model in physics, the evaluation model of coordination Coupling degree of competitive sports system in a province is:

$$C = \{F(x) \times G(y) \times Q(z) / \left[\frac{F(x) + G(y)}{3} \right]^3\}^3$$

According to the establishment of principal component analysis in question 1, the index with the largest score coefficient was extracted from the five components as the principal component index.

3.3.2. Solution of Linear Combination Coefficient.

According to the formula standardized number/the square root of the characteristic root of the corresponding principal component, the corresponding coefficients of each index are solved, and the specific results are shown in Table 6.

Table 6. Linear combination coefficients

Zscore(R3 Cultural, sports and media expenditure)	0.303705	0.029523	0.07254	0.008712	0.114379
Zscore(S2 Number of gold MEDALS in the National Games)	0.295038	-0.01395	0.060064	-0.14058	-0.25736
Zscore(R8 Number of traditional sports schools)	0.29412	-0.16702	0.036698	-0.07756	0.03703
Zscore(S3 Number of athletes in elite sports teams)	0.293759	-0.01458	-0.13742	0.091591	0.023492
Zscore(R2 Sports system public budget expenditure)	0.282445	0.123447	0.209733	0.186777	0.192741
Zscore(R4 Number of full-time coaches)	0.280677	-0.10639	-0.154	0.112451	-0.22286
Zscore(R10 Sports lottery sales)	0.272298	-0.22012	0.045647	-0.0258	-0.15541
Zscore(R5 Number of sports reserve talents)	0.247928	-0.12222	-0.19895	-0.14149	-0.14489
Zscore(S1 The number of athletes who have won world Olympic championships)	0.24099	-0.08309	0.178427	-0.11477	0.473665
Zscore(P3 population size)	0.238603	-0.33341	-0.1446	-0.00357	0.036125
Zscore(R7 Number of youth sports clubs)	0.213085	-0.10464	0.078442	-0.14306	0.521852
Zscore(P1 per capital GDP)	0.210042	0.354656	0.146096	-0.05371	-0.23001
Zscore(R1 Number of sports venues per capita)	-0.00641	0.046346	0.622145	-0.05508	-0.2513
Zscore(P4 population growth)	-0.07425	-0.26105	0.46583	-0.25226	-0.06948
Zscore(P5 population density)	-0.13736	-0.04	0.066618	0.629381	0.244098

Percentage of variance by the last line, you can see five index component contribution rate, and has reached 81.348%, says 20 composition, selection of the five principal components can explain 81.348% of the total variance, therefore, from the point of the results of the total variance explained table, we can extract the five principal components as an indicator of anything after processing.

3.4. Grey Correlation Analysis Method

The obstacle factor diagnostic model is to analyze the data of each index of competitive sports in each region, calculate the obstacle degree of each factor from two levels of index category and index, so as to determine the factors hindering the sustainable development of competitive sports in each region at present. The calculation formula of the diagnosis model of hindrance factor is as follows:

$$I_{ij} = 1 - Z_{ij}$$

$$A_{ij} = \frac{I_{ij} G_j}{\sum_{j=1}^{16} I_{ij} G_j}$$

Where, is the deviation degree of the JTH index of the i th sample; I_{ij} Is the weight of the JTH index in the evaluation system; A_{ij} Is the hindrance degree of the JTH index of the i th sample.

3.4.1. The Establishment of Grey Relational Analysis Model

Grey correlation analysis method for supplier selection decisions for lots of uncertainty factors and their relations, the organic combination of quantitative and qualitative methods, make originally complex decision problem become more clear and simple, and convenient calculation, and can exclude the subjective arbitrariness of policy makers to some extent, the conclusion is more objective, has the certain reference value.

Determine the comparison object (evaluation object) and reference sequence (evaluation standard). Suppose there are M evaluation objects and N evaluation indexes, and the reference number is listed as the comparison number. $x_0 \{x_0(k) | k = 1, 2, \dots, n\}$ $x_i \{x_i(k) | k = 1, 2, \dots, n\}$, $i = 1, 2, \dots, m$.

Determine the corresponding weight of each indicator value. Analytic hierarchy process can be used to determine the corresponding weight of each indicator, where is the corresponding weight of the KTH evaluation indicator. $w = [w_1, \dots, w_n]$ w_k ($k = 1, 2, \dots, n$).

Calculate the grey correlation coefficient:

$$\xi_i(k) = \frac{\min_s \min_t |x_0(t) - x_s(t)| + \rho \max_s \max_t |x_0(t) - x_s(t)|}{|x_0(k) - x_i(k)| + \rho \max_s \max_t |x_0(t) - x_s(t)|}$$

Is the correlation coefficient of the comparison sequence to the reference sequence on the KTH index, where $\rho \in [0, 1]$ is the resolution coefficient. x_i x_0 ρ Wherein, they are called two-stage minimum difference and two-stage maximum difference respectively.

$$\min_s \min_t |x_0(t) - x_s(t)|, \max_s \max_t |x_0(t) - x_s(t)|$$

Generally speaking, the higher the resolution coefficient is, the higher the resolution is. ρ ρ The smaller, the smaller the resolution.

Calculate the grey weighted correlation degree. The calculation formula of grey weighted correlation degree is as follow:

$$r_i = \sum_{k=1}^m w_k \xi_i(k).$$

Where, r_i is the grey weighted correlation degree of the i th evaluation object to the ideal object.

Evaluation and analysis. Rank the evaluation objects according to the gray weighted correlation degree, and establish the correlation order of the evaluation objects. The greater the correlation degree, the better the evaluation result.

3.4.2. Solution of the Model

Table 7. Score and order of obstacle degree in each region.

area	indicators	score	ranking	area	indicators	score	ranking
The eastern region	S1	0.8386	1	The central region	R11	0.8431	1
	R6	0.8026	2		S3	0.7337	2
	R11	0.7941	3		R3	0.7165	3
	P6	0.7829	4		P1	0.714	4
	R7	0.727	5		P6	0.7117	5
	P5	0.6738	6		P4	0.6911	6
	R8	0.6551	7		R1	0.6899	7
	P3	0.6434	8		R9	0.684	8
	R2	0.6432	9		S2	0.6516	9
	P4	0.6332	10		R2	0.6393	10
	R3	0.6187	11		R4	0.6368	11
	R4	0.617	12		R10	0.628	12
	R1	0.6089	13		P3	0.6134	13
	R10	0.6059	14		P5	0.5917	14
	R5	0.5564	15		R7	0.5752	15
	S2	0.5558	16		R8	0.5669	16
	S3	0.5489	17		S1	0.5667	17
	P1	0.5232	18		P2	0.5562	18
	P2	0.5188	19		R6	0.5466	19
	R9	0.5031	20		R5	0.5042	20
In the western region	R8	0.8254	1	In the northeast	P4	0.7778	1
	S1	0.7879	2		R5	0.7684	2
	R11	0.7682	3		R6	0.7653	3
	R5	0.7146	4		R2	0.7539	4
	S3	0.6849	5		S1	0.7511	5
	R6	0.6758	6		R1	0.7225	6
	S2	0.6734	7		R7	0.7017	7
	P3	0.6466	8		P6	0.6948	8
	R4	0.613	9		P2	0.6572	9
	P4	0.6127	10		R4	0.613	10
	R10	0.6098	11		R3	0.6076	11
	R1	0.6096	12		S2	0.5897	12
	R2	0.6055	13		P3	0.5895	13
	R3	0.5985	14		R9	0.5864	14
	P6	0.5903	15		P5	0.5851	15
	R9	0.5688	16		R10	0.5809	16
	P1	0.5639	17		R11	0.5789	17
	R7	0.5571	18		R8	0.5735	18
	P5	0.5527	19		P1	0.5636	19
	P2	0.4882	20		S3	0.5616	20

According to the grey correlation method, the obstacle degree of each region was solved. 20 indexes of per capita GDP (P1), respectively (P2), population urbanization rate (P3), the natural population growth rate (P4), population density (P5), illiterate population accounted for more than 15 years of age population proportion (P6), won the world champion athlete/the item number (S1), won the national games gold MEDALS (S2), the number of excellent sports team athletes (S3), the per capita number of sports venues, (R1) of the sports system, public budget spending (R2), style media spending (R3), the number of full-time coaches (R4), the number of sports reserve talented person (R5), the number of referees development (R6), number of youth sports club (R7), traditional sports project school number (R8), the third industry of GDP ratio (R9), sports lottery sales (R10), scientific research funds (R11). Score and order of obstacle degree in each region are shown in Table 7.

From the above results, the main obstacle factors can be selected according to the score of each obstacle factor. Now take each obstacle factor score ranked in the top five as the main obstacle factors of the region, the main obstacle factors of the eastern region to win the world champion athlete/the item number (S1), the number of referees development (R6), access to funding (R11), illiterate population accounted for more than 15 years of age population proportion (P6), the number of youth sports club (R7). The main obstacle factors in the central region are access to scientific research funds (R11), number of elite sports team athletes (S3), expenditure on sports, sports and media (R3), per capita GDP (P1), and proportion of illiterate population in population over 15 years old (P6). The main obstacle factors in the western region are the number of traditional sports schools (R8), the number of world/Olympic champion athletes (S1), the number of scientific research funds (R11), the number of sports reserve talents (R5), and the number of excellent sports team athletes (S3). The main obstacle factors in northeast China are the natural population growth rate (P4), the number of sports reserve talents (R5), the number of referee development (R6), the public budget expenditure of sports system (R2), and the number of athletes winning world/Olympic championships (S1).

4. Conclusions and Discussions

It can be seen from the above results that the returns to scale of Hainan, Shanxi, Anhui, Jiangxi, Inner Mongolia, Gansu and Ningxia will increase in the next 10-20 years, indicating that the development of competitive sports in these provinces is good in the future, and there is a large room for improvement. However, the same return to scale in other provinces indicates that the development of competitive sports in these provinces will not change much in the next 10-20 years, mainly because these provinces have less room for increase in return to scale compared with Hainan, Shanxi, Anhui, Jiangxi, Inner Mongolia, Gansu and Ningxia.

By integrating the weight of five first-level indicators with principal component analysis, the mathematical model for evaluating the comprehensive evaluation of sustainable development of Regional competitive sports in China is obtained as follows:

$$CSS=0.3729CSP+0.1641CSR+0.1561CSC+0.1754CST+0.1314CSB.$$

After that, provinces are divided into four parts: eastern, western, central and northeast. By comparing the scores of provinces in each region, it can be found that the scores of provinces in the eastern region have a great advantage in the overall trend, while there is little difference among provinces in the other three regions. Among the provinces in eastern China, Guangdong has the highest comprehensive score of competitive sports. Sichuan province has the highest comprehensive score of competitive sports among the provinces in western China. Hubei province has the highest comprehensive score of competitive sports among the provinces in

central China. Liaoning has the highest comprehensive score of competitive sports among the provinces in northeast China.

According to the standard of coupling evaluation table, the coordinated development level of competitive sports system in each province is evaluated. The coupling level of Beijing is primary coupling, indicating that the coordinated development level of competitive sports system in Beijing is good. The coupling grade of Guangdong province is good coupling, indicating that the coordinated development level of competitive sports system in Guangdong is very good. Similarly, it can be used to evaluate the coordinated development level of competitive sports system in other provinces.

On the basis that each province is divided into four regions, the top five obstacle factors in each region are selected as the main obstacle factors in the region according to the solution results. The main obstacles in the eastern region were the number of world/Olympic champion athletes (S1), the number of referees (R6), access to scientific research funds (R11), the proportion of illiterate population over 15 years old (P6), and the number of youth sports clubs (R7). The main obstacle factors in the central region are access to scientific research funds (R11), number of elite sports team athletes (S3), expenditure on sports, sports and media (R3), per capita GDP (P1), and proportion of illiterate population in population over 15 years old (P6). The main obstacle factors in the western region are the number of traditional sports schools (R8), the number of world/Olympic champion athletes (S1), the number of scientific research funds (R11), the number of sports reserve talents (R5), and the number of excellent sports team athletes (S3). The main obstacle factors in northeast China are the natural population growth rate (P4), the number of sports reserve talents (R5), the number of referee development (R6), the public budget expenditure of sports system (R2), and the number of athletes winning world/Olympic championships (S1).

The conclusion of the prediction process shows that Hainan, Shanxi, Anhui, Jiangxi, Inner Mongolia, Gansu and Ningxia will have an increasing return to scale in the next 10 to 20 years, and competitive sports will have a good development in the future, with a large space for improvement. However, compared with Hainan, Shanxi, Anhui, Jiangxi, Inner Mongolia, Gansu and Ningxia, other provinces have less room for increase in return to scale, which leads to the same return to scale, indicating that the development of competitive sports in these provinces in the next 10-20 years will be relatively unchanged.

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References

- [1] Li C Y. Empirical analysis of atmospheric environmental governance performance -- principal component analysis based on PSR model [J]. Journal of Central University of Finance and Economics, 2016(03):104-112.
- [2] Yi Ping, FANG Shiming. Study on coupling coordination degree of socio-economic and eco-environmental benefits of geoparks: A case study of Songshan World Geoparks [J]. Resources science, 2014,36(01):206-216.
- [3] Geng Songtao, Yang Jingjing, LIAO Xuelin. Journal of southeast university (philosophy and social science edition), 2020,22(03):90-98+153.
- [4] Guo Rongzhong, SHEN Haijian, Yang Minhua. Evaluation of land ecosystem health based on improved PSR model in Changsha-Zhuzhou-Xiangtan Region [J]. Environmental Monitoring Management and Technology, 201,33(03):29-34.

- [5] Zhang Sanyuan, Ye Meng. Analysis of coupling coordination and obstacle factors between new urbanization and land intensive use in Hubei Province [J]. Yangtze River Forum, 2021(03):31-39.
- [6] Zhou Qijun, TANG Lingfei. Analysis of coupling coordination between industrial structure and employment structure -- a case study of Jiangsu Province [J]. Jiangsu Business Theory, 2021(07): 135-138.
- [7] Shi Baojuan, Meng Li. Journal of North China University of Science and Technology (Social Science Edition), 201, 21(04):41-48.
- [8] Wu Ying, Han Yuhang. Research on the development mechanism, problems and Countermeasures of crowd maker space based on PSR model: A case study of a district in Shanghai [J]. China Economic and Trade Guide, 2021(08):4-7.
- [9] Lu K C. Research on ecological evaluation of green highway based on PSR model. Northeast Forestry University, 2021.
- [10] Fang Xiang, Yang Gangqiao, Huang Dan. Multi-functional performance evaluation and obstacle factor analysis of rural industrial integration [J]. Acta Agriculturae Zhejiangensis, 201, 33(05):932-943. (in Chinese with English abstract).