Weight Analysis of Rural Multidimensional Poverty Index Based on DEMATEL Model: A Case Study of Shanxi Province in China

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Abstract: In the current research on poverty indicators, most of them endow equal weights in all dimensionalities or slightly improve on the basis of equal weights. To improve the scientific calculation of weights, this paper analyzes the weights of multidimensional poverty indicators in the DEMATEL model. Through the combination of living poverty and development poverty, the five dimensionalities of income, expenditure, education and social security, population quality and development environment are unified, and the weight of multidimensional poverty indicators is calculated based on a survey on relevant expert. Simultaneously, which factors are the more important ones and should be endowed more weights are particularly discussed. The research shows that the proportion of net income per capita accounts for the largest weight, which is the core indicator. The proportion of own income and labor force transfer rate are the key indicators, which will directly affect the result of income proportion. This article can provide theoretical reference for further research.

1. Introduction

With the continuous development of economy, our country has achieved some success in alleviating poverty. However, it is still at the primary stage in the theoretical research of poverty alleviation methods. In particular, the setting of weights of multidimensional poverty indicators is generally established arbitrarily. So, the previous methods have some deficiencies. In the course of conducting research on poverty index, it is necessary to effectively combine regional living poverty with development poverty. At the same time, in accordance with the principle of being practical and realistic, scientific and effective evaluation criteria are set.

Most foreign studies on poverty decomposition research the current situation and causes of poverty in a country from a macro perspective, which decomposes economic growth, income inequality and changes in welfare policies. Wu Y decomposes the changing effects of poverty into four aspects: growth effect, inequality effect, growth rate effect and distribution effect [1]. Chuang H measures poverty in income inequality in the United Kingdom and the United States and explains how economic trends and government policies affect income distribution [2]. Armagan explored the changes in aggregate income in six developing countries between 1980 and 1998 and analyzed the impact of globalization on poverty in all countries. The results show that different income growth illustrates the diversity of most poverty trends, but some of the alternative variables are not explained, and the impact of inequality change is relatively small except for Eastern Europe and Central Asia [3]. Yalonetzky G explores and assesses the contribution of changes in total poverty to internal and external sectors by building a theoretical framework for the Cameroonian sector. The results showed that rural labor transfer can be used as a strategy for household to ease the deterioration of the carrier of poverty and co-growth [4]. Angulo R decomposed the changes in poverty in Cameroon between 1984 and 1996. The results of the experiment demonstrate the potential contribution of moderate increases in income distribution in pro-poor households in Cameroon to poverty alleviation (Angulo

R, 2015) [5].

On the basis of poverty research, the methods of multidimensional poverty measurement and its weight confirmation have been continuously improving. The Multidimensional Poverty Index (MPI) consists of 10 household indicators such as education, health, property, services, school education, nutrition, and health systems [6]. The current research was simply to give equal weight to all dimensionalities or to improve slightly based on equal weights. However, the difference in weights setting will have a great impact on the results of study of poverty [7]. For example, in the sensitivity analysis of multidimensional poverty indicators, the weight adjustment will greatly affect the index size. Therefore, it is very important to use a reasonable method to establish the weight of multidimensional poverty indicators. The scientific and reasonable method of weight determination can make the evaluation of indicators more convincing. In this paper, the DEMATEL model is carried out for mostly poverty indicators weight analysis, and its application has been studied.

2. Research Methods

In this study, DEMATEL model is mainly used to analyze the weights of multidimensional poverty of Shanxi province. We need to collect comprehensive and reasonable information for a complicated system. It is necessary to collect information about internal professionals, and collect relevant external information to make sure the system contains all the elements. After analyzing the collected information, it is confirmed that the system contains N elements that determine whether there is a direct impact on the relationship between system elements and the strength of the relationship. Then a digraph is constructed. If the element U_i has a direct influence on the element U_j, then an arrow drawn by U_i is directed to U_j and the number 0-3 is used to indicate the intensity of the relationship between the indicators, where 0-3 respectively represent no effect, slight influence and great influence. After that the directed graph is transformed into the direct relation matrix M.

Where n is the number of indicators, a_{ij} figures represent the degree of interaction between expert opinion index U_i and influence index U_j, and its diagonal elements a_{ij} is set to 0. Setting X represents a normalized direct relation matrix, which can be expressed as the results shown in Eqs. (1) and (2). Based on the normalized direct relation matrix X, the comprehensive influence matrix T is obtained by using equation (3). Afterwards, the degree of interaction between elements are calculated, and $t_{ij}(i, j = 1,2, \dots, n)$ is set as an element in T, indicating that the index j is affected by the comprehensive influence of the index i. The sum of rows is recorded as D_i, indicating the comprehensive influence value of the corresponding elements of each line on other elements, which is called as the influence degree. The sum of the columns is recorded as R_i which means that the corresponding elements in each column are affected by the comprehensive influence value of other factors, which is called the affected degree. D_i and R_i are respectively calculated by the following formula (4) and formula (5):

$$X = \lambda \times M \tag{1}$$

$$\lambda = \frac{1}{\max\limits_{1 \le i \le n}} \left(\sum_{j=1}^{n} M_{ij} \right) \tag{2}$$

$$T = X(I - X)^{-1} \tag{3}$$

$$D_i = \sum_{j=1}^{n} t_{ij} \ (j = 1,2, \dots, n) \tag{4}$$

$$R_j = \sum_{i=1}^{n} t_{ij} \ (i = 1,2, \dots, n) \tag{5}$$

Based on the above analysis, we can calculate the centrality and the cause of each factor. The value of D+R is the centrality, as shown in the following formula (6), which shows the position of the element in the evaluation index system and the size of its role. If the center of the feature is higher, it indicates that the feature is more important throughout the system. Suppliers have greater willingness to improve. The value of D-R is the cause, as shown in the following formula (7). If the

degree of reason is greater than 0, it means that this factor is the cause type and has an impact on other indicators. If it is less than 0, the feature will be biased towards the affected element, which will have much room for improvement [8].

$$\text{Centrality} = \mathrm{D}_i + \mathrm{D}_j = \sum_{i=1}^{n} t_{ij} + \sum_{j=1}^{n} t_{ij} \tag{6}$$

$$\text{Cause degree} = \mathrm{D}_i - \mathrm{D}_j = \sum_{j=1}^{n} t_{ij} - \sum_{i=1}^{n} t_{ij} \tag{7}$$

The above method is applied to analyze the weights of poverty indicators. The steps are as follows: from the research purpose, the research indicators or elements are determined; the correlation between the elements is quantified. First, according to the set scale, the method of expert judgment is used to determine the direct influence degree of each element. At the same time, the experts' judgments are summed up and the direct influence matrix is obtained by means of statistical analysis. Then, the normalization directly affects the matrix and the comprehensive influence matrix is calculated. After that, the degree of influence between the corresponding elements are calculated, the center and cause of the corresponding element are also calculated. In the end, after the center of the element is calculated, the weight of each element would be calculated, then the index of each element will be processed or evaluated according to the whole process.

To study the application process of the above research methods, this paper takes Shanxi Province as an example to conduct the research and analysis, and uses the DEMATEL model to carry on the weight analysis of poverty indicators in Shanxi region. Through the combination of living poverty and development poverty, the five dimensionalities of income, expenditure, education and social security, population quality and development environment are unified, and the above dimensionalities are taken as the core indicators. The weight analysis is carried out on the basis of meeting the basic criteria of poverty indicators. A basic overview of the five basic indicators (Dimensionalities) is given in Table 1 [9].

Table. 1 Multidimensional poverty indicators

Dimensionality	Indicator
Basic income level	Per capita GDP
	Gini coefficient
	Own income ratio
Consumption	Engel's coefficient
	Per capita consumption level
Regional education and social security	Degree of education
	Teachers situation
	Education input
	Insured ratio
Basic quality of regional staff	Per capita life quality index
	Per capita labor value index
	Labor knowledge level
Develop environment	Traffic level
	Information delivery method
	Talent inflow rate

As shown in Table 1, the corresponding subordinate indicators are set on the corresponding basic indicators (Dimensionalities), and the subordinate indicators are assigned serial numbers respectively. In this paper, a questionnaire is distributed to 50 experts to obtain the data, which are statistically analyzed. The DEMATEL model is used for data processing.

3. Results

After a statistical analysis based on the data, the average of the interrelationships between the indicators was taken as the direct influence matrix between the indicators. After normalizing the

matrices, the normalized matrix is obtained.We can calculate the centrality and the cause of each factor. Afterwards, the parameters can be calculated by the DEMATAL model.

Based on the above calculation, the entropy weight of poverty index is calculated, and the weight matrix is obtained with the data in the calculation process, in which the index entropy weight is also obtained. The results are shown in Table 2. At the same time, we draw the weight of multidimensional poverty basic indicators as shown in Table 3.

Table. 2 Poverty indicators entropy

Index	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8
	0.086	0.066	0.071	0.066	0.065	0.062	0.066	0.071
Index	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	/
	0.063	0.055	0.067	0.068	0.063	0.065	0.066	

Table. 3 Multidimensional poverty indicator weights

Dimensionality	**Indicator**	**Index**	**Weight summary**
Basic income level	Per capita GDP	0.086	0.223
	Gini coefficient	0.066	
	Own income ratio	0.071	
Consumption	Engel's coefficient	0.066	0.131
	Per capita consumption level	0.065	
Regional education and social security	Degree of education	0.062	0.262
	Teachers situation	0.066	
	Education input	0.071	
	Insured ratio	0.063	
Basic quality of regional staff	Per capita life quality index	0.055	0.190
	Per capita labor value index	0.067	
	Labor knowledge level	0.068	
Develop environment	Traffic level	0.063	0.194
	Information delivery method	0.065	
	Talent inflow rate	0.066	

In the study, we found that the sum of the weights of the income and expenditure components reached 0.354, indicating that there is a certain lack of spending power in the region and the income cannot be effectively enhanced. It can be seen that income and expenditure have a certain proportion in the multidimensional poverty in the Shanxi region.

Judging from the results in Table 3, the weight of regional education and social security accounts for 0.262, accounting for the largest proportion. Summarizing the order of the above factors, the order of weights is listed in descending order, from regional education and social security, basic income level, development environment, basic quality of regional staff to consumption, indicating the importance of regional education and social security in regional development. Only by guaranteeing the basic quality of life and educational needs of residents, and ensuring the basic educational level of the labor force, can we lay the foundation for economic development. At present, although the local government in Shanxi Province has increased its investment on alleviating poverty, its implementation may be deviated from established goals.

4. Conclusion

In this paper, the weights of multidimensional poverty indicators are analyzed through the DEMATAL model. The weight matrix is obtained by combining the data, which comes from the information provided by the anti-poverty professionals working in relevant department of Shanxi Province, in the calculation process. China is striving for a peaceful, prosperous, and inclusive society and aims to alleviate poverty and hunger (leaving no one behind) by 2020. To achieve this, development and social policy need to focus on alleviating multidimensional poverty. Through the

above comprehensive analysis, in the five dimensionalities of multidimensional poverty, regional education and social security, development environment and basic income level are the three core dimensionalities. Therefore, to improve the anti-poverty efficiency, we should start with three aspects of action: increasing education and social security investment, perfecting the development environment and improving the capacity for income growth.

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