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Global national equity assessment based on comprehensive evaluation model

Zefeng Liu[1,*], Ruikai Zhu[2], Yongming Chen[3], Zihan Chen[4], Zhuoyan Zhou[5], Weijun Du[6]

[1]School of Mathematics and Statistics, Nanjing University of Information Science & Technology, Nanjing, 210044, China
[2]School of Computer and Software, Nanjing University of Information Science & Technology, Nanjing, 210044, China
[3]Changwang School of Honors, Nanjing University of Information Science & Technology, Nanjing, 210044, China
[4]School of Mathematics and Statistics, Nanjing University of Information Science & Technology, Nanjing, 210044, China
[5]Jiangsu Key Laboratory for Optoelectronic Detection of Atmosphere and Ocean, Jiangsu Collaborative Innovation Center on Atmospheric Environment and Equipment Technology (CICAEET), Nanjing University of Information Science & Technology, Nanjing, 210044, China
[6]Jurong Senior High School of Jiangsu Province, Zhenjiang, 212400, China
[*]Corresponding author: 1248630653@qq.com

Abstract: *The purpose of the United Nations is to promote peaceful development in the world, which should be based on the equitable development of all countries. To evaluate global equity, this paper establishes an integrated comprehensive national conditions consistency (CNCC) model to evaluate the concept of global equity. First, to describe the concepts of input and output, this paper introduces comprehensive National conditions (CNC) and expected Comprehensive National conditions (ECNC). For CNC, this paper selects three levels of classification, selects 12 indicators closely related to CNC from four aspects, and uses the hierarchical analysis process modified by the entropy weight method to analyze the index coefficient. Subsequently, CNC and ECNC were integrated, and the concept of CNCC was introduced, which was used to describe global equity.*

Keywords: *global equity, comprehensive evaluation model, comprehensive national conditions*

1. Introduction

The founding purpose of the United Nations is to promote global peace and development and promote the realization of world justice. The definition of justice cannot be summarized by egalitarianism. To measure the degree of global equity, Ayelet Banai proposes a reconciliation between two core and seemingly conflicting principles of contemporary global justice theory, global equality of opportunity and self-determination [1], Eszter Kollar argues that a preferable task for the political philosophy of migration is to find ways to coherently uphold the collective self-determination claim of global equality of opportunity [2], Feiyang Xu argues that countries on the margins of globalization are suffering the consequences of worsening global wealth distribution. The whole world is moving towards polarization [3], Sisi Zhou discussed the relationship between the equality of natural resources and global equity according to Steiner's global egalitarianism [4]. Scholars have measured the fairness of the world from different aspects[5-7]. However, no scholars have conducted a relatively comprehensive measurement of global equality.

This article believes that global equity is the matching degree of various attributes of a country with its national strength, economic strength, and other objective indicators. Therefore, we establish CNCC evaluation model to measure equity in each country, in which the low matching degree (the attribute is not compared with the metric index) and the excessive matching (the attribute is more than the metric index) are considered as the embodiment of inequity.

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2. The global equity measurement of different countries

This article argues that global equity should be determined by the degree of equity of countries around the world. One of the first things we have to solve is to measure the equity of each country in the international community. The definition of equity cannot be generalized with equalitarianism. Here, we believe that global equity is the matching degree of various attributes of a country with its national strength, economic strength, and other objective indicators. Therefore, we establish $CNCC$ evaluation model to measure equity in each country, in which the low matching degree (the attribute is not compared with the metric index) and the excessive matching (the attribute is more than the metric index) are considered as the embodiment of inequity.

2.1 The quantification of CNC

To make our $CNCC$ model more logical and convincing, we define indexes from three levels.

(1) Politics

Diplomatic index X_1. The diplomatic index is calculated based on the total number of embassies, consulates, permanent missions, and other diplomatic organizations that a country has set up abroad. It represents a country's diplomatic capability.

States fragility X_2. States fragility is a measure of a country's political failure based on factors including population pressure, ethnic conflict, brain drain, public service, human rights, and the rule of law.

Legal index X_3. The Legal system index is a comprehensive assessment of a country's compliance with laws based on eight aspects, including constraints on government powers, absence of corruption fundamental rights, civil justice, and so on.

(2) National disordered level

Casualty numbers X_4 (number). Casualty numbers refer to the total number of people killed or injured in human-caused accidents in each country between 1988 and 2017.

Crime index X_5. Crime Index is an estimation of the overall level of crime in a given city or country.

Economical loss X_6 (dollar). Specifically, economical loss refers to the total economic losses suffered by each country in the face of man-made accidents.

(3) Economic situation

Difference between exports and imports X_7 (dollar per year). The difference between exports and imports refers to the difference between a country's exports minus imports for each year between 1960 and 2020.

Currency reservation X_8 (dollar). Currency reservation refers to funds reserved in case unexpected events affect the livelihood of the country, including national fiscal revenue and foreign exchange reserves.

GDP per capita X_9 (dollar per person). GDP per capita is an effective tool for people to understand and grasp the macroeconomic operation of a country or region. It is often used as an indicator to measure economic development in development economics and is one of the most important macroeconomic indicators.

(4) Citizen blessing degree

Medical care rates X_{10} (% of total). Medical care rates refer in particular to the rate of measles vaccination at birth, which reflects the health of the growing child.

Education length X_{11} (year). Education length represents the length of compulsory school years in each country and reflects the educational attainment of the entire population.

ISSN 2616-5805 Vol. 4, Issue 2: 46-52, DOI: 10.25236/AJMS.2023.040207

Employment rates X_{12} (% of total). Employment rate refers to the employment rate of each country's population in 2021, which reflects whether people have a source of income.

2.2 Comprehensive evaluation system of analytic hierarchy process modified by entropy weight methods

With the evaluation indicators defined above, we plan to establish the evaluation model by using an analytic hierarchy process. So, we need to determine the weights of these indicators. Meanwhile, the analytic hierarchy process is a completely subjective method. To enhance the rationality of weight allocation, we use the completely objective entropy weight method to modify it, which can effectively eliminate subjective error to some extent.

Firstly, In the hierarchical analysis method, the pairwise comparison matrix of indicators based on empirical and expert evaluation is shown in Figure 1.

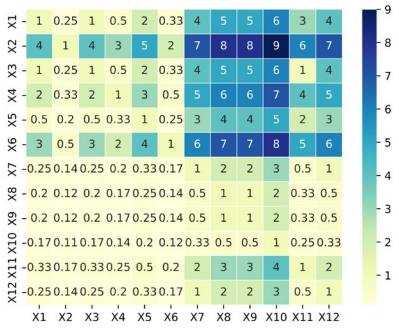

Figure 1: Pairwise comparison matrix of all indicators

To prevent the decision makers from serious logical deviation in the selection, a consistency test is required to test whether there is a logical error in the pair comparison matrix. Through the pair comparison matrix, we can calculate the maximum feature value and its corresponding feature vector, using consistency index, random consistency index and consistency ratio for consistency test. Define consistency indicators:

$$CI = \frac{\lambda - n}{n-1}, \tag{1}$$

where n is the matrix order and λ is the maximum characteristic root.

CI Close to zero represents satisfactory consistency; the bigger the CI, the more serious the inconsistency is. To measure the size of CI, The random consistency index RI is introduced, which is determined by the order of the comparison judgment matrix. The value rule is shown in Table 1.

Table 1: Average random consistency index RI

Order n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.25	0.89	1.12	1.26	1.36	1.41	1.46	1.49

We choose specific methods for random structure: build e Pairwise comparison matrix $A_1, A_2, \cdots, A_p$. Then the consistency index can be obtained $CI_1, CI_2 \cdots, CI_e$

$$RI = \frac{CI_1 + CI_2 + \cdots + CI_e}{e} = \frac{\frac{\lambda_1 + \lambda_2 + \cdots + \lambda_e}{e} - n}{n-1}, \tag{2}$$

where e represents the rank of a matrix, then we define the consistency ratio as

$$CR = \frac{CI}{RI}. \tag{3}$$

When $CR < 0.1$, it indicates that the pin-pair comparison matrix conforms to the consistency. Through the consistency test, the consistency test result of this paper shows that $CI = 0.0169$, tends to 0, with a satisfactory consistency, so the index weight obtained from the tomographic analysis can be obtained.

The analytic hierarchy process results are shown below in Table 2.

The entropy weight method is an objective weight assignment method that can measure system uncertainty. Make the evaluation result in more accord with the actual situation. Information entropy can be used to measure the amount of information between indicators when determining indicators and

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evaluation matrix. There is a negative correlation between entropy value and information content. The larger the information content of an index is, the larger the weight is and the smaller the uncertainty is. The smaller the entropy is, the higher the entropy is. Entropy value can also judge the uncertainty and dispersion degree of each index in the supplier's decision-making scheme. The larger the dispersion degree of the index is, the more obvious the effect is, and the better the correction effect on the subjective decision is.

Table 2: AHP results

Indicators	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
results	0.095	0.263	0.088	0.138	0.065	0.193	0.030	0.020	0.020	0.015	0.045	0.03

Calculate the proportion of the homogeneity index value of the j_{th} index of the i_{th} supplier to the sum of all supplier index values:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}, i = 1, \cdots, n, j = 1, \cdots, m, \tag{4}$$

Where x_{ij} is the value of the index, then we calculate the entropy value of item j:

$$e_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}). \tag{5}$$

Therefore, we calculate the weight vector of each indicator:

$$\omega_{\text{ij}} = \frac{1-e_j}{\sum_{j=1}^{m} d_j}, \tag{6}$$

The calculation results are shown in Table 3. The entropy weight method is an objective decision-making method, which modifies the evaluation result objectively.

Table 3: EWM results

Indicators	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
results	0.010	0.085	0.106	0.078	0.056	0.075	0.098	0.063	0.080	0.094	0.078	0.086

According to previous studies [8], when the combined weight coefficients of entropy weight method and analytic hierarchy process are 0.3 and 0.7 respectively, the modification effect of entropy weight method is the best. The subjective deviation can be eliminated while fully reflecting the production guarantee. The comprehensive evaluation result of the supplier importance degree can be calculated by the following formula:

$$Var_g = W_1 Var_e + W_2 Var_A, \tag{7}$$

where Var_g is the modified index weight, W_1 and W_2 are the combined weight coefficients of the entropy weight method and ANALYTIC hierarchy process respectively, Var_{e} and Var_{A} are the index weights of entropy weight method and analytic hierarchy process respectively, $W_1 = 0.3, W_2 = 0.7$ substitute the indicator data of suppliers into the model to obtain the comprehensive evaluation score of production security of each supplier.

Finally, we can get the index coefficient in the evaluation model in Table 4.

Table 4: Index coefficient weight

Indicators(I)	Indicators(II)	Weights	Indicators(III)	Weights
CNC	PI	0.4449	Diplomatic index	0.09608
			States fragility	0.20945
			Legal index	0.09305
	ESI	0.3953	Difference between exports and imports	0.11974
			Currency reservation	0.06243
			GDP per capita	0.15742
	NDLI	0.0704	Casualty numbers	0.05028
			Crime index	0.0331
			Economical loss	0.03817
	CBD	0.0894	Medical care rates	0.03858
			Education length	0.05478
			Employment rates	0.04692

ISSN 2616-5805 Vol. 4, Issue 2: 46-52, DOI: 10.25236/AJMS.2023.040207

2.3 The introduction of $ECNC$

It's worth noting here that what we're looking for is not just metric weighting, but matching degree. To this end, we need to find the corresponding index that can be matched, and here we think such index can be called $ECNC$. They are listed below:

- CNS: Comprehensive national strength of each country.
- ECR: Lowest crime rate in the country (Here we consider that all countries want zero crime).
- EEG: Expected economic growth rate of each country.
- HI[7]: Happiness of each country's inhabitants.

These four indexes correspond to PI, NDLI, ESI and CBD respectively.

In order to match, the value of the second-level index of each country is calculated first, and the formula is as follows:

$$\begin{cases} PI = w_1 y_{1j} + w_2 y_{2j} + w_3 y_{3j} \\ NDLI = w_4 y_{4j} + w_5 y_{5j} + w_6 y_{6j} \\ ESI = w_7 y_{7j} + w_8 y_{8j} + w_9 y_{9j} \\ CBD = w_{10} y_{10j} + w_{11} y_{11j} + w_{12} y_{12j} \end{cases} . \tag{8}$$

Then the four second-level indicators and four $ECNC$ indicators are standardized in pairs, and the final $CNCC$ matching degree can be calculated by the following formula:

$$CNCC = 0.4449 \times \frac{PI}{CNS} + 0.3953 \times \frac{NDLI}{ECR} - 0.0704 \times \frac{ESI}{EEG} + 0.0894 \times \frac{CBD}{HI} \tag{9}$$

Through fuzzy clustering analysis, we finally divide $CNCC$ into 5 categories, respectively representing the proportion relationship between their input and return, as is shown in Figure 2. If the value of $CNCC$ is between 0.8798 and 1.4851, we can think this country is relatively fair, to take it a step further, if the value of $CNCC$ is close to 1.1358, this country is in an absolutely fair situation. Therefore, we identify 1.1358 as a critical value that represents an optimal equity.

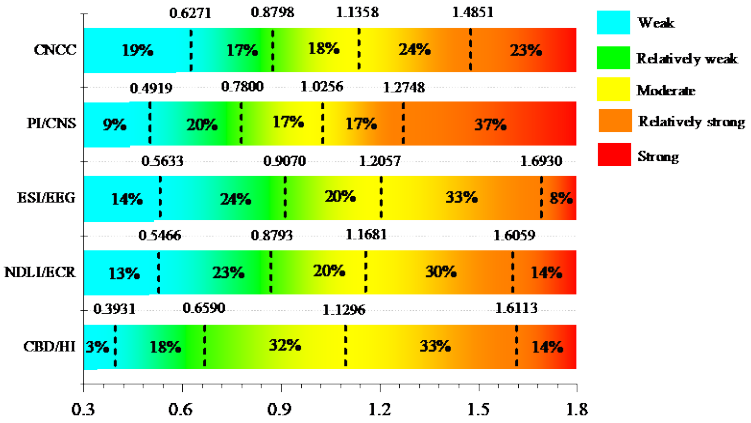

Figure 2: Clustering results of the index.

The colder the color is, the more the country is in an unfair situation. Vietnam, for example, has a $CNCC$ value of 0.57, indicating that despite the country's efforts to achieve economic growth, there is little to show for it.

The color in the middle of the cool color and warm color indicates that the country's effort and expected return are in a good proportional relationship. For example, the $CNCC$ value of Israel is 1.12, indicating that it is in a fair environment.

The warmer the color, the more the country is in surplus. For example, the $CNCC$ value of the United States is 1.53, indicating that as long as less capital is invested, greater benefits can be obtained. It has much more benefit than other countries.

The index scores of the Top10 countries are shown in Figure 3.

ISSN 2616-5805 Vol. 4, Issue 2: 46-52, DOI: 10.25236/AJMS.2023.040207

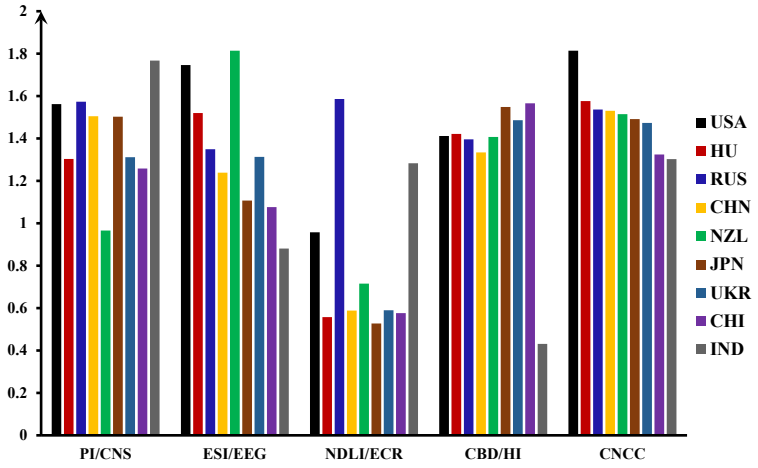

Figure 3: Top 10 countries bar chart.

3. Unified worldwide $CNCC$

After getting the level of equity in each country, we need a global assessment of equity. Then, we find that the Wilson coefficient [9] and extreme difference are often used to measure the inequity of distribution of the rich and the poor. Therefore, we use these two coefficients to measure the global equity at the same time, where the Wilson coefficient represents the dispersion degree of the equity in various countries and extreme difference represents the difference between the high and low levels of equity. They are calculated separately from the following equation.

$$V_u = \frac{1}{\mu}\sqrt{\sum_{i=1}^{n}\frac{(x_i-\mu)^2 p_i}{P}}\ , \Delta_{ed} = V_{u\,max} - V_{u\,min}, \tag{10}$$

where x_i denotes a single data in a data set, μ denotes the arithmetic mean of the data set, p_i denotes the frequency of occurrence of the ith data set, and $P = \sum_{i=1}^{n} p_i$ denotes the sum of the frequencies. Where V_u is Wilson coefficient, which represents the unified worldwide equity.

In this case, in order to calculate a global uniform $CNCC$ indicator based on a collection of $CNCC$ indicators from more than one hundred country regions around the world, we used the evaluation method of Wilson coefficient.

After doing the calculations, we get the final result, which is the Wilson coefficient, representing how fair the world is today. In addition, we calculate the extreme difference of $CNCC$, which represents the trend of polarization in the world.

$$V_u = 0.062756449,\ \Delta_{ed} = 1.4573.$$

It should be noted that the values we obtain here are based on 2019 data only, to tell it in another way, it is absolute estimates for a single year. Accurately speaking, such an assessment is meaningless, but we have succeeded in building a complete world equity assessment model, which we will use in the following questions, where model successfully demonstrates its power.

4. Results

4.1 The calculation of V_u in global equal situation

In the above fuzzy clustering results, we define the acceptable equity index of a country, namely $CNCC$, within the range of 0.8798~1.1358. But to measure global equity, we need to know what the model is like when it's fairer. Therefore, we do the following operations.

● Using random algorithm, each country is randomly assigned a value in the range of 0.8798~1.1358. And we choose the actual value of the number of countries we use in $CNCC$ model: 197.

● For each random case, two parameters of the model are calculated: Wilson coefficient and extreme difference.

ISSN 2616-5805 Vol. 4, Issue 2: 46-52, DOI: 10.25236/AJMS.2023.040207

After 1000 repetitions, we can obtain the parameter values of the model in a fairer world background.

4.2 Calculation results

Calculation results are shown below:

$$V_u = 0.0136, \Delta_{ed} = 0.2534.$$

The Wilson coefficient of 2019 is 361.76% larger and extreme difference is 458.59% larger than the data above.

5. Conclusions

With the development of knowledge economy and the advancement of economic globalization, the gap between the world's rich and poor is becoming more and more pronounced, Growing global development imbalances. To measure the degree of global equity, we believe that global equity is the matching degree of various attributes of a country with its national strength, economic strength and other objective indicators. Therefore, we establish CNCC evaluation model to measure equity in each country, in which the low matching degree (the attribute is not compared with the metric index) and the excessive matching (the attribute is more than the metric index) are considered as the embodiment of inequity.

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