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2014

Mathematical Contest in Modeling (MCM/ICM) Summary Sheet

Summary

Coach assessment is a kind of multi-index problem, which means the result cannot be gotten by accurate calculation directly. In this paper, the coach assessment model is built to make a comprehensive evaluation of coach competency in order to solve this problem. Meanwhile, gender factor and competitive factor are put forward to deal with the influence of time and gender.

Considering differences between different sports events, which can affect the determination of index and weights, sports can be divided into 6 parts according to competitive nature and competitive characteristics. Furthermore, analyzing the different groups from the aspect of the operational requirement characteristics, sport performance assessment's objectivity, simulative matches' possibility and training's difficulty, the difference degree can be gotten, which is helpful in weight determination.

Then we build the coach assessment model based on Analytic hierarchy process (AHP) and fuzzy mathematics. AHP is a decision-making method for multi-index problems. It is particularly suitable in situation where results cannot be got by accurate calculation directly. So we can make the assessment based on AHP. However, AHP is not accurate in data processing, especially when there are too many dates. Thus shift and range transform method in fuzzy mathematics is applied to accomplish data processing in order to improve the accuracy of the result.

Meanwhile, the influence of gender and time should be considered in the model to improve the model accuracy. Career barriers for female first is analyzed by Career Barriers Inventory (CBI) and the difference between male and female coaches is proved to be not ignored when assessing their career performance. Then the gender factor which is decided by the gender inequality index of the United Nations is introduced to our mode because of its impact on score of influence force index. Competition fierce degree, which is represented by competitive factor and gotten by quantitative calculation, is proved to be related to the time because competition and team number increases when time goes by according to the data. This factor is introduced in the data processing of model and the influence of time can be given in this way. Actually, winning in 2013 is more meaningful than in 1913 after calculation.

The model is solved by AHP method as well as shift and range transform method .The top 5 coaches (from No.1 to 5) in basketball are Pat Summitt, Mike Krzyzewski, Adolph Rupp, Dean Smith and Bob Knight respectively. Top 5 coaches in football are Bear Bryant, Tom Osborne, Nick Saban and Eddie Robinson, Bobby Bowden. And top 5 coaches in baseball are Mike Martin, Gordie Gillespie, Paul Mainier, Augie Garrido and Mark Marquess.

Key words: sports division AHP fuzzy mathematics gender factor competitive factor

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1 Introduction

Jack Welch, former chairman and CEO of General Electric, has ever said, “The best leader is coach”. An appropriate coach assessment system plays an essential role for the reform and development of sports and cultivation of management talents. We accept a task to help *Sports Illustrated* look for the “best all time college coach” male or female for the previous century. Considering the fact that coach through every one’s eye is quite different, we should determine rational and justice assessment metrics while discussing all possible sports, both genders and time’s influence with a mathematical model.

The metrics and methods of coach assessment have been extensively study in the world since the late 20th century. In 1973, McClelland proposed a new notion--competency to replace traditional intelligence measure for coach assessment and built a coach competency model [1]. In 2001, Wean Goldsmiths pointed out that players’ sport performance and number of champions couldn’t be the exclusive standard to access a coach and we should pay more attention to his contributions to players and sport development [2]. In 2004, Li Yong adopted research method of literature, Delphi method and analytic hierarchy process (AHP) [3]to assess coaches objectively, reasonably and comprehensively which we can learn from. In 2006, Zhang Xinzong introduced the Coaching Behavior Assessment System (CBAS) which was proposed by Smiths and Small of Washington University to access coaches’ performance [4]. Actually, CBAS only concludes on-the-spot behaviors of coaches, and we should add extra assessment metrics to complement the assessment method of CBAS. In addition to AHP, fuzzy comprehensive evaluation method, structural equation model and so forth have been applied in the coach assessment system.

In our work, to build an appropriate model to assess coaches, we need to choose the fair and reasonable assessment metrics, i.e., evaluating index system named in our model. Synthesizing previous assessment metrics, on the one hand, we know that we cannot evaluate coach only by his external conditions such as team’s sport performance, numbers of championships or educational background, we should also take his potential and deep traits and characteristics into account. On the other hand, we hope the metrics in our assessment systems are as objective as possible to make evaluating work towards scientifically quantitative analysis. So when determining evaluating index system, we should combine subjective metrics with objective metrics, and quantify subjective metrics by objective indexes as far as possible to build a coach assessment model with rationality, objectivity and justifiability.

After preliminary analysis, we intend to apply such study approaches:

(1) Research method of literature:

(a) Study theories of coaches' competency in the literature about sport training theory, psychology and management science.

(b) Papers about systemic evaluation methods in the world.

(2) Questionnaire survey:

Design and give out questionnaires to specialists in relevant field and acquire helpful evaluating information.

(3) Transplantation method:

Use the evaluating achievements in other field as a reference and optimize the assessment programs.

(4) Mathematical statistics method:

Adopt analytic hierarchy process (AHP) and shift and range transform method in fuzzy mathematics to dispose of coaches' assessment metrics qualitatively and quantitatively. To deepen our model, we need take sport event groups, gender and time's influence into consideration to make our model more universal. We know that the National Collegiate Athletic Association (NCAA) is a nonprofit association of 1,281 institutions, conferences, organizations, and individuals that organizes the athletic programs of many colleges and universities in the United States and Canada [5]. In our paper, because of the large scale and authority of NCAA, we only rank the college coaches based on the data and information we get from NCAA's database. Eventually, we will present our model's top 5 coaches in each of 3 different sports and explain our results for sports fans.

2 Classification and characters of sport events

Before determining an appropriate model to look for best American college coach for all possible sports, it is essential for us to classify sport events into several groups. Considering NCAA (National Collegiate Athletic Association) which is authoritative and representative for competitive sports of college level in U.S., we will merely classify sport items of NCAA and research their characters for further college coach assessment.

2.1 Classification of sport events

Since a valid classification of sports events makes great contributions to researching and understanding the traits and principles of different sport events, the method of classification has been rationalized and improved gradually. Up till now, specialists in the field of sport theory have proposed three major methods [6] to classify based on main factors of competitive ability, movement structure, and appraising method of sport performance which can classify all possible sports from different angles.

As we know, the essence of competitive sports, and the common traits in NCAA competitive sport events are competitiveness which can reflect the difference of sport events and groups apparently. It is more beneficial for revealing the traits and item groups' characters through the view of competition. Therefore, to take above three classification methods and our new discover into account, we adopt a classification method based on the standard of competitive nature and characteristics to systematically analyze sport events and groups in NCAA.

Competitive nature is chosen as the first-order standard to classify, we can sort NCAA's sport events into two groups: direct competitive event group and indirect competitive event group. Direct competitive event group are composed of sport events with attack-and-defense relationship while indirect competitive event group are composed of sport events without attack-and-defense relationship.

Then competitive characteristics are determined as the second-order classification standard. We can further classify direct competitive event group into four parts: grapple competitive event group, body-contact competitive event group, non-body-contact competitive event group, and net-separated competitive event group. According to the existing sport events in NCAA [7], grapple competitive event group includes 3 sport events: boxing, wrestling, and fencing; body-contact competitive event group includes 7 sport events: football, soccer, basketball, field hockey, ice hockey, lacrosse, and water polo; non-body-contact competitive event group includes 4 sport events: baseball, softball, bowling, and golf; net-separated competitive event group includes 2 sport events: tennis, and volleyball.

Similarly, we can classify indirect competitive event group into two parts: simultaneous competitive event group and consecutive competitive event group. And simultaneous competitive event group includes 4 sport events: outdoor track, indoor track, cross country, and rowing; consecutive competitive event group 5 sport events: outdoor field, indoor field, gymnastics, rifle, and skiing. The classification results of sport events in NCAA are presented as follows:

Table 1 Classification of sport events in NCAA

Competitive nature	Competitive characteristic	Sport events
Direct	Grapple	boxing, wrestling, fencing
	Body-contact	football, soccer, basketball, field hockey, ice hockey, lacrosse water polo
	Non-body-contact	baseball, softball, bowling, golf
	Net-separated	Tennis, volleyball
Indirect	Simultaneous	outdoor track, indoor track, cross country, rowing
	Consecutive	outdoor field, indoor field, gymnastics, rifle, skiing

2.2 Characteristics of different sport events

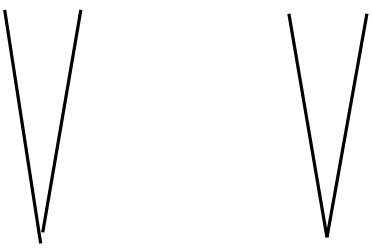
After an appropriate classification, we will research and analyze the characteristics of different competitive event groups so that we can determine reasonable evaluation indexes for coach assessment. We study different competitive event groups from four characteristics: operational requirement, objectivity of sport performance assessment, possibility of simulative matches and difficulty of training [8].

2.2.1 Characteristics of operational requirement

According to the classification of sport events in NCAA, the degrees of competitive confrontation of different event groups make great difference and the ranking from highest to lowest is: grapple, body-contact, non-body-contact, net-separated, simultaneous, and consecutive competitive event group.

Differences in degree of competitive confrontation will contribute to differences in anti-interference requirements of skilled movement and it has a positive correlation between each other, i.e., a higher degree of competitive confrontation is accompanied with a higher anti-interference requirements of skilled movement. And operational requirement of sport event bear a relationship to degree of competitive confrontation, anti-interference requirements of skilled movement and number of a team's members. The eventual evaluation standards of operational requirement in different competition event groups are expressed as follows:

Table 2 Operational requirement characteristics of different event groups

Event groups	Degree of competitive confrontation	Anti-interference requirements of skilled movement	Operational requirement
Grapple			★★★
Body-contact			★★★★★★
Non-body-contact			★★★★★
Net-separated			★★★
Simultaneous			★
Consecutive			★

Note: more★ represents higher operational requirement.

2.2.2 Characteristics of sport performance assessment's objectivity

The appraising methods of sport performance about different competitive event groups are quite different from each other, which cause significant differences of sport performance assessment's objectivity. And controllability of matches is related to objectivity of sport performance assessment. The less the objectivity of sport performance assessment is, the less the controllability of matches is.

Table 3 Sport performance assessment's objectivity of different event groups

Competitive nature	Competitive characteristic		Objectivity of sport performance assessment
Direct	Grapple		★★
	Body-contact		★
	Non-body-contact		★★
	Net-separated		★★★★★
Indirect	Simultaneous		★★★★★★
	Consecutive	Score	★★
		Measure	★★★★★

Note: more★ represents greater objectivity of sport performance assessment.

2.2.3 Characteristics of simulative matches' possibility

One of effective and efficient methods to improve sport performance is to conduct abundant training and practice including simulative matches. Different event groups have different possibility of simulative matches. The direct competitive event groups are relevant to attack-and-defense relationship. The skill and tactics can improved accessibly, and players as well as coaches can achieve practical experience under the background of simulative matches with attack-and-defense relationship. Thus, such

competitive event groups have more requirements and less possibility in simulative-match training. Furthermore, possibility of simulative matches is related to gender and the concrete results are as follows:

Table 4 Simulative matches' possibility of different event groups

Competitive nature	Competitive characteristic	Possibility of simulative matches		
		Whole	Men	Women
Direct	Grapple	★★★	★★	★★★★
	Body-contact	★	★	★★
	Non-body-contact	★★	★	★★
	Net-separated	★★★★	★★	★★★★
Indirect	Simultaneous	★★★★★	★★★★★	★★★★★
	Consecutive	★★★★★	★★★★★	★★★★★

Note: more★ represents less possibility of simulative matches.

2.2.4 Characteristics of training's difficulty

In accordance with degree of competitive confrontation, anti-interference requirements of skilled movement, operational requirement, objectivity of sport performance assessment and possibility of simulative-match training, we promote a comprehensive evaluation standard of training's difficulty and our findings are present as Table 5.

Table 5 Training's difficulty of different event groups

Competitive nature	Competitive characteristic	Difficulty of training	
		Men	Women
Direct	Grapple	★★★★★★	★★★★★
	Body-contact	★★★★★★	★★★★★
	Non-body-contact	★★★★★	★★★★
	Net-separated	★★★★	★★★★
Indirect	Simultaneous	★★	★★
	Consecutive	★★	★★

Note: more★ represents more difficulty of training.

3 Coach assessment model

In last part, sports are divided into different categories. As for different kinds of sports, we should search for reasonable and scientific ways to make an assessment of coaches. Analytic hierarchy process (AHP) is a decision-making method for multi-index, multi-standard problems. It is particularly suitable in situation where results cannot be got by accurate calculation directly. Considering there are many indexes of coach assessment,

AHP shall be a great way for this problem. Meanwhile, some data processing methods in fuzzy mathematics can be applied in order to improve the accuracy of the result.

3.1 Model building

3.1.1 Evaluating index system determination

Coach assessment involves various indexes and the comprehensiveness and accuracy of indexes are especially virtual to the model. Rushall and Wiznuk (1985) came up with coach evaluation questionnaire (CEQ) to study the influencing factors of coach competence. They got the conclusion that main indexes for coach assessment are personal quality of coach himself, interpersonal relationship and organizing capacity. Feltz, Chase and Mor-itiz (1999) [9] put forward competence efficacy table. In this table, they pointed out the indexes of coach evaluation consist of motivation capacity, technique capacity, character training capacity and command ability. Besides, in 2009, Xing Jie and Zhu Bochao [10] divided evaluating indexes into three parts, which are the professional knowledge, technique capacity about sports and leading ability, respectively.

Analyzing the indexes put forward by previous researches, subjective indexes including leading ability, technique capacity about sports, organizing capacity and character training capacity have been highly valued. However, objective indexes such as successful percent and victory numbers of competition are ignored in most cases. Actually, although subjective indexes can determine objective indexes, objective indexes are more accurate and intuitive

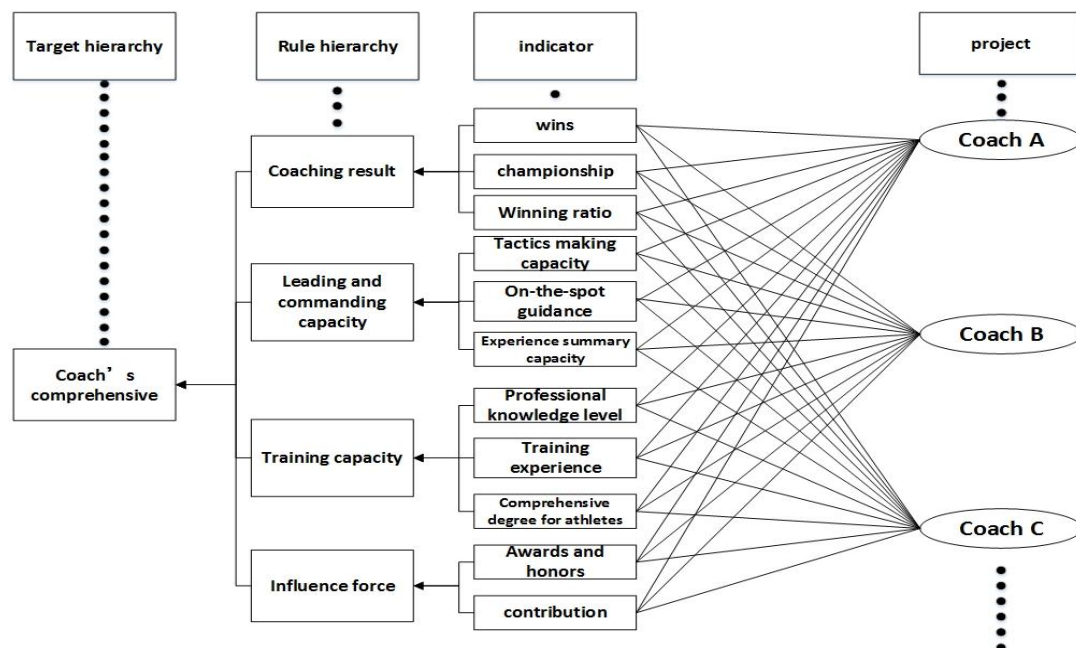


Figure 1 AHP hierarchical structure

Considering previous study and the advantages of objective indexes, we combine subjective and objective factors. Meanwhile, in order to represent and distinguish all kinds of sports, we give the evaluating index system as the figure 1 above.

In figure 1 above, we divide indexes into two layers. The first layer is rule hierarchy and the second is indicator hierarchy. Rule hierarchy is composed of several corresponding estimate factors, and it is estimate indexes integrated from factors of the same kind in indicator hierarchy. Indexes in rule hierarchy include: coaching result of coaches, leading and commanding capacity, training capacity and influence force of coach.

- (1) Coaching result: this index is composed of three indexes in indicator hierarchy including wins, championship and winning ratio. Where, wins is victory number of completion in a coach's career; championship is championship number; winning ratio is percentage of winning for the coach, which can be gotten by formula
$$winning\ ratio = \frac{wins}{matches}$$
. Matches is the total number of competition, including wins, losses and ties.
- (2) Leading and commanding capacity: this index represents coach's ability to lead his team preparing, taking part in a match and making tactics, which is virtual in body-contact competitive event group. It is composed of tactics making capacity, on-the-spot guidance capacity and experience summary capacity.
- (3) Training capacity: this index represents coach's ability to manage a team and train athletes. It is composed of professional knowledge level, training experience and comprehensive degree for athletes' phycology. In fact, training experience can be reflected by coaches' working years; professional knowledge level can be reflected by coaches' educational background; comprehensive degree for athletes' phycology can be reflected by whether a coach has athlete background.
- (4) Influence force of coach: this index represents coach's social influence. It is composed of a coach's ward and honors as well as contributions to corresponding sports. Where, ward and honors can reflect public assessment for the coach; contributions can reflect coaches' status.

Apart from rule hierarchy and indicator hierarchy, the highest layer is target hierarchy: coach's competency. The lowest is project hierarchy including different coaches.

3.1.2 Weight determination

(1) Determining weight of rule hierarchy

According to AHP and evaluating index system, we suppose A to denote coach's comprehensive level. Meanwhile, four indexes in rule hierarchy (including coaching result of coaches, leading and commanding capacity, training capacity and influence force of coach) are denoted by B_1, B_2, B_3, B_4 respectively. Besides, we suppose b_{ij} to express the relative importance B_i compared to B_j .

In order to build judgment matrix, we create importance degree valuation as table 1 below according to 1-9 proportion scale.

Table 6 Importance degree valuation

SCALE	RELATIVE IMPORTANCE
1	Equally important
3	A little more important
5	More important
7	Much more important
9	Rather more important

Note: 2,4,6,8 is relative importance lying between adjacent scales; $b_{ij} = \frac{1}{b_{ji}}$

From the table 1, if $b_{12}=3$, then it means B_1 is a little more important than B_2 . Similarly, if $b_{12}=1/3$, then it means B_2 is a little more important than B_1 . And comparison matrix can be given as below.

Table 7 Comparison matrix in rule hierarchy

A	B_1	B_2	B_3	B_4
B_1	1	b_{12}	b_{13}	b_{14}
B_2	b_{21}	1	b_{23}	b_{24}
B_3	b_{31}	b_{32}	1	b_{34}
B_4	b_{41}	b_{42}	b_{43}	1

When $\lambda = \lambda_{\max}$, we can get the weight vector $X = (x_1, x_2, x_3, x_4)$. Where x_i is the weight of B_i .

Consistency check of comparison matrix:

$$CI = \frac{\lambda_{\max} - 4}{3} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

Where, CI is consistency index; CR is consistency ratio; RI is average consistency index. If $CR < 0.1$, the consistency of comparison matrix is acceptable.

Besides, according to table 2-table 5, the operational requirement characteristics, sport performance assessment's objectivity, simulative matches' possibility and training's difficulty of different event groups are different. That is to say, the weights of B_1, B_2, B_3, B_4 in different event groups is not the same. So we cannot give the universal weights value in model building. As for different event group in table 1, we should determine its weight of rule hierarchy respectively in problem solving.

(2) Determining weight of indicator hierarchy

Suppose $C_1, C_2, C_3 \cdots C_{11}$ to express the 11 indexes in indicator hierarchy. According to AHP, similarly, we can get the weights of all the indexes compared to rule hierarchy. Suppose y_{ij} is the weight of C_j compared to corresponding index B_i it belongs to in rule hierarchy. Then:

$$w_j = y_{ij} \cdot x_i \quad (i=0,1,2,3,4; \quad j=0,1,2 \cdots 11) \quad (3)$$

Where, w_j is the weight of C_j compared to A (coach's competency).

Consistency check should be taken in the same way as formula (1), formula (2). If $CR < 0.1$, the consistency of comparison matrix is acceptable.

3.1.3 Data processing based on shift and range transform

Analytic hierarchy process (AHP) is a decision-making method for multi-index, multi-standard problems. It is particularly suitable in situation where results cannot be got by accurate calculation directly [11]. However, AHP is not accurate in data processing, especially when there are too many dates. So we apply shift and range transform method in fuzzy mathematics to accomplish data processing in order to improve the accuracy

of the result.

Suppose D_{ij} is the data of coach i about index C_j in indicator hierarchy. Then applying shift and range transform method to deal with data. The method is showed as blow:

$$D_{ij}^* = \frac{D_{ij} - \min_{1 \leq j \leq 11} \{D_{ij}\}}{\max_{1 \leq j \leq 11} \{D_{ij}\} - \min_{1 \leq j \leq 11} \{D_{ij}\}} \quad (i=1,2,3 \cdots m) \quad (4)$$

Where, D_{ij}^* is the corresponding data of D_{ij} after data processing, m is coach number. After data processing in this way, $D_{ij}^* \in (0, 1)$, so the bad effect of different dimension is eliminated. Meanwhile, this method is more accurate than building comparison matrix method in AHP.

3.1.3 Comprehensive assessment indicator determination

After the date processing and weight determination, according to AHP, the score of coach i can be given as below.

$$S_i = \sum_{j=1}^{11} D_{ij}^* \cdot w_j \quad (i=1,2 \cdots m) \quad (5)$$

Where, S_i represent the coach's comprehensive level and we can make an assessment of coach's competency according to it.

3.2 Coach assessment model considering genders

3.2.1 Differences of male and female coaches

To analyze the influence of genders on the coach assessment, we should have a research on the male and female coaches in the sport history. Taking basketball coaches as an example, we make an incomplete statistics with the coaches' information from NCAA's database [12][13][14] to find out the distinct between male and female coaches. On the list of college men's basketball coaches with 600 wins, there are 81 male coaches without any female coach. And on the list of college women's basketball coaches with

600 wins, nearly $\frac{2}{3}$ of 54 basketball coaches are female; however, these female coaches are active only since late 20th and early 21th centuries because the rise of women's basketball is late and development is relatively backward. The preliminary finding obtained from above incomplete statistics is that the number of female basketball coaches is far less than the number of male in the basketball history, which can prove that being a good sport coach for female is much more difficult than male and we should have different evaluation standards for coach assessment when considering genders.

Then we search for relevant literature to find specific career barriers for female's development and achievement in the sport career. Considering the nature and characteristics of female, female has less advantages in sport field which is related to body and strength mostly. So female coaches will meet more working pressure and more competence dispute than male. Due to sexual discrimination, females will have less opportunities for education and working which harm to improvement and development of knowledge, capacity and working experience in female's career. That's more, females play a more important role in family and devote more energies to family through a traditional viewpoint, which will have unfavorable impact on career. Overall, the main career barriers for female contain gender characteristics and differences, work pressure, mental and physical troubles, and family fetters. Now, we can further prove that the differences of male and female coaches cannot be ignored when assessing coaches with both genders. We should determine which evaluating indexes will be influenced by the factor of gender in further study.

3.2.2 Gender factor to coach assessment model

According to the career barriers for female we analyze above, we illustrate that being a sport coach for female has more challenges and to achieve better performance and appraise for female is much more difficult than male. Considering evaluating indexes in our coach assessment system, we determine to creatively introduce a gender factor to reflect the gender's influence on coach assessment model. The gender factor predominantly effects on influence force index and different gender of coaches has different gender factor. If the score of coach A's influence force is x , then considering coach A's gender, the final score of coach A's influence force is $x \times \text{gender coach}$.

Through scanning data resources, we find out a gender inequality index from *the 2013 Human Development Report* of United Nations Development Programme [15], which can help us to decide the real value of different gender factor. The gender inequality index value of United States is 0.256 and the value of gender factor could be chosen as following table:

Table 8 Gender factor values

Gender	Gender factor value
Male	1.000
Female	1,256

3.3 Coach assessment model considering time

3.3.1 Relationship between time and coach assessment

To analyze the influence of time on the coach assessment, we should considerate that time is related to the level of competition in sports history. More importantly, the level of competition can affect winning ratio. We can get the relationship through comparison of two years. In 1913, the number of college team which participate in kinds of competition is much smaller than now. Good results that coaches desire is easier to obtain. In other words, coaches can get higher winning ratio. The influence of such competition on coach's coaching is relatively little. In contrary, there are many kinds of sports competition and almost each college has their own team for competition in 2013. This greatly promote competition and affect the college coach's winning ratio. Now, we can further prove that the time and coach assessment have a close relationship when assessing coaches. We should determine which evaluating indexes will be influenced by the factor of time in further study.

3.3.2 Competitive factor to coach assessment model

In order to quantitatively study the impact of time on the evaluation of coaches, we propose a new index, competitive factors, which are related to the coach's winning ratio.

Competitive factor δ is a measure of a coach's coaching performance indicator. It is influenced by different period. The factors which we research in the above model make a difference in time line horizon. We can evaluate the different periods of sports competition through it. We want to construct relationship between δ and t

We take NCAA league basketball tournament in the United States of America as an example to research the competitive factors in different periods of effects on the best college coaches [16]. Through making an investigation on the developing course of NCAA league basketball tournament, we find out a lot of useful data. The main data are as follows.

- NCAA league basketball tournament begins in 1939. There are only eight teams participating in the league.
- Teams participating in the league increase to 16 teams until 1951.

- In 1975, the number of teams expand to 32 again. And teams increase to 48.
- The so-called 64-strong league is held in 1985.
- In 1980, NCAA league basketball tournament is first broadcasted at Madison square.

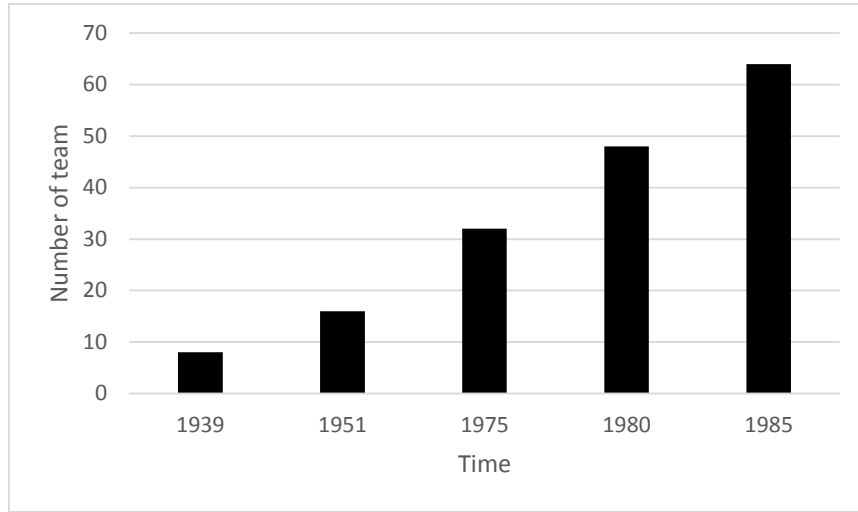


Figure 2 Relationship between the numbers of NCAA league basketball team and time

According to above figure we can get the number of NCAA team in 1939,1951,1975,1980 and 1985. After finding massive literature, we know that the team number is very small. However, we cannot omit them or considerate it as zero so as to produce the huge error. Therefore, we considerate δ as 0.1 approximately. Furthermore, we can make the above date change into δ through normalized data processing. Above we get δ specific formula.

$$\delta = \begin{cases} 0.1 & 1913 \leq t \leq 1939 \\ 0.125 & 1939 < t \leq 1951 \\ 0.25 & 1951 < t \leq 1975 \\ 0.5 & 1975 < t \leq 1980 \\ 0.75 & 1980 < t \leq 1985 \\ 1 & 1985 < t \leq 2013 \end{cases} \quad (6)$$

The formula tells that as t increases, δ becomes larger. In other words, there are more competition between teams. Good results that coaches desire is more and more difficult to get. The value of winning ratio is lower. Competition factor δ to reflect the coach's winning ratio is credible.

Suppose that t is coach's coaching time, and t can be divided into six parts $t_j (1 \leq j \leq 6)$. Each part is corresponding to one winning ratio at coach's coaching time.

Commonly, there, we suppose winning ratio as pct . Different time has different

winning ratios $pct_j (1 \leq j \leq 6)$. As we know as follow:

$$pct_j = \frac{w_j}{m_j} \quad (1 \leq j \leq 6) \quad (7)$$

Where, w_j is winning matches during t_j ; m_j is total matches during t_j . We can obtain the calculation method of pct^* .

$$pct^* = \frac{\sum_{j=1}^6 pct_j \cdot \delta \cdot t_j}{\sum_{j=1}^6 t_j} \quad (1 \leq j \leq 6) \quad (8)$$

The pct^* is weighing winning ratio, which can accurately reflect δ . What's more, δ is influenced strongly by t . To sum up, time affect coach assessment make through controlling competitive factor.

3.4 Model solving

We choose to make an assessment of basketball, football and baseball coaches from 1913-2013. Considering basketball, football belong to different sports event groups compared with baseball according to table 1, we should determine the weights of these two groups respectively. Meanwhile, because of different competitive factors (the factor connected with time) of different sports, there exist differences among these sports in data processing.

3.4.1 The assessment of basketball coaches

(1) Determining weight of rule hierarchy

According to table 2-table 5, we can build the comparison matrix in rule hierarchy as table 3 below. Where, B_1 is coaching result of coaches; B_2 is leading and commanding capacity; B_3 is training capacity; B_4 is influence force of coach.

Table 9 Comparison matrix in rule hierarchy in basketball

A	B_1	B_2	B_3	B_4
B_1	1	4	2	3
B_2	$\frac{1}{4}$	1	$\frac{1}{2}$	1
B_3	$\frac{1}{2}$	2	1	2
B_4	$\frac{1}{3}$	1	$\frac{1}{2}$	1

Then, when characteristic value $\lambda = \lambda_{\max} = 4.0104$, we can get the weight vector

$$X = (x_1, x_2, x_3, x_4) = (0.4778, 0.1281, 0.2561, 0.1380) \quad (9)$$

Where x_i is the weight of B_i in rule hierarchy.

Consistency check of comparison matrix: $CR = \frac{CI}{RI} = 0.0038 < 0.1$, so the weight result is acceptable.

(2) Determining weight of indicator hierarchy

There are totally 11 indexes in indicator hierarchy.

For B_1 (coaching result), it is composed of wins, championship and winning ratio.

These indexes can be denoted by C_1, C_2, C_3 .

As for B_2 , it is composed of tactics making capacity, on-the-spot guidance capacity and experience summary capacity. These indexes is too subjective and hard to assess, so we use match numbers to represent B_2 in actual calculation in order to get the accurate result. And match numbers is denoted by C_4 . Obviously, it is not necessary to build comparison matrix, the weight of C_4 is equal to the weight of B_2 .

As for B_3 , it is composed of professional knowledge level, training experience and comprehensive degree for athletes' phycology. In fact, training experience can be reflected by coaches' working years (denoted by C_5); professional knowledge level can

be reflected by coaches' educational background (denoted by C_6); comprehensive degree for athletes' psychology can be reflected by whether a coach has athlete background (denoted by C_7).

As for B_4 , a coach's award and honors as well as contributions. The two indexes are denoted by C_8 and C_9 . there is no need to build comparison matrix about C_8 and C_9 because the index number is too small.

Comparison matrix:

Table 10 Comparison matrix of indicator hierarchy in basketball

B_1	C_1	C_2	C_3	B_3	C_5	C_6	C_7
C_1	1	2	$\frac{1}{3}$	C_5	1	5	2
C_2	$\frac{1}{2}$	1	$\frac{1}{2}$	C_6	$\frac{1}{5}$	1	$\frac{1}{2}$
C_3	3	2	1	C_7	$\frac{1}{2}$	2	1

Then the weight of indicator hierarchy can be given as table 5 below.

Table 11 The weight of indicator hierarchy in basketball

Rule hierarchy	B_1			B_2	B_3			B_4	
Single ranking	0.4778			0.1281	0.2561			0.1380	
Indicator hierarchy	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Single ranking	0.2631	0.1897	0.5472	1	0.5954	0.1283	0.2674	0.37	0.63
General ranking	0.126	0.091	0.261	0.1281	0.152	0.033	0.071	0.051	0.087

(3) Data processing and score determination

In this processing, we carry on data processing according to formula (4) in matlab. Meanwhile, we introduce gender factor and competitive factor according to formula (7).

In order to quantify the data about reward and honors, we rank the honors and awards of different kind. We denote that the full marks of honors and awards are 5. As for awards and honors, the mark of every national award or honor in NCAA nationally is 1; the mark of other awards or honors nationally is 0.8; the mark of other awards which is not nationally is 0.5.

After data processing, we get the score of coach according to formula (5) and transform it into marks between 1 to100. The result of assessment in basketball can be given as table 12 below.

Table 12 Top 20 college coaches in basketball

rank	name	C1	C2	C3	C4	C5	C6	C7	C8	C9	M/F	score
1	Pat Summitt	1.00	0.67	0.92	0.72	0.56	0.00	1.00	0.63	1.00	F	99.8
2	Mike Krzyzewski	0.75	0.33	0.68	0.69	0.56	0.00	1.00	0.67	1.00	M	83.3
3	Adolph Rupp	0.55	0.33	0.86	0.42	0.68	0.33	1.00	0.58	0.75	M	82.3
4	Dean Smith	0.96	0.00	0.50	1.00	0.92	0.67	0.00	1.00	0.75	M	82.0
5	Bob Knight	0.76	0.08	0.52	0.80	0.84	0.67	1.00	0.75	0.50	M	80.3
6	Herb Magee	0.56	0.17	0.71	0.50	0.48	0.33	1.00	0.75	1.00	M	77.1
7	Geno Auriemma	0.52	0.67	1.00	0.32	0.16	0.33	0.00	0.67	1.00	M	72.0
8	Tara VanDerveer	0.62	0.17	0.84	0.48	0.40	0.33	1.00	0.29	0.50	F	71.3
9	Phog Allen	0.29	0.25	0.60	0.34	0.96	0.00	1.00	0.13	1.00	M	71.2
10	Jim Boeheim	0.69	0.08	0.63	0.66	0.52	0.33	1.00	0.33	0.50	M	70.6
11	Jody Conradt	0.60	0.08	0.61	0.60	0.56	0.33	1.00	0.63	0.50	F	69.6
12	Jim Calhoun	0.55	0.08	0.48	0.64	0.60	0.33	1.00	0.54	0.75	M	68.8
13	John Wooden	0.13	1.00	0.80	0.11	0.20	0.33	1.00	0.46	0.75	M	66.4
14	Clarence Gaines	0.46	0.08	0.31	0.68	0.92	0.00	1.00	0.38	0.75	M	66.1
15	Don Meyer	0.65	0.08	0.60	0.65	0.48	0.00	1.00	0.08	0.50	M	65.0
16	Lute Olson	0.80	0.00	0.50	0.86	0.72	0.00	0.00	0.42	0.50	M	64.6

17	Mike Strong	0.38	0.00	0.84	0.29	0.36	0.33	1.00	0.75	0.50	M	63.2
18	Henry Iba	0.33	0.17	0.45	0.46	0.68	0.00	1.00	0.17	1.00	M	62.9
19	Jim Phelan	0.4	0.0	0.1	0.7	1.0	0.3	1.0	0.1	0.5	M	61.9
20	Jerry Tarkanian	0.26	0.08	0.74	0.24	0.28	0.67	1.00	0.04	0.75	M	58.35

3.4.2 The assessment of football coaches

Because football and basketball belong to the same sport event group according to table 1, so the weight of indicator hierarchy in football is equal to that in basketball. However, the competitive factor of these two sports is different, so there exists difference in data processing.

Table 13 Top 20 college coaches in football

Rank	Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	Score
1	Bear Bryant	0.72	0.67	0.44	0.87	0.78	1	0	0.5	0.33	97.32
2	Tom Osborne	0.61	0.67	0.53	0.68	0.51	0.5	1	0.5	0.00	92.25
3	Nick Saban	0.46	0.67	1.00	0.29	0.10	0	1	0.5	0.00	87.98
4	Eddie Robinson	0.43	0.33	0.62	0.46	0.37	0	1	1	0.00	80.53
5	Bobby Bowden	0.39	1.00	0.45	0.51	0.39	0	1	0.5	0.00	80.13
6	Glenn Scobey Warner	0.41	0.33	0.51	0.54	0.63	0	1	0	0.33	79.94
7	Larry Kehres	0.41	0.67	0.64	0.41	0.27	1	1	0	0.00	79.38
8	Ken Sparks	0.19	0.67	0.77	0.16	0.05	0	1	0	1.00	78.37
9	Roy Kidd	0.25	0.67	0.40	0.38	0.29	0	1	1	0.67	78.18
10	Kevin Donley	0.10	1.00	0.53	0.17	0.05	0.5	1	1	0.67	77.79
11	Jim Tressel	0.39	0.33	0.18	0.77	0.83	0	1	0	0.00	70.55
12	Amos Alonzo Stagg	0.12	0.67	0.68	0.16	0.10	1	1	0	0.33	70.40
13	Joe Paterno	0.20	0.33	0.46	0.30	0.15	1	1	1	0.33	70.01
14	Bo Schembechler	0.15	0.33	0.14	0.44	0.41	1	1	1	0.67	69.61
15	LaVell Edwards	0.03	1.00	0.53	0.10	0.00	0.5	1	1	0.33	68.57
16	Dennis Douds	0.17	0.67	0.30	0.37	0.24	1	1	0.5	0.33	67.03
17	Brian Kelly	0.01	0.67	0.79	0.00	0.05	0	1	0.5	0.33	66.72
18	Lou Holtz	0.30	0.33	0.69	0.29	0.32	0	0	0.5	0.33	64.82

19	Jake Gaither	0.09	1.00	0.58	0.13	0.10	0	1	0.5	0.00	63.45
20	Ron Schipper	0.20	0.33	0.48	0.29	0.32	0	1	0	0.33	60.99

3.4.3 The assessment of baseball coaches

Basketball, football belong to different sports event groups compared with baseball according to table 1, so the new weight of indicator hierarchy should be determined in baseball. Using the same method, we can give the weight of indicator hierarchy in baseball as table 14 below.

Table 14 The weight of indicator hierarchy in baseball

Rule hierarchy	B_1			B_2	B_3			B_4	
Single ranking	0.5342			0.1	0.2278			0.138	
Indicator hierarchy	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Single ranking	0.2631	0.1897	0.5472	1	0.5954	0.1283	0.2674	0.37	0.63
General ranking	0.141	0.101	0.292	0.100	0.136	0.029	0.063	0.051	0.087

After data processing in Matlab, similarly, we can give the final mark of baseball coach.

Table 15 Top 20 college coaches in baseball

Rank	Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	Score
1	Mike Martin	1.00	0	0.48	1.00	1.00	0	1	0.13	0.33	94.87
2	Gordie Gillespie	0.86	0	0.76	0.69	0.34	0	1	0.60	0.67	93.76
3	Paul Mainieri	0.49	0	1.00	0.27	0.50	0	1	0.40	0.33	87.62
4	Augie Garrido	0.79	0	0.95	0.52	0.34	0	0	1.00	0.33	87.38
5	Mark Marquess	0.45	1	0.70	0.38	0.63	0	0	0.67	0.33	85.55
6	Tim Esmay	0.55	0.5	0.45	0.61	0.42	0	1	0.27	1.00	83.48
7	Dave Serran	0.98	0	0.54	0.94	0.63	0	0	0.00	0.67	82.14

8	Don Schaly	0.94	0.25	0.71	0.77	0.39	0	0	0.07	0.33	81.47
9	Bill Holowaty	0.57	0.25	0.38	0.68	0.45	1	1	0.27	0.67	78.39
10	Ed Cheff	0.48	0	0.93	0.29	0.21	0	1	0.27	0.33	77.18
11	Gene Stephenson	0.30	0.5	0.75	0.23	0.24	0	1	0.20	0.67	76.86
12	Larry Hays	0.19	0.25	0.76	0.14	0.24	0	1	0.13	0.67	69.14
13	Cliff Gustafson	0.38	0	0.57	0.39	0.61	0	1	0.27	0.33	69.01
14	Ron Fraser	0.50	0	0.39	0.60	0.68	0	1	0.13	0.33	67.00
15	Mike Fox	0.44	0.5	0.58	0.43	0.26	0	0	0.13	0.67	65.57
16	Rod Dedeaux	0.15	0.5	0.60	0.16	0.11	0	1	0.40	0.67	64.54
17	Chuck Hartman	0.14	0	0.87	0.05	0.61	0	0	0.07	0.33	60.73
18	Jim Morris	0.18	0	0.62	0.19	0.68	0	1	0.13	0.00	59.79
19	Ray Tanner	0.10	0.5	0.33	0.26	0.24	0	1	0.80	0.67	58.48
20	Frank Vieira	0.14	0.25	0.42	0.24	0.21	0	1	0.47	0.67	55.96

4 Conclusions and evaluation

4.1 Conclusions

Before modeling, we classify all possible sport events in NCAA into different competitive event groups and researching the characteristics of different event groups which has impact on the weight of evaluating indexes. We build a coach assessment model considering four major indexes: coaching result of coaches, leading and commanding capacity, training capacity and influence force of coach, which is analyzed by analytic hierarchy process (AHP) combined with shift and range transform method of fuzzy mathematics. Considering both genders and time's influence, we introduce two factor--competitive factor and gender factor for further and more universal study. We calculate and solve coach assessment and ranking of three sports--basketball, football, and baseball and make some conclusions as follows:

(1) The evaluating indexes are identical for all possible sports in our model. And different competitive event groups have distinct in four characteristics--operational requirement, objectivity of sport performance assessment, possibility of simulative

matches and difficulty of training, which will influence on the real value of index's weight.

(2) The evaluating indexes are determined considering both subjective and objective factors. And the weight of evaluating indexes can be well set with AHP and shift and range transform method of fuzzy mathematics.

(3) We creatively introduced two factors to discuss the more universal model of coach assessment. The gender factor will have impact on the scores of influence force index. And competitive factor is decided by time, and it will effect on the calculation results of winning ratio.

(4) The final result of top 5 coaches in three different sports under our model is shown in the table.

Table 16 Top 5 coaches in three sports

Ranking \ Sport	Basketball	Football	Baseball
1	Pat Summitt(F)	Bear Bryant	Mike Martin
2	Mike Krzyzewski	Tom Osborne	Gordie Gillespie
3	Adolph Rupp	Nick Saban	Paul Mainieri
4	Dean Smith	Eddie Robinson	Augie Garrido
5	Bob Knight	Bobby Bowden	Mark Marquess

4.2 Evaluation

In our model, we combine AHP with data processing method in fuzzy mathematic. Meanwhile, the gender factor and competitive factor are introduced and applied in model creatively to improve the accuracy and completeness of the assessment result. Besides, in order to improve comprehensiveness of indexes, we divide sports event into 6 different groups and study the characteristic of every group, which can provide the reference for indexes system determination. However, there exist certain error as for the weights of some subjective indexes, which affect the accuracy of result in some sense.

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6 Special report






Who is top 5?

Do you have favorite college coach of NCAA? The latest college coach ranking has been released on February 11th, 2014 in three popular sports--basketball, football and baseball. The top 5 “best all time college coach” under our assessment are here.





Top 5 coaches of basketball

Top1	Top2	Top3	Top4	Top5
Pat Summitt	Mike Krzyzewski	Adolph Rupp	Dean Smith	Bob Knight
				

Top 5 coaches of football

Top1	Top2	Top3	Top4	Top5
Bear Bryant	Tom Osborne	Nick Saban	Eddie Robinson	Bobby Bowden
				

Top 5 coaches of baseball

Top1	Top2	Top3	Top4	Top5
Mike Martin	Paul Mainieri	Gordie Gillespie	Augie Garrido	Mark Marquess
				

Maybe, you will be astonished by the result that top 1 college coach of basketball is Pat Summitt, a woman. Then how do we conduct our coach assessment work?

The outcome of this college coach ranking of NCAA is obtained under an objective and systematical assessment method with a mathematics model. To assess the college coaches of all possible sports, we classify competitive sport events into 2 big classes and 6 small event groups and analyze the differences between these event groups into four factors: operational requirement, objectivity of sport performance assessment, possibility of simulative matches and difficulty of training. In our model, we assess college coaches of different sport with the identical evaluating indexes, and the differences of sport events' characteristics have influence on the real value of index's weight.

We seek the opinions of specialists, draw lessons from literature and consider the combination of objective and subjective factors to determine the evaluating indexes including coaching result of coaches, leading and commanding capacity, training capacity and influence force of coach, which can be quantify through 9 further indexes: wins, championship and winning ratio, match numbers, coaches' working years, coaches' educational background, athlete background, coach's awards and honors and contributions.

We create two factors to reflect gender and time's influence on our coach assessment model. Considering that career barriers of female are much more than male, we introduce the gender factor which will affect the score of influence force index. When it comes to time, we know that competitive degree is related to time. So we introduce competitive factor decided by time, which will influence the calculation results of winning ratio. These are our innovative approaches.

After determining the weight of evaluating index by mathematical statistics method and model solving, the top 5 college coaches of three different sports are worked out considering both genders and time.