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A Hierarchical Analysis Approach to Analyzing Global Equity through the Quality of Life of Newborns

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Abstract. This paper explores the highly subjective issue of global equity and presents two models for defining and measuring it over time. The paper makes several basic assumptions to simplify the problem, including using various child indicators to evaluate quality of life, subjectively assessing their impact, and weighting them to obtain the quality-of-life value. The paper defines absolute and relative fairness and shows how the quality of life of newborns correlates with equity. The models use the Analytic Hierarchy Process and quality-of-life values to identify factors that affect equity and assess it between different countries. The paper validates the models using historical data and existing conclusions. Overall, the paper provides a framework for evaluating and improving global equity that can help address issues such as poverty, environmental pollution, and lack of resources.

Keywords: Global Equity; Define Fairness; Hierarchical Analysis Process.

1. Introduction

Today's world is not yet a perfect and fair world [1-3]. For some developing countries, they still often have famine, environmental pollution and lack of educational resources [4-8]. Such a distressed life destroys their souls and bodies, making them face thin, even empty eyes. For us, we may not imagine the extreme poverty, but such problems cannot be directly ignored under the mainstream that promotes global equity [9-12].

However, global equity is a highly subjective issue with many interpretations. Through an in-depth analysis of the background of the problem and the study of a large number of fair literatures [13-15], combined with the actual situation, the problem can be expressed as follows:

How to quantify fairness and distinguish between absolute and relative fairness.

How the quality of life of new-borns correlates with equity.

Combining historical data and existing conclusions to verify the correctness of the model to measure global equity.

2. General Assumptions and Notations

The following basic assumptions are made to simplify problems.

(1) Take the various child indicators as the indicators to evaluate the quality of life;

(2) The impact of QoL indicators on QoL can be subjectively assessed by questionnaire;

(3) The quality of life can be obtained by scoring the size of the indicator variable and weighting the sum of the quality of life;

(4) All discussions consider only those who are able to work, and not those who rely only on social assistance.

Table 1. Symbol and Explanation

Symbol	Explanation
X_i	An indicator variable reflecting the quality of life
W_i	the weight of the i-th indicator in the quality-of-life value
Q_i	The degree of development is the quality-of-life value of the i-th country
T_i	different time points
T_i	time variable when mining asteroids
C	The total amount of ore collected by humans in unit time (constant, unit: ton
n_i	the comprehensive strength of the country whose development level is the i-th
Y_i	The degree of development is the mine production obtained by the i-th country in asteroid mining
n_i	the sum of the comprehensive strengths of all countries on the earth, there is $n = n1 + n2 + n$
$\frac{n_i}{n}$	the relative value of the comprehensive strength of various countries

Introduce the variables that affect QoL values as follows:

Table 2. Index and Variables

name of index	variables
neonatal mortality rate	x_1
Mortality rate for children under 5 years old	x_2
expected life	x_3
HIV infection ratio under 17	x_4
developmental state	x_5
Receiving the primary education ratio	x_6
Government education expenditure	x_7
dropout rate of preschool children	x_8
family economic status	x_9
Child labor ratio	x_{10}

3. Hierarchical analysis method and model validation

3.1 Define global equity

In the world, there is no absolute fairness, only relative fairness [16,17]. This means that fairness is compared between two objects vertically (over time) or horizontally (in space). People subjectively compare the quality of life between two countries to determine their perception of fairness.

The concept of an absolute fairness value (E_a) involves reducing the quality-of-life values of two countries and then obtaining the square of the difference. This value is a measure of the comparison between the two qualities of life at the same time. However, it is important to note that the size of the E_a value does not necessarily represent the degree of fairness at that particular time. The formula for calculating E_a is expressed as follows:

$$E_a = (Q_i - Q_j)^2 \quad (i, j = 1,2,3)$$

The absolute fairness difference (E_d) is a measure of the difference between the absolute fairness values of two countries at two time points. When E_d is greater than 0, it indicates an increase in the gap between the two countries, resulting in an unfair situation. On the other hand, when E_d is less than 0, it indicates a decrease in the gap and a move towards fairness. The formula for calculating E_d is expressed as follows:

$$E_d = E_{a_{t_i}} - E_{a_{t_j}} \quad (i, j = 1,2,3.....)$$

The relative fairness value (E_r) is calculated by determining the variance of the quality-of-life values (Q) of the three categories of countries at the same time point. This value represents the disparity in quality-of-life values between different countries. By comparing E_r at different time points, it is possible to determine whether the gap between countries is narrowing or widening, and whether there is an increase in fairness. The formula for calculating E_r is expressed as follows:

$$E_r = \frac{\sum (Q_i - \overline{Q_i})^2}{n - 1}$$

The relative fairness difference (E_v) is calculated by determining the difference between the relative fairness value (E) at different time points. If E_v is greater than 0, it indicates that the global equity gap has widened and become more unfair compared to the previous time point. Conversely, if E_v is less than 0, it indicates that the gap has narrowed, and the situation has become fairer. The formula for calculating E_v is expressed as follows:

$$E_v = E_{r_i} - E_{r_j} \quad (i, j = 1,2,3.....)$$

After defining equity, the next step is to identify the factors that affect quality of life and thus equity. These factors mainly come from the quality of life of newborn children. It is important to consider these factors when assessing the level of equity between different countries and over time.

3.2 Calculate Weights Using AHP and Quality-of-Life Values

AHP can combine quantitative analysis and qualitative analysis, and use the experience of decision makers to judge the relative importance of the impact of each indicator variable on the target [18]. Analytic hierarchy process can be used to analyze the weight of the variable factor x_i that affects the quality-of-life value [19,20]. Firstly, we need to classify ten variables for our analysis:

Health dimension: x_1 neonatal mortality rate, x_2 under-five mortality rate, x_3 life expectancy, x_4 under-17 HIV infection rate, x_5 developmental status;

Education dimension: x_6 primary education rate, x_7 government spending on education, x_8 preschool dropout rate;

Economic dimension: x_9 family economic status, x_{10} child labor rate.

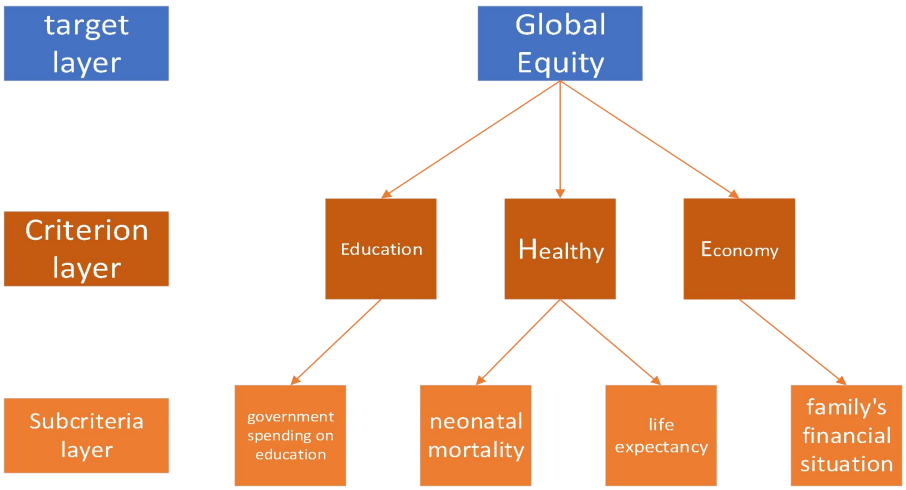

Fig. 1 Factors that Affect Fairness

The above three levels jointly affect the quality-of-life value Q_i. Therefore, we regard the above indicators as the criterion layer, and use the analytic hierarchy process to calculate the weight of each indicator through the data obtained from the survey. Fig. 1 provides a quick look at these three levels. We surveyed 466 students and asked them to rate each indicator in pairs, which we gave using a 1-5 scale method by Table 3.

Table 3. Quantification of Importance

Scaling	Meaning
1	Indicates that two elements are of equal importance compared to
3	Indicates that the former is slightly more important than the latter
5	Indicates that when comparing two elements, the former is significantly more important than the latter
2, 4	Represents the median value of the above adjacent judgments
Reciprocal of 1 to 9	Indicates the importance of responding to the comparison of the two-factor exchange order

From this, we can get a reciprocal matrix A of 10×10. However, the human evaluation may not satisfy the "transitivity" (for example, apples are better than pears, pears are better than bananas, and bananas are better than apples), so it is necessary to check the consistency of the reciprocal matrix A:

Step 1: Consistency Metrics: $\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1}$.

Among them, λ is the largest characteristic root of the reciprocal matrix A; n is the only non-zero characteristic root.

Step 2: Then calculate the corresponding average random consistency index RI method for randomly creating 500 pairwise comparison matrices $A_1, A_2, A_3, \ldots, A_{500}$, then we can get the consistency index $\mathrm{CI}_1, \mathrm{CI}_2, \ldots, \mathrm{CI}_{500}$ as:

$$RI = \frac{CI_1, CI_2, ..., CI_{500}}{500} = \frac{\frac{\lambda_1 + \lambda_2 + ... + \lambda_{500}}{500} - n}{n - 1}$$

Step 3: Calculate the Consistency Ratio CR:

$$CR = \frac{CI}{RI}$$

If CR<0.1, it can be considered that the consistency of the judgment matrix A is acceptable, there is satisfactory consistency, and the consistency test is passed. After judgment, all judgment matrices conform to the consistency test. Through factor analysis of each level and each index variable, we get the following results:

We can see that the sum of the "weights" of each group is not equal to 1 at this time. After calculating the weights by the arithmetic mean method, geometric mean method and eigenvalue method (the calculation process is cumbersome, and only the results are published to save space), we can finally get the weights of each index variable in the quality-of-life value:

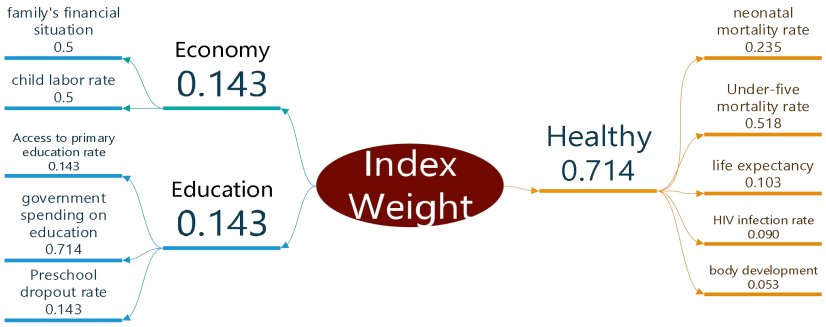

Fig. 2 The Weight of the Indicator at Each Level

When evaluating variable indicators, we define 1 to 10 points to represent the degree of a certain indicator of this type of country. A score of 1 is very poor for a variable, and a score of 10 is very good. (The lower the neonatal mortality rate, the mortality rate of children under five years old, the HIV infection rate, the dropout rate of preschool children and the child labour ratio, the better the quality of life, and the higher the score). We control the score within the interval (1,8), which helps us to analyse the impact of planetary mining on various indicators in the future. The size of the scores judged in the table is based on the comparison and ranking of various indicators released by the United Nations. In addition, the scores of each indicator variable of the three types of countries are averaged.

The order of scoring in the table below is based on neonatal mortality, under-five mortality, life expectancy, HIV infection rate, developmental status, primary education rate, government spending on education, preschool dropout rate, household economic status, child labour The order of proportions is scored. For the convenience of writing, the above scores are represented by variables a_i (i=1,2, 3, 10).

Note: The left side is the score of an indicator in 2010, the right side is the score of an indicator in 2018 [21,22].

Table 4. Ratings for the Indicators for 2010 And 2018 in Three Categories of Countries

Country type	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Developed	(6,7)	(7,7)	(7,8)	(4,4)	(7,7)	(7, 8)	(8,8)	(7,8)	(6,7)	(7,7)
Developing	(3,3)	(3,4)	(4,4)	(3,3)	(3,3)	(3 ,4)	(2,3)	(3,3)	(2,3)	(3,3)
Poor	(1,1)	(2,2)	(1,2)	(1,2)	(1,1)	(2, 2)	(1,1)	(1,1)	(1,1)	(1,2)

Then, we can get the formula for the quality-of-life value:

$$Q_i = (a_1W_1 + a_2W_2 + a_3W_3 + a_4W_4 + a_5W_5)W_H + (a_6W_6 + a_7W_7 + a_8W_8)W_{Ed} + (a_9W_9 + a_{10}W_{10})W_{Ec}$$

Substituting the data from the above table into the formula yields the following table:

Table 5. Quality of Life Values for Three Categories of Countries

Country type	Q_i	
	2010	2018
Developed	6.665034	7.018764
Developing	2.897798	3.461701
Poor	1.389587	1.598889

Absolute Equity Difference Between Developed and Developing Countries $E_d = -0.210173$. This shows that from 2010 to 2018, residents of developing countries subjectively believed that they had become more equitable compared with developed countries.

But E_d is an absolute number that cannot reflect the whole world's view of faimess. So, we introduce the relative fairness difference E_v. By formula $E_r = \frac{\sum (Q_i - \bar{Q}_i)^2}{n-1}$ and $E_v = E_{r_i} - E_{r_j}$, the global relative faimess difference from 2010 to 2018 can be obtained $Ev = 0.20017$.

4. Summary

The study analyzed the subjective perceptions of equity among residents of developed and developing countries from 2010 to 2018 using the absolute equity difference E_d and relative fairness difference E_v. The results showed that while residents of developing countries believed they had become more equitable compared to developed countries, the global relative fairness difference increased from 2010 to 2018, indicating a widening global equity gap.

These findings are consistent with the State of the World's Children report, which shows that despite improvements in the quality of life over the past decade, one third of countries still do not meet the minimum standards set by the United Nations. The number of children who did not meet the target increased by 2.67% year-on-year since 2010.

Overall, this paper presents a useful framework for evaluating and improving global equity. By validating the models using historical data and existing conclusions, the study highlights the potential of this approach to address issues such as poverty, environmental pollution, and resource scarcity.

In conclusion, while quality of life has improved across various countries, the global equity gap has widened. This highlights the urgent need to address this issue, and the framework proposed in this paper can help policymakers and researchers identify potential solutions.

Acknowledgements

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