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Study of Athletic Ability Evaluation Model for Professional Football Teams Based on the Extension Theory

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The athletic ability evaluation on professional football teams is a complicated decision-making process with multi-attribute and at multi-level. Fuzzy decision information during the analysis of athletic ability of professional football teams is studied with the combination of qualitative and quantitative methods and an athletic ability evaluation model is proposed based on the extension theory. Firstly, factors that influence the athletic ability of professional football teams are analysed, according to which the evaluation indictors are confirmed. Secondly, based on the extension theory, the matter-element model is established to analyse the athletic ability of professional football teams. The matter-element models for classic domain and for sector domain are constructed according to the grade of the athletic ability. Next, the extension correlation degree is computed according to the extension distance and the extension correlation coefficient between the object under evaluation and the classic domain or the sector domain of indicators. From the extension correlation degree, the object can be evaluated. Last but not the least, the model is verified through a case study.

1. Introduction

Football is such a sport that emphasizes skills, tactics and individual ability. It attracts more and more sports lovers owing to the instinct passion for sport and a unique style of performance. As the development of competitive sports, professional football teams pay more attention to competitive skills and spare no effort to develop themselves. The evaluation of athletic ability has become one of the concerns of professional football teams [Guo (2007), Huang (2013) and wang (2010) reported]. In recent years, studies of athletic ability of professional football teams have taken off. Some researchers comprehended the issue from different perspectives and yielded fruitful results[chen (2012), Deng(2010), Du(2014) ,Yang (2004) and Zhu et al (2012) reported].However, the evaluation of athletic ability of professional football teams is intertwined with various factors, some of which are fuzzy and uncertain. Existing methods and models have some limitations. For example: (1) traditional method of fuzzy mathematical calculation fails to deal with fuzzy information as it defines the indicator value before the analysis of athletic ability, which is not fuzzy analysis virtually; (2) traditional methods fail to treat the relation of position in fuzzy information interval and result in errors; (3) the evaluation system and model of athletic ability is not modelled. Therefore, this paper proposes to study the athletic ability of professional football teams based on extension [CAI Et Al (2013), Ti et al (2014), Y et al (2014) and Zhai et al (2014) reported]. An athletic ability evaluation model is established as an improvement of relevant studies.

2. Indicators of athletic of professional football teams and the matter-element model

2.1 Indicators and the evaluation index system of athletic ability

After literature review, questionnaire analysis and consultation with experts in this field, following the scientific principle, the objective principle, the comprehensive principle, the principle of subjectivity and the comparable principle, this paper establishes three criteria layers for athletic ability analysis, namely ability of coaching staff, team building and ability of individual athletes. Indicators under each criteria layer are shown in Table 1.

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Table 1: Index system of athletic ability of professional football teams

System layer	Criteria layer	Index layer
The index system of athletic ability of professional football teams U	Ability of coaching staff U_1	Game strategy arrangement u_{11}
		Adjustments during games u_{12}
		Team training ability u_{13}
		Basic qualities u_{14}
		Coordination and organization skills u_{15}
	Team building U_2	Capital investment u_{21}
		Echelon building u_{22}
		Team management u_{23}
		Construction of incentive mechanism u_{24}
		Team cohesion u_{25}
	Ability of individual athletes U_3	Athletic quality u_{31}
		Athletic skill u_{32}
		Athletic function u_{33}
		Psychological quality u_{34}
		Cooperation and coordination ability u_{35}
		Tactic execution ability u_{36}
		Wisdom during games u_{37}

2.2 Matter-element model of athletic ability

According to the concept and model of matter-element in extents, a matter-element model for athletic ability of professional football teams can be established. Corresponding to the layers and the content in Table 1, the matter-element model $\boldsymbol{R}_U$ is:

$$\boldsymbol{R}_U = \begin{bmatrix} U & U_1 & V(U_1) \\ & U_2 & V(U_2) \\ & U_3 & V(U_3) \end{bmatrix} \tag{1}$$

Where $V(U_1)$, $V(U_2)$ and $V(U_3)$ refer to the value of indicator set U_1, U_2 and U_3.

The matter-element models of the criteria layer can be expressed by $\boldsymbol{R}_{U_i}, 1 \le i \le 3$:

$$\boldsymbol{R}_{U_i} = \begin{bmatrix} U_i & u_{i1} & v(u_{i1}) \\ & u_{i2} & v(u_{i2}) \\ & \vdots & \vdots \\ & u_{in} & v(u_{in}) \end{bmatrix} \tag{2}$$

3. Athletic ability evaluation model for professional football teams based on the extension theory

3.1 Standardization of indicators

There are two categories of indicators for athletic ability evaluation, namely quantitative indicator and qualitative indicator. It is necessary to standardize them. For qualitative indicators, a 0-1 ratio scale is used to measure the value of indicator. The value $v(u_j)$ of indicator j is expressed as:

$$v(u_j) = \left[v^a(u_j), v^b(u_j)\right], \quad 0 \le v^a(u_j) \le v^b(u_j) \le 1 \tag{3}$$

Where, 0 is the worst state and 1 is the best state.

For quantitative indicators, if the original value of indicator j is $v^*(u_j) = \left[v^{*-a}(u_j), v^{*-b}(u_j)\right]$, and when it is a the bigger-the better positive indicator, the standardized value $v(u_j)$ is:

$$v\left(u_j\right)=\left[v^a\left(u_j\right),v^b\left(u_j\right)\right]=\left[v^{*-a}\left(u_j\right)/v_+^{*-b}\left(u_j\right),v^{*-b}\left(u_j\right)/v_+^{*-b}\left(u_j\right)\right] \tag{4}$$

Where: $v_+^{*-b}\left(u_j\right)$ is an ideal positive value of indicator j.

If the original value of indicator j is $v^*\left(u_j\right)=\left[v^{*-a}\left(u_j\right),v^{*-b}\left(u_j\right)\right]$, and when it is the smaller-the better positive indicator, the standardized value $v\left(u_j\right)$ is:

$$v\left(u_j\right)=\left[v^a\left(u_j\right),v^b\left(u_j\right)\right]=\left[v_-^{*-b}\left(u_j\right)/v^{*-b}\left(u_j\right),v_-^{*-b}\left(u_j\right)/v^{*-a}\left(u_j\right)\right] \tag{5}$$

Where: $v_+^{*-b}\left(u_j\right)$ is an ideal negative value of indicator j.

3.2 Classic domain matter-element and section domain matter-element

Suppose there are m grades in the athletic ability evaluation. The classic domain matter-element of different grades for indicators can be established after standardization.

The matter-element R_i^C of Grade $i\left(1<i<m\right)$ is:

$$R_i^C=\left[N_i,C,V\right]=\begin{bmatrix} N_i & c_{i1} & \langle v_{i1}^a,v_{i1}^b\rangle \\ & c_{i2} & \langle v_{i2}^a,v_{i2}^b\rangle \\ & \vdots & \vdots \\ & c_{in} & \langle v_{in}^a,v_{in}^b\rangle \end{bmatrix} \tag{6}$$

Among them, $v_{1j}^a=0$, $v_{mj}^b=1$.

On the basis of m grades of matter-element for indicator j, the section domain matter-element model R_o^C of indicator j can be constructed:

$$R_o^C=\left(N_o,C,V\right)==\begin{bmatrix} N_0 & c_{01} & v_{01} \\ & c_{02} & v_{02} \\ & \vdots & \vdots \\ & c_{0n} & v_{0n} \end{bmatrix}=\begin{bmatrix} N_0 & c_{01} & \langle 0,1\rangle \\ & c_{02} & \langle 0,1\rangle \\ & \vdots & \vdots \\ & c_{0n} & \langle 0,1\rangle \end{bmatrix} \tag{7}$$

3.3 Extension distance and extension correlation function

Through survey, questionnaire and statistical analysis, the values of indicators of athletic ability of professional football teams are available. So the matter-element model R_D for the object under evaluation is:

$$R_D=\left[N_D,C,V\right]=\begin{bmatrix} N_D & c_{D1} & \langle v_{D1}^a,v_{D1}^b\rangle \\ & c_{D2} & \langle v_{D2}^a,v_{D2}^b\rangle \\ & \vdots & \vdots \\ & c_{Dn} & \langle v_{Dn}^a,v_{Dn}^b\rangle \end{bmatrix} \tag{8}$$

According to the extension theory, the extension distance $\rho_D\left(ij\right)$ between matter-element R_D and the classic domain R_i^C of Grade i about the j-th matter element is:

$$\rho_D\left(ij\right)=\left(\rho_D^{v_{Dj}^a}\left(ij\right)+\rho_D^{v_{Dj}^b}\left(ij\right)\right)/2 \tag{9}$$

Among them, $\rho_D^{v_{Dj}^a}\left(ij\right)=\left|v_{Dj}^a-\frac{v_{ij}^a+v_{ij}^b}{2}\right|-\frac{v_{ij}^b-v_{ij}^a}{2}$, $\rho_D^{v_{Dj}^b}\left(ij\right)=\left|v_{Dj}^b-\frac{v_{ij}^a+v_{ij}^b}{2}\right|-\frac{v_{ij}^b-v_{ij}^a}{2}$.

Similarly, the extension distance $\rho_o\left(ij\right)$ between matter-element R_D and the classic domain R_i^C of Grade i about the j-th matter element is:

$$\rho_o\left(ij\right)=\left(\rho_o^{v_{Dj}^a}\left(ij\right)+\rho_o^{v_{Dj}^b}\left(ij\right)\right)/2 \tag{10}$$

Among them， $\rho_o^{v_{Dj}^a}(ij) = \left|v_{Dj}^a - \frac{1}{2}\right| - \frac{1}{2}$ ， $\rho_o^{v_{Dj}^b}(ij) = \left|v_{Dj}^b - \frac{1}{2}\right| - \frac{1}{2}$

Therefore, the extension correlation coefficient $k(ij)$ between matter-element R_D and the classic domain R_i^C of Grade i about the j -th matter element is:

$$k(ij) = \begin{cases} -\rho_D(ij)/\left|v_{ij}\right| & \left\langle v_{Dj}^a, v_{Dj}^b \right\rangle \in \left\langle v_{ij}^a, v_{ij}^b \right\rangle \\ \rho_D(ij)/\left(\rho_o(ij) - \rho_D(ij)\right) & \left\langle v_{Dj}^a, v_{Dj}^b \right\rangle \notin \left\langle v_{ij}^a, v_{ij}^b \right\rangle \end{cases} \quad (11)$$

3.4 Weight allocation based on comprehensive analysis method

The influence of indicators on the evaluation of athletic ability of professional football teams can be distinct under different principles. Therefore, weight should be given to indicators to make the evaluation more reliable. This paper adopts the comprehensive analysis method to allocate weight. Assume p experts are invited. 0-1 ratio scale is used to score on n indicators. The initial judgment matrix $\boldsymbol{A}$ is:

$$\boldsymbol{A} = \left[a_{ij}\right]_{pxn} \quad (12)$$

The weight w_j of indicator j of athletic ability of professional football teams is:

$$w_j = \sum_{s=1}^{p} a_{st} / \sum_{t=1}^{n} \sum_{s=1}^{p} a_{st} \quad (13)$$

3.5 Extension correlation degree and realization of the algorithm

With the acquirement of the extension correlation coefficient $k(ij)$ between matter-element R_D and the classic domain R_i^C of Grade i about all matter-elements, the extension correlation degree $\lambda(i)$ can be calculated:

$$\lambda(i) = \frac{1}{n}\sum_{j=1}^{n} k(ij) \quad (14)$$

If the weight w_j of indicators is considered, the weighed extension correlation degree between matter-element R_D and the classic domain R_i^C of Grade i about the j -th matter element, the extension correlation degree $\lambda(i)$ can be calculated as:

$$\lambda_w(i) = \sum_{j=1}^{n} \left(w_j * k(ij)\right) \quad (15)$$

Thus, according to the extension correlation degree, the grade of the object can be judged. If it satisfies:

$$\lambda_w(k) = \max_{1 \le i \le m}\left(\lambda_w(i)\right) \quad (16)$$

4. Case study

Performance prediction, development and planning and tactic management for a football team should be based on present athletic ability and state of the team. Consequently, the athletic ability of a team participating in A-class League is studied, in order to verify the model. After consulting with experts and team managers, the athletic ability of a team is divided into four grades, namely excellent (grade 4), good (grade 3), mediocre (grade 2) and poor (grade 1). The classic domain and the section domain of indicators are shown in Table 2.

Table 2: Classic domain and section domain of indicators

Grades	Classic domain	Section domain
Grade 4	0.9-1.0	0-1.0
Grade 3	0.8-0.9	0-1.0
Grade 2	0.6-0.8	0-1.0
Grade 1	0-0.6	0-1.0

On the basis of the survey and statistical analysis, the matter-element models $\boldsymbol{R}_{U_1}$, $\boldsymbol{R}_{U_2}$ and $\boldsymbol{R}_{U_3}$ of athletic ability of this professional football teams are expressed below:

$$\boldsymbol{R}_{U_1}=\begin{bmatrix} U_1 & u_{11} & \langle 0.75,0.85\rangle \\ & u_{12} & \langle 0.80,0.90\rangle \\ & u_{13} & \langle 0.80,0.90\rangle \\ & u_{14} & \langle 0.80,0.90\rangle \\ & u_{15} & \langle 0.75,0.85\rangle \end{bmatrix}, \quad \boldsymbol{R}_{U_2}=\begin{bmatrix} U_2 & u_{21} & \langle 0.80,0.90\rangle \\ & u_{22} & \langle 0.70,0.80\rangle \\ & u_{23} & \langle 0.75,0.85\rangle \\ & u_{24} & \langle 0.70,0.80\rangle \\ & u_{25} & \langle 0.60,0.70\rangle \end{bmatrix} \quad \boldsymbol{R}_{U_3}=\begin{bmatrix} U_3 & u_{31} & \langle 0.70,0.80\rangle \\ & u_{32} & \langle 0.75,0.85\rangle \\ & u_{33} & \langle 0.80,0.90\rangle \\ & u_{34} & \langle 0.60,0.70\rangle \\ & u_{35} & \langle 0.80,0.90\rangle \\ & u_{36} & \langle 0.70,0.80\rangle \\ & u_{37} & \langle 0.70,0.80\rangle \end{bmatrix}$$

According to the formula introduced in this paper, the extension distance (See Table 3) and the extension correlation coefficient (See Table 4) between the matter-element and different grades are computed below.

Table 3: Extension distance of athletic ability

Criteria layer	Index layer	Grades				Section domain
		Grade 4	Grade 3	Grade 2	Grade 1	
U_1	u_{11}	0.10	0	0	0.20	-0.20
	u_{12}	0.05	0	0.05	0.25	-0.15
	u_{13}	0.05	0	0.05	0.25	-0.15
	u_{14}	0.05	0	0.05	0.25	-0.15
	u_{15}	0.10	0	0	0.20	-0.20
U_2	u_{21}	0.05	0	0.05	0.25	-0.15
	u_{22}	0.15	0.05	-0.05	0.15	-0.25
	u_{23}	0.10	0	0	0.20	-0.20
	u_{24}	0.15	0.05	-0.05	0.15	-0.25
	u_{25}	0.25	0.15	-0.05	0.05	-0.35
U_3	u_{31}	0.15	0.05	-0.05	0.15	-0.25
	u_{32}	0.10	0	0	0.20	-0.20
	u_{33}	0.05	0	0.05	0.25	-0.15
	u_{34}	0.25	0.15	-0.05	0.05	-0.35
	u_{35}	0.05	0	0.05	0.25	-0.15
	u_{36}	0.15	0.05	-0.05	0.15	-0.25
	u_{37}	0.15	0.05	-0.05	0.15	-0.25

Table 4: Extension correlation coefficient of athletic ability (continue)

Criteria layer	Index layer	Grades			
		Grade 4	Grade 4	Grade 4	Grade 4
U_1	u_{11}	-0.333	0	0	-0.500
	u_{12}	-0.250	0	-0.250	-0.625
	u_{13}	-0.250	0	-0.250	-0.625
	u_{14}	-0.250	0	-0.250	-0.625
	u_{15}	-0.333	0	0	-0.500
U_2	u_{21}	-0.250	0	-0.250	-0.625
	u_{22}	-0.375	-0.167	0.250	-0.375
	u_{23}	-0.333	0	0	-0.500
	u_{24}	-0.375	-0.167	0.250	-0.375
	u_{25}	-0.417	-0.300	0.250	-0.125

Table 4: Extension correlation coefficient of athletic ability

U_3	u_{31}	-0.375	-0.167	0.250	-0.375
	u_{32}	-0.333	0	0	-0.500
	u_{33}	-0.250	0	-0.250	-0.625
	u_{34}	-0.417	-0.300	0.250	-0.125
	u_{35}	-0.250	0	-0.250	-0.625
	u_{36}	-0.375	-0.167	0.250	-0.375
	u_{37}	-0.375	-0.167	0.250	-0.375

Based on the formula of extension correlation degree, and given the weight of indicators in the criteria layer $w=(0.50,0.20,0.30)$, the extension correlation degrees between matter-element of athletic ability and different grades can be computed, namely $\lambda=(-0.319,-0.059,-0.034,-0.496)$. According to the attribution principle, the athletic ability of this team lies in between Grade 3 and Grade 2.

5. Conclusions

In this paper, classification of athletic abilities of professional football teams is discussed. The athletic ability evaluation index system for professional football teams is established. Based on the extension theory, an improved athletic ability evaluation model is confirmed. By computing the extension distance, the extension coefficient and the extension correlation degree, a quantitative description of the athletic ability is achieved, which enlightens a new of evaluation. The model proposed in this paper has definite meaning, simple calculation and is easy to realize on the computer. It is very practical and can be widely applied.

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