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Research on Comprehensive Evaluation of Poor students' Identification based on AHP method

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Abstract: The main problem solved in this paper is to establish an analytic hierarchy process evaluation model and calculate the poverty index according to the factors affecting student poverty, so as to scientifically evaluate, divide and determine the degree of student poverty, and then provide model and data support for poverty alleviation work. First of all, the data in the topic are preprocessed to eliminate the data that can not reflect the effective statistics, and then through the statistical method, the four influencing factors of average consumption in canteen, consumption times (reciprocal), variance and average consumption in supermarket are statistically analyzed to describe the consumption situation. Then four kinds of influencing factors are selected as the criterion layer, the scale of the importance of the influencing factors is determined by pairwise comparison, the judgment matrix of the criterion layer is constructed, and the maximum eigenvalue is calculated to test whether the matrix is consistent. Calculate the consistency ratio to determine the consistent performance acceptance. The influence weight of each factor is obtained by normalization, and the poverty index is calculated.

1. Introduction

At present, the identification and relief of poor students is one of the important components of the “smart campus” [1]. Big data technology is used to quickly screen and compare a large amount of information, and a mathematical model is established to automatically identify the poor students in colleges and universities [2]. This can provide effective support for the accurate identification of poor students in colleges and universities, which is conducive to the scientific classification of students’ difficulties, and the effective implementation of identifying and rescuing poor students.

2. Construction of Analytic hierarchy process Model

2.1 Creation of the hierarchical model

The hierarchy is generally divided into three layers.

1) The highest layer: There is only one element in this level [5], which is generally a predetermined goal or ideal result of the problem, and is therefore also referred to as a target layer.

2) Intermediate layer: This level contains the intermediate link involved in achieving the target,

which can be composed of several hierarchies, including the criteria required, subtitle, and therefore also referred to as a standard layer [3].

3) The bottom layer: This level includes various measures, decision options, etc., which are available for achieving goals, and therefore also referred to as measures or protocol layers.

2.2 Construction of judgment Matrix

Suppose it is now comparing n factors $X=\{x_1,\ldots,x_n\}$ influence between a factor z. That is, two factors X_i and Y_i are taken at a time, the ratio of the impact of α_{ij} means X_i and Y_i on Z. All comparison results are represented by matrix $A=(\alpha_{ij})_{n*n}$, called a pair of comparative judgment matrices[4] (ie, judgment matrix) between Z-X. If the ratio of the influence of X_i and Y_i on Z is α_{ij} , the ratio of X_i and Y_i to Z is $\alpha_{ji}=\frac{1}{\alpha_{ij}}$.

Table 1: Scale meaning

Scale	Meaning
1	Compared with the two factors, they are of the same importance
3	The former is slightly more important than the latter
5	The former is obviously more important than the latter.
7	The former is more important than the latter
9	The former is extremely important than the latter
2, 4, 6, 8	The intermediate value of the above adjacent judgment
Countdown	If the importance ratio of factor i to factor j is α_{ij}, then the ratio of factor j to factor I importance is $\alpha_{ji}=\frac{1}{\alpha_{ij}}$

Finally, it should be pointed out that it is necessary to make $\frac{n(n-1)}{2}$ pairwise judgments. Compared with n-1, it can provide more information. Through repeated comparisons from different angles, a reasonable ranking can be derived.

2.3 Hierarchical single sorting and consistency check

The judgment matrix A corresponds to the eigenvector W of the largest eigenvalue λ_{max}, and after normalization, it is the ranking weight of the relative importance of the corresponding factors at the same level to a factor at the upper level. This process is called hierarchical single ranking. If the comparison results are completely consistent, the elements of matrix A should also satisfy the

$$\alpha_{ij}\alpha_{jk}=\alpha_{ik},\forall i,j,k=1,2,\ldots,n \tag{1}$$

The positive reciprocal matrix which satisfies the relation (1) is called the consistent matrix (that is, the rows and columns of the matrix are proportional). It is necessary to check whether the constructed (reciprocal) judgment matrix An is seriously inconsistent in order to determine whether to accept A.

The steps to the consistency test of the judgment matrix are as follows:

(1) Calculate consistency indicators CI:

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{2}$$

(2) Find the corresponding average random consistency index RI. The following table shows the value of RI for n=1……9:

Table 2: RI value

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

(3) Calculate the consistency ratio CR

$$CR = \frac{CI}{RI} \tag{3}$$

When CR<0.10, it is considered that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix should be modified properly.

2.4 Hierarchical total sorting and consistency test

Let the upper level (layer A) contain a total of m factors, and their total ranking weights are $\alpha_1, \dots, \alpha_m$, respectively. Let the next level (layer B) contain n factors $B_1, \dots, B_N$, their hierarchical single ranking weights for Aj are B (when B_i is not related to A_j, $b_{ij} = 0$). Now find out the weight of each factor in layer B about the overall goal, that is, find the total ranking weight of each factor in layer B.

Let the pairwise comparison judgment matrix of the factors related to Aj in layer B pass the consistency test in the single sort, the consistency index of the single sort is CI(j), (j =1~m), and the corresponding average random consistency index is RI (j). The random consistency ratio of the total sort in layer B is:

$$CR = \frac{\sum_{j=1}^{m} CI(j)\alpha_j}{\sum_{j=1}^{m} RI(j)\alpha_j} \tag{4}$$

When CR<0.10, it is considered that the hierarchical total ranking results have satisfactory consistency and accept the analysis results.

3. Construction of consumption model

(1) Subjectively identify the data that spend less than 20 times in the canteen in 20 days as invalid consumption, so as to eliminate this part of the data.

(2) The average amount of each consumption in the canteen is negatively correlated with the degree of poverty.

(3) The consumption behavior of the supermarket other than eating is negatively related to the degree of poverty.

(4) The number of consumption in the canteen is positively correlated with the degree of poverty.

(5) The fluctuation of consumption within 20 days (that is, variance) is considered to be negatively related to the degree of poverty, and the data with maximum variance are excluded.

As a result, the available data sets are screened out, and the four influencing factors are statistically analyzed: average consumption in canteen (B_1), consumption times (reciprocal) (B_2), variance (B_3) and average consumption in supermarket (B_4). The relevant data are analyzed as follows:

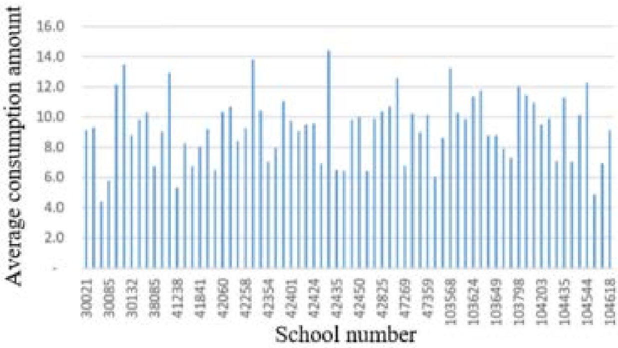

Figure 1: Average consumption amount

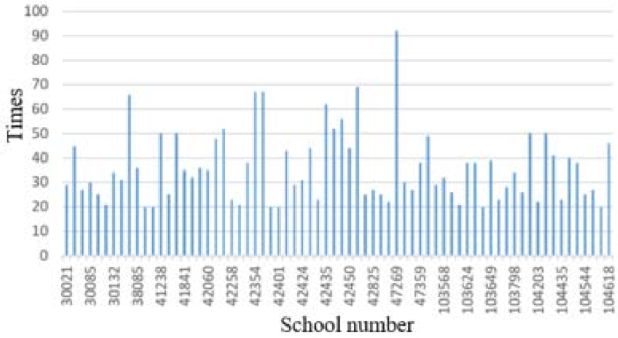

Figure 2: Consumption frequency of canteen

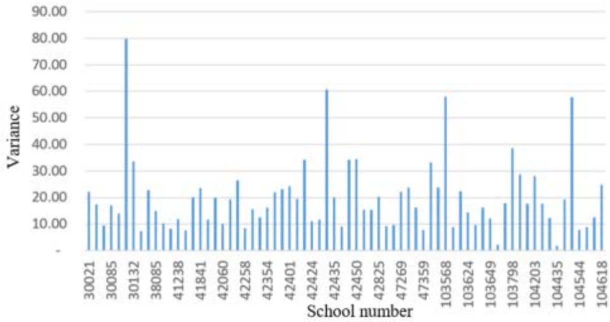

Figure 3: 20-day consumption fluctuation (variance)

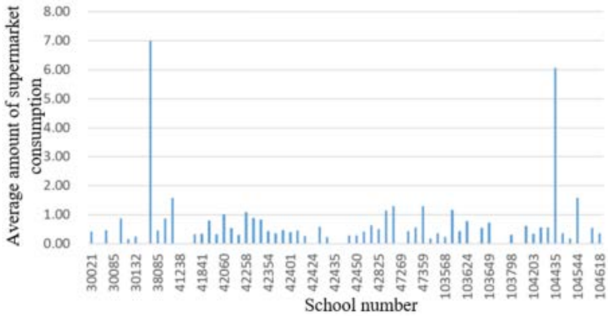

Figure 4: Average consumption in supermarkets

Through data preprocessing and statistical analysis, four factors reflecting students' poverty degree are obtained. According to the relevant literature, four factors are obtained.

Use fitting to make an image of the average amount of consumption in the canteen. Get the following image

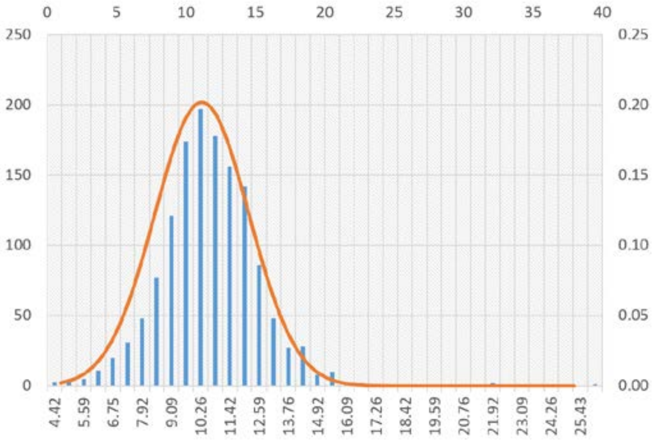

Figure 5: Average consumption in canteen

It can be seen that the consumption of students in the canteen is almost a normal distribution, and it can be concluded that because the sample is independent and identically distributed, the average consumption and variance of each student are independent of each other. In the same way, we can do other variable images, which can be seen that they almost obey normal distribution and meet the requirements of Analytic hierarchy process (AHP).

4. Solution of Analytic hierarchy process Model

Set criterion layer judgment matrix:

Table 3: Judgement matrix

A	B_1	B_2	B_3	B_4
B_1	1	1/3	1/2	2
B_2	3	1	2	5
B_3	2	1/2	1	3
B_4	1/2	1/5	1/3	1

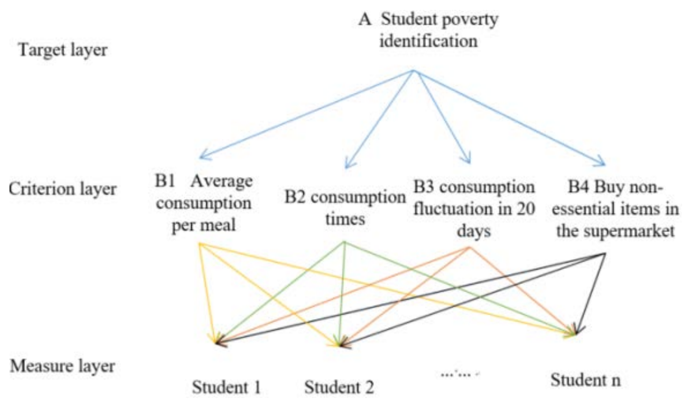

Figure 6: Diagram of Analytic hierarchy process

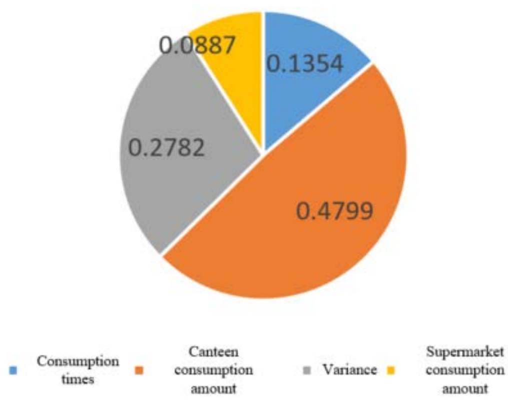

Figure 7: Proportion of each weight

The maximum eigenvalue of the matrix is calculated to be 3.8250. According to the formulas (2) and (3), the consistency index CI=-0.0583 is calculated, and the consistency ratio CR=-0.0655 is less than 0.10. It shows that the consistency of the matrix is acceptable.

The normalized data are processed, and the corresponding weights of the influencing factors are calculated by the arithmetic average method as follows.

Multiply according to the weight and the normalized result, the formula is:

$$I = \omega_{a1} * a_1 + \omega_{a2} * a_2 + \omega_b * b + \omega_{s2} * s^2 \tag{5}$$

The student poverty index is as follows:

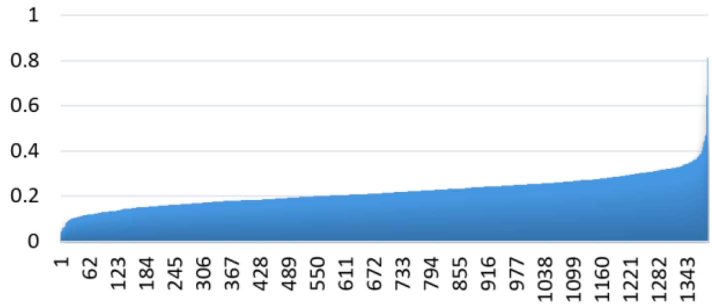

Figure 8: School poverty index

According to the ranking of the poverty index, the lower the index, the greater the degree of poverty. According to a survey conducted by Xinhua News Agency, the proportion of poorer students in colleges and universities is about 20%, and that of especially poor students is about 8%. Calculated according to this proportion from the data set, the number of poorer students and the number of poor students in the data are obtained.

5. Conclusion

In this paper, an analytic hierarchy process evaluation model is established to calculate the poverty index to scientifically evaluate, divide and determine the poverty degree of students, so as to provide model and data support for poverty alleviation work. First of all, the data in the topic are preprocessed, and then through the statistical method, the four influencing factors of average consumption in canteen, consumption times (reciprocal), variance and supermarket are statistically analyzed, and the consumption situation is described. And select the pairwise comparison of these four indicators to determine the scale of the importance of the influencing factors, construct the criterion layer judgment matrix, and calculate the maximum eigenvalue to test whether the matrix is consistent. Calculate the consistency ratio to determine the consistent performance acceptance. The influence weight of each factor is obtained by normalization, and the poverty index is calculated.

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