

Research on the development of urban and rural basic education based on analytic hierarchy method

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Abstract. In order to analyze the factors affecting basic education, such as the number of schools, the condition of basic equipment, the number of teachers, and the proportion of school area in elementary, middle, and high schools, we derived the time difference between urban and rural basic education for this period by finding various types of data for rural and urban areas from 2010 to 2022 and then comparing and analyzing the various types of data for rural and urban areas. The analytical hierarchy was then used to determine the importance of these indicators. This shows that the gap between urban and rural basic education has widened over time in these areas discussed. From 2010 to 2022, the changes in the penetration of information technology, the number of multimedia devices, the promotion rate, and the students' and physical education; satisfaction with the use of multimedia devices and the problems that teachers encounter when using multimedia were analyzed for both urban and rural primary and secondary schools. The TOPSIS integrated analysis was used to determine the most important influencing factors and their impact on the level of basic education. Finally, it was concluded that multimedia technology has both favorable and unfavorable effects on the level of basic education, but the favorable effects far outweigh the unfavorable effects, and overall it still greatly promotes the development of the level of basic education and helps to promote the balanced development of education. Before the implementation of the double reduction policy, we looked for the extracurricular tuition of rural and urban primary, middle and high school students, the promotion rate of rural and urban primary and secondary schools, and the proportion of extracurricular activities. Then we looked for corresponding data after the implementation of the double reduction policy, analyzed the correlation of these data, determined the impact of these data on the level of basic education, and used the analytical hierarchy to rank the importance of these factors. This policy has reduced the pressure of involutional competition for urban students and enriched their after-school life. For rural children, transfer rates have increased.

Keywords: AHP, GRA, Double reduction policy.

1. Introduction

From a global perspective, with the rapid development of science and technology, the deep integration of information technology and education is the general trend [1]. As early as in the "Ten-Year Development Plan for Education Informatization (2011-2020)", China has clearly put forward [2]." The key point to support the environment is to deploy education information network in advance to solve the problem of low penetration rate of education information network, unbalanced development, problems in rural and remote areas, and difficulties in accessing the Internet in regional schools Help teachers apply information technology to improve teaching quality, focus on

narrowing the digital gap between regions, urban and rural areas, and schools, and promote balanced development of education[3].

Basic education is national quality education for all students, and its fundamental purpose is to lay a solid foundation for improving the quality of the whole nation and laying a good foundation for lifelong learning and participation in social life for all school-age children and teenagers [4]. In China, basic education includes early childhood education (generally 3-5 years old), compulsory education (generally 6-15 years old), high school education (generally 16-19 years old) and literacy education [5]. This includes compulsory education at the primary and junior high school levels. To analyze the temporal differences between urban and rural basic education from 2010 to 2022, we must first dig into the information contained in basic education, analyze the ratio of each indicator through hierarchical analysis, and select a few factors with the greatest influence by ranking the ratio from highest to lowest for analysis, i.e., we select the number of schools, promotion rate, and number of teachers in urban and rural primary, middle, and high schools during these 12 years for statistical analysis. The data of urban and rural areas were compared and analyzed one by one by time to get the time difference between rural and urban basic education status [6].

Before the implementation of the "double reduction" policy, we looked for the extracurricular tutoring of rural and urban elementary, middle, and high school students, the promotion rate of rural and urban elementary and middle schools, and the percentage of extracurricular activities [7]. Then we looked for the corresponding data after the implementation of the double reduction policy, and analyzed the importance of these factors by using gray relational analysis to rank the importance of these factors from highest to lowest [8], so as to conclude that this policy mainly affects the level of basic education in both rural and urban areas. Several factors with higher importance were analyzed in both rural and urban areas, namely, the comparative analysis of rural basic education before and after the implementation of the double-reduction policy, and the comparative analysis of urban basic education before and after the implementation of the double-reduction policy [9]. The impact of dual abatement policies on the difference between urban and rural basic education was explored through hierarchical analysis [10].

2. Materials and Methods

2.1. Analytic Hierarchy Process model

BP neural network is a multi-layer network with error reverse propagation, which is composed of input layer nodes, hidden layer nodes and output layer nodes. This process has been reduced to an acceptable level of error to the network output, or to a predetermined number of learning times. The network structure is shown in Figure 1.

Hierarchical analysis refers to a complex multi-objective decision-making problem as a system, decomposing the objective into multiple objectives or criteria, and then into several levels of multiple indicators (or criteria, constraints), and calculating the hierarchical single ranking (weights) and total ranking through the fuzzy quantification method of qualitative indicators, in order to serve as a systematic method for objective (multi-indicator) and multi-program optimization decision-making. The use of AHP to solve problems is roughly divided into four basic steps, the specific process is shown in the following figure:

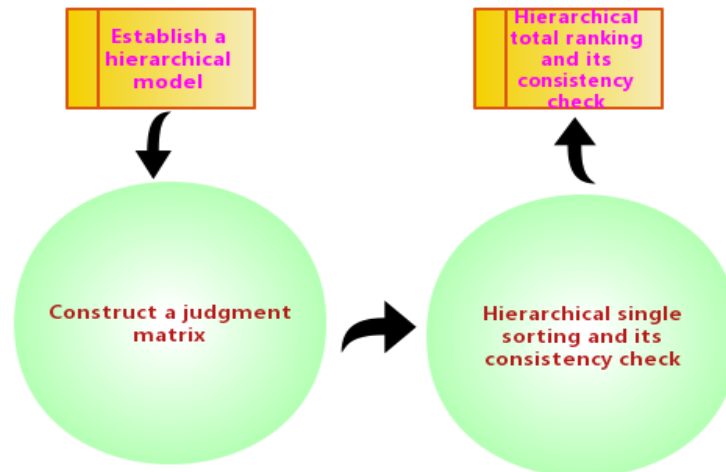


Figure 1. Hierarchical Analysis Method structure

Establishing a hierarchical model is the most important step in AHP and can be divided into the highest layer, middle layer, and lowest layer, and the top layer usually has only one element, indicating the purpose of solving the problem. Measures, programmes and policies taken by the middle layer to achieve the overall goal. The lowest level includes decision-making schemes, various ways and methods for solving problems, and the specific hierarchy is shown in the figure.

2.2. Multiple linear regression model

Changes in socioeconomic phenomena are often influenced by multiple factors, so multiple regression analysis is generally performed, and we refer to regressions that include two or more independent variables as multiple linear regressions. Statistical model:

Sample mean:

$$\bar{X} = \frac{1}{n} \sum X_i \quad (1)$$

Sample variance:

$$S^2 = \frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2 \quad (2)$$

Sample standard deviation:

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2} \quad (3)$$

We first test whether we can use multiple linear regression analysis by first making scatter plots and observing whether there is a good linear relationship between the factors.

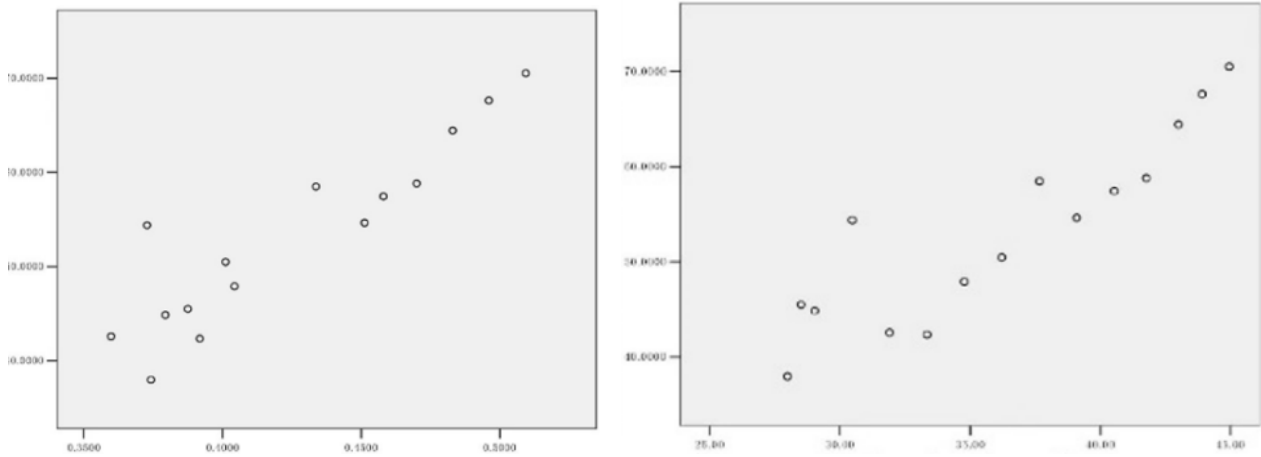


Figure 2. Scatter Chart

The results were found to have a good linear relationship, and linear regression could be used to analyze.

Measure the degree of fit of multiple linear regression, which is defined as:

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST}$$

$$\begin{aligned} SST &= \sum (y_i - \bar{y})^2 \\ SSR &= \sum (\bar{y} - \hat{y}_i)^2 \\ SSE &= \sum (y_i - \hat{y}_i)^2 \end{aligned} \quad (4)$$

Where SSR is the sum of regression squares, SSE is the sum of residuals of squares, $SSE = SST - SSR$, SST is the sum of total squares, $0 \leq R^2 \leq 1$, the closer R^2 is to 1, the higher the degree of regression plane fitting. y_i is the observation of y , $\hat{y}_i$ is the predicted value of the regression equation, $\bar{y}$ is the mean of $\bar{y} = \sum_{i=1}^n y_i / n$,

Analysis of variance (significance test of regression equations) F-test:

$$F = \frac{SSR/p}{SSE/(n-p-1)} = \frac{\sum (\bar{y} - \hat{y})^2 / p}{\sum (y_i - \hat{y}_i)^2 / (n-p-1)}$$

$$F \sim F(p, n-p-1), x_1, x_2 \dots x_p, p \quad (5)$$

are the number of independent variables

3. Model construction and solving

3.1. AHP model construction and solution

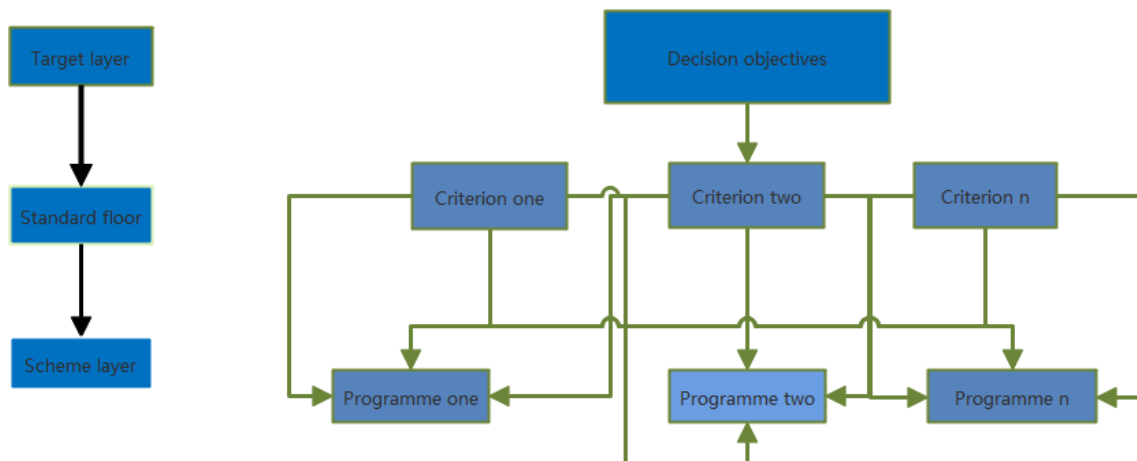


Figure 3. Flow Chart

Ranking the various impact indicators of urban and rural basic education through the analytic hierarchy method will yield the most important impact indicators, which will be of great use in proposing decision-making plans. The top level is called the target level, and the indicators that have the greatest impact on the difference between urban and rural education, the lowest level is the program level, there are five criteria to choose from, C1 is the number of various types of schools, C2 is the proportion of teachers and students in various types of schools, C3 is the promotion rate of various types of schools, C4 is the number of students in various types of schools, and C5 is the proportion of school area. The weighting of the criteria for the objectives and the weighting of each criterion by programme is determined by comparison with each other. The weight of the scheme layer to the standard layer and the weight of the target layer are synthesized, and finally the weight of the scheme layer to the target layer is determined. The program level is the status of P1 primary school education, P2 junior high school education, P3 high school education, to compare C1, C2 ... C n. Take two factors Ci and Cj for the previous factor O each time, and express the ratio of the influence of Ci and Cj on O with a_{ij} conditions.

$$A = (a_{ij})_{n \times n} \quad (6)$$

$$a_{ij} > 0, a_{ji} = \frac{1}{a_{ij}} (i \neq j, i, j = 1, 2, \dots, n) \quad (7)$$

3.2. Construction of multiple linear regression model for solving

Univariate linear regression is a relatively simple regression model in the regression model. It describes the change of a certain value so as to affect another data variable, while the univariate linear regression model is expressed by mathematical expression

$$Y = \beta_0 + \beta_1 X + \varepsilon \quad (8)$$

The relationship between two of the variables, Y and X, is described in two parts. One part is the linear change of Y caused by the change of X, namely $\beta_0 + \beta_1 x$, the other part is caused by all other random factors, recorded as ε . This formula accurately expresses the close relationship between variables x and y, but the degree of closeness is not as high as the special relationship that x uniquely determines y.

Equation is called the theoretical model of linear regression with one variable Y versus X. Generally, Y is the interpreted variable (dependent variable), X is the interpreted variable (independent variable), β_0 and β_1 is an unknown parameter β_0 is the regression constant, β_1 is the regression coefficient. ε Indicates the influence of other random factors. General assumptions ε It is an unobservable random error. It is a random variable, usually assumed ε Meet:

$$\begin{cases} E(\varepsilon) = 0 \\ Var(\varepsilon) = \sigma^2 \end{cases} \quad (9)$$

Table 1. Model Summary

Model Summary				
Models	R	R ²	Adjustment R ²	Error in standard estimation
1	0.987	0.975	0.970	0.085591

From the above table we can see that the values of R and R² are very high and the adjusted R² value is higher than 0.97, which makes this model very applicable.

Table 2. ANOVA

Model	Sum of square	Degree of freedom	Mean Square	F	Significance
Regression	279.206	3	93.069	1290.046	0.000 ^b
Residuals	0.794	11	0.72		
Total	280.000	14			

The F value is 1290.046 and the probability is $0.000 < 0.05$, so the regression equation is extremely significant.

4. Results and Analysis

4.1. AHP model results and analysis

The matrix that makes the above equation true is called a positive and inverse matrix. In this with C1, C2 ... C5 in turn represents the five criteria, use the pairwise comparison method (make $C_5^2 = \frac{5 \times 4}{2} = 10$ comparisons) The resulting contrast matrix is:

$$A = \begin{bmatrix} 1 & 1 & 1 & 4 & 1 \\ 1 & 1 & 2 & 4 & 1 \\ 1 & 1/2 & 1 & 5 & 3 \\ 1/4 & 1/4 & 1/5 & 1 & 1/3 \\ 1 & 1 & 1/3 & 3 & 1 \end{bmatrix} \quad (10)$$

Matrix A $a_{32} = 2$. It means that the ratio of C3 to the proportion of teachers and students in C2 to goal O is 2:1. So among these five indicators, C1 is the most important, followed by C2 and C3, C5 again, and finally C4.

From these conclusions, we can develop targeted measures to narrow the gap between urban and rural education, first by addressing the most serious problem of the number of schools, especially in rural areas, and then by balancing the ratio of teachers to students in schools, so that there are not more teachers than students, resulting in an imbalance in the ratio. After that, it is necessary to expand the size of schools, etc.

4.2. Analysis of multiple linear regression model results

After the implementation of the double reduction policy, the extracurricular tutoring activities of urban and rural primary and secondary school students have significantly decreased, but before that, the growth rate and number of extracurricular tutoring activities of urban primary and secondary school students were far higher than those of rural students. After the implementation of the policy, the decline in extracurricular tutoring activities of urban primary and secondary schools was far greater than that of rural villages, narrowing the gap between urban and rural basic education. In addition, extracurricular activities are gradually enriched, such as the increase of art courses and the proportion of sports, which is more conducive to the comprehensive development of urban and rural students' moral, intellectual, physical, artistic and labor. It is more conducive to the balanced development of urban and rural basic education. According to the enrollment rate, the implementation of the double reduction policy has not reduced the enrollment rate, but has increased. The high school entrance examination and the college entrance examination are examinations for selecting talents. Before the implementation of the double reduction policy, urban students can live in the city on the premise of making up lessons. However, rural children make up lessons far less than urban students, which is unfair for rural students to go to school. After the implementation of the double reduction policy, fairness can be better reflected on the premise that no one makes up lessons. Although the gap

between rural and urban education levels is still large, the gap between urban and rural education will be greatly reduced compared with the previous, which is more conducive to promoting the balanced development of education.

Table 3. Coefficient

Coefficient				
non-standardized coefficient		Standard coefficient	t	Sig.
B	standard error	beta		
0.034	.		1.454	0.171
.	0.013	0.444	5.42	0
0.005	0.001	0.588	7.187	0

Table 4. Residual Value Statistics

residual value statistics					
	minimal value	maximum value	average value		N
predicted value	0.367728	0.490095	0.424811	0.0490365	15
residual value	-0.015623	0.0102702	0	0.0079202	15
standardized predicted values	-1.164	1.515	0	1	15
standardized residual value	-1.771	1.2	0	0.905	15

Table above shows that the correlation coefficient R is 0.987, the coefficient of determination R^2 value is 0.975, and the adjustment coefficient of determination is 0.970, which is ideal for regression. F in Table is 229.765, which corresponds to a probability of $0.000 < 0.05$, so it is statistically significant and significant. The multiple linear regression equation is obtained, The constant term $t=1.454$, corresponding to a probability of $0.171 > 0.05$, the constant term is not significant and should be eliminated

5. Conclusion and Discussion

5.1. Advantages of the model

Systematic analysis methods. The extent to which each factor at each level influences the outcome is quantified, very clear and unambiguous. Concise and practical decisionmaking methods. It is easy to understand, the calculations are often simple, and the results obtained are simple and clear, which is easy for decisionmakers to understand and master. Less quantitative data information is required. This approach addresses many practical problems that cannot be solved with traditional optimization techniques. Our model based on a large amount of factual data has a high accuracy. linear equations are very easy to calculate and are used for rapid evaluation.

5.2. Deficiencies of the model and improvements

No new options for decision-making. There are few quantitative data, many qualitative components, and it is not easy to be convincing. When there are too many indicators, the data statistics are large, and the weight is difficult to determine. Evaluation: This method can be used for systematic reviews of unstructured properties as well as systematic reviews of multiple objectives, multiple criteria, multiple periods.

References

- [1] Author: Liu Hong liang Book Title [Mathematical Models and Modeling Algorithms]. Edition (August 2016 First Edition). Place of publication: Beijing. Publisher: Published by Science Press, Year of publication: 2016.226-230.

- [2] Author: Abstract dishes that love metaphysics. Grey correlation - analyze the correlation degree of GDP influencing factors, URL: https://blog.csdn.net/weixin_45666249/article/details/113841666?spm=1001.2101.3001.6650.4&utm_medium=distribute.pc_relevant.none-task-blog-2%7Edefault%7ECTRLIST%7ERate-4-113841666-blog-106178983.pc_relevant_3mothn_strategy_recovery&depth_1-utm_source=distribute.pc_relevant.none-task-blog-2%7Edefault%7ECTRLIST%7ERate-4-113841666-blog-106178983.pc_relevant_3mothn_strategy_recovery&utm_relevant_index=5 Access time: October 23, 2022.
- [3] Author: China Education Network, Title: Basic Education Development 2018 Survey Report, URL: https://www.eol.cn/e_html/zxx/report/wz.shtml. Access time. October 22, 2022.
- [4] Author: Li Xin Rong. Nomination [Primary school students to participate in extracurricular auxiliary research - taking Dalian W School as an example]. Preservation place: Dalian, preservation unit: Liaoning Normal University, year: 2022
- [5] Li Xiaohan. An analysis of the relationship between China's marine economic development and transportation based on multiple linear regression analysis model [J/OL]. Transportation Energy Conservation and Environmental Protection. <https://kns.cnki.net/kcms/detail//10.1261.U.20230227.1646.008.html>.
- [6] Xu Chunxia. The evaluation index system of international innovative composite talents based on hierarchical analysis method
- [7] Research [J]. Heilongjiang Education (Higher Education Research and Evaluation), 2022(09): 58 - 61.
- [8] Tong Juan. Evaluation of employment quality of college students based on hierarchical analysis [J]. Modern Electronic Technology, 2018, 41(07): 160 – 164
- [9] Wen Tong, SPSS Statistical Analysis Advanced Tutorial [M], Higher Education, 2004.
- [10] Tong Juan. Evaluation of college students' employment quality based on hierarchical analysis method [J]. Modern Electronic Technology, 2018, 41(07): 160 - 164.