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Evaluation of sports Industry development Status -- Based on optimal weighting method model

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Abstract: "The fourteenth Five-year plan" proposed a new goal that promote the sports industry to become a pillar of China's national economy. Therefore, reasonably evaluate the development current situation of China's sports industry is of great significance to build the future development path of sports industry. As a result, this paper adopts the optimal weighting method to construct the evaluation index system of sports industry development level. Based on the empirical results and the new situation of sports industry, the following suggestions are put forward: In order to promote the high-quality development of China's sports industry, it is necessary to optimize the sports industry structure, improve the sports market mechanism, and promote sports consumption.

1. Introduction

During the 13th Five-Year Plan period, the development of China's sports industry entered a new stage. From 2015 to 2019, the total size of China's sports industry increased from 1.71 trillion yuan to 2.95 trillion yuan, with a total growth rate of 83% and an annual growth rate of 14.6%. By the end of 2019, China's sports industry had had 289,000 legal entities and employed 5.051 million people. At the same time, the industrial structure is being constantly optimized, and sports industry is increasingly integrated with other industries. On 25 October, 2021, the "14th Five-year Plan for Sports Development" officially issued by the General Administration of Sport of China, putting forward the target of building a sports powerful nation by 2035 and making the sports industry to be a pillar industry of the national economy.

With the gradual slowdown of China's economic growth and continuous adjustment of the industrial structure, the sports industry that has huge development potential has become a new driving force to promote the transformation and upgrading of China's industrial structure, driving the growth of diversified consumption, promoting the healthy and sustainable development of China's economy. Especially, the sports service industry, which is low-carbon and environmentally-friendly and high added, has become a key force to help China achieve the goal of "carbon neutrality" and promote green economic transformation in China. However, through a search on CNKI, it is found that after a slight increase of the number of literatures related to sports industry in 2015, the development of that is relatively stagnant. It can be seen that there is a lack of professional research on related fields in China, playing a limited role in promoting the high-quality development of the sports industry.

Therefore, it is of great significance to evaluate the status quo of China's sports industry effectively, to summarize the reform achievements of the sports industry in the past, to find the problems in the development of the sports industry, and to tap the potential of high-quality development of the sports industry.

2. Literature review

The construction of sports industry evaluation system has important reference value for evaluating the development structure and level of China's sports industry. Huang Haiyan and Xu Kaijuan et al (2019) summarize the development process of China's sports industry statistics in a theoretical perspective and put forward suggestions for the optimization of China's sports industry statistics system from seven aspects. Yang Feng, used Porter diamond model and various carding statistical methods to build a prediction model for the output value of China's regional sports industry. Based on dynamic reform, efficiency reform, quality reform and the statistical data of sports industry in a city of China, Wang Chenxi and Man Jianghong constructed an evaluation index system of high-quality development of sports industry.

In recent years, many scholars also have put forward suggestions for the transformation, upgrading and healthy development of China's sports industry based on the internal and external environment. Lu Dong (2021) uses SWOT analysis method to study the opportunities and challenges faced by China's sports industry. Bao Xiaoming (2020) analyzed the complex and changeable domestic and foreign environments faced by China's sports industry during the "14th Five-year Plan" period, and put forward countermeasures for the development of the sports industry in combination with the COVID-19 epidemic and changes in the international political situation. Huang Haiyan (2020) theoretically summarized the bottlenecks existing in the development of China's sports industry and elaborated the implementation path of promoting China's sports industry to become a pillar industry according to the future situation.

To sum up, with China's sports industry entering the stage of rapid development, China's scholars' research on the evaluation indicators and status of the sports industry is also deepening. However, the construction of the sports industry evaluation system is limited to small regions, and the evaluation of the overall sports development level is limited in the theoretical stage, lacking reliable empirical model support. Based on the optimal weighting method, this paper selects reliable data to construct an empirical model for the evaluation of the development current situation of the sports industry.

3. Evaluation index system construction and data collection

According to the national economic accounting indicators in the "China Statistical Yearbook" issued by the National Bureau of Statistics, we select relevant economic indicators; according to the sports industry statistics announcement issued by the General Administration of Sport of China and the sports data in the "China Statistical Yearbook", we select the relevant sports indicators.

The evaluation index system of the development level of the sports industry consists of two first-level indexes:

The first is the economic index, which contains three secondary indexes, including per capita GDP representing the overall situation of the national economy, Engel coefficient representing the consumption structure of residents, and the household consumption level index representing the consumption ability.

The second is the sports index, which contains six secondary indexes, including added value of sports service industry, manufacturing industry and construction industry representing the sports industry growth situation; the number of athletes who won world championship representing the sports career development level; sports financial input representing the government financial support

and sports market index annual turnover representing activity in the sports market.

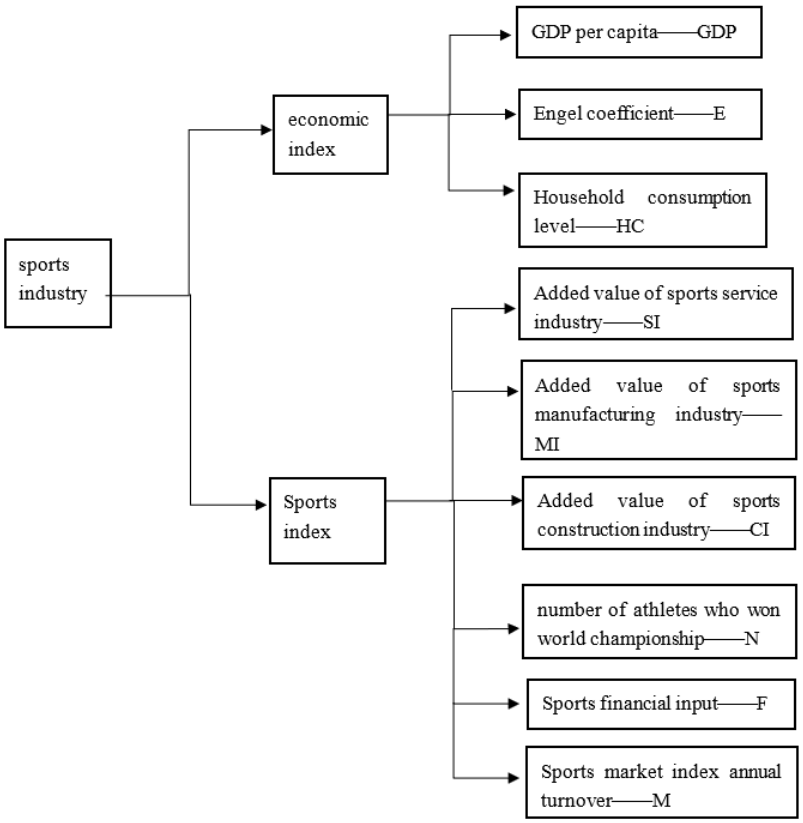

Fig. 1: Frame diagram of sports industry evaluation

This paper evaluates the development level of sports industry based on the time series data from 2006 to 2020 in China. The relevant data of per capita GDP, Engel coefficient, household consumption level and the number of athletes winning world champions come from China Statistical Yearbook. The data of added value of sports service industry, manufacturing industry and construction industry come from the annual data announcement of sports industry of the General Administration of Sport of China. The sports financial input from 2006 to 2012 is taken from the "Sports Financial Input, Development of Sports Financial Cause and Economic Growth", and the data of sports financial input from 2013 to 2020 are estimated according to its estimation method. Annual turnover of sports market index comes from Wind database.

4. Calculation method of index weight

4.1 Index weight calculation method based on AHP

Analytic Hierarchy Process (AHP) is a hierarchical weight decision analysis method by using network system theory and multi-objective comprehensive evaluation method. In this method, complex problems are decomposed into various factors based on in-depth analysis, and these factors are grouped into a hierarchical structure, according to the dominant relationship. The relative importance of each factor in the hierarchy can be determined by pair comparison. So AHP provides a more concise and practical decision-making method for solving complex problems.

1) Constructing judgment matrix

The judgment matrix is to judge the importance of two indexes, and the general structure of the judgment matrix is as follows.

$$\begin{bmatrix} C & C_1 & C_2 & C_3 \dots & C \\ C_1 & C_{11} & C_{12} & C_{13} \dots & C_{1n} \\ C_2 & C_{21} & C_{22} & C_{23} \dots & C_{2n} \\ C_3 & C_{31} & C_{32} & C_{33} \dots & C_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ C_n & C_{n1} & C_{n2} & C_{n3} & C_{nn} \end{bmatrix} \quad (1)$$

$C_i$and $C_j$represent the underlying element associated with $C.C_{ij}$represents the relative importance value of C_i compared to C_j. And so on, we compare the importance of each element in the same level with each element in the previous level and construct the judgment matrix.

The relative importance of each index is determined by pairwise comparison. The paper uses 1-9 scale to measure the importance of factors (as shown in Table 1).

Table 1 Grade 9 scale table

scale	meaning
1	Factor i is as important as factor$j$
3	Factor i is slightly more important than factor$j$
5	Factor i is more important than factor$j$
7	Factor i is much more important than factor$j$
9	Factor i is extremely more important than factor$j$
2, 4, 6, 8	The median of the two adjacent judgments aforesaid
reciprocal	The importance of factor j compared to i

2) Test the compatibility of judgment matrix

We need to conduct compatibility test on the constructed judgment matrix, and the calculation formula of its incompatibility degree is as follows:

$$CI = \frac{\lambda - max}{n-1} \quad (2)$$

If $CI = 0$, it indicates that the judgment matrix has complete consistency and the whole system has consistency. Professor Saaty also introduced the average random consistency index RI. The specific data is in the following table.

Table 2 Average random consistency index of dimensional vectors N

N	RI
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

According to the calculated $CI$and RI given by the table, we can calculate CR, according to $CR = CI/RI$, if $CR < 0.1$ it is considered that the judgment matrix compatibility is good, otherwise, we need to rejudge the judgment matrix.

3) Weight and synthesis score calculation

Hierarchical order uses the formula $CX = \lambda_{max}$. The we calculate the maximum eigenvalueλ_{max} of C, the corresponding eigenvector $X = (X_1, X_2, X_3, \cdots, X_n)^T$ and transform qualitative relationship to quantitative relation. Normalize the weight:

$$X_i^* = \frac{X_i}{\sum_1^n X_i} \quad i = (1,2,3,\cdots n) \quad (3)$$

4.2 Index calculation method based on entropy method

Entropy method is widely used in economic field to determine objective weight.

Data normalization:

As the measurement units of each index are not unified, the indexes should be standardized before calculating the comprehensive weight, which is convert the absolute value of the index to the relative value so as to solve the homogenization problem of different quality index values. As the selected economic and sports indicators are all positive indicators, we use the positive index standardization processing formula:

$$x'_{ij} = \frac{x_{ij} - min\{x_{1j},\cdots x_{nj}\}}{max\{x_{1j},\cdots x_{nj}\} - min\{x_{1j},\cdots x_{nj}\}} \quad (4)$$

x'_{ij}-- Calculate the standardized value of the i th year under index j in the evaluation system of sports industry; x_{ij}-- Actual value of year i under index j in sports industry evaluation system.

Calculate the proportion of i the scheme indicator value under item j

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} (i = 1,2,L,m; j = 1,2,L,n) \quad (5)$$

P_{ij}-- The proportion of the value of year i under index j in the sports industry evaluation system

Calculate the entropy value of item e_j

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

$$k = 1/\ln(n), \quad e_j \geq 0$$

e_j-- Entropy value of index j in sports industry evaluation system

Calculate information entropy redundancy:

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

g_j-- Entropy redundancy of index j in sports industry evaluation system

Calculate the weight of each indicator

$$w_j = \frac{g_j}{\sum_{j=1}^m g_j} \quad (8)$$

w_j-- The weight of index j in sports industry evaluation system

Calculate the synthesis score:

$$s_i = \sum_{j=1}^m w_j p_{ij} (9)$$

4.3 The principle of optimal weighting method

Both the analytic hierarchy Process and the entropy weight method mentioned above have certain disadvantages. The weight determination of the former is completely from subjective judgment, with

too much qualitative color.The latter, through strict mathematical deduction, tends to ignore the importance of the index itself and the subjective intention of decision-makers.The optimal weighting method is often used to analyze evaluation problems, and its core idea is the combination of analytic hierarchy process and entropy weight method, a method considers both subjective analysis and objective analysis. The calculation method is that the weight calculated by AHP method multiplied by a certain proportion plus the weight calculated by entropy method multiplied by a certain proportion, and then we obtain the optimal weight.

5. Calculation of sports industry evaluation index system

The model is calculated by using the evaluation index system of sports industry development level and the index weight calculation method introduced above.

(1) AHP weight calculation:

Table 3 Economic index judgment matrix

	GDP	E	HC
GDP	1	7	3
E	1/7	1	1/3
HC	1/3	3	1

CI = 0.0035, CR =0.0060<0.1, indicating good compatibility of judgment matrix.

Table 4 Sports index judgment matrix

	SI	MI	CI	N	F	M
SI	1	2	5	8	5	2
MI	1/2	1	3	5	3	1
CI	1/5	1/3	1	2	1	1/3
N	1/8	1/5	1/2	1	1/3	1/5
F	1/5	1/3	1	3	1	1/3
M	1/2	1	3	5	3	1

CI =0.0090, CR =0.0072<0.1, indicating good compatibility of judgment matrix.

According to the judgment matrix, the index weight of AHP is obtained

Table 5 Indicators of AHP and their weights

First grade indicators	The weight	Second grade indicators	The weight	AHP weight
Economic indicators	0.25	GDP	0.6694	0.16735
		E	0.0879	0.021975
		HC	0.2426	0.06065
Sports indicators	0.75	SI	0.3834	0.28755
		MI	0.211	0.15825
		CI	0.0746	0.05595
		N	0.039	0.02925
		F	0.081	0.06075
		M	0.211	0.15825

Seen from the table, the index weights obtained by AHP are in the following order: SI>MI>GDP>M>F>HC>CI>N>E

(2) Weight calculation by entropy weight method

According to the entropy weight calculation method introduced above, the calculation results of

each index are normalized to obtain the dimensionless data and the entropy weight.

Table 6 Entropy weight of each index

indicators	The weight
GDP	0.0627
E	0.0024
HC	0.0722
SI	0.3505
MI	0.0738
CI	0.1147
N	0.0639
F	0.0825
M	0.1773

Seen from the table, the ranking order of index weights obtained by entropy weight method is SI>M>CI>F>MI>HC>N>GDP>E

(3) Optimal weighting method calculation

The weight obtained by the analytic hierarchy process multiplied by the coefficient of 0.4 plus the weight obtained by the entropy weight method multiplied by the coefficient of 0.6 to obtain the weight of the optimal weighting method. The calculation results are shown in the table 7. The ranking results of weights of all indicators are consistent with the ranking results of entropy weight method. The results obtained from the completely subjective judgment of AHP is adjusted by objective adjustment to obtain the optimal weight of all indicators in the evaluation of sports industry.

Table 7 Weight calculation results of optimal weighting method

indicators	The weight
GDP	0.03762
E	0.00144
HC	0.04332
SI	0.2103
MI	0.04428
CI	0.06882
N	0.03834
F	0.0495
M	0.10638

6. Analysis and development suggestions of sports industry evaluation system

To sum up, the weight of sports indicators is much higher than that of the economic indicators. It can be seen that the development of the sports industry has its own rules of industrial development and unique driving force for industrial development, rather than rely too much on the development of the national economy. In recent years, the sports industry shows an upward trend of rapid development, and relevant data also show that the growth rate of China's sports industry from 2006 to 2019 is far beyond the national GDP growth rate. It can be seen that China's sports industry, as a sunrise industry, has great potential for high-quality development, and is expected to become a new economic growth point to promote economic development under the downward pressure of China's economy.

In the three different weight calculation methods, the weight of added value of sports service

industry is always the largest, so we can conclude that sports service industry is a key factor to promote the development of sports industry. Sports service industry, which belongs to the third industry, has such unique advantages as eco-friendly and high added value and has close links with belongs to the third industry. Therefore, it is of great significance to develop the sports service industry, in order to enhance linkages with other industries, broaden the boundaries of the sports industry and promote the transformation and upgrading of industrial sectors.In addition, the sports service industry is closely linked with mass sports, and the development of sports service industry can drive the people to participate in sports activities, so as to enrich sports culture and improve the physical quality and happiness of the national life. For instance, a sports event can drive the linkage of culture, media, tourism, real estate, catering and other industries; can greatly stimulate people's enthusiasm for sports and fitness and promote the development of community culture and the improvement of national cohesion.

Therefore, we should promote the development of sports service industry, enrich service supply mode, and improve service quality and efficiency. In addition, we should relax the limitation of access to sports service industry and simplify the examination and approval procedures for commercial and public sports events so as to allow more social capital and sports subjects to enter the sports service industry and promote the diversification of sports service. At the same time, we should also actively promote the integration of sports service industry and high-tech industry, so as to expand the radiation scope of the industry and better assist the development of sports industry.

It can be seen from the comparison of weights of various indicators within the economic indicators that the weight of residents' consumption level is relatively high. So we can conclude that with the continuous development of China’s economy and the improvement of people's living standards, people's consumption level is also constantly upgraded, consumption structure is constantly adjusted, and consumer products are more diversified. As a healthy consumption, happy consumption and development-oriented consumption, sports consumption is in line with people's demand for high quality life and spiritual civilization.

Therefore, in order to promote the high-quality development of China’s sports industry, consumption growth among the "three carriage" is an important driving force for the development of the industry, and a key factor to promote the development and upgrading of China’s sports industry. Meanwhile, stimulating the vitality of sports consumption also helps to meet people's growing high-quality and diversified consumer demand.

From the comparison of sports indexes, we can find that the wight of annual turnover of sports market index exceeds that of sports financial input. Since the announcement of "Several Opinions on Accelerating the Development of Sports Industry and Promoting Sports Consumption", the marketization degree of China’s sports industry has been continuously improved. The development of the sports industry no longer simply relies on the "nationwide system", but turns to depend on professional commercialization and marketization operation.

Therefore, it is of great significance to further activate the market mechanism of sports industry, promote the traditional drivers to be replaced by new ones, optimize the finance service in sports market, render tax incentives and policy support to the scientific and technical sports enterprises with great development potential, enrich and expand sports main market players and improve the market supervision system to guide the healthy sustainable development of sports market.

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