Fuzzy Comprehensive Evaluation of Rural Information Poverty in China —- Case Study of Hebei Province

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FUZZY COMPREHENSIVE EVALUATION OF RURAL INFORMATION POVERTY IN CHINA CASE STUDY OF HEBEI PROVINCE

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Abstract: Information poverty is a new form of poverty in information society. With the growing information-gap between urban and rural areas, information poverty is prevailing in the vast rural areas in China. It is largely restricted the new rural construction and the social harmonious development of villages and towns and must be resolved. The evaluation of rural information poverty is the premise to resolve it. In order to estimate the problem, index system of rural informatization evaluation of Hebei province was designed by means of Delphi. Then, according to the survey of farmers' information demand, AHP and FCE were used to estimate rural information poverty of Hebei province. The purpose of this study is to provide a new operational approach in evaluating or solving rural information poverty and constructing rural informatization in China.

Keywords: rural areas, information poverty, fuzzy comprehensive evaluation (FCE)

1. INTRODUCTION

Information poverty, a new form of poverty, has become a common problem around the world. With the development of information and communication technology, it is more prominent and must be resolved. Abroad, the first concern of it is from the "digital gap". Lloyd Morrisett (1995) pointed out that the "digital divide" was awareness of a divide between the information haves and the information have-nots. It is real concerned by the whole world derived from the series of reports: Falling Through the Net published by United States long-distance communications and information administration (NTIA). Hu Angang (2005) pointed out that the Governments of developed countries provided universal services as a principal method to resolve it. In United States, Government has adopted a series of positive measures such as legislation, social participation and Government's encouragement and so on. In Japan, Government has promoted the computer's popularization in rural areas through agricultural networks, financial support and computer training (Tian Ye, 2001). In Korea, Government started the "Information Network Village" project in 2001 to eliminate the "digital divide" (Ren Guisheng, 2006).

In China, information poverty is becoming more prominent in rural areas. Digital divide is huge between villages and towns (Mei Fangquan, 2007), which has seriously hindered agricultural development, rural progress and farmers' income. In order to solve rural information poverty, Government has promulgated a series of policies to promote the rural informatization. The majority of researches have been in the macro-field such as the significance, influencing factors, policies and measures and so on (Wen Jianlong, 2005; Liu bin, 2006; Wei Gang et al., 2006; Ding Kuili, 2007). At present, researches on the evaluation of rural information poverty are almost blank. In this study, index system of rural informatization evaluation of Hebei province was designed. Based on this system, Analytic Hierarchy Process and Fussy Comprehensive Evaluation were used to estimate rural information poverty of 6 different regions in Hebei province. The purpose of it was to provide an operational approach and a reference for evaluating or revolving rural information poverty in Hebei province or other areas.

2. DESIGNING INDEX SYSTEM OF RURAL INFORMATIZATION EVALUATION OF HEBEI PROVINCE

Informatization is not only an important cause of information poverty but also an effective way to solve it. The level of informatization is inversely proportional relationship to the extent of information poverty. In this study, index system of rural informatization evaluation of Hebei province was the basis of the evaluation of rural information poverty of Hebei province. According to index system of national informatization of China, index system of rural informatization of China and the characteristics of rural informatization of Hebei province, index system of rural informatization evaluation of Hebei province was designed through the Delphi method to evaluate rural information poverty of Hebei province. It has 3 stair indexes and 8 second grade indexes, shown in Table 1.

Tab. 1 Index system of rural informatization evaluation of Hebei province

stair index	second grade index
subjective environment of rural informatization	1. per capita annual net income of farmers (yuan)
	2. proportion of high school or above of farmers (%)
infrastructure of rural informatization	3. popularization rate of telephone (include mobile telephone) (sets/100 households)
	4. number of computer owned per 100 rural households (set)
	5. number of TV set owned per 100 rural households (unit)
	6. popularization rate of information service station at village (%)
effect of rural informatization	7. ration of internet users in rural areas (%)
	8. ration of information from telecommunication networks, radio and television networks and the internet (%)

3. COUNTING THE INDEX WEIGHT OF RURAL INFORMATIZATION EVALUATION SYSTEM OF HEBEI PROVINCE BY AHP

Rural informatization evaluation of Hebei province was a multi-index comprehensive evaluation, the core algorithm of it focused on the calculation method of the index weight. In this study, Analytic Hierarchy Process (AHP) was used to calculate the weight.

3.1 Steps of AHP

AHP was put forward by professor T.L.Saaty (Lu Taihong, 1998), including the following four steps.

(1) Establishing stepped hierarchy model. The stepped hierarchy model of this study shown in Figure 1 was established based on Table 1, with 3 layers and 8 principal evaluation indexes.

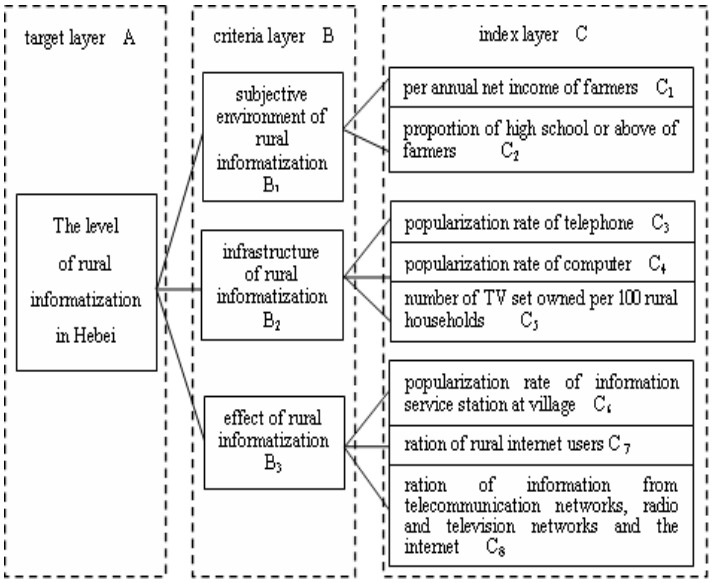

Fig.1 Frame of rural informatization evaluation model of Hebei

(2) Constructing comparison judgement matrix. By pairwise comparing elements of the same layer in accordance with certain upper factor, each element of the judgement matrix is able to be defined. The relative importance of each element follows 1-9 scale of comparison. On the basis of the scores that experts provided, several judgement matrixes can be established.

(3) Monolayer weights order and its consistency test. Monolayer weights order is defined as the importance that each element of No.(k+1) layer relative to No.k layer is ordered according to the judgement matrix. In order to ensure the effectiveness of monolayer weights order, the judgement matrix should be dealed with consistency test judged by the random consistency ratio *CR*. If $CR < 0.1$, the result can meet the requirements and so the order weights accepted. Otherwise, it must be

adjusted to meet the consistency test. *CR* is calculated in accordance with the following formula.

$CR=CI/RI$

Where: *CI* is the consistency index, *RI* is the average random consistency index, and $CI=(\lambda_{max} - n) / (n - 1)$ (λ_{max} is the largest eigenvalue, *n* is the number of the order of judgement matrix)

(4) Total weights order of hierarchy and its consistency test. Total weights order of hierarchy refers to the relative importance that each element of No.(k+1) layer relative to the certain element of No.k layer is ordered according to the monolayer weights order. Similarly, its consistency test should be done. If *CR* <0.1, it can be satisfied and accepted. Otherwise, it is necessary to be adjusted.

Where: $CR = \frac{CI}{RI} = \sum_{j}^{m} a_j CI_j / \sum_{j}^{m} a_j RI_j$

3.2 Result of AHP

The monolayer weights order of this study passed the consistency test. And the result of total weights order of hierarchy was shown in Table 2.

Tab.2 Estimation matrix and weight of rural informatization index system of Hebei

criteria layer *B*	B_1	B_2	B_3	total level ranking	ranking result
index layer *C*	0.101	0.226	0.674	weight	
C_1	0.750	0	0	0.075	4
C_2	0.250	0	0	0.025	7
C_3	0	0.236	0	0.053	6
C_4	0	0.682	0	0.154	2
C_5	0	0.082	0	0.018	8
C_6	0	0	0.091	0.062	5
C_7	0	0	0.218	0.147	3
C_8	0	0	0.691	0.466	1
CR	0	0.057	0.047	0.057	*CR*＜0.1
RI	0	0.580	0.580	0.580	meet the test of consistency

Table 2 shows that the main indexes to influence the level of Hebei rural informatization are index C_8 (information ration from telecommunication networks, radio and television networks and internet), C_4 (popularization

rate of computer) and C_7 (ration of rural internet users) shown in Figure 1. The total weight of which is up to 0.767. It points out that the main task of rural informatization of Hebei in the future is to strengthen the development of informational technology infrastructure and to improve the popularization rate of computer and network. And it can also provide a reference in evaluating the level of rural informatization.

4. FUSSY COMPREHENSIVE EVALUATION OF RURAL INFORMATION POVERTY OF HEBEI

Hebei province, located in the eastern part of China, has diverse types of terrain divided into 6 geo-economic regions—suburbs, piedmont areas, mountainous areas, Bashang plateau areas, littoral areas and low plain areas. According to index system of rural informatization evaluation of Hebei province, the level of rural informatization of 6 different regions was evaluated by Fussy Comprehensive Evaluation (FCE) to evaluate rural information poverty of Hebei province. FCE, a fuzzy decision-making method, was put forward by L.A.Zadeh and R.E.Bellman in 1965. By constructing a hierarchy of fuzzy subset, the membership degree of fuzzy indicator reflected the evaluated object can be identified and then the integration of each indicator can be obtained by fuzzy principles.

4.1 Steps of Fussy Comprehensive Evaluation

4.1.1 Determination of factor set of evaluated object

Based on Figure 1, the evaluated object of this study was divided into 1 target set (U) and 3 criteria subsets (U_1，U_2，U_3).

U=(U_1, U_2, U_3)=(subjective environment of rural informatization, infrastructure of rural informatization, effect of rural informatization)

U_1=(U_{11}，U_{12})=(per annual net income of farmers, proportion of high school or above of farmers)

U_2=(U_{21}，U_{22}，U_{23})=(popularization rate of telephone, popularization rate of computer, number of TV set owned per 100 rural households)

U_3=(U_{31}，U_{32}，U_{33})=(popularization rate of information service station at village, ration of rural internet users, ration of information from tele-communication networks, radio and television networks and internet)

4.1.2 Definition of comment set

This study took 5 comments—(better, good, average, poor, poorer), and their corresponding scores were shown in Table 3.

Tab.3 Comment set and score comparison chart

comment set	better	good	average	poor	poorer
score	90-100	70-90	50-70	30-50	10-30

4.1.3 Single-factor evaluation

It is to determine the membership grade of each hierarchy subset and then to establish the fuzzy relationship matrix *R*.

4.1.4 Comprehensive evaluation

It is to compute the fussy comprehensive evaluation vector *B* based on the weight vector *W* and the fuzzy relationship matrix *R*. The formula is $B=W\bullet R$.

Where: the weight vector *W* can be checked in Table 2.

4.1.5 Computing the final value of comprehensive evaluation

Fussy comprehensive evaluation vector *B* multiplied comment set score vector $(100，90，70，50，30)'$ equaled comprehensive evaluation value *T*. That is, $T = B \bullet (100，90，70，50，30)'$.

4.2 Data source

First of all, the data came from 446 rural households located in 6 different regions in Hebei province. Secondly, statistical results of the survey were counted by K-means clustering analysis for 5 categories with SPSS 12.0 statistical software. Finally, the clustering result of each index was ranked in descending order, then the fuzzy subset of membership grade was obtained.

4.3 Results and discussion

The followings were comprehensive evaluation results of rural informatization of 6 regions in Hebei province by FCE.

$$B_{Suburbs} = (0.1252 \quad 0.3907 \quad 0 \quad 0 \quad 0)$$

$$B_{Piedmont} = (0.0348 \quad 0.1252 \quad 0 \quad 0.3141 \quad 0.0418)$$

$$B_{Mountainous} = (0 \quad 0.0120 \quad 0.0424 \quad 0.1475 \quad 0.3141)$$

$$B_{Bashang} = (0 \quad 0 \quad 0.3559 \quad 0 \quad 0.1600)$$

$$B_{Littoral} = (0.3634 \quad 0.0025 \quad 0.0991 \quad 0.0468 \quad 0.0041)$$

$$B_{Low-plain} = (0 \quad 0.4132 \quad 0.0534 \quad 0.0076 \quad 0.0418)$$

The result of FCE is a fuzzy vector. If compared on a number of objects, it is often difficult to obtain a clear comparison of the conclusions. In order to resolve this problem, the value T of a comprehensive evaluation is calculated according to the formula: $T = B(100 \quad 90 \quad 70 \quad 50 \quad 30)'$

Where: vector B is the result of FCE, (100 90 70 50 30) is the greatest score of the grading comment sets shown in Table 3.

According to the formula, the comprehensive evaluation value T of 6 regions in Hebei province were obtained and shown in Table 4. Then, based on the inversely proportional relationship between the level of informatization and information poverty, the evalulation of rural information poverty of 6 regions in Hebei province was obtained and shown in Table 4. The extent of information haves was prescribed (richer, rich, average, poor, poorer) corresponding with 5 comment set shown in Table 3.

Tab.4 Evaluation of rural informatization and extent of information haves of 6 regions in Hebei province

area	comprehensive evaluation result		level of rural informatization	extent of information haves
	scorce T	ranking		
suburbs	47.6832	1	poor	poor
littoral	45.9686	2	poor	poor
low plain	42.5532	3	poor	poor
piedmont	34.4380	4	poor	poor
Bashang plateau	29.7112	5	poorer	poorer

mountainous areas	20.8400	6	poorer	poorer

Table 4 shows that the level of rural informatization of 6 different regions is poor and information poverty is prevalent in Hebei province. And with the value *T* gradually decreasing, the extent of information poverty is gradually increasing. The value *T* of mountainous areas is the minimum. Accordingly, the extent of its information poverty is the most serious. Then, followed by Bashang plateau areas. Therefore, more attention should be paid to the two regions during rural informatization in Hebei province.

The level of informatization directly reflects the extent of information poverty. The higher level of informatization in a certain area, the more achievements of informational civilization shared by people and the more convenient way to get information, and the lower level of information poverty. Instead, the opposite is true. Therefore, strengthening rural informatization is an effective way to resolve information poverty in rural areas in China.

5. CONCLUSION

In this study, the evaluation system of rural informatization of Hebei province was designed by Delphi to estimate the rural information poverty of Hebei province. The weight coefficients of indexes at all levels of this evaluation system were fixed by Analytic Hierarchy Process. Then, based on the results, Fussy Comprehensive Evaluation was used to estimate the rural information poverty of 6 different regions in Hebei province. Result of this study indicated that information poverty was prevailing in rural areas in Hebei province, especially more prominent in mountainous areas and Bashang plateau areas where more attention and more investment should be given to solve rural information poverty and to promote rural informatization and the coordinated development between urban and rural areas in Hebei province.

The evaluation of rural information poverty is the premise to resolve rural information poverty. Rural information poverty involves many aspects, so the method to evaluate it is very important. The method AHP and the method FCE are a combination of qualitative and quantitative analysis. It is a new way to evaluate or measure the extent of rural information poverty by AHP and FCE. This study provided a new operational approach in evaluating and resolving information poverty in rural areas. Due to the different level of rural informatization in different

provinces or regions, the index system of rural informatization evaluation should be in the light of the local conditions to design and to conduct an objective evaluation of rural information poverty.

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