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College Basketball Coach Evaluation Based on Dynamic DHGF Evaluation Model

Si-Jing Meng[1], Yuan-Biao Zhang[2], Gui-Sen Xu[3] & Jun-Ta Wu[3]

[1]International Business School, Jinan University, Zhuhai 519070, China

[2]Packaging Engineering Institute, Jinan University, Zhuhai 519070, China

[3]Electrical and Information School, Jinan University, Zhuhai 519070, China

Correspondence to: Yuan-Biao Zhang, Packaging Engineering Institute, Jinan University, Zhuhai 519070, China. E-mail: zybt@jnu.edu.cn

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Abstract

The use of mathematical evaluation model is more and more widely, including the comprehensive evaluation of college coaches. In this paper, we build DHGF model using the Delphi method, AHP, Gray Relation and Fuzzy Judgment to evaluate college couches quantitatively. Based on DHGF model, we analyze the influence of timeline on the scores of evaluation indexes, get Plus Function, so as to adjust experts score. So we get dynamic DHGF evaluation model. Then, we apply the model to men's college basketball matches. After that, we discuss that this model is applicable for choosing the best college coach or coaches (past or present) from among either male or female coaches in all sports fields. And we will apply the model to evaluation problems with large time span or with many affecting factors.

Keywords: *DHGF* algorithm; evaluation index; dynamic evaluation model

1. Introduction

Build a mathematical model to choose the best college coach or coaches (past or present) from among either male or female coaches. This problem essentially belongs to evaluation problem about human. Traditional solutions include Delphi method, AHP, Gray Relation and Fuzzy Judgment. Delphi technique is easy to conduct and broadly representative but its subjectivity is too strong. AHP can get a ranking but its comparison and judgment process is relatively coarse and it can't do classification. Grey Correlation has very few demands on sample size, its computation complexity is low but it has low resolution, it does not take qualitative factors into account. Fuzzy Judgment has quantitative fuzzy phenomenon but its inaccurate judgments or incomparable results are existed. The four methods in practical use are not comprehensive.

Qian proposed comprehensive integration method from qualitative to the quantitative, combine the expert group, data, and a variety of information with the computer, combine theory with experience knowledge of various disciplines, play their overall and comprehensive advantages(Qian, Yu & Dai, 1990). Wuli-Shili-Renli approach was proposed (Gu, 1995). Based on Qian's and Gu's researches, Xu and Zhang put forward a new comprehensive integrated algorithm from the qualitative to the quantitative transformation, it is formed by Delphi, AHP , grey correlation analysis and the fuzzy evaluation (Xu & Zhang, 1998). They applied DHGF algorithm to evaluating information system project, DHGF gives full play to several method's advantages and controls their disadvantages, its feasibility and effectiveness are showed in the practice example (Xu & Zhang, 1999). DHGF algorithm is used to evaluate the power plants' developing levels with satisfactory results (Cheng, An & Han, 2002). Zhu, Ma and Zhou built talent competitiveness evaluation model of colleges, which applied DHGF algorithm to evaluation about human (Ma et al., 2010). Research found that DHGF algorithm can be applied to evaluation about human, it has high scientific nature and operability.

In this paper, we establish DHGF model, set up comprehensive evaluation indexes to evaluate college coaches. Based on the studies conducted by Xu and Zhu, we further expand the model, we analyze the influence of timeline on the scores of third-grade indexes, get Plus Function, so as to adjust experts scores. So we get dynamic DHGF evaluation model. Using this method, we can choose the best college coach or coaches (past or present) from among either male or female coaches.

2. Basic Model Based on *DHGF*

DHGF algorithm is a mathematical method for quantitative evaluation, which uses the Delphi method, AHP, Gray Relation and Fuzzy Judgment. It uses the improved Delphi to construct the evaluation index system, obtains the weighted matrix by using Analytic Hierarchy Process (AHP), uses Grey Correlation to count expert grading, gets evaluation conclusions through Fuzzy Evaluation.

2.1 Using Delphi Technique to Establish Evaluation Index System C

We use Delphi technique to choose evaluation indexes, which makes sure that the chosen indexes can be fewer but better. First, experts proposed evaluation indexes plan. Then we screen and summarize the indexes to determine evaluation index system C

$$C = [C_1,\ C_2,\ldots C_n],$$

Where, n denotes the number of evaluation indexes.

2.2 Using AHP to Determine the Weight Subset W

According to evaluation index system, we integrate the evaluation criteria of experts, use AHP to create comparative judgment weight matrix, i.e, we create weighted fuzzy subset on evaluation index system

$$W = [W_1,\ W_2,\cdots W_n]$$

Where, W_i is the weight of the i-th factor Ci in Factors Set C, and there is

$$\sum_{i=1}^{n} W_i = 1, 0 < W_i < 1$$

2.3 Using Grey Correlation Model to Calculate Grey Weight R

2.3.1 Determine Evaluation Sample Matrix

Supposing that there are *r* experts participating in the evaluation, the evaluation on indexes of experts constitute the sample matrix, where, d_{li} denotes the *l*-th expert's evaluation for the *i*-th index, it is a score between 1 and 100. The higher the score, the better the index.

$$D = (d_{li})_{r\times n} = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ d_{l1} & d_{l2} & \cdots & d_{ln} \end{bmatrix}$$

2.3.2 Determine Evaluation Level *U*

Based on the *WSR* thought and the Measure Theory, We use $U = [U_1,\ U_2,\cdots U_m]$ to express pros and cons of indexes. Where, *m* represents that there are *m* levels, such as Excellent, Good, Medium and Poor.

2.3.3 Determine the Grey Class of Evaluation

To determine the grey class of evaluation is to determine the level of grey class evaluation, grey number of grey class and whiten weight function of grey class.

Grey class should be determined by qualitative analysis according to evaluation level. The inflection points of whiten weight function are called thresholds d_1, d_2, d_3. There are two ways to get thresholds: one is analogy method according to guidelines or experience; the other is to find maximum, minimum and equivalence values as upper limit, lower limit and equivalence from sample matrix.

2.3.4 Calculate Grey Statistics

Based on whiten weight functions, using grey statistics method to calculate the weight that d_{li} belongs to the *p*-th evaluation standard $f_p(d_{li})(1 \le p \le m)$, then calculate grey statistics numbers T_{ip} and overall Grey statistics numbers T_i of judging matrix. :

$$T_{ip} = \sum_{l=1}^{r} f_p\left(d_{li}\right), \quad T_i = \sum_{p=1}^{m} T_{ip}$$

2.3.5 Calculate Grey Evaluation Weight and Weight Matrix

We integrate the evaluation of indexes from experts, supposing $r_{ip}=T_{ip}/T_i$ represents the weight that the *i*-th index should be classified as the *j*-th evaluation. Then, a single factor fuzzy evaluation weight matrix R is constituted based on r_{ip}.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ \mathrm{r}_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

2.4 Using Fuzzy Mathematics to Judge Evaluation Level Z

We take weighted subset W and single factor fuzzy evaluation weight matrix R into operation. After normalized processing, we get fuzzy synthetic evaluation matrix H:

$$H = [h_1,\ h_2, \cdots h_n] = WR$$

Determine the level of evaluation objects collections according to the demands of a hierarchy project by managers and specialists, i.e, determine the rank matrix S:

$$\mathrm{S} = [\mathrm{U}_1,\ \mathrm{U}_2, \cdots U_m]^T$$

Then, we can calculate the final evaluation result:

$$Z = BS$$

The greater the Z values, the better the coach.

3. Dynamic DHGF Evaluation Model Based on Time Line Horizon

In the improved model, we consider the impact on the scores of third-grade indexes over time. So scores of experts can be adjusted.

3.1 Timeline Effects on Innovative Ability Score

Innovation ability is related to the coach himself as well as the number of innovations at a time.

The number of innovations versus time is in line with S-type functions.

When considering timeline effects on Innovative Ability score, take the reciprocal of the slope in the corresponding period of S-function as a multiplier, the multiplier will affect the score of Innovative Ability.

3.2 Timeline Effects on Indexes Related to Gender Bias or Racial Discrimination

As time goes by, gender bias and racial discrimination have a great impact in the development of sports in colleges.

The entering for women or blacks to the field of sports has become difficult due to gender bias and racial discrimination. Because of gender bias and racial discrimination, women coaches or black college coaches would meet with many obstacles and need more efforts.

We want to reduce the impact of gender bias and racial discrimination on the above third-grade indexes scores. In the improved model, we find the variation of the impact of gender bias and racial discrimination on third-grade indexes with the timeline. We give the above third-grade indexes scores extra points. We get Plus Function about gender bias $g_1(x)$, Plus Function about racial discrimination $g_2(x)$.

3.3 The Fitting of Third-grade Index Based on Timeline Effects

Some specific data of a third-grade index are difficult to find. We found the third-grade index and another accurate third-grade index are related. So we find the variation of the accurate index with the timeline, then find out the variation of the vague index with the timeline, finally, we can fit out each year's function of the vague index change over time.

3.4 Economic impact on indexes score caused by the passage of the timeline

Sports economic function has been developed over time. We reviewed the literature, considered sports commercialization variation as the timeline goes, study the effects of commercialization on the indexes score, thereby we correct the basic model of the indexes' scores.

4. Exemplification

Apply the model to men's college basketball matches, we can get the top 5 "best all time college coach" for the previous century in men's college basketball.

We log in authority sites to search information about coach evaluation, screen data to get ten of the greatest basketball coaches. Based on the evaluation index system, we calculate the individual coach comprehensive evaluation scores.

4.1 Evaluation Index System C Based on Delphi Technique

In this paper, in accordance with the "theory-concept-operationalization-index" program , we determines the "competency - responsibility - performance" structure model, and build the evaluation index system C of college sports coaches evaluation based on 6 factors, namely Essential Criteria, Coaching Ability, Usually Work, Game Adjust Ability, Work Performance, Management Performance.

There are 3 first-grade index in evaluation index system. It is shown as following:

1) A1 (Competency)

Under A1, there are 2 second-grade indexes: B1 (Essential Criteria), B2 (Coaching Ability).

B1 (Essential Criteria) includes 4 third-grade indexes: C1 (Professional Moral Quality), C2 (Body Psychological Quality), C3 (Professional Training Experience), and C4 (Professional Knowledge).

B2 (Coaching Ability) includes 3 third-grade indexes: C5 (Training Execution), C6 (Impart Ability), C7 (Innovation Ability).

2) A2 (Responsibility)

Under A2, there are 2 second-grade indexes: B3 (Usually Work), B4 (Game Adjust Ability).

B3 (Usually Work) includes 2 third-grade indexes: C8 (Training Quality), C9 (Relationship With Players).

B4 (Game Adjust Ability) includes 2 third-grade indexes: C10 (Competition Command Capability), C11 (Tactical Options).

3) A3(Performance)

Under A3, there are 2 second-grade indexes: B5 (Work Performance), B6 (Management Performance).

B5 (Work Performance) includes 7 third-grade indexes: C12 (Athlete's Success Rate), C13 (Victory Rate), C14 (Total Number Of Coached Games), C15 (Title number & Semi-final number), C16 (Progress Rate), C17 (Honorary Title), C18 (Popularity).

B6 (Management Performance) includes 4 third-grade indexes: C19 (Team Cohesiveness), C20 (Athlete's Compete Style), C21 (Athlete's Psychological Quality), C22 (Athlete's Moral Character).

4.2 The Weight Subset W Based on AHP

4.2.1 Determine First-grade Index

According to the experts' opinions, we conclude that the relative importance scale of the first-grade index

	A1	A2	A3
A1	1	1/3	1/7
A2	3	1	3/7
A3	7	7/3	1

We create first-grade index judgment matrix V

$$V = \begin{bmatrix} 1 & 1/3 & 1/7 \\ 3 & 1 & 3/7 \\ 7 & 7/3 & 1 \end{bmatrix}$$

Using MATLAB for Consistency check and calculating the largest eigenvector of V. We get maximum eigenvalue $\lambda_V = 3$, consistence index $CI = \frac{\lambda_V - 3}{3-1} = 0$, the consistency ratio index $CR = \frac{CI}{RI} = 0 < 0.1$. It proves the judgment matrix can pass consistency check. Then, first-grade index weight vector is $W_V = [0.09\ 0.27\ 0.64]$.

4.2.2 Determine Second-grade Index

Using the same method, we can get the second-grade index judgment matrix

$$V21 = \begin{bmatrix} 1 & 1/3 \\ 3 & 1 \end{bmatrix}, V22 = \begin{bmatrix} 1 & 3 \\ 1/3 & 1 \end{bmatrix}, V23 = \begin{bmatrix} 1 & 5 \\ 1/5 & 1 \end{bmatrix}$$

After the test, they all can pass consistency check. Then, we get the second-grade index weight vector is

$$W_{V21} = [0.25, 0.75], W_{V22} = [0.75, 0.25], W_{V23} = [0.83, 0.17]$$

4.2.3 Determine Third-grade Index

Using the same method, we can get the third-grade index judgment matrix

$$V31 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}, V32 = \begin{bmatrix} 1 & 1/3 & 1/5 \\ 3 & 1 & 3/5 \\ 5 & 5/3 & 1 \end{bmatrix}$$

$$V33 = \begin{bmatrix} 1 & 1/3 \\ 3 & 1 \end{bmatrix}, \quad V34 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

$$V35 = \begin{bmatrix} 1 & 1/7 & 1/5 & 1/5 & 1/3 & 1/5 & 1/3 \\ 7 & 1 & 7/5 & 7/5 & 7/3 & 7/5 & 7/3 \\ 5 & 5/7 & 1 & 1 & 5/3 & 1 & 5/3 \\ 5 & 5/7 & 1 & 1 & 5/3 & 1 & 5/3 \\ 3 & 3/7 & 3/5 & 3/5 & 1 & 3/5 & 1 \\ 5 & 5/7 & 1 & 1 & 5/3 & 1 & 5/3 \\ 3 & 3/7 & 3/5 & 3/5 & 1 & 3/5 & 1 \end{bmatrix}, V36 = \begin{bmatrix} 1 & 3 & 3 & 3 \\ 1/3 & 1 & 1 & 1 \\ 1/3 & 1 & 1 & 1 \\ 1/3 & 1 & 1 & 1 \end{bmatrix}$$

After the test, they all can pass consistency check. Then, we get the third-grade index weight vector is

$$W_{V31} = [0.25, 0.25, 0.25, 0.25], \quad W_{V32} = [0.11, 0.33, 0.56],$$

$$W_{V33} = [0.25, 0.75], \quad W_{V34} = [0.5, 0.5],$$

$$W_{V35} = [0.03, 0.24, 0.17, 0.17, 0.10, 0.17, 0.10], W_{V36} = [0.5, 0.17, 0.17, 0.17]$$

4.2.4 Determine Combination Weight Vector

The combination weight of evaluation index is equal to the product of the first-grade index weight, the second -grade index weight and the third-grade index weight, it is shown as the following table:

Table 1. Competency evaluation index

First-grade index	Weight	Second-grade index	Weight	Third-grade index	Weight	Combination weight
A1	0.09	B1	0.25	C1	0.25	0.005 6
				C2	0.25	0.005 6
				C3	0.25	0.005 6
				C4	0.25	0.005 6
		B2	0.75	C5	0.11	0.007 5
				C6	0.33	0.022 5
				C7	0.56	0.037 5

Table 2. Responsibility evaluation index

First-grade index	Weight	Second-grade index	Weight	Third-grade index	Weight	Combination weight
A2	0.27	B3	0.75	C8	0.25	0.050 6
				C9	0.75	0.151 9
		B4	0.25	C10	0.50	0.033 8
				C11	0.50	0.033 8

Table 3. Performance Evaluation Index

First-grade index	Weight	Second-grade index	Weight	Third-grade index	Weight	Combination weight
A3	0.64	B5	0.83	C12	0.03	0.018 3
				C13	0.24	0.128 2
				C14	0.17	0.091 6
				C15	0.17	0.091 6
				C16	0.10	0.054 9
				C17	0.17	0.091 6
				C28	0.10	0.054 9
		B6	0.17	C19	0.5	0.054 4
				C20	0.17	0.018 5
				C21	0.17	0.018 5
				C22	0.17	0.018 5

4.3 Grey Weight R Based on Grey Correlation Model

Statistical grey class is divided into 4 classes, namely, Excellent, Good, Medium and Poor. Whiten weight functions of different classes are shown as following:

- Whiten weight function f_1 of grey class "Excellent" (More than 85 points)

$$f_1(d_{li}) = \begin{cases} \frac{1}{85} d_{li}, & d_{li} \in [0,85] \\ 1, & d_{li} \in [85,100] \end{cases}$$

- Whiten weight function f_2 of grey class "Good" (Around 80 points)

$$f_2(d_{li}) = \begin{cases} \frac{1}{80} d_{li}, & d_{li} \in [0,80] \\ 2 - \frac{1}{80} d_{li}, & d_{li} \in [80,100] \end{cases}$$

- Whiten weight function f_3 of grey class "Medium" (Around 70 points)

$$f_3(d_{li}) = \begin{cases} \frac{1}{70} d_{li}, & d_{li} \in [0,70] \\ 2 - \frac{1}{70} d_{li}, & d_{li} \in [70,100] \end{cases}$$

- Whiten weight function f_4 of grey class "Poor" (Below 60 points)

$$f_4(d_{li})=\begin{cases}1, & d_{li}\in[0,60]\\ 2-\dfrac{1}{60}d_{li}, & d_{li}\in[60,100]\end{cases}$$

4.4 Timeline Effects on Indexes Related to Gender Bias or Racial Discrimination

Gender bias and racial discrimination affect the scores of third-grade indexes as follows: Relationship with Players, Victory Rate, Progress Rate and Honorary Title.

We want to reduce the impact of gender bias and racial discrimination on the above third-grade indexes scores. In the improved model, we find the variation of the impact of gender bias and racial discrimination on third-grade indexes with the timeline. We give the above third-grade indexes scores extra points.

We reviewed the relevant literature, then we find the variation of the impact of gender bias and racial discrimination on third-grade indexes with the timeline. The timeline we selected is from 1913 to 2013, then we get Plus Function about gender bias $g_1(x)$, Plus Function about racial discrimination $g_2(x)$.

$$g_1(x)=\begin{cases}\dfrac{1}{45}x+8, 0\le x\le 45\\ 5x-218, 45<x\le 65\\ \dfrac{1}{20}x-\dfrac{1}{4}, 65<x\le 85\\ 0, 85<x\le 100\end{cases}$$

$$g_2(x)=\begin{cases}\dfrac{1}{50}x+8, 0\le x\le 50\\ 5x-243, 50<x\le 70\\ \dfrac{1}{20}x-\dfrac{1}{2}, 70<x\le 85\\ 0, 85<x\le 100\end{cases}$$

Then add extra points to the initial scores of Relationship with Players, Victory Rate, Progress Rate and Honorary Title according to $g_1(x)$ and $g_2(x)$.

4.5 Timeline effects on The Total Number of Games Coached score

The Total Number of Games Coached could reflect the level of the coach. In the early days, the society has a small number of total games a year, which will affect The Total Number of Games Coached at that period. So we find the variation of each year's total games with the timeline. We give The Total Number of Games Coached score extra points.

We found the team number and each year's total games are related positively. Therefore, we use the number of teams every year instead of each year's total games, then fit out each year's total games function change over time.

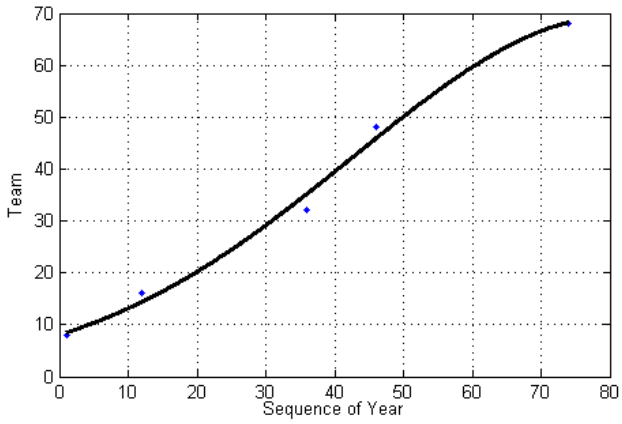

Figure 1. The relationship between team number and year

General model Gauss1:

$$f(x) = 69.67 \times e^{-\left(\frac{x-82.11}{55.7}\right)^2}$$

Table 4. Gaussian fitting parameters

coefficient			SSE	17.77
a1	69.67	(47.68, 91.66)	R-square	0.992 5
b1	82.11	(41.59, 122.6)	Adjusted R-square	0.984 9
c1	55.7	(20.04, 91.37)	RMSE	2.981

Fig. 1 shows fitting function is a Gaussian function. When considering the impact of the timeline goes on The Total Number of Games Coached score. In the fitting function, take the reciprocal of the slope in the corresponding period of Gaussian function as a multiplier, the multiplier will affect the score of The Total Number of Games Coached.

Based on the evaluation index system and data we searched, thus we calculate the individual coach comprehensive evaluation score, and sort the results in the following table:

Table 5. Ranking of basketball coaches

Ranking	1	2	3	4	5
Name	John Wooden	Dean Smith	Bob Knight	Don Haskins	Pete Newell
Comprehensive Evaluation	96.25	95.34	94.41	92.54	92.38
Ranking	6	7	8	9	10
Name	Lute Olson	Mike Krzyzewski	Adolph Rupp	Jim Boeheim	John Calipari
Comprehensive Evaluation	92.12	91.56	91.53	90.07	89.57

5. Conclusion

In the basic model, we set up comprehensive evaluation indexes, use the Delphi method, AHP, Gray Relation and Fuzzy Judgment, get DHGF evaluation index system for college coaches.

The innovation of this model is that indexes are detailed discussed, so the DHGF model is dynamic.

In the improved model, we study the variation of gender bias along with timeline to identify indexes affected by gender bias, we get the corresponding Plus Function, add the corresponding scores extra points to third-grade indexes. Therefore, the evaluation model in this paper applies to two different genders of coach.

In this paper, indexes are comprehensive and objective, so the model for the various college sports has a broad applicability. Some indexes vary in different sports game systems, we can do the appropriate adjustments. Therefore, the evaluation model in this paper is applicable to all types of college sports.

As a future work, based on the detailed discussion of timeline and indexes, we will consider apply the models to evaluation problems with large time span or with many affecting factors.

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