



## Analytic hierarchy process-based Chinese sports industry structure scheme optimization selection and adjustment research

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### ABSTRACT

Sports industry proportion in economic development contribution has been constantly rising, is newly-developed sunrise industry with incredibly dynamic. By far Chinese sports industry product proportion occupied in GDP is far less than European and American developed countries. Promote Chinese sports industry rapidly development, optimize sports industry structure is the key to perfect sports industry development. The paper according to analytic hierarchy process, discusses sports industry structure optimized schemes, and gets optimal scheme and implementation methods of adjusting each scheme.

**Key words:** Analytic hierarchy process, sports industry, industry structure optimization, optimal scheme

### INTRODUCTION

Sports industry structures are mutual correlated, industries correlation effects, motive power principle and coordination mechanism are complex and changeable, reasonable sports industry structure has important significances in sports industry healthy, rapidly development. To adjust sports industry structure and optimize industrial structure setting, different scholars put forward each kind of schemes. Formers have made lots of discussion in the schemes' merits [1-5].

The paper according to documents and interviewing experts, it establishes sports industry structure scheme selected hierarchical structure, researches sports industry institution scheme optimal problems from quantization perspective [6-9]. Finally it gets optimal scheme, which provides theoretical references for sports industry structure development.

Table 1: Sports hierarchical structure

Target layer	Criterion layer $B$	Scheme layer $C$
Sports industry optimization(A)	Increase sports demand structure( $B_1$ )	Improve government and market relations( $C_1$ )
	Strengthen sports supply structure( $B_2$ )	Perfect sports industry policies( $C_2$ )
	Perfect sports trade structure( $B_3$ )	Increase public service construction( $C_3$ )
	Perfect social structure( $B_4$ )	Establish sports industrial districts( $C_4$ )
	Intensify sports industries combination( $B_5$ )	

### SPORTS HIERARCHICAL SCHEME DEFINING

According to experts' opinions and documents, define criterion layer and scheme layer that speed up sports construction, as following Table 1.

#### Construct hierarchical structure

In analytic hierarchy process optimization decision-making algorithm, hierarchical structure mainly has three layers, 1, target layer(A), 2, criterion layer( $B^m$ ), 3, scheme layer ( $C^n$ ). According to criterion layer constraint conditions, calculate schemes weight sizes for multiple schemes, and according to weight sizes, rank and define schemes priorities. Sports industry structure optimization hierarchical structure is as following Figure 1.

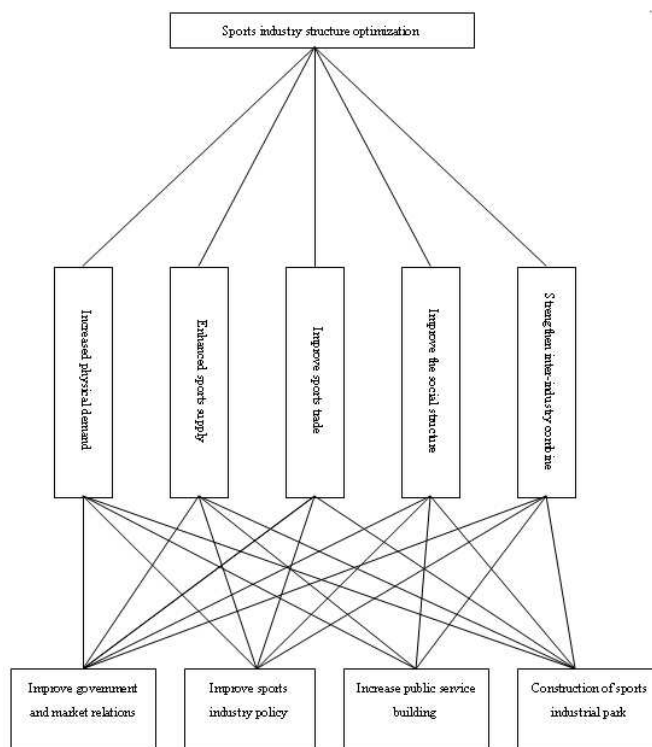


Figure 1: Sports industry structure optimization hierarchical structure

#### Judgment matrix

In sports industry structure optimization layers, criterion layer has five conditions  $B=(B_1, B_2, \dots, B_5)$ , which has restriction in target fulfillment. By comparing criterion importance, comparison result is using 1-9 or their reciprocal to express [10, 11].  $B_i, B_j$  Importance comparison structure is using  $a_{ij}$  to express, all comparison result composes judgment matrix A. Its expression is as following:

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{pmatrix}$$

Among them, after Saaty researching, it is thought that using 1~9 scale to express comparison structure conforms to people judgment ability. Use 1~9 numbers and their reciprocals to express  $a_{ij}$  value. Number respective expressive definitions are as following Table 2.

Table 2: 1-9 scale meaning

Scale	Meaning
1	Indicates two factors have equal importance by comparing
3	Indicates the former is slightly more important than the later by comparing two factors
5	Indicates the former is more important than the later by comparing two factors
7	Indicates the former is more important than the later by comparing two factors
9	Indicates the former is extremely more important than the later by comparing two factors
Even number	Represents importance is between two odd numbers
Reciprocal	Represents importance is between two odd numbers

**Weight vector and maximum feature value calculation**

Firstly, make normalization on all column vectors of A and get matrix D:

$$D = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \bullet \begin{pmatrix} 1/\sum_{i=1}^n a_{i1} & 0 & \cdots & 0 \\ 0 & 1/\sum_{i=1}^n a_{i2} & \cdots & 0 \\ 0 & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1/\sum_{i=1}^n a_{in} \end{pmatrix}$$

Matrix then carries out solving sum by line:

$$E = D \bullet (1 \ 1 \ \cdots \ 1)_{1 \times n}^T$$

$$E = (e_{11} \ e_{12} \ \cdots \ e_{1n})^T$$

Normalize matrix E and solve weight vector:

$$W = (w_1 \ w_2 \ \cdots \ w_n)^T = \left( e_{11} / \sum_{i=1}^n e_{i1} \ e_{12} / \sum_{i=1}^n e_{i2} \ \cdots \ e_{1n} / \sum_{i=1}^n e_{in} \right)^T$$

Maximum feature value, weight vector corresponding maximum feature value, then it surely has:

$$AW = \lambda_{\max} W$$

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{w_i}$$

**Consistency test**

$CI$  Represents matrix consistency indicator,  $CR$  represents matrix consistency ratio, test matrix consistency by

calculating the two indicators:  $CI = \frac{\lambda_{\max} - n}{n - 1}$ , among them,  $n$  represents judgment matrix one layer factors number,

and meanwhile it also the matrix order:  $CR = \frac{CI}{RI}$ .

Among them,  $RI$  represents Random Consistency Index value, as following Table 3 show.

Table 3: RI value table

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Assume in layer B that m pieces of factors values computational result is  $\alpha_m$ , corresponding consistency indicator value is respectively  $CI_m$ , in next layer C, n pieces of factors to layer A computational weight is  $\beta_{nm}$ , then layer

C factors total arrangement weight is:  $w_i = \sum_{j=1}^m \alpha_j \beta_{ij}$ .

$$CR = \frac{\sum_{j=1}^m \alpha_j CI_j}{\sum_{j=1}^m \alpha_j RI_j}$$

Combination consistency test consistency ratio is:

Judgment criterion whether matrix meets consistency or not is: when  $CR \geq 0.1$ , it is reasonable. When  $CR < 0.1$ , it is unreasonable.

## SPORTS INDUSTRY STRUCTURE ADJUSTMENT OPTIMAL SCHEME

### Criterion layer and scheme layer weight vector calculation

According to Table 1, sports development hierarchical structure constructed judgment matrix and calculation weight vector are respectively as following Table 4-9.

Table 4: Factor B to target A importance weight

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	W
B <sub>1</sub>	1	1	1/7	1/3	1/5	0.058
B <sub>2</sub>	1	1	1/7	1/3	1/5	0.058
B <sub>3</sub>	7	7	1	3	2	0.456
B <sub>4</sub>	3	3	1/3	1	1	0.183
B <sub>5</sub>	5	5	1/2	1	1	0.246

Table 5: Scheme C to criterion B<sub>1</sub> importance weight

B <sub>1</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	W
C <sub>1</sub>	1	3	7	8	0.576
C <sub>2</sub>	1/3	1	5	5	0.276
C <sub>3</sub>	1/7	1/5	1	3	0.097
C <sub>4</sub>	1/8	1/5	1/3	1	0.052

Table 6: Scheme C to target B<sub>2</sub> importance weight

B <sub>2</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	W
C <sub>1</sub>	1	2	3	1/5	0.166
C <sub>2</sub>	1/2	1	3	1/7	0.114
C <sub>3</sub>	1/3	1/3	1	1/9	0.055
C <sub>4</sub>	5	7	9	1	0.665

Table 7: Scheme C to target B<sub>3</sub> importance weight

B <sub>3</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	W
C <sub>1</sub>	1	3	7	5	0.598
C <sub>2</sub>	1/3	1	2	1	0.170
C <sub>3</sub>	1/7	1/2	1	1/2	0.082
C <sub>4</sub>	1/5	1	2	1	0.150

Table 8: Scheme C to target  $B_4$  importance weight

$B_4$	$C_1$	$C_2$	$C_3$	$C_4$	$W$
$C_1$	1	1	1/5	3	0.148
$C_2$	1	1	1/5	3	0.148
$C_3$	5	5	1	9	0.647
$C_4$	1/3	1/3	1/9	1	0.057

Table 9: Scheme C to target  $B_5$  importance weight

$B_5$	$C_1$	$C_2$	$C_3$	$C_4$	$W$
$C_1$	1	2	5	3	0.483
$C_2$	1/2	1	3	1	0.229
$C_3$	1/5	1/3	1	1/3	0.080
$C_4$	1/3	1	3	1	0.208

**Computed result, consistency test**

Carry out consistency test and combination consistency test on above five judgment matrixes' weight vector calculation, maximum feature value and consistency test indicator list as following Table 10-11.

Table 10: Selection scheme weight and test indicator

B W C	$B_1$	$B_2$	$B_3$	$B_4$	$B_5$
$C_1$	0.058	0.058	0.456	0.183	0.246
$C_2$	0.576	0.166	0.598	0.148	0.483
$C_3$	0.276	0.114	0.170	0.148	0.229
$C_4$	0.097	0.055	0.082	0.647	0.080
$C_5$	0.052	0.665	0.150	0.057	0.208
$\lambda_j$	4.206	4.108	4.026	4.032	4.033
$CR_j$	0.076	0.038	0.0096	0.012	0.012

Table 11: Scheme layer total arrangement weight table

Target layer	Scheme layer	Weight
Sports industry optimization(A)	Improve government and market relations( $C_1$ )	0.4616
	Improve sports industry policy( $C_2$ )	0.1836
	Increase public service building( $C_3$ )	0.1843
	Construction of sports industrial park( $C_4$ )	0.1716

**CONCLUSION**

In sports industry structure optimization schemes, according to analytic hierarchy process calculation, it gets "improve government and market relations" scheme weight is the maximum one, therefore optimal scheme should work on transforming government functions, well handling with market and government relations, construct market-oriented sports industry. The scheme should be priority considered in concrete implementation.

Improve government and market relations have comprehensive advantages, its prominent advantage is that it can perfect sports trade structure, which has largest impacts on sports trade. Perfect sports industry policy's prominent

advantage is increasing sports demand, improving market demand ability. Increase public service construction's prominent advantage is perfecting social structure, improving sports industry structure survival environment. Prominent advantage is increasing sports supply structures that can vigorously promote sports production manufacturing development, strengthening sports product and service supply. Different districts sports industry structure has specificities, government selects proper schemes according to practical situations to propel to sports industry development and optimize industry structure.

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