

Research on the measurement of sustainable development of Chinese competitive sports based on PSR model

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Keywords: PSR model, entropy weight method, Chinese competitive sports, factor obstacle degree

Abstract: Entering the "14th five-year plan" period, Chinese competitive sports shoulders new strategic tasks and missions of the times. The study of Chinese competitive sports is of great significance for its sustainable and healthy development. This study selects 31 provinces and municipalities in China as the research objects. , Based on the relevant data of the 2017 China Sports Statistical Yearbook, 20 indicators were selected as the pressure indicators, state indicators, and response indicators of the PSR model, and the evaluation system was divided into target layer (G), system layer (S), indicators layer (I) 3 levels, using the entropy weight method to empower, build a comprehensive evaluation model for the sustainable development of regional competitive sports in China and score and rank the comprehensive level of sustainable development of regional competitive sports, and then based on the factor obstacle model, Looking for the obstacle factors of China's competitive sports system. Finally, according to the research results and the actual situation, draw relevant conclusions and give suggestions for the sustainable development of Chinese competitive sports.

1. Introduction

If sports are strong, China will be strong, and if national sports are prosperous, sports will be prosperous. Since the 18th national congress of the communist party of China, general secretary Xi Jinping has paid great attention to and attached great importance to the development of sports, and has always led the healthy and orderly development of sports from the perspective of the great rejuvenation of the Chinese nation and the aspirations of the people for a better life. The "14th five-year plan" and the outline of the 2035 long-term goals clearly stated that by 2035, my country will become a "sports power", which shows that the party and the government attach great importance to the cause of national fitness and their firm determination to promote the construction of a sports power. Studying the sustainable development of competitive sports in China is of great practical significance for actively promoting the high-quality development of competitive sports and comprehensively enhancing the comprehensive strength of competitive sports.

At present, many domestic scholars have studied the sustainable development of Chinese competitive sports from different angles and algorithms. The development of the theoretical analysis was carried out [1]. Shao Guihua systematically reviewed the previous research on the

sustainable development of Chinese competitive sports and the research on the sustainable development of regional competitive sports and individual projects in "research on sustainable development of Chinese competitive sports" [2]. The scientific and reasonable technical route and research paradigm of the sustainable development of competitive sports are given: system analysis, establishment of sustainable development indicators, system simulation, decision-making and feedback.

Experts and scholars have given unique suggestions on issues related to the sustainable development of competitive sports in China, but most of the research adopts theoretical analysis, and there is still a lack of statistical analysis of data. It is necessary to promote the sustainable development of competitive sports in China.

2. Empirical analysis of sustainable development of Chinese competitive sports indicators based on PSR model

The PSR model is a theoretical model for ecological and environmental indicators proposed by the organization for economic cooperation and development and the united nations environment program on the basis of research by the Canadian government in the late 1980s, where P represents the external pressure received by the land system, and S represents the changing state of natural resources, where R stands for the protection measures taken by humans to ameliorate adverse effects [3]. Since there are many influencing factors involved in the development of competitive sports, it is necessary to form a complete index evaluation system for comprehensive evaluation based on the actual development of competitive sports in China and regional characteristics. After screening, 20 indicators were selected as the pressure indicators of the PSR model. Status indicators, response indicators, and the evaluation system is divided into three levels: target layer (G), system layer (S), and indicator layer (I). The evaluation indicators are shown in Table 1.

Table 1 Evaluation index system of sustainable development of competitive sports in China

target layer(G)	system layer(S)	indicator layer(I)	unit	directionality
Sustainable Development Level of Regional Competitive Sports in China	Stress indicator(S ₁)	per capita GDP(I ₁)	Yuan	positive
		urbanization rate(I ₂)	%	positive
		total population(I ₃)	Ten thousand people	positive
		natural population growth rate(I ₄)	%	positive
		Population density(I ₅)	people/km	negative
		The proportion of illiterate population over the age of 15 (I ₆)	%	negative
	Status indicator(S ₂)	Number of world/Olympic champion athletes(I ₇)	people	positive
		Get the number of gold medals in the National Games(I ₈)	pieces	positive
		Number of elite sports team players(I ₉)	people	positive
	Response indicator(S ₃)	Number of sports venues per capita(I ₁₀)	pc/10,000 people	positive
		Sports system public budget expenditure(I ₁₁)	million	positive
		Cultural and media expenditure(I ₁₂)	billion	positive
		Number of full-time coaches(I ₁₃)	people	positive
		Number of sports reserve talents(I ₁₄)	people	positive
		Number of referees developed(I ₁₅)	people	positive
		Number of youth sports clubs(I ₁₆)	individual	positive
		Number of schools with traditional sports programs(I ₁₇)	place	positive
		The ratio of tertiary industry to GDP(I ₁₈)	%	positive
		Sports lottery sales(I ₁₉)	million	positive
		receive research funding(I ₂₀)	million	positive

From table 1, the 20 indicators in the indicator layer (I) are divided into units and directions. According to the directionality, it is divided into positive index and negative index. The larger the value of the positive index, the higher the sustainable development level of competitive sports in all provinces in China, and the lower the vice versa; the larger the value of the negative index, the more regional sports. The lower level of sustainable development of sports, the higher the vice versa. In order to facilitate the subsequent use of the indicators, the differences in the simple dimensions of the indicators are eliminated and processed.

For positive indicators:

$$x'_{ij} = \frac{x_{ij} - \min\{x_j\}}{\max\{x_j\} - \min\{x_j\}} \quad (1)$$

For negative indicators:

$$x'_{ij} = \frac{\max\{x_j\} - x_{ij}}{\max\{x_j\} - \min\{x_j\}} \quad (2)$$

where $\min\{x_j\}$ is the minimum value in the j-th indicator data in each region. $\max\{x_j\}$ is the maximum value in the j-th indicator data in each region. x_{ij} is initial data for the jth indicator in the ith region.

The entropy weight method is used to weight the indicators, and all indicators are considered comprehensively, which is more objective [4]. The calculation steps of the entropy weight method are:

Assuming that there are n objects to be evaluated, the forwardization matrix composed of m evaluation indicators is as follows:

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (3)$$

Let its normalized matrix be denoted as Z, where Z_{ij} represents the element in the ith row and jth column of Z:

$$Z_{ij} = \frac{x_{ij} - \min\{x_{1j}, x_{2j}, L, x_{rj}\}}{\max\{x_{1j}, x_{2j}, L, x_{rj}\} - \min\{x_{1j}, x_{2j}, L, x_{rj}\}} \quad (4)$$

Its probability matrix is:

$$p_{ij} = \frac{Z_{ij}}{\sum_{i=1}^n Z_{ij}} \quad (5)$$

The information entropy is:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^n p_{ij} \ln(p_{ij}) \quad (6)$$

Information utility is:

$$d_j = 1 - e_j \quad (7)$$

Entropy weight:

$$W_j = \frac{d_j}{\sum_{j=1}^m d_j} \quad (8)$$

The specific results obtained are shown in table 2.

Table 2 Indicators and their corresponding weights

Index layer	Per capita GDP	Urbanization rate	Total population	natural population growth rate	Population density	Proportion of illiterate population
Weight(%)	4.30	1.41	3.43	2.10	1.82	0.50
Index layer	Number of world / Olympic champion athletes	Number of gold medals won in the National Games	Number of elite athletes	Number of sports venues per capita	Public budget expenditure of sports system	Sports and media expenditure
Weight(%)	17.53	0.59	3.45	3.46	4.66	3.68
Index layer	Number of full-time coaches	Number of Sports Reserve Talents	Number of referees	Number of youth sports clubs	Number of Traditional Sports Schools	Ratio of tertiary industry to regional GDP
Weight(%)	2.93	3.23	5.93	4.70	6.70	5.30
Index layer	Sports lottery sales	Obtain scientific research funds				
Weight(%)	4.98	13.99				

Through table 2, we can see the specific values of the 20 indicators and their corresponding weights. We can intuitively observe the difference between the corresponding weights of each indicator. Among them, the indicator "the number of athletes who have won world/Olympic championships" has the largest proportion, accounting for 17.53%, and the second indicator is "receiving scientific research funds", accounting for 13.99%.

Combining with the comprehensive evaluation model of sustainable development of regional competitive sports in China, the existing 2017 data about competitive sports in 31 provinces in China are brought into the model, and the comprehensive evaluation values of the pressure system, state system and response system of each province can be obtained. Considering that the importance of pressure, state and response in the system is basically the same, we take 1/3 of their corresponding comprehensive development index, and the comprehensive level of sustainable development of competitive sports in each province can be calculated by the following formula:

$$G_j = \sum_{j=1}^3 \left(S_{ij} \times \frac{1}{3} \right) \quad (9)$$

where S_{ij} is the evaluation value corresponding to the j th system index of the i th province, G_j is the evaluation value of the comprehensive level of the sustainable development of competitive sports in the j th province.

Rank in ascending order according to the evaluation value. See Table 3 for the specific calculation results.

Table 3 Comprehensive evaluation value and ranking

City / Province		Beijing	Tianjin	Hebei	Shanghai	Jiangsu	Zhejiang	Fujian
Comprehensive level	Value	0.0374	0.0266	0.0317	0.0493	0.0621	0.0461	0.0325
	Rank	9	5	8	4	6	20	15
City / Province		Shandong	Guangdong	Hainan	Shanxi	Anhui	Jiangxi	Hainan
Comprehensive level	Value	0.0558	0.0811	0.0177	0.0256	0.0302	0.0234	0.0347
	Rank	1	29	14	7	16	3	12
City / Province		Hubei	Hunan	Inner Mongolia	Guangxi	Chongqing	Sichuan	Guizhou
Comprehensive level	Value	0.0384	0.0320	0.0276	0.0252	0.0212	0.0424	0.0189
	Rank	22	24	17	2	31	11	18
City / Province		Yunnan	Tibet	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang
Comprehensive level	Value	0.0278	0.0203	0.0276	0.0187	0.0192	0.0192	0.0237
	Rank	28	13	30	19	23	27	26
City / Province		Liaoning	Jilin	Heilongjiang				
Comprehensive level	Value	0.0347	0.0227	0.0263				
	Rank	21	25	10				

3. Diagnosis of Chinese Competitive Sports Barrier Index Based on Factor Barrier Model

Since there are many influencing factors affecting Chinese competitive sports, in order to better diagnose the obstacle indicators, the factor obstacle degree model can be used here [5-6], and the existing data are used to carry out empirical analysis of the indicators, and to diagnose and analyze the obstacle degrees and subsystems of each index. The construction of the obstacle factors of sustainable development indicators of competitive sports in China, the main obstacle factors are found from the 20 indicators given, and there are 4 calculation indicators:

Factor contribution:

$$A_j = W_j \times W_{ij} \quad (10)$$

Index deviation:

$$B_{ij} = 1 - X'_{ij} \quad (11)$$

The single-index obstacle degree:

$$c_j = \frac{B_{ij} \times A_j}{\sum_{j=1}^{20} (B_{ij} \times A_j)} \times 100\% \quad (12)$$

Subsystem Obstacle:

$$C_j = \sum c_j \quad (13)$$

where W_j is the weight of the index, W_{ij} is the weight of the j th indicator in the i th area, X'_{ij} is the j th indicator is at the i values that tend to normalize the data.

Table 4 Obstacle degree factors and degree of obstacle

City / Province	Obstacle degree factor						
	I ₇	I ₂₀	I ₁₈	I ₁₅	I ₁₆	I ₁₁	I ₁₇
Beijing	8.67	8.11	0.00	8.00	7.78	6.11	8.24
Tianjin	7.32	7.30	4.35	7.33	7.31	5.41	6.14
Hebei	7.39	7.21	7.16	6.34	4.26	6.19	6.18
Shanghai	9.25	0.00	3.11	9.24	7.11	0.00	6.92
Jiangsu	10.42	1.51	10.66	0.00	8.05	6.51	5.04
Zhejiang	9.97	10.35	7.68	8.98	4.54	6.84	4.86
Fujian	7.76	7.64	7.42	7.94	8.06	5.69	6.98
Shandong	9.33	8.74	10.26	6.29	11.86	7.59	2.10
Guangdong	0.00	12.49	14.67	13.46	0.00	1.79	0.00
Hainan	6.14	6.07	3.95	6.05	6.10	5.87	6.06
Shanxi	6.91	6.66	5.32	3.26	6.48	6.20	6.51
Anhui	7.14	6.94	7.13	6.69	3.62	6.15	4.87
Jiangxi	6.69	6.60	6.63	5.23	5.63	6.03	5.66
Henan	7.51	7.54	7.51	5.24	4.94	6.50	5.26
Hubei	8.12	2.47	7.33	5.08	5.32	5.96	6.79
Hunan	7.46	7.46	6.12	3.17	5.48	5.98	6.17
Inner mongolia	7.23	6.94	5.79	4.42	5.23	6.17	6.86
Guangxi	6.68	6.94	6.59	6.29	6.07	5.69	6.54
Chongqing	6.52	6.58	5.45	6.60	4.62	6.14	6.15
Sichuan	8.12	8.20	6.99	3.82	6.24	5.97	2.81
Guizhou	6.17	6.09	5.75	4.91	6.02	5.32	5.98
Yunnan	6.71	6.80	5.86	2.18	5.59	5.88	6.54
Tibet	5.94	5.08	4.53	5.94	5.48	5.94	5.91
Shaanxi	6.95	5.71	7.13	5.33	6.54	5.78	6.11
Gansu	6.23	5.60	4.33	5.60	5.45	5.04	5.22
Qinghai	6.17	6.17	5.48	5.20	5.21	6.10	5.97
Ningxia	6.28	6.25	5.55	5.55	5.23	6.06	6.05
Xinjiang	6.69	6.57	6.06	5.91	5.78	5.88	6.69
Liaoning	7.61	7.92	5.87	4.44	4.64	6.78	6.10
Jilin	5.26	5.93	5.88	6.25	5.03	5.46	5.33
Heilongjiang	6.63	6.48	4.49	6.75	5.63	5.29	5.37

Due to too much data, we only show the top 7 indicators of obstacle degree factors and obstacle degree values, as shown in table 4, there are also subsystem obstacle degree analysis results, as shown in Fig.1.

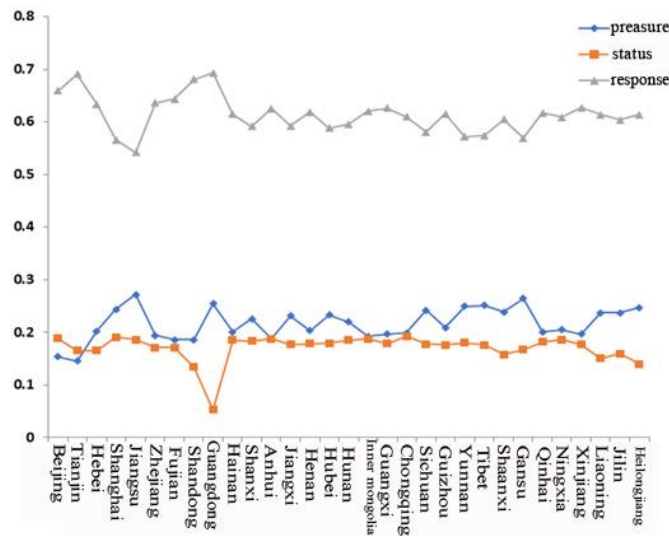


Figure 1 Subsystem obstacle degree line chart

From table 4, we can see that the main obstacle factors affecting the sustainable development of competitive sports in each region are the number of world/Olympic champion athletes (I₇), the scientific research funding (I₂₀), the ratio of the tertiary industry to the regional GDP (I₁₈), the number of referee development (I₁₅), the number of youth sports clubs (I₁₆), the public budget expenditure of the sports system (I₁₁), and the number of schools with traditional sports programs (I₁₇). From Fig. 1, we can directly observe that the impact of the response system on the sustainable development of competitive sports in various provinces is far greater than that of the pressure system and the state system [7]. Most of the main obstacle factors in table 4 are in the response system.

4. Conclusion

Based on the PSR model, this study established a comprehensive evaluation model for the sustainable development of regional competitive sports in China by preprocessing the data and using the entropy weight method to determine all the indicators of the given data and determine the weight of each indicator. The comprehensive level of sustainable development of competitive sports in each province is scored and ranked. From the results, the comprehensive level of sustainable development of competitive sports in the eastern region is generally higher than that of other regions in the central region. Sincerely, the comprehensive level of sustainable development of competitive sports in the western and northeastern regions is relatively weak in the national provincial scope. The comprehensive level of sustainable development of sports has a certain relationship with the local economy and other factors.

By constructing the index obstacle factors of sustainable development of competitive sports in China, using the existing data to conduct empirical analysis of the indicators, diagnosing and analyzing the obstacle degree of each index and subsystem obstacle degree, judging the main obstacle factors affecting the sustainable development of competitive sports in each region, and obtaining The amount of scientific research funding, the ratio of the tertiary industry to the regional output value, and the number of youth sports clubs are all obstacles that affect the comprehensive level of sustainable development of competitive sports. The government can start with these aspects

and formulate some policies to promote the development of competitive sports in my country.

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