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Research Article

Identifying the Best Coach by an Improved AHP Model

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The evaluation of coaches in college ball game is very essential, since a better choice of coaches will help get more scores for a team. In this paper, a simple, however, comprehensive model is proposed to evaluate college coaches of a century. By comparing the compressive index of different coaches in the evaluation, the top five coaches are found with their influence over time discussed either. Based on data of certain sport, a basic model is introduced. The superimposed application of the model makes it possible for the data of different levels to deliver proper evaluation. And by optimizing the data, we can provide precise evaluation items and authentic synthetic scores for each coach. Among their applications, the models of various sports are obtained in which relatively accurate results are still available. Although a number of deficiencies were disclosed by multiple expansions, this model is still simple, accurate, and valuable to select the best coaches.

1. Introduction

Volumes have explored the success of the sport teams or the related competitive pattern based on simple data analysis and statistics [1, 2], however, to some extent, with the problem of inaccuracy. Moreover, through such simple analysis, we cannot evaluate the coaches in multiple aspects accurately [3, 4]. In order to address the shortcomings above, we optimize our AHP model and build a new evaluating system [5].

As an important member of the sports team, coaches played a role of selecting outstanding athletes and drawing up the whole plans for their training [6, 7]. Thus, the quality of coaches is crucial to the development of the team [8–10]. Therefore, building appropriate models in selecting the best coaches is of great importance and the process can be as follows.

Firstly, we determine the basic model as the basis of our work. After the analysis upon the subject, we find that this can be evaluated by different indexes—qualitative and quantitative [5, 11]. Besides, we also find that it is so hard to build specific differential or algebraic formula due to the failing quantization and uniform of each index. However, the model of analytic hierarchy process (AHP) can avoid the weakness of relation between each index [12–14]. We change the question into specific conditions which can evaluate the objectives. As to those conditions of the same kind, we make our judgments on their importance level and build matrix with them. By calculating the largest eigenvalue and eigenvector of this matrix, we get the weight of each evaluating condition and then achieve the appraisal of the greatest college coaches with all the work above [5].

After that, we define, screen out, and classify the specific conditions for the evaluation. In practice, we build a sub-model firstly to test the influence of gender and time axis which are both not clear yet. During our test on time axis, we screen out secondary index to build statistics model which shows the relationship between times and team intuitively. This model also gives us a clear vision of the changing of American basketball competence. It is easy to find that coaches who work in an environment of higher competence tend to have higher professional level. At the meantime, we select index sharing the same level with time to finish the whole analysis hierarchy process.

Finally, we use our model to do the appraisal of the ten greatest CBC and more persuasive top five in them after more indexes being added in the model. With the existing data, this model can be applied to different sports to select the greatest

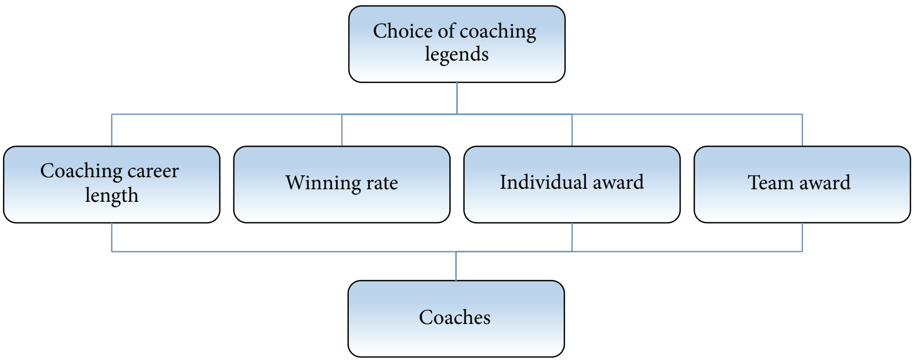

Figure 1: General graph model.

coaches in different fields. However, the comparison between results of the model and common sense can help us find that the results do not seem to be so accurate which means more analysis is needed to contribute to the optimization.

2. Model Building

The goal of our team is quite clear which is to look for "the best of all time college coach" of both male and female for the previous century. This paper introduces a quantifying model with factors that have already been precisely classified. The model can be used to evaluate coaches on their excellence directly. It contains impersonal data such as time, winning rate, and game award and, at the meantime, personal factors such as experiment experience which works in importance classification process.

Figure 1 shows our model intuitively.

2.1. Assumptions. Other factors such as individual personalities do not influence our results [11].

The assuming ranking of the factors is accurate while creating and using the model [15].

2.2. Factors. In this part, we consider as many as possible direct factors that influence coaches' professional level and career awards, among which choose four as key indexes, which are coaching career length, winning rate, individual award, and team award [16].

Winning rate refers to the ratio between NACC team quantity in middle year of objective's career [17] and average quantity of nearly a century to judge the average intense level of competence in this field [18, 19]. Optimization of the winning rate is achieved with algebraic expression, fitness of winning rate, and average intense level of competence using a certain coefficient [20]. We find that time axis plays an important role in this process. With the passage of time, the increase of team quantity indicates the increase in winning rate under objective coaches. As for this question, analysis hierarchy process does not only split practical and abstract problems into certain specific evaluating index but also show how index of low level influences the chain transition through computing index of different level.

Moreover, we can achieve the comparability between each decisive factor by quantizing and sequencing the importance of indexes of the same class. The model we introduced adds more persuasion to index of high level with integrative use of indexes of lower level and reference to objective law. In this way, we fully utilize the existing data and optimize high level index to make our model closer to reality.

Table 1: Variable definitions mentioned in model 1.

Items	Characters
Year	x
Team quantity	y
Average team quantity in near a century	Y
Participation times in middle year of coach's career	Z
Winning rate	P

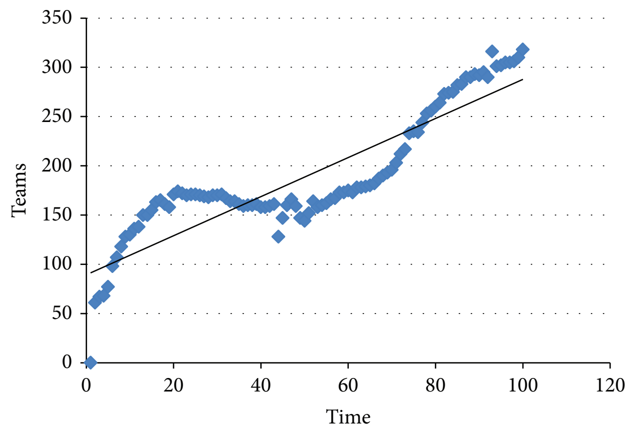

Figure 2: Curve of year and teams (basketball).

3. The Proposed Model

3.1. Description of Timeline. First we assign different letters to the variables in favor of the later modeling (Table 1).

By searching quantity of NCAA participating teams of different years and conducting simple regression analysis, we get the curve graph in Figure 2 (Table 2).

Table 2: Coefficients in Figure 2.

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	−3729.584	116.622	0.954	−31.980	0.000

We can find from this graph that quantity of participating teams first experiences a fast rising section and then gradually decreases:

$$y = ax + b. \tag{1}$$

By applying Matlab, we get a model that basically fits this trend:

$$y = 2.015x - 3729.584, \tag{2}$$

where x is regression variable, that is, time.

Then we compute and find the fitting formula of participating teams, in which 2.015 is regression coefficient and other factors that influence y are contained in random error −3929.584.

After this, we optimize the winning rate, one of the indexes, by using relation between teams. It is easy to understand that competence of each team ascends with the participating team and so is level to win. With the data of winning rate of related team as reference and the optimization, now we can give better evaluation to coach.

We assume the winning rate after optimization is (model 1)

$$Q = P + P * \frac{Z - Y}{Y}. \tag{3}$$

Take John Wooden as an example. The middle year of his coaching career is 1961. Taking 1961 into $y = 2.015x - 3729.584$, we can get $Z = y = 221.831$. We define year 1964 as the middle of the nearest century and gave 1964 into (2); we get $Y = 227.876$. Giving P, Z, and Y into (3), then we obtain $Q = 0.783$. Repeat the above calculation and then finish Table 3.

Data of winning rate after optimization are as in Table 3.

Table 3: Relevant data in optimization.

	Attached list one			
Coach	Year	P	$Z(y)$	Q
John Wooden	1961	0.804	221.831	0.783
Adolph Rupp	1951.5	0.822	202.689	0.731
Jim Calhoun	1992.5	0.697	285.304	0.873
Mike Krzyzewski	1995	0.764	290.341	0.973
Bob Knight	1987	0.776	274.221	0.934
Dean Smith	1979.5	0.793	259.109	0.902
Rick Pitino	1996.5	0.706	293.364	0.909
Billy Donovan	2004.5	0.710	309.484	0.964
Branch McCracken	1952	0.750	203.696	0.670
Denny Crum	1986.5	0.666	273.214	0.799
Hank Iba	1950	0.731	199.666	0.641
Roy Williams	2001.5	0.696	303.439	0.927
Jim Boeheim	1995.5	0.756	291.349	0.967
Tubby Smith	2003	0.790	306.461	1.062
Tom Izzo	2005	0.774	310.491	1.055
Gary Williams	1995	0.688	290.341	0.877
Jud Heathcote	1983.5	0.740	267.169	0.868
Jerry Tarkanian	1986	0.711	272.206	0.849
John Calipari	2001.5	0.649	303.439	0.864
Jim Harrick	1991.5	0.656	283.289	0.816
Al McGuire	1971	0.693	241.981	0.736
Phog Allen	1931	0.804	161.381	0.569

3.2. Description of Findings

3.2.1. Data Preprocessing. First we search and gather over 3000 sets of data about different college coaches, including their coaching career length, individual award, winning rate under his or her lead, and team award. Then we remove those who can hardly be the top five due to their too short career or very low winning rate. Finally, we have minimized our database to 150 coaches.

Then we optimize data about award of coaches left and carry out a small-scale analysis hierarchy process (AHP). (Model 2) [21].

(i) Presumption.

(1) The evaluation of importance of award in this approach is accurate.

(2) The higher this value is, the bigger the influence on objectives hierarchy it has.

Table 4: Variable definitions mentioned in Model 2.

Items	Characters
Winning rate	Q
Individual honor	M
Team honor	N
Coaching career length	U
Final score	S

(ii) Definition of Factors. See Table 4.

(iii) Objective Level Assigns. See Table 5.

(iv) Comparison Matrix and Weight Calculation. We get two factors, C_i and C_j, every time and define a_{ij} as the ratio of C_i and C_j. We can express all these results in pairwise comparison matrix [22]:

$$A = \left(a_{ij}\right)_{n^2}, \quad a_{ij} > 0, \ a_{ji} = \frac{1}{a_{ij}}. \tag{4}$$

Table 5: Priority order evaluating different games.

Award	Importance level
CREG	C_1
NCAA	C_2
FF	C_3
NC	C_4

After matrix A, we find the largest eigenvalue $\lambda_{\max}$ and its eigenvector ω. We normalize ω and get the sequencing weight of $C_2, \ldots, C_n$.

In order to judge whether the inconsistency of A stands within limits, we need to commit consistency examination.

Steps are as follows:

(1) computing consistency index CI:

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}, \quad (5)$$

(2) average random consistency index RI (Table 6),

(3) computing consistency index CR to formula (4),

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}. \quad (6)$$

When $\mathrm{CR} < 0.1$, we reckon that matrix will pass consistency examination.

(v) Objective Hierarchy-Wise Quantization. We define W as the objective hierarchy mark and x as the rule hierarchy data.

Computing formula is

$$W = x_1\omega_1 + x_2\omega_2 + x_3\omega_3 + x_4\omega_4. \quad (7)$$

(vi) Input Data and Get the Conclusion. Input data and get comparison matrix:

$$A = \begin{pmatrix} 1 & \frac{1}{2} & \frac{1}{3} & \frac{1}{5} \\ 2 & 1 & \frac{1}{2} & \frac{1}{3} \\ 3 & 2 & 1 & \frac{1}{2} \\ 5 & 3 & 2 & 1 \end{pmatrix}. \quad (8)$$

See Table 7.

We can find that $\lambda = 4.0145$, $\mathrm{CI} = 0.0048$ from formulae (4), (5), and (6), while $\mathrm{CR} = 0.0054 < 0.1$; this result passes consistency examination.

After normalization, we find that $\omega_1 = 0.0882$; $\omega_2 = 0.1570$; $\omega_3 = 0.2720$; and $\omega_4 = 0.4829$.

Using formula (5) to compute the final mark of each coach, data are as follows (Table 8).

3.2.2. Model Building (Model 3)

(i) Presumption. (1) Individual award begins from 1. (2) Quantization of each coach reflects his or her comprehensive competence.

(ii) Build Hierarchy Structure. The first hierarchy is objective (O): integrate optimum decision order.

The second is rule hierarchy (C): evaluation factors are as follows in order: team award, winning rate (optimized), and coaching career. They are taken as C_k $(k = 1, 2, 3, 4)$.

The third hierarchy is project: we define N the person evaluated $(N \geq 2)$ and they are taken as P_n $(n = 1, 2, \ldots, N)$.

(iii) Determine the Weight of Rule Hierarchy to Objective Hierarchy and Examine its Consistency. After normalization of feature vector, we get the weight vector of (C) to (O).

(iv) Determine Weight of Project Hierarchy (P) *to Rule Hierarchy* (C). Build comparison matrix between project hierarchy (P) and (C): $B_K = (b_{i,j}^{(k)})$, $b_{i,j}^{(k)} = (T_i^{(k)}/T_J^{(k)})$ $(i, j = 1, 2, \ldots, N;\ k = 1, 2, \ldots, N)$. Obviously matrix B_K is of consistency.

We can normalize B_K to find weight vector of P to C_k, taken as

$$W^{(k)} = \left(w_1^{(k)}, w_2^{(k)}, \ldots, w_N^{(k)}\right) \quad (k = 1, 2, 3, 4). \quad (9)$$

Obviously all B_K have consistency. With its feature we can find its largest eigenvalue.

$\lambda_{\max}^{(k)} = N$, $\mathrm{CR}_2^{(k)} = 0$ both are the eigenvectors of $\lambda_{\max}^{(k)}$. We can normalize them to find weight vector of P to C_k, taken as

$$W^{(k)} = \left(w_1^{(k)}, w_2^{(k)}, \ldots, w_N^{(k)}\right)^T \quad (k = 1, 2, 3, 4). \quad (10)$$

That is, find weight vector of P to C, and ratio indicator of consistency is

$$\mathrm{CR}_2 = \sum_{K=1}^{4} \mathrm{CR}_2^{(k)} = 0. \quad (11)$$

(v) Determine Combination Weight W of Project Hierarchy (P) *to Objective Hierarchy* (O). We have known that weight of C to O is W_1 and P to C is W_2, so weight of P to O is

$$W = W_1 * W_2 = \left(w_1, w_2, \ldots, w_N\right)^T \quad (12)$$

whose combination consistency ratio index is $\mathrm{CR} = \mathrm{CR}_1 + \mathrm{CR}_2 = 0.0054 < 0.1$. Thus combination weight W can be the evidence for objective decision.

(vi) Input Data Comprehensive Order. Because of w_n $(n = 1, 2, \ldots, N)$ in the combination weight $W = (w_1, w_2, \ldots, w_N)$ is the weight W of contestant coach P_n to objective hierarchy (O); that is, w_n shows aggregative indicator of contestant coach P_n.

Put them in order and then we get our resolution.

TABLE 6: Index of RI while "n" is different.

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

TABLE 7: Result of weight.

	C_1	C_2	C_3	C_4	Weight
C_1	1	1/2	1/3	1/5	0.0882
C_2	2	1	1/2	1/3	0.1570
C_3	3	2	1	1/2	0.2720
C_4	5	3	2	1	0.4829

TABLE 8: Ranking result.

Coach	CREG	NCAA	FF	NC	W
John Wooden	16	16	12	10	12.0162
Adolph Rupp	28	20	2	4	10.6766
Jim Calhoun	16	23	4	3	8.9613
Mike Krzyzewski	12	29	6	4	10.0464
Bob Knight	17	27	6	2	9.6892
Dean Smith	15	23	5	2	7.6514
Rick Pitino	11	28	5	3	7.0053
Billy Donovan	9	26	7	0	6.8662
Branch McCracken	11	30	4	1	6.7289
Denny Crum	16	13	11	0	7.5926
Hank Iba	13	28	7	1	7.5255

TABLE 9: Varies data after normalization (basketball).

	U	N	M	Q
John Wooden	0.009	0.009	0.033	0.028
Adolph Rupp	0.012	0.009	0.005	0.025
Mike Krzyzewski	0.012	0.006	0.005	0.023
Bob Knight	0.011	0.008	0.005	0.022
Jim Calhoun	0.012	0.008	0.011	0.021
Roy Williams	0.009	0.004	0.005	0.018
Dean Smith	0.008	0.008	0.016	0.018
Denny Crum	0.012	0.008	0.005	0.017
Ralph Miller	0.010	0.007	0.005	0.017
Rick Pitino	0.013	0.005	0.022	0.016

3.2.3. Substituting Data to Solve the Model. Take $N = 150$. Use *Matlab* to make matrix from 150 samples of four indicators. Solve the weight of the solution layer to the guideline layer. Normalize the data (Table 9).

Using the weight of the solution layer to the guideline layer, find the weight of combination. (We omit the formula because the data is fussy.)

Rank the scores of each sample, comparing their priority [23] (Table 10).

TABLE 10: Comparison of priority (basketball).

Coach	U	N	M	Q	S
John Wooden	29	0.672	6.000	12.016	0.024
Adolph Rupp	41	0.627	1.000	10.677	0.017
Jim Calhoun	40	0.751	2.000	8.961	0.015
Mike Krzyzewski	39	0.837	1.000	10.046	0.015
Bob Knight	36	0.803	1.000	9.689	0.015
Dean Smith	26	0.775	3.000	7.651	0.015
Rick Pitino	42	0.782	4.000	7.005	0.015
Billy Donovan	37	0.830	3.000	6.866	0.014
Branch McCracken	38	0.575	2.000	6.729	0.013
Denny Crum	41	0.687	1.000	7.593	0.013

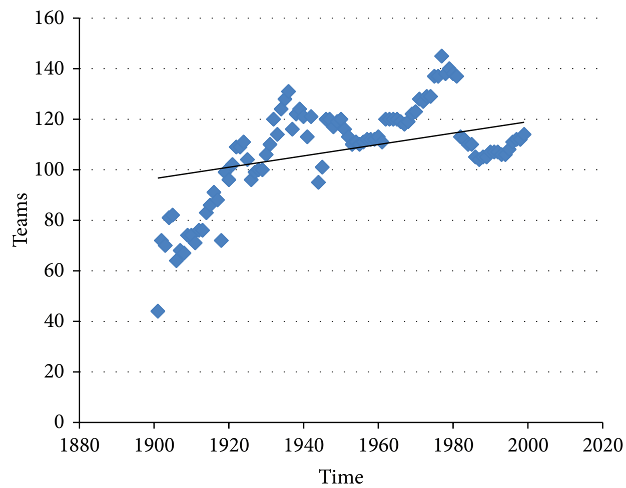

FIGURE 3: Curve of year and teams (football).

4. Applications

4.1. Example A: Application of Football

4.1.1. Timeline Influence. Using the above method fitting the number of teams and time, get the line (Figure 3 and Table 11).

4.1.2. Model Application [24]

(1) Data preprocessing: first, we also collected a lot of data, eliminated the project with obvious flaw, and thus selected 150 samples from 3000 teams from all over USA.

(2) Applying molds 2 and 3, we got the data (Tables 12 and 13).

Thus, we selected the top five "greatest coaches" (football).

Table 11: Coefficients in Figure 3.

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	−331.208	79.890	0.464	−4.146	0.000

Table 12: Varies data after normalization (football).

P	U	N	M	Q
Joe Paterno	0.016577	0.007846	0.025862	0.030626
Bobby Bowden	0.014414	0.007767	0.008621	0.027922
Bear Bryant	0.013694	0.007785	0.008621	0.020647
Mack Brown	0.01045	0.007158	0.00431	0.01662
Tom Osborne	0.009009	0.0087	0.00431	0.016413

Table 13: Comparison of priority (football).

P	U	N	M	Q	S
Joe Paterno	46	0.756	6.000	16.803	0.024
Bobby Bowden	40	0.749	2.000	15.319	0.019
Bear Bryant	38	0.750	2.000	11.328	0.015
Mack Brown	29	0.690	1.000	9.119	0.012
Tom Osborne	25	0.839	1.000	9.005	0.012

Table 14: Varies data after normalization (hockey).

P	U	N	M	Q
Jerry York	0.0455	0.0313	0.0516	0.0922
Red Berenson	0.0341	0.0338	0.0323	0.078
Bill Beaney	0.0375	0.0355	0.0452	0.0745
John "Snooks" Kelley	0.0409	0.0339	0.0258	0.0603
Mike McShane	0.0364	0.0333	0.0387	0.0603

Table 15: Comparison of priority (hockey).

P	U	N	M	Q	S
Jerry York	40	0.614	8.000	13.000	0.0686
Bill Beaney	33	0.697	7.000	10.500	0.0584
Red Berenson	30	0.663	5.000	11.000	0.057
Mike McShane	32	0.654	6.000	8.500	0.0489
Jack Parker	40	0.643	9.000	7.000	0.0477

4.2. Example B: Application of Hockey

4.2.1. Data Preprocessing. Owing to limited data, 30 groups of hockey coaches were selected for the test. Because of the limited amount of actual data, the model was not suitable for the application in winning rate or may cause some errors.

4.2.2. Model Application. Applying models 2 and 3, we got the data as in Tables 14 and 15.

Thus, we selected the top five "greatest coaches" (hockey).

5. Discussion and Conclusion

The correction of the winning rate improves the influence of timeline, which means that there is a certain time having an influence on the coach's achievement. By applying the model, we have successfully elected five "best ever coaches" in different sports. Verified with network selection by coaches ranking model, we established our model with certain accuracy. It is obvious that there are advantages as follows.

(1) The Absence of Data. In the process of establishing and applying this model, we found that the following problems may be the cause. While developing the indicators, 360-degree comprehensive assessment can ideally measure their professionalism and personal abilities. In addition to team honors, personal honors, coaching career length, and winning rate, some other indicators such as criminal records and other data can also measure their individual accomplishment. We believe that the evaluation of the best coaches lies not only in his achievements, but also in his personal qualities and charisma. Only in this way can we evaluate the coaches roundly.

In the definition of a formula to measure how the low level indicator affects the timeline, we hope to fit multivariate data with timeline includes the intense level of competition, people's attention on the events, state's financial investment in sports and data on media, and other technology development so that we can optimize the timeline overall.

Because of the lack of data, we selected the most important indicator-intense level of competition to optimize data through the definition of new formulas.

(2) Limited in Extension. We build model I as an example.

In the promotion of football, we obtain that $R^2 = 0.464$, indicating that the number of teams is less affected by time. Segmenting the function and then fitting in each part allow us to obtain a much more accurate function which is pretty close to the real data. Through access to information, we found that in 1933 the National Football League set up tournament for the first time, which greatly promoted the commercialization of sport. We speculate that this is also the reason why the number of teams peaked around 1930, while in 1940 a significant change in the rules occurred to American football competition. We speculate that this caused the number of participating teams to reach the minimum in the time period 1940–1945.

(3) Subjective Theories. When using AHP as a classic model, we cannot avoid our subjective opinions influencing the indicators. This obviously concludes our personal ideas and results in unavoidable error.

Although we cannot come up with a certain answer to the evaluation results of the best college coach through the use of the mathematical model described in this paper to select the best coach, we can generally conclude accurate result which matches the results online largely. Thus, we can consider that the model has a strong practicality. We consider that evaluating coaches in different aspects helps select the best coach for the team, making the team more competitive and excellent.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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