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Research on Evaluation for Population Quality in China Based on FAHP

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Abstract: Evaluation for Population quality is very important for implementation of national human resources management. It can be manifestation of development potential and integrated competitiveness of a country. In view of the previous scholars mainly using Analytical Hierarchy Process (AHP) to analysis the population quality in China, the aim of the study is to uses Fuzzy Analytical Hierarchy Process (FAHP) to analysis it. The study builds an evaluation index system for the population quality with 12 selected indicators from three aspects: Physical quality, cultural quality and labor skills quality. On this basis, by making use of Fuzzy Analysis Hierarchy Process (FAHP), a quantitative analysis is made for Chinese population quality level. The study concludes that the population quality in China is still on the level slightly above the middle.

Key words: FAHP, population quality, delphi method, membership, consistent judgment matrix

INTRODUCTION

Population quality is the stipulation of population in terms of its quality which includes ideological quality, cultural quality, physical quality, etc. Ideological quality is the state of consciousness dominating people's behavior. Cultural quality is the ability of people to understand and change the world. Physical quality is the base of population quality. Having been viewed as the indication of national development potential and comprehensiveness, the population quality plays an important role in economic and social development of a country. Therefore, the call for improving population quality is increasingly loud.

In recent years, as an increasing number of scholars have realized the significance of population quality in economic and social development, many of them begin analyzing population quality quantitatively and some progresses have been made. Based on three indexes of "population quality index" (PQLI), Qu and Xu (2010) divide the population quality into three parts: Physical quality, cultural quality and labor skill quality. They select nine indexes in total, giving specific statistical indexes of each aspect and analyze population quality of Jiangsu province by using the method of principal component analysis. The result is that there are obvious differences among provincially administered municipalities which suggests provincial government and its functional department should make different policies, responding to each actual situation. The authors think that only strengthening the exchange of talents, capital and technology can be a long-term solution. Xiao (2007) selects eleven indexes that divide population quality into four parts: Physical quality, cultural quality, labor skills quality and moral quality and evaluates population quality level with AHP. The result shows that both Chinese physical and moral quality levels are low and the overall level should be improved. Zhang *et al.* (2003) apply grey relational cluster method to analyzing and evaluating the population quality of 14 main ethnic minorities with five indexes: Life expectancy, per capita agricultural and industrial output value, infant mortality rate, fertility rate and literacy rate of people above 15 years old. Combining physical quality, cultural quality and labor skills quality, Bai *et al.* (2012) set up a population quality evaluation system with the method of principal component analysis. And they also make an empirical analysis to study the relationship between population quality and economic development. The result shows an obvious positive relation.

In view of the previous scholars mainly using Analytical Hierarchy Process (AHP) to analysis the population quality in China, the study uses fuzzy Analytical Hierarchy Process (FAHP) to analysis it.

METHODS

Considering the complex and circulating consistency check of Fuzzy Analytic Hierarchy Process (FAHP), based on previous research achievements, this study employs FAHP to build an evaluation index system of Chinese population quality and makes a quantitative analysis of it. Using the methods of FAHP, this study finds that the population quality in China is still on the level slightly

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above the middle. Therefore, Chinese population quality must be further improved in the future.

EVALUATION INDEX SYSTEM OF POPULATION QUALITY LEVEL

Building population quality evaluation index system. The structure of AHP index system consists of the target level, the criteria level and the indexes level. In this study, the target level refers to overall level of population quality (∪) which can be further divided into physical quality (U_1), cultural quality (U_2) and labor skills quality (U_3) (Qu and Xu, 2010; Bai *et al*., 2012). And then these three parts consist of criteria levels. Under each criteria level, some specific evaluation indexes are selected as well. Here chooses infant mortality rate (%) (U_{11}), mortality rate of children under five years old (%) (U_{12}), the proportion of labor-age population (%) (U_{13}), morbidity rate of infection diseases (morbidity of A or B class infectious diseases) (one per ten thousand) (U_{14}), mortality rate of diseases (death rate of A or B class infectious diseases) (%) (U_{15}) to measure physical quality level; choose gross entrance rate of the national university (%) (U_{21}), the percent of people without finishing primary school (%) (U_{22}), the number of college students per one hundred thousand people (U_{23}) and per capita education years (U_{24}) to measure cultural quality and choose the number of scientists and engineers engaged in researches and development (unit: million per year) (U_{31}), the number of approved patent application per million people (U_{32}) and the percent of employed population who have finished technical secondary school (U_{33}) to measure labor skills quality.

Building fuzzy comparison matrix: Based on the evaluation index system, fuzzy comparison matrix should be set up to assess the importance of each factor of the next level. To construct the matrix, these influencing factors should be compared in pair to determine their scores in terms of each importance and then fill these scores into matrix (Yi and Peng, 2009). Use 0.1 to 0.9 scale method to assign, shown in Table 1 (Su *et al*., 2011).

Using Delphi method analyzes each index of the constructed index system statistically and build fuzzy comparison matrix of each level, as shown in Table 2-5.

Table 2 is the fuzzy judgment matrix of criteria level of the FAHP index system and Table 3-5 are three fuzzy judgment matrix of index level. According to the results of the fuzzy judgment matrix (including Table 2-5), the study will build the fuzzy consistent matrix.

Building fuzzy consistent matrix: Sign:

$$r_i = \sum_{k=1}^{n} r_{ik} \, (i = 1, 2, \cdots, n)$$

and set:

$$r_{ij} = \frac{r_i - r_j}{2n} + 0.5$$

then transfer the above fuzzy judgment matrix into fuzzy consistent matrix (Yin, 2011).

Order in single level: According to the following equation, calculate the weight of compared importance of each index of some level relative to that of upper level:

$$w_i = \frac{\sum_{j=1}^{n} b_{ij}}{n\alpha} + \frac{1}{n} - \frac{1}{2\alpha} (i = 1, 2, \cdots, n)$$

It can be calculated the weight of compared importance of each index of some level relative to that of upper level. This study takes the parameter α. And according to Table 6, it can g et α = 1, $w_1 = 0.4167$, $w_2 = 0.3167$, $w_3 = 0.2667$, thus, the weight of importance of each index of criteria level compared to that of target level is:

Table 1: Definition and explanation of 0.1 to 0.9 scale method

Scale	Definition	Explanation
0.5	Equally important	Compare two elements and they have the some importance
0.6	Slightly more important	Compare two elements and one is slightly more important than the other
0.7	Obviously more important	Compare two elements and one is obviously more important than the other
0.8	Much more important	Compare two elements and one is much more important than the other
0.9	Extremely more important	Compare two elements and one is extremely more important than the other
0.1	Adverse comparison	If matrix r_{ij} is a result of comparing element a_i and element a_j, then the matrix r_{ji} represents the result from adverse comparison and it will have $r_{ij}+r_{ji} = 1$
0.2		
0.3		
0.4		

Table 2: Fuzzy judgment matrix of criteria level of the FAHP index system

Variable	U_1	U_2	U_3
U_1	0.5	0.7	0.8
U_2	0.3	0.5	0.6
U_3	0.2	0.4	0.5

U_1 is physical quality, U_2 is cultural quality and U_3 is labor skills quality

Table 3: Fuzzy judgment matrix 1 of index level of the FAHP index system

U_1	U_{11}	U_{12}	U_{13}	U_{14}	U_{15}
U_{11}	0.5	0.6	0.7	0.6	0.5
U_{12}	0.4	0.5	0.6	0.4	0.6
U_{13}	0.3	0.4	0.5	0.4	0.3
U_{14}	0.4	0.6	0.6	0.5	0.4
U_{15}	0.5	0.4	0.7	0.6	0.5

U_1 is physical quality, U_{11} is infant mortality rate, U_{12} is mortality rate of children under five years old, U_{13} is the proportion of labor-age population, U_{14} is morbidity rate of infection diseases, U_{15} is mortality rate of diseases

Table 4: Fuzzy compare matrix 2 of index level of the FAHP index system

U_2	U_{21}	U_{22}	U_{23}	U_{24}
U_{21}	0.5	0.4	0.7	0.4
U_{22}	0.6	0.5	0.6	0.7
U_{23}	0.3	0.4	0.5	0.4
U_{24}	0.6	0.3	0.6	0.5

U_2 is cultural quality, U_{21} is gross entrance rate of the National University, U_{22} is the percent of people without finishing Primary School, U_{23} is the No. of college students per one hundred thousand people, U_{24} is per capita education years

Table 5: Fuzzy judgment matrix 3 of index level of the FAHP index system

U_3	U_{31}	U_{32}	U_{33}
U_{31}	0.5	0.6	0.3
U_{32}	0.4	0.5	0.2
U_{33}	0.7	0.8	0.5

U_3 is labor skills quality, U_{31} is the No. of scientists and engineers engaged in researches and development, U_{32} is the No. of approved patent application per million people, U_{33} is the percent of employed population who have finished technical secondary school

Table 6: Fuzzy consistent matrix of criteria level of the FAHP index system

U	U_1	U_2	U_3
U_1	0.5	0.6	0.65
U_2	0.4	0.5	0.55
U_3	0.35	0.45	0.5

U_1 is physical quality, U_2 is cultural quality and U_3 is labor skills quality

$$W = [w_1, w_2, w_3]^T = [0.4167, 0.3167, 0.2667]^T$$

Similarly, according to fuzzy consistent matrix of Table 7-9, the weight of importance of each index of index level compared to that of criteria level can be calculated:

$$W_1 = [w_{11}, w_{12}, w_{13}, w_{14}, w_{15}]^T$$
$$= [0.22, 0.2, 0.17, 0.2, 0.21]^T$$

$$W_2 = [w_{21}, w_{22}, w_{23}, w_{24}]^T$$
$$= [0.25, 0.2833, 0.1276, 0.25]^T$$

$$W_3 = [w_{31}, w_{32}, w_{33}]^T =$$
$$[0.3167, 0.2667, 0.41676]^T$$

Table 7: Fuzzy consistency matrix of index level of the FAHP index system

U_1	U_{11}	U_{12}	U_{13}	U_{14}	U_{15}
U_{11}	0.5	0.54	0.6	0.54	0.52
U_{12}	0.46	0.5	0.56	0.5	0.48
U_{13}	0.4	0.44	0.5	0.44	0.42
U_{14}	0.46	0.5	0.56	0.5	0.48
U_{15}	0.48	0.52	0.58	0.52	0.5

U_1 is physical quality, U_{11} is infant mortality rate, U_{12} is mortality rate of children under five years old, U_{13} is the proportion of labor-age population, U_{14} is morbidity rate of infection diseases, U_{15} is mortality rate of diseases

Table 8: Fuzzy consistency matrix of index level of the FAHP index system

U_2	U_{21}	U_{22}	U_{23}	U_{24}
U_{21}	0.5	0.45	0.55	0.5
U_{22}	0.55	0.5	0.6	0.55
U_{23}	0.45	0.4	0.5	0.45
U_{24}	0.5	0.45	0.55	0.5

U_2 is cultural quality, U_{21} is gross entrance rate of the National University, U_{22} is the percent of people without finishing Primary School, U_{23} is the No. of college students per one hundred thousand people, U_{24} is per capita education years

Table 9: Fuzzy consistency matrix of index level of the FAHP index system

U_3	U_{31}	U_{32}	U_{33}
U_{31}	0.5	0.55	0.4
U_{32}	0.45	0.5	0.35
U_{33}	0.6	0.65	0.5

U_3 is labor skills quality, U_{31} is the No. of scientists and engineers engaged in researches and development, U_{32} is the No. of approved patent application per million people, U_{33} is the percent of employed population who have finished technical secondary school

Table 10: Result of ordering in whole level under the method of FAHP

	U_1	U_2	U_3	
U	0.4167	0.3167	0.2667	W
U_{11}	0.2200			0.0917
U_{12}	0.2000			0.0833
U_{13}	0.1700			0.0708
U_{14}	0.2000			0.0833
U_{15}	0.2100			0.0875
U_{21}		0.2500		0.0792
U_{22}		0.2833		0.0897
U_{23}		0.2167		0.0686
U_{24}		0.2500		0.0792
U_{31}			0.3167	0.0845
U_{32}			0.2667	0.0711
U_{33}			0.4167	0.1111

U is overall level of population quality, U_1 is physical quality, U_2 is cultural quality and U_3 is labor skills quality, U_{11} is infant mortality rate, U_{12} is mortality rate of children under five years old, U_{13} is the proportion of labor-age population, U_{14} is morbidity rate of infection diseases, U_{15} is mortality rate of diseases, U_{21} is gross entrance rate of the National University, U_{22} is the percent of people without finishing Primary School, U_{23} is the No. of college students per one hundred thousand people, U_{24} is per capita education years, U_{31} is the No. of scientists and engineers engaged in researches and development, U_{32} is the No. of approved patent application per million people, U_{33} is the percent of employed population who have finished technical secondary school

Ordering in whole levels: On the basis of the above results of single level ordering, it can multiply the weight of each index compared to the criteria level it belongs to by the weight of the criteria level compared to the target level to calculate the weight of whole level ordering. The result can be found in the far right column of Table 10.

EMPIRICAL ANALYSIS FOR CHINESE POPULATION QUALITY WITH FAHP

In view of the previous scholars mainly using Analytical Hierarchy Process (AHP) to analysis the population quality in China, the study uses fuzzy Analytical Hierarchy Process (FAHP) to analysis it. The FAHP can combine the advantages of quantification and objectivity of AHP and of Inclusiveness of Fuzzy Comprehensive Evaluation Method (FCEM), therefore it is well suited to China's population quality assessment. That is, the study use Fuzzy Analysis Hierarchy Process (FAHP) to make a quantitative analysis for Chinese current population quality level.

Building remark set and remark matrix of target level: The standard evaluating population quality is divided to 5 degrees and the remark set is expressed as:

$$V = \{v_1, v_2, v_3, v_4, v_5\} = \{\text{extremely high, relatively high, medium, relatively low, extremely low}\}$$

For single element evaluation, to make sure the target membership degree of each index in a more reasonable and objective way, use Delphi method, inviting some experts and setting an assessment team to give evaluation according to the above remark set. And finally, the fuzzy remark matrix $(R_{U_1}, R_{U_2}, R_{U_8})$ of physical quality U_1, cultural quality level of U_2 and labor skills level U_3 is as follows:

$$R_{U_1} = \begin{bmatrix} 0.1467 & 0.2264 & 0.3052 & 0.2142 & 0.1073 \\ 0.1041 & 0.1875 & 0.3564 & 0.2023 & 0.1497 \\ 0.1257 & 0.2017 & 0.3352 & 0.1996 & 0.1378 \\ 0.1000 & 0.2361 & 0.2927 & 0.2123 & 0.1589 \\ 0.1186 & 0.2102 & 0.3102 & 0.2074 & 0.1536 \end{bmatrix}$$

$$R_{U_2} = \begin{bmatrix} 0.1803 & 0.2015 & 0.3321 & 0.1945 & 0.0916 \\ 0.2202 & 0.2234 & 0.3401 & 0.1547 & 0.0616 \\ 0.1789 & 0.2203 & 0.3358 & 0.1477 & 0.1173 \\ 0.1996 & 0.2409 & 0.3286 & 0.1304 & 0.1005 \end{bmatrix}$$

$$R_{U_3} = \begin{bmatrix} 0.1042 & 0.1458 & 0.2569 & 0.3102 & 0.1829 \\ 0.1143 & 0.1557 & 0.2706 & 0.3214 & 0.1380 \\ 0.1876 & 0.2201 & 0.3312 & 0.1547 & 0.1064 \end{bmatrix}$$

Comprehensive evaluation of target level is used: Choose operator to do fuzzy calculation and it can get comprehensive evaluation vector (S_1, S_2, S_3) of target level that corresponds to the element of criteria level:

$$S_1 = W_1 * R_{U_1} = [0.1194 \;\; 0.2130 \;\; 0.3191 \;\; 0.2075 \;\; 0.141]$$

$$S_2 = W_2 * R_{U_2} = [0.1961 \;\; 0.2216 \;\; 0.3343 \;\; 0.1571 \;\; 0.0909]$$

$$S_3 = W_3 * R_{U_3} = [0.1417 \;\; 0.1794 \;\; 0.2915 \;\; 0.2484 \;\; 0.1391]$$

So, the remark matrix of criteria level is:

$$\bar{S} = \begin{bmatrix} 0.1194 & 0.2130 & 0.3191 & 0.2075 & 0.1410 \\ 0.1961 & 0.2216 & 0.3343 & 0.1571 & 0.0909 \\ 0.1417 & 0.1794 & 0.2915 & 0.2484 & 0.1391 \end{bmatrix}$$

Do the second fuzzy evaluation and then it can get:

$$S = W * \bar{S} = [0.2068 \;\; 0.3166 \;\; 0.2025 \;\; 0.1246]$$

Assign the evaluation degree: extremely high, relatively high, medium, relatively low, extremely low with 5, 4, 3, 2, 1. The comprehensive fuzzy evaluation score of Chines current population quality is:

$$S^* = 3.0545$$

As $3 < S^* = 3.045 < 4$, it can be included that although China has been in efforts to push quality education and have taken many actions to improve the qualification of the whole nation for many years, the population quality is still in the level of slightly higher above the middle and it should be further improved in the future.

CONCLUSION

The population quality plays a significant role in the development of social and economic development of a country. It reflects the development potential and comprehensive competitiveness of the country to some extent. This study employs fuzzy analytical hierarchy process building an evaluation index system model from three aspects: Physical quality, cultural quality and labor skills quality and an empirical test is taken as well. The result shows that the level of Chinese population quality is slightly higher than the middle and it should be further improved in the future.

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