

Research on the Development Level of China's Agricultural Rural Modernisation Based on Delphi, Entropy Weight and Topsis Methods

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Abstract. This paper proposes a comprehensive assessment model through the Delphi, entropy weight and Topsis methods to address the complexity and diversity of China's agricultural and rural modernisation development. Firstly, the relative weights of each indicator in the modernisation of agriculture and rural areas were determined through expert surveys and weighted averages, and consistency tests were conducted to verify the credibility of the results. Secondly, the use of the entropy weight method is detailed, where the weights are determined by calculating the information entropy value of the indicators, and the final weight results are normalised. Further, the application of the Topsis method in assessing the development level of agricultural and rural modernisation in each province and city is described, and the comprehensive scores of each region are derived and graded by comparing the distances from the ideal solution and the negative ideal solution. Finally, the degree of realisation of agricultural and rural modernisation in China's provinces and cities is assessed and analysed based on the scores, demonstrating the differences and trends in the modernisation process in different regions.

Keywords: Modernisation of Agriculture and Rural Areas, Weighting, Integrated Assessment.

1. Introduction

Today, with globalisation and unbalanced urban-rural development, the promotion of China's agricultural and rural modernisation has become an important strategy for national economic development and social stability [1-2]. However, due to geographical differences, resource endowment and uneven policy implementation, there are significant differences in the modernisation process among regions, and how to scientifically assess and accurately classify the level of modernisation of agriculture and rural areas has become an important topic for current research [3].

In China, the development of agricultural and rural modernisation is affected by a variety of factors, including the level of economic development, scientific and technological inputs, infrastructure construction, and ecological environmental protection. These factors not only show differences in different regions, but also have complex and variable interrelationships and degrees of influence. Therefore, in order to better understand and promote the balanced development of agricultural and rural modernisation, it is necessary to adopt scientific assessment methods to deeply analyse and quantify the role of these influencing factors. The data in this article comes from the National Statistical Office

This paper will propose a comprehensive assessment model based on the Delphi method, entropy weight method and Topsis method to solve the key problems of how to determine the weight distribution of the influencing factors, how to assess the modernisation level of each region, and how to set up a corresponding hierarchical classification system. The Delphi method, as a classic method of expert opinion survey, can help us obtain reasonable suggestions for weight allocation from different expert groups; the entropy weight method can deal with the problem of inconsistency in the quantitative outlines of multiple indicators, and assigns appropriate weights to each indicator through

information entropy calculation[4-5]; and the Topsis method combines the comparison of ideal and negative ideal solutions, so as to determine the relative degree of superiority of modernisation levels of each region.

Through the application of these methods, this paper aims to provide policy makers and decision makers with a scientific basis for optimising resource allocation and promoting balanced development of agricultural and rural modernisation, so as to achieve the dual goals of economic development and social progress.

2. Modernisation Development Level Classification Model

2.1. Delphi method for obtaining indicator weights based on expert opinion

With the help of experts from the agricultural sector, government departments, research departments and universities, we determined the relative weights of the indicators affecting the development of agricultural and rural modernisation in the provinces and cities. First we sent a questionnaire to the expert group to determine the relative importance of each indicator. In the questionnaire, we asked the experts to rate each indicator on a scale of 1-5, depending on the importance of each indicator to the modernisation of agriculture and rural areas. They were indicated as not important, less important, average, more important and very important, respectively [6-7]. Then, based on the experts' comments, we weighted the scores of each indicator to determine the relative weight of each indicator in the development of agricultural rural modernisation $\omega_i^{(1)}$. These weights will provide us with key information for identifying priority areas for development, setting development goals and accelerating the process of modernisation of agriculture and rural areas. Indicators with high scores mean that their roles in the modernisation of agriculture and rural areas are more important and have higher weights; conversely, indicators with low scores mean that their roles in the process of modernisation of agriculture and rural areas are minor and have lower weights.

Conduct consistency test: after determining the weights, we use AHP hierarchical analysis to conduct consistency test to ensure the reliability and accuracy of the weights, AHP hierarchical analysis is a commonly used method, which can decompose the problem into a hierarchical structure, so that it is easier to determine the weights.

The specific process of AHP hierarchical analysis method is as follows:

1. Multiply the weight matrix and the eigenvectors to get the weighted eigenvectors.
2. Calculate the consistency index $CI = (\lambda_{\max} - n) / (n - 1)$.
3. Calculate the random consistency indicator $CR = CI / RI$, where RI stands for random consistency indicator, which can be derived from a table based on the number of indicators.
4. If $CR < 0.1$, it indicates that the weighting results have a high degree of confidence. Conversely if $CR \geq 0.1$, the accuracy of the weighting results needs to be revisited.

(iii) From $CR < 0.1$, we can assume that the expert group's opinion is more consistent and the weighting results are more credible and acceptable. Determine the relative weights of the final indicators in the development of modernisation of agriculture and rural areas according to the expert's opinion and the consistency test results [8].

2.2. Entropy weight method to determine the weight

Entropy weight method is a commonly used method for determining the weights of multiple indicators, which can solve the contradictory problems of multiple indicators with different scales and units, and can objectively and fairly determine the weights of each indicator. We weighted the indicators according to the entropy weighting method $\omega_i^{(2)}$, The data were first processed to form the following data matrix.

$$R = (r_{ij})_{m \times n} \quad (1)$$

The basic idea of entropy weight method is to establish information entropy model by measuring the size of information entropy between indicators, and then calculate the weight of indicators according to the information entropy value of indicators [9-10]. The formula is as follows:

$$\omega_i^{(2)} = \frac{(1 - E_j)}{(\sum_{j=1}^n (1 - E_j))} \quad (2)$$

Included among these, $\omega_i^{(2)}$ indicates the weight of the i th indicator, E_j denotes the information entropy of indicator j and n denotes the number of indicators.

The information entropy can be expressed by the following equation:

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij} \ln p_{ij} \quad (3)$$

$$p_{ij} = \frac{r_{ij}}{\sum_{j=1}^n r_{ij}} \quad (4)$$

The so-called information entropy refers to the magnitude of uncertainty of a data set. The smaller the information entropy is, the smaller the uncertainty of that data set is, i.e., the purer the data set is; on the contrary, the larger the information entropy is, the larger the uncertainty of the data set is, i.e., the more cluttered the data set is.

Therefore, in the entropy weight method, for each indicator, we first calculate its information entropy value, and then use the above formula to calculate the corresponding weights.

Finally, the obtained weights of each indicator are normalised, i.e., each weight is divided by the sum of all weights to obtain the new weights after normalisation $\omega_i^{(2)}$.

We end up with a weighting of:

$$\omega_i = \frac{\alpha \omega_i^{(1)} + \beta \omega_i^{(2)}}{\sum_{i=1}^n \alpha \omega_i^{(1)} + \beta \omega_i^{(2)}} \quad (5)$$

The weighting values of the indicators are shown in the table 1:

Table 1. Indicator weights for measuring China's agricultural and rural modernisation.

Indicator	weights
Total power of agricultural machinery/cultivated land	0.077
Level of agricultural science and technology input	0.119
Effective irrigation rate	0.063
Increase in output value of agriculture, forestry, animal husbandry and fishery services	0.007
Livestock production value/total agricultural output value	0.012
Total output value of fishery/total agricultural output value	0.035
Comprehensive grain production capacity	0.058
Land productivity	0.046
Agricultural labour productivity	0.033
Financial expenditure on agriculture/agricultural output value added	0.062

Rural financial savings per capita	0.016
Depth of agricultural insurance	0.022
Reduction in agricultural fertiliser application rate (%)	0.029
Environmental protection input/GDP	0.042
Number of biogas projects	0.017
Road density	0.021
Number of rural health centres/total number of villages	0.041
Number of village-run hydropower stations	0.026
Rural domestic sewage treatment rate	0.026
Rural domestic waste disposal rate	0.014
Rural sanitary latrine penetration rate	0.013
Number of Adopters in Rural Residential Homes for the Elderly / Rural Population	0.024
Total Expenditure on Rural Minimum Subsistence Security	0.015
Number of rural special hardship cases under centralised support	0.029
Per capita disposable income of rural residents	0.026
Per capita disposable expenditure of rural residents (yuan/person)	0.017
Rural residents' food consumption expenditure as a proportion of	0.016
Per capita electricity consumption	0.038
Rural Internet penetration rate	0.011
Average year-end car ownership per 100 rural households	0.009
Average years of education	0.009
Rural residents' expenditure on education, culture and entertainment	0.009
Township Cultural Stations	0.009
Comprehensive mechanisation rate of crops (%)	0.010

2.3. Topsis method for scoring the level of development of agricultural and rural modernisation in provinces and municipalities

Topsis (Technique for Order of Preference by Similarity to Ideal Solution) is a commonly used multi-attribute decision-making method to arrive at an optimal solution by comparing alternatives with the ideal and negative ideal solutions. The basic idea is to find a reference point that has the smallest distance from all alternatives, i.e. closest to the ideal solution, and the largest distance from all alternatives, i.e. farthest from the negative ideal solution. At the same time, Topsis method also meets the idea of determining the relative weights of each indicator using a combination of subjective and objective methods.

The specific steps of Topsis method are as follows:

1. Determine the decision matrix, which contains m provinces and cities and n evaluation indicators.
2. Determine the weight of each evaluation indicator.
3. Determine the optimal value and the worst value for each evaluation index according to its goodness.
4. Standardise the raw data and transfer the data to the standardised database.
4. Standardise the raw data and transform them into dimensionless data.
5. Calculate the distance between the development level of agricultural and rural modernisation in each province and city and the ideal and negative ideal solutions. Methods such as Euclidean distance or Manhattan distance can be used here.
6. Calculate the composite score of the development level of agricultural rural modernisation in each province and city. The higher the composite score, the closer the programme is to the ideal solution.
7. Rank the provinces and cities according to the comprehensive score, and get the ranking table of the comprehensive score of the development level of agricultural rural modernisation of each province and city.

Set the score of the i th province and city on the j th evaluation index as

$$a_{ij}(i=1, 2, 3\dots m, j=1, 2, 3,\dots n)$$

Where a larger positive indicator is better and a smaller negative indicator is better.

The weight vector is $\omega_i = (\omega_1, \omega_2, \omega_3, \dots \omega_n), \sum_{j=1}^n \omega_j=1$.

Then the distance of the k th province and city from the ideal solution and the negative ideal solution are respectively

$$D_k^+ = \left(\sum_{j=1}^n \omega_j (a_{kj}/r_j^- - r_j^+) \right)^{\frac{1}{2}} \quad (6)$$

$$D_k^- = \left(\sum_{j=1}^n \omega_j (a_{kj}/r_j^+ - r_j^-) \right)^{\frac{1}{2}} \quad (7)$$

A composite score for the level of development of agricultural and rural modernisation is then calculated for each province and municipality C_k :

$$C_k = \frac{D_k^-}{D_k^+ + D_k^-} \quad (8)$$

After obtaining the composite score of the level of agricultural and rural modernisation development of each province and city, a linear transformation is carried out through the "linear transformation standardisation" to convert the score of the level of agricultural and rural modernisation development of the middle-developed countries into 60 points.

The specific steps of one linear transformation are as follows:

1. Divide 60 by the score of this group of data to get the change factor.
2. The rest of the data are multiplied by the change factor to change the score.

2.4. Classification of agricultural and rural modernisation

The development path of China's agricultural and rural modernisation is divided into three categories: not at all modernised, fully modernised and partly modernised and partly not modernised.

Comparing the scores of the modernisation level of agriculture and rural areas in the existing provinces and cities with the modernisation level of agriculture and rural areas in the middle-developed countries in the world, if the region with the lowest level of modernisation in the country reaches the modernisation level of the middle-developed countries in the world, it means that the country has completely entered into modernisation; if the region with the highest level of modernisation in the country fails to reach the modernisation level of the middle-developed countries in the world, it means that If the region with the highest level of modernisation has not reached the level of modernisation of the middle developed countries of the world, the country is not modernised at all; if some regions have reached the level of modernisation of the middle developed countries of the world and others have not, the country is in the third state of modernisation. If the third state of modernisation is met, a hierarchy of the degree of modernisation can be established according to the following method.

As can be seen from the above comparison, the data satisfy the third development status of agricultural and rural modernisation. Therefore, we classify 0-30 as the preparation stage, 30-50 as the starting stage, 50-70 as the preliminary development stage, 70-90 as the basic realisation stage,

and 90-100 as the developed stage, and establish a grading system for the degree of modernisation in agriculture and rural areas. The scores of the degree of modernisation in agriculture and rural areas in 2020 in each province and city are shown below. In 2020, most of the provinces and cities in China will be at the initial stage of development and starting point of preparation for the modernisation of agriculture and rural areas, with the level of modernisation of agriculture and rural areas in the southeastern region being higher, while the level of modernisation of agriculture and rural areas in the northern provinces and cities will be lower overall.

3. Conclusions

In this paper, this paper conducted in-depth research and analysis on the development level of China's agricultural and rural modernisation by applying the Delphi method, entropy weight method and Topsis method. Firstly, this paper used the Delphi method to obtain the relative weights of the indicators from experts in multiple fields and established the key influencing factors in the development of modernisation of agriculture and rural areas. Secondly, this paper dealt with the quantitative inconsistency between multiple indicators through the entropy weight method, assigned scientific weights to each indicator, and effectively solved the data processing problem in the assessment process. Finally, the Topsis method was used to comprehensively assess the level of agricultural and rural modernisation in each province and city, resulting in detailed assessment results and grade classifications.

Through this study, this paper find that there are obvious differences in the process of agricultural and rural modernisation in different regions, with the eastern coastal regions generally showing a high level of modernisation, while the central and western regions are relatively backward. This difference is mainly affected by economic development, scientific and technological inputs, infrastructure construction and other factors. Therefore, the government should formulate differentiated policy measures to target the process of agricultural and rural modernisation and promote balanced development between regions. In addition, this study provides some ideas and suggestions for further improving the assessment model in the future, such as combining more emerging methods and technologies to further enhance the accuracy and scientificity of the assessment. For example, machine learning algorithms can be introduced to analyse big data to discover deeper influencing factors and dynamic change patterns. In summary, through the research in this paper, this paper not only gained an in-depth understanding of the multidimensional characteristics of China's agricultural and rural modernisation development, but also provided theoretical support and practical guidance for achieving the goal of comprehensively building a modern socialist country. It is hoped that this study can provide useful references and lessons for scholars and policy makers in related fields.

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