International Journal of u- and e- Service, Science and Technology
Vol.8, No. 12 (2015), pp.285-294
http://dx.doi.org/10.14257/ijunesst.2015.8.12.29

Graduate Employment Decision-making based on Analytic Hierarchy Process

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Abstract

Introduce the basic ideas, principle and modeling approach of the analytic hierarchy process and take examples of post selection and decision of graduates, making specific demonstration about the utilization of AHP to prove the scientificity and practicability of AHP for multi-attribute decision-making problems.

Keywords*: Decision-making Problems, Analytic Hierarchy Process, Employment Decisions.*

1. Multi-attribute Decision-making Problems

There may be several kinds of natural conditions facing the people, and meanwhile there are also several kinds of action plans alternative for people when they are dealing with problems. Decision maker is required to make the decision based on the known information in such case, i.e. select the optimal action plan, and such problems are classified into decision-making problems [1-3]. The several natural conditions faced by people are also known as natural state or abbreviated to state that is existed objectively and uncontrollable factor. The alternative action plans are collectively referred to as decision that is controlled factor. The decision maker is responsible for selecting the plan.

As a major constituent part of the decision-making analytical problems, the multi-attribute decision-making is widely existed in the real life. For example, buy a house. It is necessary to comprehensively consider the price, area, floor, position, surrounding environment and other various factors of the house. Although the multi-attribute decision-making problems lie in different backgrounds, they usually have some common features:

①It is always mutual conflicting between attribute**s** (with different dimensions);

②There may be qualitative attribute and quantitative attribute in an attribute set at the same time;

③Attribute normally constitute a hierarchical structure;

④Sometimes the decision information is not complete, and the decision maker can only provide the incomplete information of decision parameters;

Based on the link where the decision maker provides information and its sufficient degree, the multi-attribute decision-making can be classified into 3 categories. They are decision without preference information, decision with attribute preference information and decision with preference information among the alternative plans. In decisions with attribute preference information, such decisions with the known attribute weight base information are applied most widely to create linear distribution method, simple weighting method, AHP and other classical decision-making methods.

Mechanisms of various multi-attribute decision-making methods are also varied and have different application scopes in practice. By contrast, AHP is more useful

ISSN: 2005-4246 IJUNESST

decision-making tool [4-8]. It is a systemic analysis method which put forward by Professor Saaty who is an American operational research expert in 1971 which was introduced into China from 1982, and then its theory has been constantly deepened and developed. Because AHP is characterized by simple application, easy understanding, high practicability etc. it is also widely applied in many fields of practical decision-making problems.

2. Basic Ideas of AHP

Basic ideas of AHP are to firstly establish an internal independent hierarchical structure describing system functions or features based on requirements of problems, then give the corresponding proportional scale relying on relative importance between any two factors (or objective, criterion or plan) compared, and build the judgment matrix which some factor on the upper layer corresponds to the relevant factor on the lower layer so as to give the relative importance sequence for the relevant factor to some factor on the upper layer. The sequencing problem is core problem of AHP, including principles of the hierarchical structure, scale and sequencing.

In the aspect of research on AHP's scale, Literature [9] puts forward a new scaling method by reference to cultural In the aspect of research on AHP's scale, Literature [10] puts forward a new scaling method by reference to cultural traditions and habits in China after the detailed analysis of the scale of AHP sequencing. Literature [11] believes that the commonly-used scale method doesn't conform to the language and theory customs of humans so that it puts forward the indirect structuring method for judgment matrix of sequence scale, and explains that the method can effectively eliminate the effects of deviation which caused from the commonly-used scale method for AHP on the practical conclusions to improve reliability and accuracy of evaluation and decisions.

In the aspect of research on AHP's consistency check, Literature [12] believes that the judgment matrix structured by 1-9 scale method presented by Saaty is unable to completely ensure the satisfactory consistency, and puts forward the weight calculation by 1-9 scale method and eigenvalue method on the basis of comprehensive analysis of 3 scale method and 0.1-0.9 scale method presented by other scholars to strive for the rank preservation of results by AHP. Literature [13] believes that the consistency check for judgment matrix structured by 1-9 scale method at the consistency ratio of $CR<0.1$ is premised on practical experience in AHP presented by Saaty, and thus it lacks theoretical basis. It is suggested to not only consider this provision, but also combine with interval method for consistency check while applying AHP. Literature [14] believes that the problem of on the lower layer, the judgment of the overall consistency of judgment matrix not meeting the satisfactory consistency conditions with respect to AHP exists, and puts forward the necessary and sufficient conditions with satisfactory consistency and a new method for calculating consistency index without the maximum characteristic value, and thus the maximum characteristic value of judgment matrix can be very easily calculated by this method.

3. Principle of AHP

It is necessary to commence from principle of AHP if Analytic Hierarchy Process research is carried out. The principle of AHP is to firstly establish a clear hierarchical structure to break down the complex decision problem, secondly introduce the measurement theory to demonstrate the quantitative judgment standard of humans by relative scale through pairwise comparison, thirdly build the judgment matrix layer by layer and calculate the weight of all judgment matrixes one by one

on this basis, and finally calculate the comprehensive weight of all plans and totally sequence all hierarchies. The decision maker will select the appropriate plan depending on the weight of different plans [5, 8, 16]. The principle is formulated as follows:

Weight factor of n decision plans is represented by W:

$$W^T = [W_1 W_2 \cdots W_n] \tag{1}$$

Based on 1-9 scale, judgment matrix A is obtained by pairwise comparison of n decision plans:

$$A = (a_{ij})_{n \times n} \tag{2}$$

Where:

$$a_{ij} = \frac{W_i}{W_j} \tag{3}$$

$$a_{ji} = \frac{1}{a_{ij}} \tag{4}$$

Thus

$$AW = nW \tag{5}$$

When A is consistent matrix, n is the characteristic value of A, and W is the characteristic vector of A,

$$AW = \lambda W \tag{6}$$

$$\lambda_{\max} \geq n \tag{7}$$

When A is positive and negative matrix, n is the characteristic value of A, and W is the characteristic vector of A

$$\lambda_{\max} = n \tag{8}$$

The decision maker measures the weight of all decision plans totally through the single hierarchical arrangement and the multiple hierarchical arrangements, and selects the appropriate plan for the decision objective based on the weight.

Thus it can be seen that AHP quantizes the subjective judgment of people and transforms a qualitative question to a quantitative question for analysis by adopting a certain scale. It is a rare, simple and practical multi-criteria evaluation method.

4. Modeling of AHP

AHP is structured by simulating the thinking and judging process of people for complex problems. It provides a new, simple and practical modeling method for decision and sequencing of multi-attribute decision-making problems [4, 11-12].

AHP can be divided into the following four steps:

1) Analyze the relation among all factors in the system, and establish the hierarchical structure of the system;

Firstly methodize and layer the problems to build a hierarchical structure model when applying AHP for analysis and decision of problems. These hierarchies can be classified into 3 categories: topmost hierarchy (target hierarchy), intermediate hierarchy (criterion hierarchy), and lowermost hierarchy (plan hierarchy). Hierarchy quantity of the hierarchical structure is related to the complex degree of problems and detailed degree of necessary analysis, but generally hierarchy quantity is unlimited, and the number of factors controlled by each element at every hierarchy is normally not more than 9.

2) Conduct pairwise comparison of the importance of each element at the same hierarchy on a certain criterion on the superior hierarchy to build the judgment matrix of pairwise comparison;

Affiliation among elements at upper and lower hierarchies is determined after building the hierarchical structure. The next step is to respectively determine the weight of elements at every hierarchy. The proportions of various criterions at criterion hierarchy in the target measurement are not always identical, and the decision maker considers that they respectively account for a certain proportion. Figures 1-9 and its reciprocals are used as scale to define the judgment matrix A. As show in Table 1:

Table 1. Standards for a_{ij} Value

1-9 Scale	Meaning	Grade
	Indicate they have same importance after comparison of two factors	
a_{ij} =1	Indicate the former is slightly more important than the later after comparison of two factors	1
a_{ij} =3	Indicate the former is obviously more important than the later after comparison of two factors	2
a_{ij} =5	Indicate the former is mightily more important than the later after comparison of two factors	3
a_{ij} =7	Indicate the former is extremely more important than the later after comparison of two factors	4
a_{ij} =9	Indicate the mid value between adjacent ……respectively	
2, 4, 6, 8	If importance ratio of factor *i* to factor *j* is a_{ij}, then importance ratio	5
Reciprocal	of factor *j* to factor *i* is $\frac{1}{a_{ij}}$.	

3) Calculate the relative weight of the compared element to this criterion based on the judgment matrix, and check the consistency of the judgment matrix;

①Calculate the consistency index CI

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{9}$$

Where λmax denotes the maximum characteristic value corresponding to judgment matrix A, and n denotes the order of A. When CI=0, i.e. $\lambda max=n$, A has the absolute consistency. The bigger CI is, the poorer consistency of A becomes.

②Obtain average random consistency index RI

Firstly build 500 sample matrixes by the random method and build the positive reciprocal matrix with figures randomly selected from 1-9 and their reciprocals, then calculate the average value $\lambda'_{\max}$ of the maximum characteristic root, and finally define

$$RI = \frac{\lambda'_{\max} - n}{n - 1} \tag{10}$$

For n= any figure from 1 to 9, Saaty gives the value of RI. As show in Table 2:

Table 2. Value of Random Index RI

N	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.52	0.90	1.12	1.24	1.35	1.41	1.45	1.49	1.51

③Calculate the consistency ratio CR

$$CR = \frac{CI}{RI} \tag{11}$$

When CR<0.10, judgment matrix A has satisfactory consistency; otherwise A shall be properly modified until the satisfactory consistency has been reached.

④Calculate and sequence the general sequencing weight of various hierarchies to the system, and then obtain the general sequence of various plans to the overall objective;

Calculate the sequencing weight of the relative importance of various elements at the same hierarchy to the topmost hierarchy (the overall objective), named as general hierarchical sequence, and this process is gradually carried out from top to bottom. General hierarchical sequence of the lowermost hierarchy (the plan hierarchy) is just the general sequence of n plans evaluated.

Finally obtain the weight of all decision plans at the plan hierarchy to the overall objective by AHP, and give the overall consistency index for all judgments of the whole hierarchical structure based by this combination weight, and accordingly the decision maker can make decision.

5. Application of AHP in Post Selection of Graduates

The application of any method can't be separated from acquaintance about applied objects of the method, and there is no exception for AHP. It is necessary to analyze which factors for the post selection decisions of the graduates can be quantitatively expressed and obtained, which factors are not easily quantized, which factors play a significant role in decision making, etc. for successful and excellent application of AHP in the post selection decisions of graduates[15-21]. For example, there have been 3 enterprises willing to employ the graduate after frank discussions. Then the graduate is required to have a comprehensive consideration based on the known information to select the suitable post.

1) Build a hierarchical structure model

Investigate information based on problems and build a hierarchical structure of problems by AHP based on the known information through investigation. As show in Figure 1:

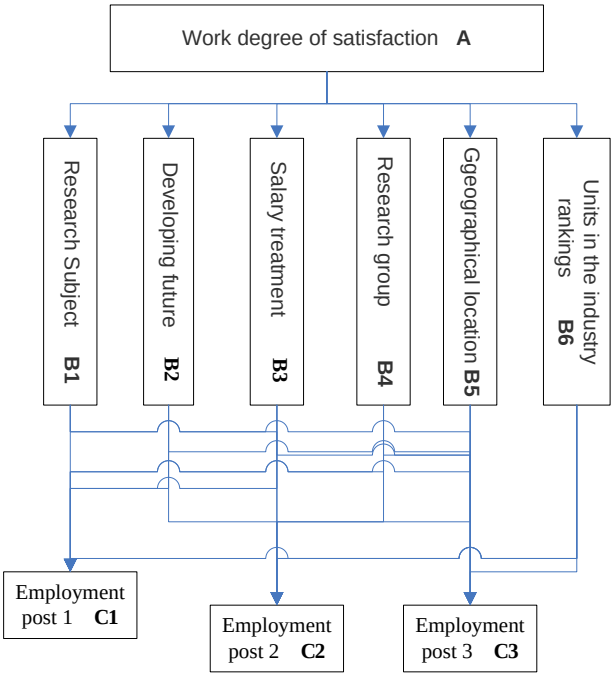

Figure 1. Schematic Diagram of Hierarchical Structure Model

2) Build judgment matrix

Build the judgment matrix of pairwise comparison at each hierarchy after the careful thinking, analysis and repeated comparison. As show in Table 3:

Table 3. Pairwise Comparison Matrix of Hierarchy B to Hierarchy A

A	B1	B2	B3	B4	B5	B6
B1	1	1	1	4	1	1
B2	1	1	2	4	1	1/2
B3	1	1/2	1	5	3	1/2
B4	1/4	1/4	1/5	1	1/3	1/4
B5	1	1	1/3	3	1	1
B6	1	2	2	4	1	1

Table 4. Pairwise Comparison Matrix of Hierarchy C to Hierarchy B1

B1	C1	C2	C3
C1	1	1/4	1/2
C2	4	1	3
C3	2	1/3	1

Table 5. Pairwise Comparison Matrix of Hierarchy C to Hierarchy B2

B2	C1	C2	C3
C1	1	1/4	1/5
C2	4	1	1/2
C3	5	2	1

Table 6. Pairwise Comparison Matrix of Hierarchy C to Hierarchy B3

B3	C1	C2	C3
C1	1	1/2	1
C2	2	1	2
C3	1	1/2	1

Table 7. Pairwise Comparison Matrix of Hierarchy C to Hierarchy B4

B4	C1	C2	C3
C1	1	1/3	5
C2	3	1	7
C3	1/5	1/7	1

Table 8. Pairwise Comparison Matrix of Hierarchy C to Hierarchy B5

B5	C1	C2	C3
C1	1	1	7
C2	1	1	7
C3	1/7	1/7	1

Table 9 Pairwise Comparison Matrix of Hierarchy C to Hierarchy B6

B6	C1	C2	C3
C1	1	5	7
C2	1/5	1	2
C3	1/7	1/2	1

The judgment matrix of all factors at the criterion hierarchy to the target hierarchy is A, and the judgment matrix of all factors at the plan hierarchy to each factor at the criterion hierarchy is B. All matrixes are shown as follows:

$$A=\begin{bmatrix} 1 & 1 & 1 & 4 & 1 & 1 \\ 1 & 1 & 2 & 4 & 1 & \frac{1}{2} \\ 1 & \frac{1}{2} & 1 & 5 & 3 & \frac{1}{2} \\ \frac{1}{4} & \frac{1}{4} & \frac{1}{5} & 1 & \frac{1}{3} & \frac{1}{4} \\ 1 & 2 & \frac{1}{3} & 3 & 1 & 1 \\ 1 & 2 & 2 & 4 & 1 & 1 \end{bmatrix} \quad B_1=\begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{2} \\ 4 & 1 & 3 \\ 2 & \frac{1}{3} & 1 \end{bmatrix} \quad B_2=\begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{5} \\ 4 & 1 & \frac{1}{2} \\ 5 & 2 & 1 \end{bmatrix}$$

$$B_3=\begin{bmatrix} 1 & \frac{1}{2} & 1 \\ 2 & 1 & 2 \\ 1 & \frac{1}{2} & 1 \end{bmatrix} \quad B_4=\begin{bmatrix} 1 & \frac{1}{3} & 5 \\ 3 & 1 & 7 \\ \frac{1}{5} & \frac{1}{7} & 1 \end{bmatrix} \quad B_5=\begin{bmatrix} 1 & 1 & 7 \\ 1 & 1 & 7 \\ \frac{1}{7} & \frac{1}{7} & 1 \end{bmatrix} \quad B_6=\begin{bmatrix} 1 & 5 & 7 \\ \frac{1}{5} & 1 & 2 \\ \frac{1}{7} & \frac{1}{2} & 1 \end{bmatrix}$$

3) Single hierarchical arrangement and consistency check

CI denotes the consistency index. When CI=0, indicate the consistent matrix; the bigger CI is, the poorer consistent degree becomes. When consistency ratio

$CR = \frac{CI}{RI}$ <0.1 (where RI can be checked by table 2), it is considered that the inconsistent degree of matrix can be accepted within the allowable limit, passing the consistency check, and its characteristic vector after normalization can be used as the weight vector. The maximum characteristic root, consistency index and consistency ratio of various matrixes calculated with matlab (program code is omitted) are shown as:

$\lambda_{max\ A}$=6.5970 $\lambda_{max\ B1}$=3.0183 $\lambda_{max\ B2}$=3.0246 $\lambda_{max\ B3}$=3 $\lambda_{max\ B4}$=3.0649

CI_A=0.1194 CI_{B1}=0.0091 CI_{B2}=0.0123 CI_{B3}=0 CI_{B4}=0.0324

CR_A=0.0963 CR_{B1}=0.0158 CR_{B2}= 0.0212 CR_{B3}=0 CR_{B4}=0.0559

$\lambda_{max\ B5}$=3 $\lambda_{max\ B6}$=3.0124

CI_{B5}=0 CI_{B6}=0.0071

CR_{B5}=0 CR_{B6}=0.0122

Because consistency ratio of various matrixes is < 0.1, the above matrixes are qualified for consistency check, and the characteristic vector corresponding to the maximum characteristic root can be used as the weight vector after normalization. The weight vectors of the matrices is obtained with matlab (program code is omitted).

W_A=[0.1714 0.1841 0.1989 0.0435 0.1726 0.2294]-1

W_{B1}=[0.1365 0.6250 0.2385]-1

W_{B2} =[0.0974 0.3331 0.5695]-1

W_{B3} =[0.2500 0.5000 0.2500]-1

W_{B4} =[0.2790 0.6491 0.0719]-1

W_{B5} =[0.4667 0.4667 0.0667]-1

W_{B6} =[0.7396 0.1666 0.0938]$^{-1}$

4) Overall hierarchical arrangement and consistency check

Integrate the weight of plan hierarchy to criterion hierarchy with the weight of criterion hierarchy to target hierarchy and finally determine the weight of plan hierarchy to target hierarchy. By matlab, the compound weight vector of plan hierarchy to target hierarchy is calculated as T=[0.3534 0.4149 0.2316]$^{-1}$.

Consistency check of overall hierarchical arrangement: the consistency ratio of overall hierarchy is calculated as CR=0.0118<0.1 by the formula of $CR = \frac{\sum_{j=1}^{m} a_j CI_j}{\sum_{j=1}^{m} a_j RI_j}$ (where CI_j and CR_j have been calculated from the single hierarchical arrangement), and thus overall hierarchical arrangement structure has relatively satisfactory consistency and the analysis results are accepted.

5) Analysis of results

It can be known from the results of overall hierarchical sequencing weight that the priority order of these three posts respectively shown as Post 1-C1 has a weight of 0.3534, Post 2- C2 has a weight of 0.4149 and Post 3-C3 has a weight of 0.2316

to this graduate. The graduate can make the decision based on the above sequencing result, and the post with the maximum weight is the most satisfactory, i.e. Post 2-C2 is the most suitable for the graduate.

6. Conclusions

AHP can organically integrate quantitative analysis with qualitative analysis to realize the quantitative analysis of some qualitative decision problems that are difficult to be quantitated precisely; and the decision maker, the decision analyzer and the expert can mutually communicate in the analysis process to make the final decision based on the evaluation standard approved conformably.

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