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Study on the Sustainable Development of Competitive Sports in China based on PSR Model

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Abstract

Aiming at the PSR model to study the sustainable development of Chinese competitive sports, this paper uses the methods of coefficient of variation, fuzzy comprehensive evaluation and factor analysis to construct the models of fuzzy comprehensive evaluation and grey system prediction respectively, and uses the software programming such as Excel, SPSS and python to draw the conclusion of studying the sustainable development of Chinese competitive sports. The characteristic of this paper is to use the important theoretical PSR model widely used in environmental ecological governance to analyze the sustainable development of China's competitive sports ecological environment, which is a complete ecosystem composed of several independent environmental factors in a specific way, for the competitive sports ecological environment with strong applicability similar to the natural system.

Keywords

Sustainable Development of Competitive Sports in China; Fuzzy Comprehensive Evaluation Method; Coupled Co Scheduling; PSR Model; Factor Analysis; Grey System Prediction.

1. Overview of the Problem

1.1. Background Knowledge

1.1.1. General Background Introduction

Competitive sports is an important symbol to measure the development level of a country and region. The Chinese sports delegation achieved great success in the 2008 Beijing Olympic Games and the 2012 London Olympic Games. The gold, silver and bronze medals in the two Olympic Games were 89, 48 and 51 respectively, indicating that China's competitive sports has reached a new level.The brilliant achievements of China's competitive sports have aroused Chinese people's higher expectations. With the upcoming Tokyo Olympic Games and Winter Olympic Games, competitive sports will continue to make greater achievements with the trend of sustainable development and continue to play its role of gathering people's hearts and inspiring spirit.

1.1.2. Problem Generation

Competitive sports belongs to a complex large-scale system, which has the attributes of external "driving force" and internal "vitality". Once the competitive sports system is affected by external impact, external driving force or internal adaptability, the competitive sports system may stagnate or collapse, and then affect the sustainable development of competitive sports.

1.1.3. Existing Countermeasures

PSR model is a theoretical model for eco-environmental indicators proposed by the organization for economic cooperation and development and the United Nations Environment Programme on the basis of the research of the Canadian government in the late 1980s.The

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theory holds that human activities create pressure (pressure) on the environment, and then affect the environmental quality and the quantity of natural resources (state), and the behavior subject responds (responds) to the changes caused by pressure.PSR has the advantage of using the logical relationship of "cause effect response" to construct the index system, and covers the four elements of economy, society, environment and policy, so it is widely used in the environmental system.PSR conceptual model is an important theory widely used in environmental ecological governance. Because the competitive sports ecological environment is similar to the natural system, it is also a complete ecosystem composed of several independent environmental factors in a specific way, which has the characteristics of openness, complexity and dynamic balance. Therefore, PSR theory also has strong applicability in the field of competitive sports.

1.2. Relevant Information

Based on the PSR model, taking 31 provinces in 4 regions of China as the research object, this paper aims to study and analyze the related problems affecting the sustainable development of China's competitive sports by constructing the evaluation index system of China's competitive sports resilience development and making statistical analysis through the following problems.There are currently competitive sports data from 31 provinces in 4 regions of China in 2017 to analyze the sustainable development of competitive sports in each province. These data include pressure factors, state factors and response factors, with a total of 20 data.The index data comes from the 2018 China Statistical Yearbook, 2018 China Sports Yearbook, 2017 China Sports statistical yearbook, regional statistical yearbooks and the official websites of regional sports bureaus.

1.3. Problems to be Solved

Question 1: Based on PSR model, how to select indicators and determine the weight of each indicator to build a comprehensive evaluation model for the sustainable development of regional competitive sports in China?

Question 2: how to score and rank the comprehensive level of sustainable development of competitive sports in each province?

Question 3: combined with the constructed evaluation system, how to calculate the coupling coordination among the three subsystems of pressure, state and response of competitive sports system in each province, and evaluate the coordinated development level of competitive sports system in each province?

Question 4: how to diagnose the obstacles in the sustainable development of competitive sports in various provinces, and what are the main obstacles affecting the sustainable development of competitive sports in various regions?

Question 5: how to use the existing data to predict the sustainable development trend of provincial competitive sports in China in the next 10-20 years.

Question 6: summarize the analysis results.

2. Analysis of Problems

2.1. Analysis of Problem 1

Problem requirements: Based on PSR model, select indicators and determine the weight of each indicator to build a comprehensive evaluation index system for the sustainable development of regional competitive sports in China;

The way to solve the problem: determine the evaluation index set, and then calculate the weight of each index layer;

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Theories and methods that need to support modeling: objective weighting method, coefficient of variation method;

Process arrangement:

(1) Establishment of evaluation index system;

(2) Standardization of raw data;

(3) Weight determination.

2.2. Analysis of Problem 2

Question requirements: score and rank the comprehensive level of sustainable development of competitive sports in each province;

The way to solve the problem: calculate the comprehensive evaluation index, select the evaluation standard of sustainable development level, and then grade the evaluation standard of sustainable development;

The theories and methods that need to support modeling: fuzzy comprehensive evaluation method;

Process arrangement:

(1) Determine the fuzzy membership matrix;

(2) Determine the fuzzy evaluation matrix;

(3) Calculate the comprehensive evaluation matrix and get the fuzzy comprehensive evaluation results.

2.3. Analysis of Problem 3

Problem requirements: combined with the constructed evaluation system, calculate the coupling and co scheduling among the three subsystems of pressure, state and response of competitive sports system in each province, and evaluate the coordinated development level of competitive sports system in each province;

The idea to solve the problem: the coordination index is introduced to evaluate the interaction among the subsystems of pressure, state and response in the PSR model, so as to further measure the coordination degree within the system;

Theories and methods that need to support modeling: coordination index formula;

Process arrangement:

(1) Calculate the coupling and co scheduling among the three subsystems of pressure, state and response of competitive sports system in each province;

(2) Through the calculation results, the coordinated development level of competitive sports system in each province is evaluated.

2.4. Analysis of Problem 4

Problem requirements: the obstacles in diagnosis, that is, the main obstacles affecting the sustainable development of competitive sports in various regions;

The way to solve the problem: in order to comprehensively analyze and improve the sustainable development level of competitive sports in various provinces, it is necessary to evaluate the obstacle degree of individual indicators and classified indicators and look for the main obstacle factors;

Theories and methods that need to support modeling: factor analysis;

Process arrangement:

(1) Calculate the deviation degree of indicators, that is, the difference between individual indicators and the ideal value of sustainable development of competitive sports in each region;

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(2) Calculate the impact of individual indicators on the sustainable development of competitive sports in each region;

(3) Calculate the factor contribution rate, that is, the weight of a single factor to the overall goal;

(4) Select the main obstacle factors affecting the sustainable development of competitive sports in each region.

2.5. Analysis of Problem 5

Question requirements: how to use the existing data to predict the sustainable development trend of provincial competitive sports in China in the next 10-20 years;

The way to solve the problem: determine the prediction method for the sustainable development trend of China's provincial competitive sports in the next 10-20 years, that is, the principle of grey system prediction model, deal with the grey quantity, find the law of number by number, and then establish a dynamic model;

Theories and methods needed to support modeling: grey system GM (1,1) prediction model principle, least square method;

Process arrangement:

(1) The irregular original data **X (0)** are accumulated in turn to obtain the generated sequence **X(1)** with strong regularity;

(2) The accumulation matrix **B** and constant vector $\mathbf{Y_n}$ are constructed, and the coefficients are fitted and solved by the least square method;

(3) Differential modeling is carried out, and the predicted value of the original data is obtained by subtracting the data obtained from the generated model, and then the prediction is carried out.

2.6. Analysis of Question 6

Problem requirements: summarize the analysis results;

Ideas for solving problems: analyze and summarize the above five problems;

Theories and methods that need to support modeling: analysis and summary;

Process arrangement:

(1) To evaluate, analyze and summarize the sustainable development level of competitive sports in China;

(2) This paper analyzes and summarizes the pressure state response coupling coordination degree of the sustainable development of competitive sports in China;

(3) Diagnosis, analysis and summary of obstacles to the sustainable development of competitive sports in China;

(4) This paper forecasts, analyzes and summarizes the sustainable development trend of provincial competitive sports in China in the next 10-20 years.

3. Model Assumptions

The ecological environment of competitive sports is similar to the natural system, that is, a complete ecosystem composed of several independent environmental factors in their specific ways, which has the characteristics of openness, complexity and dynamic balance. It is assumed that PSR theory, an important theory widely used in environmental ecological governance in the field of competitive sports, has strong applicability.

Basic content of pressure state response (PSR) model: "pressure state response" PSR model is jointly proposed by the organization for economic cooperation and development (OECD) and the United Nations Environment Programme (UNWP). It is used to evaluate the impact of

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human activities on the ecological environment. It is a relatively mature evaluation index system.

In this model, **P** represents the external pressure on the land system, **S** represents the change of natural resources, and **R** represents the protective measures taken by human beings to improve adverse effects.

The sustainable development evaluation system of China's competitive sports is constructed with the help of PSR model, which can measure the pressure exerted on the sustainable development of China's competitive sports by factors such as per capita GDP, urbanization rate and total population, and describe the sustainable development level of economic development level and resource output level under the current situation, This paper analyzes the adaptability of the evaluation system for the sustainable development of competitive sports in China to the pressure, as well as the effectiveness of the measures and governance means affecting the environmental quality and the quantity of natural resources. Pressure, response and state restrict and influence each other, reflecting the causal relationship between environmental pressure and environmental change.

4. Explanation of Terms and Symbols

4.1. Noun Interpretation

(1) Coupling coordination degree model - used to analyze the coordinated development level of things.Coupling degree refers to the interaction and influence between two or more systems to realize the dynamic correlation of coordinated development, which can reflect the degree of interdependence and mutual restriction between systems.Coordination degree refers to the degree of benign coupling in the coupling interaction relationship, which can reflect the quality of coordination.The coupling coordination degree model involves the calculation of three index values, namely, the coupling degree **C** value, the coordination index **T** value and the coupling coordination degree **D** value.Finally, the coupling coordination degree of each item is obtained by combining the coupling coordination degree **D** value and the coordination level division standard.

(2) Grey system prediction model - the general expression of grey model (GM model for short) is GM (n, x) model, which means that the model is established for **x** variables with **n** order differential equations.

4.2. Description of Main Symbols

5. Establishment and Solution of Model

5.1. Analysis and Solution of Problem 1

5.1.1. Analysis of Problems

(1) PSR model is pressure state response model

After using the PSR model to analyze the sustainable development of competitive sports in China, following the principles of scientificity, comparability, accessibility and systematicness, an evaluation index system of 20 indexes at three levels of target level, module level and element level is constructed (Table 2).The index system can generally reflect the sustainable development of competitive sports in China, the interdependent and restrictive relationship between socio-economic sustainable development objectives and various environmental factors, and can reflect the hierarchical structure and systematic comprehensiveness of the whole evaluation.

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Table 1. Description of symbols in the model

Serial number	Symbol	Symbol description
1	P	Stress factors
2	S	State factor
3	R	Response factors
4	X_{ij}	Evaluation index system
5	W_i	Evaluation index weight
6	R_{ij}	Fuzzy membership matrix
7	V_i	Fuzzy evaluation matrix
8	C	Coordination index
9	X	Pressure system score
10	Y	Status system score
11	Z	Response system score
12	F_{ij}	Factor contribution
13	I_{ij}	Index deviation
14	(Y_{ij},y_i)	Obstacle degree
15	GM(1, 1)	Grey system model
16	B	Accumulation matrix
17	Y_n	Constant vector
18	S_1	Original data deviation
19	S_2	Residual deviation
20	P	Small error probability

(2) Index system and weight

Referring to the relevant research results at home and abroad, under the guidance of the principles of scientificity, integrity, objectives, feasibility and data availability, combined with the actual situation of the sustainable development of competitive sports in China, the PSR system model is used, with pressure factor, state factor and response factor as the target module layer, from the aspects of economy, society Starting from the four elements of environment and policy, this paper selects the index category, so as to establish the evaluation index system of sustainable development of competitive sports in China. The most common methods to determine the index weight are Delphi method, entropy method and **AHP** method. In this paper, the coefficient of variation method is used to determine the weight of each index, and the evaluation index system and the weight of each index are obtained (Table 2).

5.1.2. Solving Problems

(1) Determine the evaluation index set

This indicator set can produce a secondary evaluation indicator system as shown in Table 1:

$$X=(x_1,x_2,x_3)$$

Where, $x_i= (x_{ni1}, x_{ni2}, x_{ni3})$, i=1,2,3; $n_1=6$, $n_2=3$, $n_3=11$

(2) Determine the weight of each index layer

Using coefficient of variation method: $v_j = \frac{s_j}{x_j}$, $w_j = \frac{v_j}{\sum_{k=1}^{20} v_k}$

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The weights of the secondary evaluation index set (X_1, X_2, X_3) to the primary evaluation index set X are determined as follows:

$$W=(W_1,W_2,W_3)$$

The weights of the specific evaluation index set (X_{i1}, X_{i2}, ..., X_{in}) to the secondary evaluation index set are:

$$W_i=(W_{i1},W_{i2},...,W_{in})$$

Table 2. Evaluation index system and weight of sustainable development of regional competitive sports in China

Target layer	Module layer	Element layer	Index layer	weight
Sustainable development level	system pressure (X_1, 0.2082)	Economics (X_{11},0.0290)	X_1 per capita GDP / yuan	0.0290
		Sociology (X_{12},0.1139)	X_2 urbanization rate /%	0.0138
			X_3 total population / 10000	0.0409
			X_4 natural population growth rate /%	0.0336
			X_5 population density / (person / km2)	0.0256
		policy (X_{13},0.0653)	X_6 proportion of illiterate population in population over 15 /%	0.0653
	system state (X_2, 0.2524)	Sociology (X_{21},0.2524)	X_7 number of world / Olympic champion athletes / person	0.1561
			X_8 number of gold medals won in the National Games / piece	0.0618
			X_9 Number of elite athletes / person	0.0355
	system response (X_3, 0.5385)	Economics (X_{31},0.2625)	X_{10} public budget expenditure of sports system / 10000 yuan	0.0501
			X_{11} sports and media expenditure / 100 million yuan	0.0378
			X_{12} ratio of tertiary industry to regional GDP /%	0.0100
			X_{13} sports lottery sales / 10000 yuan	0.0501
			X_{14} scientific research funds obtained / 10000 yuan	0.1145
		Sociology (X_{32},0.2760)	X_{15} number of sports venues per capita / (piece / 10000 people)	0.0191
			X_{16} number of full-time coaches / person	0.0387
			X_{17} number of sports reserve talents / person	0.0397
			X_{18} number of referees / person	0.0612
			X_{19} number of youth sports clubs / piece	0.0497
			X_{20} number of traditional sports schools / School	0.0676

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5.2. Analysis and Solution of Problem 2

5.2.1. Analysis of Problems

(1) Fuzzy comprehensive evaluation method

Fuzzy comprehensive evaluation method is a method of analyzing and evaluating fuzzy system by using the principle of fuzzy transformation. It is a qualitative and quantitative analysis and evaluation method based on fuzzy reasoning.

(2) Division of comprehensive evaluation value of sustainable development

At present, there is no clear standard for the classification of urban sustainable development level. Based on the comprehensive consideration of the characteristics of the study area and drawing on the relevant sustainable development research results, the comprehensive evaluation value of sustainable development is divided into five levels from low to high (Table 3).

(3) According to the above two methods, the conclusion is obtained

Get the score and ranking of the comprehensive evaluation level of sustainable development of regional competitive sports in China (Table 4)

5.2.2. Solving Problems

(1) Determining fuzzy membership matrix

Considering the indicators $\mathbf{X_{ij}}$ separately, the membership matrix of regional subordination to "sustainable development" is:

$$\mathrm{R}_{ij}=\begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1n} \\ r_{i21} & r_{i22} & \cdots & r_{i2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{ij1} & r_{ij2} & \cdots & r_{ijn} \end{bmatrix}$$

Among them,

$$\mathrm{r}_{ijn}=\begin{cases} \dfrac{\mathrm{u}_{ijn}-\min(\mathrm{u}_{ijn})}{\max(\mathrm{u}_{ijn})-\min(\mathrm{u}_{ijn})} & (\mathrm{u}_{ijn}\ \text{bigger is ideal}) \\ \dfrac{\max(\mathrm{u}_{ijn})-\mathrm{u}_{ijn}}{\max(\mathrm{u}_{ijn})-\min(\mathrm{u}_{ijn})} & (\mathrm{u}_{ijn}\ \text{smaller is ideal}) \end{cases}$$

Table 3. Evaluation criteria of sustainable development level

Comprehensive evaluation value	Evaluation criteria	describe
<0.5	Extremely unsustainable	Traditional development
0.5~0.8	Unsustainable	Transition from tradition to sustainable development
0.8~0.9	Critical unsustainability	Primary sustainable development
0.9~1	Critical sustainability	Intermediate sustainable development
>1	sustainable	sustainable development

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(2) Determine fuzzy evaluation matrix

For the secondary evaluation index set $\mathbf{X_i}$, the fuzzy evaluation matrix $V_i = W_{ij} \cdot R_{ij}$ (i=1,2,3; j=1, 2, ..., n_1) is established.

(3) Fuzzy comprehensive evaluation results

Calculate the comprehensive evaluation matrix and obtain the fuzzy comprehensive evaluation result, that is, V=W (V_1, V_2, V_3).

Table 4. Score and ranking of comprehensive evaluation level of sustainable development of regional competitive sports in China

sort	province	Comprehensive evaluation level	Comprehensive sustainability	describe
1	Hainan	0.923737122	Critical sustainability	Intermediate sustainable development
2	Ningxia	0.900911387	Critical sustainability	Intermediate sustainable development
3	Qinghai	0.900179443	Critical sustainability	Intermediate sustainable development
4	Guizhou	0.880369893	Critical unsustainability	Primary sustainable development
5	Chongqing	0.873189081	Critical unsustainability	Primary sustainable development
6	Gansu	0.864791372	Critical unsustainability	Primary sustainable development
7	Xinjiang	0.861184694	Critical unsustainability	Primary sustainable development
8	Jiangxi	0.844273657	Critical unsustainability	Primary sustainable development
9	Tibet	0.842663572	Critical unsustainability	Primary sustainable development
10	Jilin	0.842469943	Critical unsustainability	Primary sustainable development
11	Guangxi	0.840905946	Critical unsustainability	Primary sustainable development
12	Shanxi	0.830424412	Critical unsustainability	Primary sustainable development
13	Tianjin	0.826779489	Critical unsustainability	Primary sustainable development
14	Heilongjiang	0.824989692	Critical unsustainability	Primary sustainable development
15	Inner Mongolia	0.812576991	Critical unsustainability	Primary sustainable development
16	Yunnan	0.809360497	Critical unsustainability	Primary sustainable development
17	Anhui	0.786389356	Unsustainable	Transition from tradition to sustainable development
18	Shaanxi	0.784189832	Unsustainable	Transition from tradition to sustainable development

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19	Hunan	0.771394709	Unsustainable	Transition from tradition to sustainable development
20	Hebei	0.760020229	Unsustainable	Transition from tradition to sustainable development
21	Liaoning	0.755009013	Unsustainable	Transition from tradition to sustainable development
22	Fujian	0.754388851	Unsustainable	Transition from tradition to sustainable development
23	Henan	0.738499149	Unsustainable	Transition from tradition to sustainable development
24	Beijing	0.725987399	Unsustainable	Transition from tradition to sustainable development
25	Hubei	0.676723856	Unsustainable	Transition from tradition to sustainable development
26	Sichuan	0.668506203	Unsustainable	Transition from tradition to sustainable development
27	Zhejiang	0.612236725	Unsustainable	Transition from tradition to sustainable development
28	Shanghai	0.581028681	Unsustainable	Transition from tradition to sustainable development
29	Shandong	0.497960369	Extremely unsustainable	Traditional development
30	Jiangsu	0.425591262	Extremely unsustainable	Traditional development
31	Guangdong	0.272757501	Extremely unsustainable	Traditional development

5.3. Analysis and Solution of Problem 3

5.3.1. Analysis of Problems

Sustainable development is a dynamic system process. PSR model can reveal the interaction and relationship among society, economy and ecological environment in a certain period of time. In a certain period of time, the pressure of sustainable development will lead to the corresponding changes of its state and policy. Therefore, coordination index is introduced to evaluate the interaction among pressure, state and response subsystems in PSR model the coordination index judges the coordination degree according to the distance between systems and the degree of dispersion.

5.3.2. Solving Problems

The calculation formula of coordination index is:

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$$C = \frac{X + Y + Z}{\sqrt{X^2 + Y^2 + Z^2}}$$

Where: **C** -- coordination index; X, Y, Z -- score value of pressure, state and response system. When the score value of pressure, state and response system is closer, the C value is closer to 1.732, indicating that the coordination degree is higher, and vice versa.

The coupling coordination degree is calculated through spssau and the data in Table 1. According to the coupling coordination degree division standard (Appendix), the results are shown in Table 5.

Table 5. Calculation results of coupling coordination degree

province	Coupling C value	Coordination index T value	Coupling coordination D value	Coordination level	Coupling coordination degree
Beijing	0.673	0.279	0.433	5	Verge of disorder
Tianjin	0.571	0.161	0.303	4	Mild disorder
Hebei	0.745	0.24	0.423	5	Verge of disorder
Shanghai	0.752	0.438	0.574	6	Reluctantly coordinate
Jiangsu	0.888	0.568	0.71	8	Intermediate coordination
Zhejiang	0.734	0.371	0.522	6	Reluctantly coordinate
Fujian	0.639	0.251	0.401	5	Verge of disorder
Shandong	0.75	0.489	0.606	7	Primary coordination
Guangdong	0.838	0.713	0.773	8	Intermediate coordination
Hainan	0.412	0.098	0.201	3	Moderate disorder
Shanxi	0.712	0.186	0.364	4	Mild disorder
Anhui	0.712	0.211	0.388	4	Mild disorder
Jiangxi	0.629	0.193	0.348	4	Mild disorder
Henan	0.723	0.268	0.44	5	Verge of disorder
Hubei	0.834	0.333	0.527	6	Reluctantly coordinate
Hunan	0.709	0.246	0.418	5	Verge of disorder
Inner Mongolia	0.694	0.174	0.347	4	Mild disorder
Guangxi	0.645	0.166	0.327	4	Mild disorder
Chongqing	0.639	0.138	0.297	3	Moderate disorder
Sichuan	0.782	0.328	0.506	6	Reluctantly coordinate
Guizhou	0.649	0.128	0.288	3	Moderate disorder
Yunnan	0.68	0.216	0.383	4	Mild disorder
Tibet	0.265	0.159	0.205	3	Moderate disorder
Shaanxi	0.748	0.238	0.422	5	Verge of disorder
Gansu	0.681	0.173	0.343	4	Mild disorder
Qinghai	0.463	0.103	0.218	3	Moderate disorder
Ningxia	0.435	0.116	0.225	3	Moderate disorder
Xinjiang	0.617	0.154	0.309	4	Mild disorder
Liaoning	0.65	0.241	0.396	4	Mild disorder
Jilin	0.787	0.174	0.37	4	Mild disorder
Heilongjiang	0.627	0.185	0.341	4	Mild disorder

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It can be seen from Table 5 that Jiangsu and Guangdong have intermediate coordination, Shandong has primary coordination, Shanghai, Zhejiang, Hubei and Sichuan have barely coordinated, Beijing, Hebei, Fujian, Henan, Hunan and Shaanxi are on the verge of imbalance, Tianjin, Shanxi, Anhui, Jiangxi, Inner Mongolia, Guangxi, Yunnan, Gansu, Xinjiang, Liaoning, Jilin and Heilongjiang have slight imbalance, and Hainan, Chongqing, Guizhou, Tibet and QinghaiModerate imbalance in Ningxia.

5.4. Analysis and Solution of Problem 4

5.4.1. Analysis of Problems

For the diagnosis and analysis of obstacle factors based on the number / person of athletes in elite sports teams, several indexes such as factor contribution $\mathbf{F_{ij}}$, index deviation $\mathbf{I_{ij}}$ and obstacle degree $\mathbf{(Y_{ij}, y_i)}$ can be introduced. The basic calculation formula is:

$$F_{ij} = R_j \times W_i \text{ , } I_{ij} = 1 - X_i$$

$$y_{ij} = \frac{F_{ij} \times I_{ij}}{\sum_{i=1}^{n} (F_{ij} \times I_{ij})} \times 100\% \text{ , } Y_{ij} = \sum y_{ij}$$

Where: is the effect degree of a single index on the overall goal; $\mathbf{I_{ij}}$ is the difference between the evaluation value of a single index and 100%; $\mathbf{W_i}$ is the weight of the **i** single index; $\mathbf{R_j}$ is the weight of the classification index to which the **i** index belongs; $\mathbf{X_i}$ is the standardized value of single index.

5.4.2. Solving Problems

According to the known data, the obtained results are shown in Table 6.

Table 6. Common factor variance

Specific indicators	initial	extract
Per capita GDP (yuan)	1	0.915
Urbanization rate (%)	1	0.928
Total population (10000)	1	0.925
Natural population growth rate (%)	1	0.673
Population density (person / km2)	1	0.818
Proportion of illiterate population in population over 15 (%)	1	0.659
Number of world / Olympic champion athletes (person)	1	0.837
Number of gold medals won in the National Games (pieces)	1	0.866
Number of elite athletes (person)	1	0.801
Number of sports venues per capita (PCs. / 10000 people)	1	0.662
Public budget expenditure of sports system (10000 yuan)	1	0.923
Expenditure on sports and media (100 million yuan)	1	0.842
Number of full-time coaches (person)	1	0.848
Number of sports reserve talents (person)	1	0.712
Number of referees (person)	1	0.679
Number of youth sports clubs (PCs.)	1	0.749
Number of Traditional Sports Schools	1	0.873
Ratio of tertiary industry to regional GDP (%)	1	0.733
Sales of sports lottery (10000 yuan)	1	0.838
Scientific research funds obtained (10000 yuan)	1	0.836

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Common factor analysis of variance mainly depends on the cumulative contribution rate of several common factor variances: the higher the cumulative contribution rate, the higher the representativeness or interpretation rate of the extracted common factors to the original variables, the better the overall effect; the lower the cumulative contribution rate, the worse the representativeness or interpretation rate of the extracted common factors, the worse the effect.

Taking less than 0.80 as the obstacle factors, it can be seen from Table 6 that the natural growth rate of population, the proportion of illiterate population in the population over 15 years old, the number of sports venues per capita, the number of sports reserve talents, the number of referees, the number of youth sports clubs and the ratio of tertiary industry to the total regional production value are all the obstacle factors affecting the sustainable development of competitive sports in each region.

5.5. Analysis and Solution of Problem 5

5.5.1. Analysis of Problems

Using the existing data, this paper forecasts the sustainable development trend of provincial competitive sports in China in the next 10-20 years;Determine the prediction method for the sustainable development trend of China's provincial competitive sports in the next 10-20 years, that is, the principle of grey system prediction model, deal with the grey quantity, find the law of number by number, and then establish a dynamic model; Theories and methods supporting modeling: grey system **GM (1,1**) prediction model principle, least square method; The irregular original data $\mathbf{X^{(0)}}$ are accumulated in turn to obtain the generated sequence $\mathbf{X^{(1)}}$ with strong regularity; The accumulation matrix **B** and constant vector $\mathbf{Y_n}$ are constructed, and the coefficients are fitted and solved by the least square method;Differential modeling is carried out, and the predicted value of the original data is obtained by subtracting the data obtained from the generated model, and then the prediction is carried out.

5.5.2. Solving Problems

(1) Principle of grey system prediction model

Grey prediction is to establish a model based on Grey module to describe the dynamic characteristics of the system.The processing of grey quantity is not to seek its statistical law and probability distribution, but to process the irregular original data into more regular time series data through certain methods, that is, the law of finding numbers by numbers, and then establish a dynamic model.

The modeling basis of grey system **GM (1,1)** model is to accumulate the irregular original data $\mathbf{X^{(0)}}$ in turn to obtain the generated sequence $\mathbf{X^{(1)}}$ with strong regularity, then construct the accumulation matrix **B** and constant vector $\mathbf{Y_n}$, fit and solve the coefficients with the least square method, carry out micro modeling, and subtract the data obtained from the generated model to obtain the predicted value of the original data, and then carry out prediction,The corresponding time function is:

$$X^{(1)}(t+1) = X^{(0)}(1) - \frac{u}{a}e^{-at} + \frac{u}{a}$$

(2) Error verification

In order to verify the reliability of the model, it is usually necessary to carry out a posteriori test on the model, first calculate the original data deviation $\mathbf{S_1}$ and residual deviation $\mathbf{S_2}$, and then calculate the posteriori ratio **C** and small error probability **P**.

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$$S_1 = \sqrt{\sum_{t=1}^{m} [X^{(0)}(t) - \overline{X}(t)]^2}$$

$$S_2 = \sqrt{\frac{1}{m-1} \sum_{t=1}^{m=1} [q^{(0)}(t) - q^{-(0)}(t)]^2}$$

$$C = \frac{S_1}{S_2}$$

$$P = \{ \left| q^{(0)}(t) - q^{-(0)}(t) \right| < 0.6745 \ S_1 \}$$

Using this model, we can get the predicted value of comprehensive evaluation of sustainable development in the next 10 to 20 years from 2017 (Figure 1)

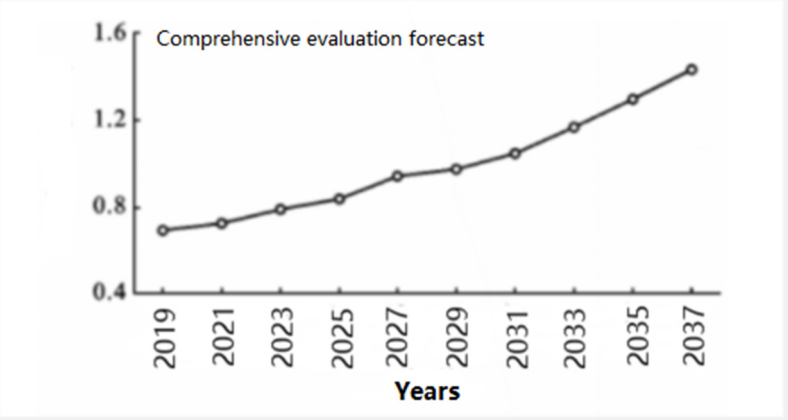

Figure 1. Predicted value of comprehensive evaluation

5.6. Analysis and Summary of Question 6

5.6.1. Analysis of Problems

Question 6 is a summary analysis of the first five questions. We can evaluate, analyze and summarize the sustainable development level of China's competitive sports, and analyze and summarize the pressure state response coupling coordination degree of China's competitive sports sustainable development, This paper makes a comprehensive consideration on the diagnosis, analysis and summary of obstacles to the sustainable development of competitive sports in China and the prediction, analysis and summary of the sustainable development trend of provincial competitive sports in China in the next 10-20 years.

5.6.2. Summary of Problems

usePSR model is feasible in quantitative analysis of China's competitive sports development. Its method is correct and the results are credible. From the internal point of view of the system, the evaluation value of sustainable development of the three modules of system pressure, state and response is coordinated with the comprehensive evaluation value, showing a synchronous upward trend.

The development should be greatly affected by per capita GDP, public budget expenditure of sports system and urbanization construction. Therefore, to promote the development process of regional and national sports, we should focus on improving per capita GDP, increasing public budget expenditure of sports system and promoting urbanization construction.

Due to the limited availability of data, the sustainable development level index system constructed this time needs to be further improved. In addition, the prediction of sustainable development level is based on the current development status. When the pressure, state and

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response factors of the current period change significantly, the prediction results will be very different. Therefore, the government and departments at all levels should continue to implement active and effective policies and measures to fundamentally understand the problems existing in the development of sports competition in China, so as to continuously improve the optimized sustainable development level and quality of sports competition in all regions of China.

6. Evaluation and Generalization of the Model

6.1. Advantages of the Model

1. This paper has a reasonable theoretical method, model, calculation, analysis, and summary of the problem;

2. Use data flexibly according to the problems to be solved;

3. This paper comprehensively and objectively expounds the sustainable development level and influencing factors of competitive sports in China;

4. Based on the guidance of PSR model theory and method, objectively analyze practical problems;

5. Research problems step by step, and slowly progress and gradually improve in the process of solving.

6.2. Disadvantages of the Model

1. Question 5. When conducting time series analysis, search and record the relevant index data in 2013 and 2009 by yourself. The resulting data will inevitably have some errors, and there is no complete statistical data;

2. When summarizing and analyzing the model, we did not conduct sensitivity analysis due to limited time;

6.3. Generalization of Model

PSR conceptual model is an important theory widely used in environmental and ecological governance. It shows that human beings obtain the materials and energy needed for survival, reproduction and development in nature, affect nature through production and consumption, exert certain pressure on the environment, and change the environmental quality and the stock (state) of resources;The changes of environment and resources in turn affect the human system and affect the development of human beings and the welfare of future generations. In order to restore the environmental quality and prevent degradation, society responds to the environmental state through cognitive, management decision-making and economic behavior.

Because the ecological environment of competitive sports is similar to the natural system, it is also a complete ecosystem composed of several independent environmental factors in their specific ways. It has the characteristics of openness, complexity and dynamic balance. It can not only be applied to the sustainable development of Chinese sports analyzed in this paper, but also be widely applied to the protection of land resources and environmentLand sustainable use evaluation, island ecosystem evaluation and wetland ecosystem health evaluation play a key role in human research on sustainable development.

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Appendix

Table 7. Kmo and Bartlett test

Kmo sampling suitability quantity		0.658
Bartlett sphericity test	Approximate chi square	595.742
	freedom	190
	Significance	0

Table 8. Classification standard of coupling coordination degree

D-value interval of coupling coordination degree	Coordination level	Coupling coordination degree
(0.0~0.1)	1	Extreme disorder
[0.1~0.2)	2	Severe imbalance
[0.2~0.3)	3	Moderate disorder
[0.3~0.4)	4	Mild disorder
[0.4~0.5)	5	Verge of disorder
[0.5~0.6)	6	Reluctantly coordinate
[0.6~0.7)	7	Primary coordination
[0.7~0.8)	8	Intermediate coordination
[0.8~0.9)	9	Good coordination
[0.9~1.0)	10	High quality coordination

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Table 9. TOPSIS evaluation calculation results

province	Distance D of positive ideal solution+	Negative ideal solution distance D-	Relative proximity C	Sorting results
Beijing	329690.206	131169.438	0.285	13
Tianjin	391801.19	72308.635	0.156	21
Hebei	258159.845	209679.636	0.448	7
Shanghai	378655.864	164048.753	0.302	11
Jiangsu	74765.53	439750.608	0.855	2
Zhejiang	174105.953	294107.284	0.628	4
Fujian	238707.197	224842.638	0.485	6
Shandong	106736.866	393310.621	0.787	3
Guangdong	22816.316	439128.667	0.951	1
Hainan	448368.044	12195.571	0.026	28
Shanxi	396669.552	62720.416	0.137	24
Anhui	341880.075	119183.319	0.258	14
Jiangxi	372461.333	88422.78	0.192	20
Henan	200092.737	281932.612	0.585	5
Hubei	267220.945	194638.571	0.421	8
Hunan	294339.8	168124.811	0.364	9
Inner Mongolia	368838.601	90992.574	0.198	18
Guangxi	399839.553	60121.889	0.131	25
Chongqing	372785.395	88978.845	0.193	19
Sichuan	361262.773	99887.95	0.217	16
Guizhou	396149.033	63171.274	0.138	23
Yunnan	310687.348	153340.22	0.33	10
Tibet	457735.11	2443.105	0.005	31
Shaanxi	328229.162	132432.574	0.287	12
Gansu	401850.481	58792.975	0.128	27
Qinghai	458600.816	3237.38	0.007	30
Ningxia	450107.515	10184.062	0.022	29
Xinjiang	400588.791	58751.701	0.128	26
Liaoning	361907.314	98033.106	0.213	17
Jilin	393771.023	65626.845	0.143	22
Heilongjiang	345138.868	114212.716	0.249	15

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Table 10. Total variance interpretation

component	Initial eigenvalue			Extract the sum of squares of the loads		
	total	Percentage variance	Cumulative%	total	Percentage variance	Cumulative%
1	8.967	44.833	44.833	8.967	44.833	44.833
2	2.976	14.88	59.713	2.976	14.88	59.713
3	1.85	9.248	68.961	1.85	9.248	68.961
4	1.273	6.365	75.326	1.273	6.365	75.326
5	1.053	5.264	80.59	1.053	5.264	80.59
6	0.795	3.973	84.563			
7	0.698	3.491	88.054			
8	0.548	2.742	90.796			
9	0.451	2.253	93.049			
10	0.346	1.728	94.777			
11	0.311	1.555	96.332			
12	0.197	0.985	97.317			
13	0.177	0.884	98.201			
14	0.109	0.546	98.747			
15	0.075	0.375	99.122			
16	0.07	0.352	99.474			
17	0.056	0.278	99.751			
18	0.029	0.144	99.896			
19	0.013	0.066	99.962			
20	0.008	0.038	100			