# Construction of the Evaluation System of Livelihood Indicators Based on Entropy Weight-TOPSIS

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**Abstract.** The construction of China's modernisation and the improvement of people's livelihood have become important issues for us to build a harmonious society; this paper makes a comprehensive evaluation of people's livelihood development level by constructing an entropy TOPSIS model. Firstly, combining the new features of development in the modernisation process, relevant indicators are constructed from culture and education, employment and income, health and medical care, society and security, housing and transportation. Then, after pre-processing the data of each indicator, the indicators with high correlation degree are screened out by grey correlation, and then the entropy weighting method is applied to assign weights to the criterion layer and the number of indicator layers. Based on the weights, a weighted target decision matrix is constructed to assess the level of livelihood development; finally, it is concluded that the national livelihood development index has been steadily increasing. It increased from 0.084 in 2013 to 0.085 in 2021. In the constructed evaluation system, the development weight of employment and income accounted for 16.9% of the secondary indicators, and the country needs to focus on employment and income issues.

**Keywords:** Modern livelihood development, TOPSIS, entropy method, gray correlation.

## 1. Introduction

People's livelihood is related to people's hearts, and people's hearts are related to the country, and promoting people's livelihood and well-being is the fundamental purpose of modernization [1-2]. In contemporary China, there is no complete theoretical system of people's livelihood, and the study of people's livelihood is often studied from one side. Gao he Rong used entropy weight method, Dagum Gini coefficient and spatial panel regression model to study the regional disparity in the development level of basic livelihood in China and the factors affecting it, and found that the development level of basic livelihood is increasing in fluctuation, the spatial heterogeneity is more significant, the high level and higher level provinces are clustered in the east, and the low level and lower level are concentrated from the west to the central part of the country [3]. Based on county-level panel data from 2007-2019 in Henan Province, Li Xi investigated the livelihood effects of regionally targeted poverty alleviation policies by using the propensity-matching score double difference method (PSM-DID). The study found that poverty alleviation and development improved the livelihood development of the targeted regions, and the policy effect is sustainable [4]. The construction of people's well-being in China's modernisation process involves many aspects, and the instability of economic development forms has set higher requirements for the high-quality development of people's livelihood, so a multi-dimensional composite design was made in designing the evaluation scheme [5]. This paper evaluates and identifies the level of livelihood development of the country for nine years from 2013 to 2021. The indicators with high correlation among the indicators were screened by grey correlation analysis, and then the screened data were selected for entropy weighted TOPSIS evaluation to derive the data and ranking of livelihood indicators for each year.

## 2. The basic funamental of Entropy weight-TOPSIS-Grey correlation

### 2.1. Selection of indicators and construction of indicator system

The system of indicators of living conditions statistics is a system of indicators for measuring, assessing and evaluating the quality of living conditions of a country or region. It includes specific indicators of education, employment, income, health care, environmental protection, etc. Under the conditions of a modern market economy, this indicator system must be comprehensive, representative, well-structured and scientifically weighted [6]. Based on the above references, a comprehensive evaluation index system for livelihood development is constructed as shown in Table 1.

**Table 1.** Comprehensive livelihood assessment index system

| Target level | standardized layer | indicator layer | Number | Direction of Indicators |
|---|---|---|---|---|
| People's livelihood development level index | Culture and Education | Investment in education percapita (Yuan/person) | $x_1$ | forward |
| | | Full-time teachers in general vocational colleges (10,000) | $x_2$ | forward |
| | | Gross participation rate in upper secondary education (%) | $x_3$ | forward |
| | | Value added by cultural and related industries compared to GDP (%) | $x_4$ | forward |
| | | Public Library Count (number) | $x_5$ | forward |
| | Employmet and income | Registered urban unemployment (%) | $x_6$ | Negative direction |
| | | Urban disposable income per capita(Yuan) | $x_7$ | forward |
| | | Engel Coefficient (%) | $x_8$ | Negative direction |
| | | Gini coefficient (%) | $x_9$ | forward |
| | Health and Medical | Food self-sufficiency (%) | $x_{10}$ | forward |
| | | Per capita health costs (yuan) | $x_{11}$ | forward |
| | | Number of medical institutions per 10,000 inhabitants (units) | $x_{12}$ | forward |
| | | Number of practicing doctors per 1,000 population (persons) | $x_{13}$ | forward |
| | Social and security | Urban/rural population covered by social pension insurance (10,000) | $x_{14}$ | forward |
| | | Number enrolled in basic medical insurance at year-end (10,000) | $x_{15}$ | forward |
| | | Spending on social security as a percentage of GDP (%) | $x_{15}$ | forward |
| | Housing and transport | Per capita rural housing area (square meters) | $x_{17}$ | forward |
| | | Per capita urban residential floor area (square meters) | $x_{18}$ | forward |
| | | Road area per city resident (square meters) | $x_{19}$ | forward |
| | | Number of buses per 10,000 inhabitants (standard units) | $x_{20}$ | forward |

### 2.2. Entropy method to determine index weights

(1) Construction of dimensionless decision matrix

When processing data, it also involves the problem of positive and negative data of different indicators. The polarization method can well solve the positive and negative problems of indicators faced in the data processing, so the standardized matrix is processed again with the help of polarization method, and the final dimensionless multi-objective decision matrix is noted as

$$V = [b_{ij}]_{m\times n} \tag{1}$$

When using the extreme difference method, the formula used for the indicators in the system involving the larger is better category is

$$b_{ij} = \frac{z_{ij} - z_{j\min}}{z_{j\max} - z_{j\min}} \tag{2}$$

The formula used in the system for indicators involving the smaller is better category is

$$b_{ij} = \frac{z_{j\max} - z_{ij}}{z_{j\max} - z_{j\min}} \tag{3}$$

In equation (2) (3), $z_{j\max}$ and $z_{j\min}$ are the two highest values corresponding to the first indicator cell.

(2) Calculate the entropy weight of the evaluation index

Since different scoring indicators will have different degrees of influence on the overall decision of the system, it is necessary to determine the weights of different scoring indicators. For a multi-objective integrated decision problem with m scoring programs and n scoring indicators, the information entropy of the scoring indicators is calculated as

$$H_j = -\frac{1}{\ln m}\left(\sum_{i=1}^{m} b_{ij}\cdot \ln b_{ij}\right) \quad (i=1,2,\cdots,m\ ;\ j=1,2,\cdots,n) \tag{4}$$

The computational element $b_{ij}$ in equation (4) comes from the dimensionless multiobjective decision matrix.

Observing the above formula (2), it is not difficult to find that for a given indicator unit $x_j$, if it contains a small difference in the original data $x_{ij}$, then the calculated value of $H_j$ will be higher; if the difference in the original data is as small as zero, that is, all values of $x_{ij}$ are equal, $H_j = H_{\max} = 1$, then this time the $x_j$ will have no effect on the evaluation of different indicators, and the oppositeis trueif the difference in the original data $x_{ij}$ is larger.

Thus, a differentiation factor $G_j$ is defined as

$$G_j = 1 - H_j \tag{5}$$

When the difference of the original data $x_{ij}$ is larger, the value of $G_j$ is larger, which is more conducive to emphasizing the role of the larger value in the subsequent comprehensive evaluation and analysis. By introducing $G_j$, the formula for entropy weight $W = (w_j)_{1\times n}$ is memorized as

$$w_j = \frac{G_j}{\sum_{j=1}^{n} G_j} \tag{6}$$

After deriving the weights, the comprehensive evaluation index is calculated based on the weights of the indicators and the constructed dimensionless decision matrix.

$$S_j = \sum_j^n w_j b_{ij} \tag{7}$$

### 2.3. TOPSIS method to determine the ideal solution

(1) Construct the weighted normalization matrix. Multiply the normalization matrix with the weights $w_j$ to weight the normalization matrix Y:

$$Y = \left(w_j z_{ij}\right)_{m\times n} = \begin{bmatrix} w_1 z_{11} & w_2 z_{12} & \cdots & w_n z_{1n} \\ w_1 z_{21} & w_2 z_{22} & \cdots & w_n z_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ w_1 z_{m1} & w_2 z_{m2} & \cdots & w_n z_{mn} \end{bmatrix} \tag{8}$$

(2) Determine the positive ideal solution $Y^+$ and the negative ideal solution $Y^-$ for Y. The expressions are as follows.

$$Y^+ = (y_1^+, y_2^+, \cdots y_n^+) \tag{9}$$

$$Y^- = (y_1^-, y_2^-, \cdots y_n^-) \tag{10}$$

In Eq. (9) (10):

$$y_j^+ = \max_i y_{ij}, y_j^- = \min_i y_{ij} \tag{11}$$

(3) Calculate the Euclidean distances $D_i^+$ and $D_i^-$ from each scheme to the positive ideal solution $Y^+$ and the negative ideal solution $Y^-$. The formulas are as follows:

$$D_i^+ = (\sum_{j=1}^m \ (y_{ij} - y_j^+)^2)^{1/2}, (i = 1,2,\cdots,m) \tag{12}$$

$$D_i^- = \left(\sum_{j=1}^m \ \left(y_{ij} - y_j^-\right)^2\right)^{\frac{1}{2}}, (i = 1,2,\cdots,m) \tag{13}$$

### 2.4. Grey correlation analysis

Based on the weighted normalization matrix Y, the gray correlation coefficients of the ith evaluation scheme with the positive ideal solution $Y^+$ and the negative ideal solution $Y^-$ are calculated with respect to the jth indicator:

$$g_{ij}^+ = \frac{\min_i \min_j |y_j^+ - y_{ij}| + \varepsilon \max_i \max_j |y_j^+ - y_{ij}|}{|y_j^+ - y_{ij}| + \varepsilon \max_i \max_j |y_j^+ - y_{ij}|} \tag{14}$$

$$g_{ij}^- = \frac{\min_i \min_j |y_j^- - y_{ij}| + \varepsilon \max_i \max_j |y_j^- - y_{ij}|}{|y_j^- - y_{ij}| + \varepsilon \max_i \max_j |y_j^- - y_{ij}|} \tag{15}$$

In Eqs. (14) (15), $i = 1, 2, \cdots, m;\ j = 1, 2, \cdots, n;\ \varepsilon \in (0, 1)$ is the resolution coefficient, which is generally taken to be 0.5. Then the gray correlations $G_i^+$, $G_i^-$ are respectively:

$$G_i^+ = \frac{1}{n}\sum_{i=1}^n \ g_{ij}^+ \tag{16}$$

$$G_i^- = \frac{1}{n}\sum_{i=1}^n \ g_{ij}^- \tag{17}$$

### 2.5. Calculate relative posting progress

(1) The obtained $D_i^+$, $D_i^-$, $G_i^+$, $G_i^-$ are dimensionless, and $d_i^+$, $d_i^-$ and $j_i^+$, $j_i^-$ are obtained sequentially. The calculation formula is

$$d_i^+ = \frac{D_i^+}{\max_i D_i^+} \tag{18}$$

$$d_i^- = \frac{D_i^-}{\max_i D_i^-} \tag{19}$$

$$j_i^+ = \frac{G_i^+}{\max\limits_i G_i^+} \tag{20}$$

$$j_i^- = \frac{G_i^-}{\max\limits_i G_i^-} \tag{21}$$

(2) The determined dimensionless weighted Euclidean distances and gray correlations were combined. The closer the program to be evaluated is to the positive ideal solution and the farther it is from the negative ideal solution, the better it is; the higher the correlation with the positive ideal solution and the lower the correlation with the negative ideal solution, the better it is. That is, the larger the values of $d_i^-$ and $j_i^+$, the closer the program is to the positive ideal solution; the larger the values of $d_i^+$ and $j_i^-$, the farther the program is from the positive ideal solution. The specific expressions are

$$S_i^+ = \alpha d_i^- + \beta j_i^+ \tag{22}$$

$$S_i^- = \alpha d_i^+ + \beta j_i^- \tag{23}$$

Eqs. (22) (23): $\alpha$ and $\beta$ are preference degrees, $\alpha + \beta = 1, \alpha, \beta \in [0,1]$, whose values are determined by the decision maker according to his own preference; $S_i^+$ and $S_i^-$ reflect the degree of proximity and remoteness to the ideal solution, respectively.

(3) Calculate the relative posting progress of the program. The formula is as follows

$$A_i^+ = \frac{S_i^+}{S_i^+ + S_i^-}, (i = 1,2,\cdots,m) \tag{24}$$

The programs are ranked according to the magnitude of the relative closeness $A_i^+$, the larger the closeness value, the better the project program.

## 3. Results

The raw data are mainly obtained from the China Statistical Yearbook, China Cultural Relics and Tourism Statistical Yearbook, etc., and the statistical bulletin and work report are also consulted to obtain the relevant data, such as the URA, and the authoritative data platforms, such as the CECN database.

### 3.1. Analysis of the weighting results of national livelihood development comprehensive evaluation indicators

Entropy value is a physical unit of measurement. For a given evaluation object unit, if it contains a lower difference of raw data, then the calculated entropy value will be higher, which means that the more useful the data of this indicator unit is, the larger the weight value it accounts for, and when the difference of raw data is small to zero, then the difference will not have any effect on the evaluation between different indicators, and the opposite is true if the difference of raw data is larger [7]. Using the entropy value method to calculate the weights of the evaluation system of a total of 20 indicators such as education funding input, the results of the indicator weights shown in Table 2 were obtained.

**Table 2.** Livelihood Development Rating Index System and Weights

| Target level | standardized layer | standardized layer weights | indicator layer | indicator layer weights |
|---|---|---|---|---|
| **People's livelihood development level index** | Culture and Education | 0.255 | Investment in education percapita (Yuan/person) | 0.057 |
| | | | Full-time teachers in general vocational colleges (10,000) | 0.054 |
| | | | Gross participation rate in upper secondary education (%) | 0.056 |
| | | | Value added by cultural and related industries compared to GDP (%) | 0.037 |
| | | | Public Library Count (number) | 0.051 |
| | Employmet and income | 0.169 | Registered urban unemployment (%) | 0.040 |
| | | | Urban disposable income per capita (Yuan) | 0.044 |
| | | | Engel Coefficient (%) | 0.056 |
| | | | Gini coefficient (%) | 0.029 |
| | Health and Medical | 0.213 | Food self-sufficiency (%) | 0.043 |
| | | | Per capita health costs (yuan) | 0.052 |
| | | | Number of medical institutions per 10,000 inhabitants (units) | 0.061 |
| | | | Number of practicing doctors per 1,000 population (persons) | 0.057 |
| | Social and security | 0.174 | Urban/rural population covered by social pension insurance (10,000) | 0.064 |
| | | | Number enrolled in basic medical insurance at year-end (10,000) | 0.067 |
| | | | Spending on social security as a percentage of GDP (%) | 0.043 |
| | Housing and transport | 0.189 | Per capita rural housing area (square meters) | 0.033 |
| | | | Per capita urban residential floor area (square meters) | 0.062 |
| | | | Road area per city resident (square meters) | 0.057 |
| | | | Number of buses per 10,000 inhabitants (standard units) | 0.037 |

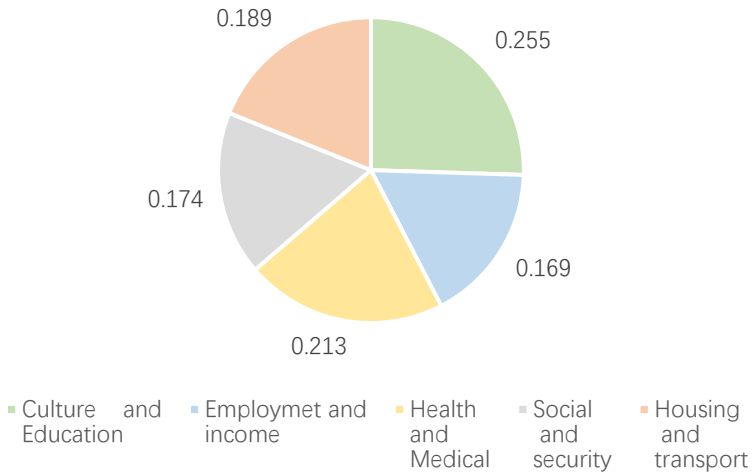


**Figure 1.** Results of secondary indicator weighting

As can be seen from Table 2 and Figure 1: the weights of the secondary indicators have some differences in size, the weight of culture and education development is the highest of the five different dimensions, at 0.255; the weight of health and medical care is 0.213, the weight of employment and income, social and security, and housing and transportation are all below 0. 2, and the weight of employment and income is 0.169, the lowest, social and security and housing and transportation are 0.173572 and 0.189609, respectively. the lowest percentage, and the weights of social and security and housing and transportation are 0.173 and 0.189, respectively.

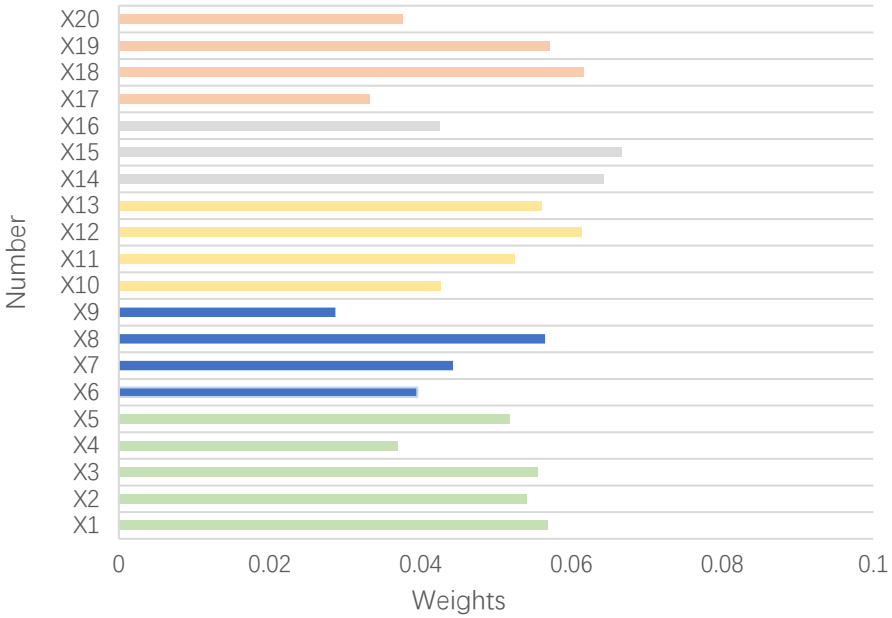


**Figure 2.** Weights of the three levels of indicators

As can be seen from Figure 2: The weights of the 20 tertiary indicators, including investment in education, per capita disposable income, the number of urban and rural residents enrolled in social pension insurance, and the number of urban built-up areas, are also somewhat different, with the weight of the value added of culture and related industries in the development of culture and education as a proportion of GDP being significantly lower than the other two, at 0.037, and the weight of per capita investment in education being 0.057. Overall, the number of participants in basic medical insurance at the end of the year has the largest weight, at 0.067, followed by the weight of 0.064 and the weight of per capita housing area. Overall, the number of basic medical insurance enrollees at the end of the year has the largest weight, 0.067, closely followed by the weight of the number of urban and rural residents' social pension insurance enrollees and the per capita housing floor area of urban

residents, 0.064 and 0.062; the three with the lowest weights are the Gini coefficient, the per capita housing floor area of rural residents, and the weight of the added value of culture and related industries in GDP.

### 3.2. Comprehensive livelihood development index analysis

People's livelihoods refer to people's lives, including food, clothing, shelter, transportation, education, and recreation. In certain societies, people's livelihood mainly includes infrastructure development, medical care, education, employment, social security, culture and sports, and environmental protection, which can affect all aspects of people's daily lives [8].

**Table 3.** Indicators of the level of development of people's livelihoods

| Year | Comprehensive livelihood index |
|---|---|
| **2013** | 0.084 |
| **2014** | 0.158 |
| **2015** | 0.264 |
| **2016** | 0.352 |
| **2017** | 0.479 |
| **2018** | 0.618 |
| **2019** | 0.746 |
| **2020** | 0.760 |
| **2021** | 0.853 |

As shown in Table 3, the country's livelihood development index steadily increases from about 0.084 in 2013 to 0.853 in 2021, with a relatively stable annual growth rate. However, observing Figure 4, the increase of the country's livelihood development index is relatively reduced in 2019-2020, which may be related to the outbreak of the Shinkansen pneumonia epidemic in late 2019, but the overall trend of better development remains unchanged.

### 3.3. Analysis of the results of posting progress

According to Eqs. (9) and (10), the positive and negative ideal solutions of each index are selected from the weighted normalization matrix, and then according to Eqs. (12) and (13), the Euclidean distance between the evaluation results of each index and the positive and negative ideal solutions is calculated, and the results are shown in Table 4.

**Table 4.** Euclidean distances

| Year | D+ | D- |
|---|---|---|
| 2013 | 0.217 | 0.049 |
| 2014 | 0.200 | 0.049 |
| 2015 | 0.177 | 0.063 |
| 2016 | 0.158 | 0.082 |
| 2017 | 0.132 | 0.116 |
| 2018 | 0.099 | 0.149 |
| 2019 | 0.071 | 0.175 |
| 2020 | 0.079 | 0.190 |
| 2021 | 0.069 | 0.211 |

According to equations (16) (17), the gray correlation between each indicator and the positive and negative ideal solutions is calculated, and the results are shown in Table 5.

**Table 5.** Gray Correlation

| | G+ | G- |
|---|---|---|
| 2013 | 0.448 | 0.929 |
| 2014 | 0.464 | 0.828 |
| 2015 | 0.503 | 0.723 |
| 2016 | 0.532 | 0.661 |
| 2017 | 0.592 | 0.599 |
| 2018 | 0.666 | 0.536 |
| 2019 | 0.754 | 0.486 |
| 2020 | 0.784 | 0.515 |
| 2021 | 0.884 | 0.488 |

The weighted Euclidean distance and the gray correlation were normalized according to Eqs. (18) to (21), and the results are shown in Table 6.

**Table 6.** Standardized Treatments

| | d+ | d- | g+ | g- |
|---|---|---|---|---|
| 2013 | 1 | 0.235 | 0.507 | 1 |
| 2014 | 0.921 | 0.230 | 0.525 | 0.892 |
| 2015 | 0.816 | 0.299 | 0.569 | 0.779 |
| 2016 | 0.727 | 0.387 | 0.602 | 0.712 |
| 2017 | 0.607 | 0.548 | 0.670 | 0.646 |
| 2018 | 0.457 | 0.704 | 0.754 | 0.577 |
| 2019 | 0.325 | 0.830 | 0.854 | 0.523 |
| 2020 | 0.364 | 0.899 | 0.888 | 0.554 |
| 2021 | 0.317 | 1 | 1 | 0.525 |

According to Eqs. (22) (23), the proximity of positive and negative ideal programs $S_i^+$ and $S_i^-$ are calculated and discussed in three cases due to the different preferences of decision makers: (1) $\alpha = \beta = 0.5$; (2) $\alpha = 0.2$, $\beta = 0.8$; and (3) $\alpha = 0.8$, $\beta = 0.2$. The results are shown in Table 7.

**Table 7.** Relative Posting Progress

| year | α=0.5 | α=0.2 | α=0.8 | sorted |
|---|---|---|---|---|
| 2013 | 0.271 | 0.312 | 0.224 | 9 |
| 2014 | 0.294 | 0.342 | 0.240 | 8 |
| 2015 | 0.352 | 0.396 | 0.304 | 7 |
| 2016 | 0.407 | 0.439 | 0.372 | 6 |
| 2017 | 0.493 | 0.503 | 0.482 | 5 |
| 2018 | 0.585 | 0.573 | 0.597 | 4 |
| 2019 | 0.665 | 0.637 | 0.696 | 2 |
| 2020 | 0.661 | 0.633 | 0.691 | 3 |
| 2021 | 0.704 | 0.674 | 0.736 | 1 |

The relative closeness calculated for the above three cases was plotted as a line graph for comparison, as shown in Figure 3.

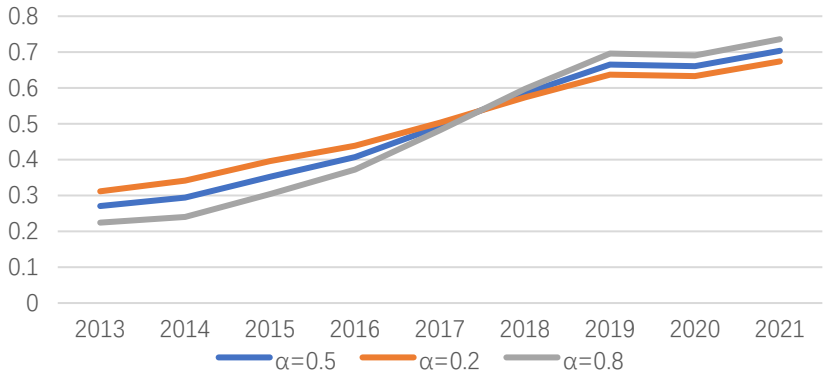


**Figure 3.** Relative progress of posting when preferences vary

It should be noted that the relative fit Ci indicates the level of livelihood development, the larger the value of Ci, the higher the level of livelihood development, and vice versa. At the same time, the size of the relative fit is also the ranking of the level of people's livelihood, in which the value of Ci ranges from 0 to 1. As can be clearly seen in table 3, the overall level of livelihood development is a situation of steady increase, which is the same as the evaluation results obtained according to the entropy weighting method in Figure 2, which verifies the effectiveness of the method. When α=0.2 and β=0.8, the development of people's livelihood is softer and more in line with the actual situation. The continuous improvement of the livelihood development index indicates that China's livelihood construction has achieved certain results, and people's sense of gain has increased. The main reasons are: (1) China's economy continues to develop. By the end of 2020, China's total GDP will have exceeded 100 trillion yuan, laying a solid material and qualitative foundation for the improvement of people's basic livelihoods; (2) the focus on securing and improving people's livelihoods in the context of development, constantly expanding the content of livelihood construction, expanding "five" livelihoods into "seven" livelihoods and building the world's first "seven", and then expanding "five" livelihoods into "seven" livelihoods and building the world's first "seven". The "five" people's livelihoods have been expanded into the "seven" people's livelihoods, and the world's largest livelihood protection system has been built [9].

At the same time, if the degree of preference is different, all of them seem to have a decline in the level of development of people's livelihood in 2020. However, with the normalization of the prevention and control of the epidemic in the country and the insistence on the implementation of the "dynamic clearing" policy, people's confidence in consumption has been boosted and the potential has been further unleashed, so that the development level of China's people's livelihood has achieved a turnaround in 2021. In the long run, China's economic development is on the rise, and people's livelihoods will continue to improve. In addition, the rate of increase of the livelihood index varies. Due to the broad coverage of people's livelihood, each year's livelihood investment projects have their own focus, coupled with the fact that different weights reflect different project indicators, if a larger proportion of weighted projects are invested in, the rate of increase of the livelihood development index in a particular year may increase, and of course, there is also the possibility that the rate of increase of the livelihood development index may decrease or even decline. Therefore, when investing in livelihood projects, there must be a scientific basis to focus on the overall social development index [10].

## 4. Conclusion

In the constructed evaluation system, the weight of employment and income development is the lowest among the second-level indexes at 0.169, and among the third-level indexes, the three items with the lowest weights are the Gini coefficient at 0.028%, the per capita housing area of rural residents at 0.033%, and the share of value added of culture-related industries in GDP at 0.037%. By analyzing the livelihood development index, we find that the overall development growth rate of

China's livelihood development level is steadily increasing, from 0.0843 in 2013 to 0.853 in 2021, with a decline to 0.760 only in 2020, which is also in line with the country's overall economic development situation.

In this paper, due to the difficulty of obtaining data for some indicators or the difficulty of unifying the data released by different institutions, the evaluation indicator body needs to be further optimized in the future. In addition, this paper adopts the entropy weighting method for calculation, which to some extent ignores the importance of the indicators themselves to the evaluation index system, and in the future it can be combined with the subjective weighting method such as the expert survey method to further determine the weights of the indicators.

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