The Evaluation of Stadium Status in China Based on Fuzzy Comprehensive Evaluation

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Abstract

With rapid development of economy, China has witnessed increasing development of sports industry which is regarded as a social cultural phenomenon. On this basis, the stadium, as the essential part of sports industry, is constantly developing. In this research, questionnaire and literature analysis and cluster analysis were adopted to determine the comprehensive evaluating indexes of domestic stadium status and sorted the indexes determined. Then, by taking Hongkan stadium in Shanghai as research object, the mathematical model of evaluating the domestic stadiums based on fuzzy comprehensive evaluation (FCE) was constructed. The conclusion showed that the level of stadium is sorted as level 2 with evaluated score of 71.53. These results indicate that the construction and management of domestic stadiums need to be improved further.

Keywords: FCE; stadium; evaluation system

1 Introduction

Since reform and opening-up in China, Chinese residents have seen increasing improvement of living standards. Meanwhile, the successful host of Beijing Olympic Games in 2008 attracts more people to participate into physical exercises. So, stadium is more popular now. At present, lots of studies on domestic stadium have been made.

Previous researches into stadium status in China have made achievements. For instance, Han changsong performed a study on the stadium resource status in China [1], and analyzed the disadvantages of the stadiums in colleges of Hubei province, China by taking the stadiums in the colleges of Hubei as an example. Besides, he provided suggestions to the exploration and utilization of stadium resources. Zhou Qing made a research into construction and management of stadium in 2009 [2-4]. By using several methods, he analyzed the construction and management status of large scale stadium; in addition, he concluded the strategies of performing construction and management of stadium in China through case study.

Based on existing studies, this research conducted a further research on the status of stadium in China. By taking Shanghai Hongkan stadium as a research object, a mathematical model of evaluating Hongkan stadium based on CFE was constructed using mathematical theory and formula. The results obtained are ideal and provide a theoretical supports for the development of relating research.

2 The Model Establishmen

2.1CLUSTER ANALYSIS OF COMPREHENSIVE EVALUATION INDEXES

People usually judge the scale of one stadium according to its accommodation. However, with popularization of network; a majority of audiences prefer to watch sport games at home by network. So, traditional evaluation view does not accord with this case [5-8]. To perform comprehensive evaluation on stadium, the authors inquired many experts, management staffs of different stadiums based on the large amount of corresponding data. This research consequently determined the comprehensive evaluation indexes of stadium [9-12]. In order to well analyze the relationship among each index, we drew cluster analysis graph of evaluation indexes as shown in Figure 1.

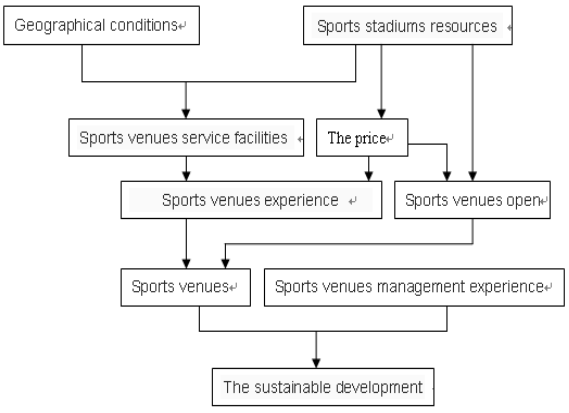

FIGURE 1. The cluster analysis of comprehensive judging Quota of the stadia and gymnasia

2.2 CONSTRUCTION OF FCE BASED MATHEMATICAL MODEL

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2.2.1 FCE

FCE is a method which is used to achieve a goal by considering the multiple influences of various factors on one object under fuzzy environment.

Two finite domains are set as follows :

$$U=\{u_1,u_2,\cdots\cdots,u_n\} \quad (1)$$

$$V=\{v_1,v_2,\cdots\cdots,v_n\} \quad (2)$$

Where U is factor set which is the set consisting of multiple factors based on comprehensive evaluation.

V is judgment set or comment set. It denotes the set constituted by various decisions

Generally, owing to the influences of each factor in U on evaluating objects are different, thus ??

The weigh allocation of factors in U is a fuzzy vector

$$A=(a_1,a_2,\cdots a_n)\ \in\ F(U) \quad (3)$$

Accumulating membership degree principle

A is the weight of each factor in U and satisfy $\sum_{i=1}^{n}a_i=1$. Besides, m comments are not necessarily absolute, so they are considered as the fuzzy set in *V* after conducting comprehensive evaluation

$$B=(b_1,b_2,\cdots b_m)\ \in\ F(V) \quad (4)$$

b indicates the role of each comment in *V* based on comprehensive evaluation.

If the fuzzy relationship from U to *V* is $R=(r_{ij})\ n\times m$,T_R, as a fuzzy conversion can be obtained using R. Therefore, the FCE based mathematical model is obtained as

(1) Factor set $U=\{u_1,u_2\ \cdots u_n\}$;

(2)Judgment set $V=\{v_1,v_2,\cdots,v_n\}$;

(3) Construction of fuzzy conversion

$$T_R{=}F(U)\rightarrow F(V)$$

$$A/\rightarrow A\cdot R$$

Where the fuzzy relationship matrix R from U to *V* is presented as

$$R=(r_{ij})\ n\times m \quad (5)$$

Hence, a ternary $(U,\ V,\ R)$ FCE based mathematical model was obtained. By assigning $A=(a_1,a_2,\cdots a_n)\ \in\ F(U)$ by input a weight, a corresponding comprehensive evaluation $B=(b_1,b_2,\cdots b_m)\ \in\ F(V)$ can be acquired

$$(b_1,b_2,\cdots b_m)\ =\ (a_1\ ,\ a_2\ ,\ a_n)\begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ & & \cdots\cdots & \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{vmatrix} \quad (6)$$

(4) Comprehensive evaluation: For $A=\{a_1,a_2,\cdots,a_n\}$, we calculate $B=A\circ R$.The evaluation needs to be made according to maximum membership degree principle.

2.2.2 Establishment of CFE based mathematical model for the stadiums in China

(1)Determination of factor set u. nine factors are selected as evaluating indexes as shown in table 1:

TABLE 1 Evaluation indexes of stadium

Factors	*Evaluation indexes*
u_1	Location condition
u_2	Stadium resource
u_3	Service facilities in Stadium
u_4	Price
u_5	Stadium experience
u_6	Opening up of stadium
u_7	Images of stadium
u_8	Management of stadium
u_9	Sustainable development

Those indexes in table 1 are closely related with each other. Based on such characteristics, u is divided into three factor sets as follows.

$U_1=\{u_1\ ,\ u_2\}$ U_1 refers to hard environment factors in stadium

$U_2=\{u_3\ ,u_4\ ,u_5\ ,u_6\ ,u_7\ ,\ u_8\}$ U_2 denotes the soft environment factors in stadium

$U_3=\{u_9\}$ U_3 represents the sustainable developing factors

So, we get $U=\{U_1\ ,U_2\ ,U_3\}$

(2) Determination of weights of each evaluation index

The representing method of weights is shown as:

$w=\{\mu_1,\mu_2,\cdots,\mu_m\},m=1,2,\cdots,7$ Where $\sum_{m=1}^{7}\mu_m=1$

There are many ways of identifying the weights of evaluation indexes such as analytic hierarchy process, normalization method and Dual contrast coefficient. In this research, the experts are invited to compare two indexes in one factor set. According to contribution of different indxes on evaluating object, different values are given. On this basis, Dual contrast coefficient is employed to determine weight of each index. The indexes system is illustrated in table 2.

TABLE 2 Comprehensive evaluation index system

U	*Weight*	u	*Weights*
Hard environment in stadium	0.560	Location condition	0.321
		Stadium resources	0.669
		Stadium image	0.058
		Price	0.120

		Stadium experiences	0.175
Soft environment in stadium	0.289	Stadium service facilities	0.295
		Stadium opening	0.120
		Stadium management	0.233
Sustainable development	0.150		

(3) Determination of comment set V

$$V=\{V_1, V_2, V_3, V_4\}$$

Where V_1 represents that stadium is in level I; V_2 represents level II; V_3 is level III; V_4 is level IV.

(4) Two-grade comprehensive evaluation of sub factor set

To obtain more accurate and real data, we randomly investigated the experts. The data were obtained based on the experts 'scores of each factor in V based on level I, II, III, and IV, by using weighted average method.

Different matrixes of varied factor sets were got as:

The matrix of U_1 is

$$R_1=\begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \end{vmatrix} \tag{7}$$

The matrix for U_2 is

$$R_2=\begin{vmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \\ b_{51} & b_{52} & b_{53} & b_{54} \\ b_{61} & b_{62} & b_{63} & b_{64} \end{vmatrix} \tag{8}$$

The matrix of U_3 is presented as

$$R_3=|c_1, c_2, c_3, c_4|$$

By allocating weights, weight vectors of each factor in sub factor set are obtained.

$$A_1=(a_1', a_2')=(0.321, 0.669) \tag{9}$$

$$A_2=(b_1', b_2', b_3', b_4', b_5', b_6') \tag{10}$$
$$=(0.058, 0.120, 0.175, 0.295, 0.120, 0.233)$$

$$A_3=(c')=0.150 \tag{11}$$

$b_1=A_1*R_1$ is deduced based on abovementioned fuzzy conversion form U to V.

(5) first grade comprehensive evaluation

b_1, b_2, b_3 are used to form a single factor evaluation matrix with U_1, U_2, U_3 as elements.

$$R=\begin{vmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \end{vmatrix} \tag{12}$$

The weights allocations of U_1, U_2, U_3 is

$$A=(R_1, R_2, R_3)=(0.560, 0.289, 0.150)$$

Hence, the first grade comprehensive evaluation is acquired as

$$B=A*R=\begin{vmatrix} 0.560 \\ 0.289 \\ 0.150 \end{vmatrix}^T * \begin{vmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \end{vmatrix} \tag{13}$$

The result obtained is $B=(t_1, t_2, t_3, t_4)$

(6) Evaluation for ranks and scores of stadium

The rank of the object is evaluated using accumulating membership degree principle. The final comprehensive evaluation results are (t_1, t_2, t_3, t_4). Namely, when $\sum_i t_k \geq 50\%$, the comments corresponding to t_i are taken as evaluation results.

In order to evaluate stadium precisely, sub set $Q=(100, 75, 50, 25)$ is build in V. The comprehensive score of each stadium is $C=B*Q^T$.

(7)Cases analysis

Based on mathematical model proposed, Hongkan stadium was comprehensively evaluated. To specific the results, the scores are given.

1)Determination of V and single factor fuzzy evaluation matrix R_{ij}.

By identifying V, let V = (I, II, III, IV), then conduct valuation on Q, we obtain $Q=(100, 75, 50, 25)$.

In the meantime, this research made a statistics on the evaluation results given by ten experts. The evaluation results of two factors in Hongkan stadium by ten experts are presented in table 3.

TABLE 3 Determination results1

	I	II	III	IV
V_{11}	5	3	2	0
V_{12}	6	4	0	0

According to table 3, it is obtained that the fuzzy evaluation matrix of V_1 in V.

$$R_1=\begin{vmatrix} 0.4 & 0.4 & 0.2 & 0.0 \\ 0.6 & 0.4 & 0.0 & 0.0 \end{vmatrix} \tag{14}$$

The evaluation results of six factors in Hongkan stadium by ten experts are shown in table 4.

TABLE 4 Determination results 2

	I	II	III	IV
V_{21}	2	4	2	2
V_{22}	2	0	4	4
V_{23}	2	2	4	2
V_{24}	6	2	2	0
V_{25}	6	4	0	0
V_{26}	4	4	2	0

The fuzzy evaluation matrix of V_2 in V is acquired.

$$R_2=\begin{vmatrix} 0.2 & 0.2 & 0.4 & 0.2 \\ 0.2 & 0.0 & 0.4 & 0.4 \\ 0.2 & 0.2 & 0.4 & 0.2 \\ 0.6 & 0.2 & 0.2 & 0.0 \\ 0.6 & 0.4 & 0.0 & 0.0 \\ 0.4 & 0.4 & 0.2 & 0.0 \end{vmatrix} \tag{15}$$

The evaluation results for the six factors in soft environment of stadium are given by ten experts, as shown in table 5.

TABLE 5 Evaluation results 3

	I	II	III	IV
V_{31}	6	2	2	0

The fuzzy evaluation matrix of V_3 in V

$$R_3 = |0.6 \quad 0.2 \quad 0.2 \quad 0.0| \tag{16}$$

2) Multilevel evaluation

By conducting evaluation on each two grade factors in V_1, we obtain

$$b_1 = A_1 * R_1 = \begin{vmatrix} 0.321 \\ 0.669 \end{vmatrix}^T * \begin{vmatrix} 0.4 & 0.4 & 0.2 & 0.0 \\ 0.6 & 0.4 & 0.0 & 0.0 \end{vmatrix} = (0.5298, 0.396, 0.0642, 0.0) \tag{17}$$

In same way,

$$b_2 = \begin{vmatrix} 0.058 \\ 0.120 \\ 0.175 \\ 0.295 \\ 0.120 \\ 0.233 \end{vmatrix}^T * \begin{vmatrix} 0.2 & 0.2 & 0.4 & 0.2 \\ 0.2 & 0.0 & 0.4 & 0.4 \\ 0.2 & 0.2 & 0.4 & 0.2 \\ 0.6 & 0.2 & 0.2 & 0.0 \\ 0.6 & 0.4 & 0.0 & 0.0 \\ 0.4 & 0.4 & 0.2 & 0.0 \end{vmatrix} = (0.4128, 0.2468, 0.2462, 0.0946) \tag{18}$$

$$b_3 = 0.150 * |0.6 \quad 0.2 \quad 0.2 \quad 0.0| = (0.09, 0.03, 0.03, 0.0) \tag{19}$$

By combing R and A, the final comprehensive evaluation results B were obtained.

$$B = A * R = \begin{vmatrix} 0.560 \\ 0.289 \\ 0.150 \end{vmatrix}^T * \begin{vmatrix} 0.5298 & 0.396 & 0.0642 & 0.0 \\ 0.4128 & 0.2468 & 0.2462 & 0.0946 \\ 0.09 & 0.03 & 0.03 & 0.0 \end{vmatrix} = (0.429, 0.298, 0.112, 0.027) \tag{20}$$

3) Evaluation of ranks and scores of Hongkan stadium

Based on accumulating membership degree principle, we obtain $t_1 + t_2 = 0.429 + 0.298 = 0.727 > 0.5$. So Hongkan stadium is level II with score of 71.53 after performing comprehensive evaluation.

$$C = B * Q^T = (0.429, 0.298, 0.112, 0.027) * (100, 75, 50, 25)^T = 71.53 \tag{21}$$

7 Conclusion

On the basis of the status of stadiums in China, this study made a comprehensive evaluation analysis. On this basis, a FCE based mathematical model for stadium was established by using Hongkan stadium in Shanghai as an example. The calculation results showed that the stadium requires to be updated to level I I stadium with evaluation score of 71.53. The results infer that current status of domestic stadiums is good, but the construction and management of stadiums still need to be improved.

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