Research On Global Equity Based on Contribution-Welfare Model

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Abstract. Based on the outcome equity idea from the proverb "more effort, more gain", this paper established a global equity index based on the assessment of national contribution level and welfare level, then measured and compared the global equity situation in 2020 and 2000. The results indicated that the international society is still under strong inequality, and the fairness situation of the international community has deteriorated in the past 20 years.The model in this paper can evaluate the contribution level and national welfare status of countries in the global scope, and measure the unfairness of the international community.

Keywords: Global Equity, Welfare Measurement, National Contribution, Analytic Hierarchy Process, Entropy Weight Method.

1. Introduction

The emergence of anti-globalization makes it more important to consider the unfairness and irrationality of the existing global distribution. For one perspective, the current global income distribution is unfair, that is, only a few countries can use capital and technology to obtain high profits. For another perspective, many developing countries fail to actively participate in the global division of labor and lack development opportunities, while developed markets are increasingly saturated, which leads to a sustained structural downturn in the global economy. Global equity needs to be obtained.

At present, there is no consensus on the standard of "fairness". One of the more famous early ideas was John Rawls's "Justice as Fairness" view [1], Walras's competitive equilibrium view that "competitive markets spontaneously reach Pareto optimality" [2]and so on. In recent years, the solutions to the problem of fair resource allocation in academia can be roughly divided into two categories: the first is to establish the resource allocation function and optimize the solution [3], which is complicated to calculate and has large model loss [4]. The second is to establish a fair evaluation system. Such schemes often only focus on economic variables while ignoring non-economic aspects, and the selection of indicators is relatively single, including coefficient of variation, Gini coefficient, and Theil index [5].

Referring to Adam Smith's Labor theory of value and Marsh's proposal in 1994 that "fairness is achieved when each subject gets the corresponding share of resources according to its own contribution" [6], this paper believes that "fairness" means that the pay should be matched with the gain, that is, those who make efforts should be rewarded accordingly.

In order to take non-economic factors into account and fill the gap of equity evaluation research at the global level, this paper establishes a "contribution-welfare" model to measure global equity and uses the welfare contribution ratio to measure the return to contribution of people in the world. The model integrates various data analysis methods including analytic hierarchy process (AHP) and entropy method and constructs two research variables of "contribution" and "welfare" by combining 30 indicators. The model's calculation method is scientific and comprehensive, which is helpful to promote the rational allocation of resources and the communication and cooperation between countries.

2. A model of global equity based on contribution-welfare

The model aims to measure the fairness level of the international society, that is, whether wealth and welfare can be reasonably distributed among countries [7]. According to the introduction, this paper defines global equity as that each country can get a reasonable return for its contribution in the world.

The model takes countries as samples, and according to the idea that fairness is to get more for more work, the correlation coefficient *CW* between national contribution (represented by *X*) and national welfare level (represented by *Y*) is calculated to measure whether a country's pay (national contribution) matches its gain (national welfare). *CW* is a measurement to evaluate the fairness of countries' participation in global affairs. When the linear correlation between contribution and welfare level is high, it means that the same proportion of contribution growth in each country can achieve the same proportion of welfare growth, which means the world is in a state of high fairness.

The calculation method of *CW* is shown in Formula (1), where *X* is the per capita contribution and *Y* is the per capita welfare of a country. When the world is absolutely fair, *CW*=1; With the decrease of *CW*, a country's payment becomes more and more inconsistent with its benefit, and the degree of equity gradually decreases.

$$CW = \frac{\mathrm{cov}(X,Y)}{\sigma X \cdot \sigma Y} \tag{1}$$

The data used in this paper come from Our World in Data and the World Bank, and a total of 30 indicators are selected to construct contribution indicators and welfare indicators to measure the degree of world equity.

2.1. Measurement of national per capita contribution X

A country's contribution to the international community covers three aspects: output, science, technology and culture, and international relations. This paper optimizes the comprehensive national strength equation proposed by Ray S. lien (director of the Center for Strategic and International Studies at Georgetown University) in 1975 [8], and additionally considers international relations, scientific and technological contributions, and cultural contributions. The output part refers to the idea of Cobb-Douglas output equation (Formula (2)) [9] in economics, which is a more comprehensive and scientific measure of a country's output capacity than GDP.

$$\begin{cases} Y = AK^{\alpha}(LE)^{\beta} \\ \alpha + \beta = 1 \end{cases} \tag{2}$$

Where *K* represents capital, *L* represents the quantity of labor, *E* represents the effective degree of labor, *LE* is the effective labor, *A* represents the technology level, α and β represent the rate of return of effective labor and capital respectively. The Cobb-Douglas output equation reflects the characteristics of decreasing factor scale effect, which is applicable to the production background of most industries.

The selected indicators for measuring national contribution per capita are shown in Table 1.

Table 1 Indexes to measure per capita contribution X.

	1st level	2nd level	3rd level
Contribution	Yield	Technology	Scientific and technical journal articles per million people
			Patent applications per million people
			Research and development expenditure (% of GDP)
			Researchers in R&D (per million people)
		Capital	Land area per million people
			GDP per capita, PPP (constant 2017 international $)
			Electricity per capita (kWh)
		Effective Labor	Employers, total (% of total employment) ×Education
	Creation	Technology	The same as Technology in Yield
		Culture	Quantity of cultural heritage
	Unity	Participation in international affairs	Total diplomatic posts
			Embassies or High Commissions
			Consulates or Consulates General
			Permanent Mission

In this paper, all indicators are positive turned and standardized, and all indicators are unified within the range of [0,10], which eliminates the influence of the order of magnitude and dimension on the construction of indicators and facilitates data reference and subsequent analysis. The processing formulas are shown in Formula (3) and (4):

$$Y_{ij} = \frac{10(X_{ij} - \min(X_j))}{\max(X_j) - \min(X_j)} \quad \text{for positive indexes} \tag{3}$$

$$Y_{ij} = \frac{10(\max(X_j) - X_{ij})}{\max(X_j) - \min(X_j)} \quad \text{for negative indexes} \tag{4}$$

Where X_{ij} is the original data of the j^{th} index of the i^{th} sample, Y_{ij} is the data after the standardization. $max(X_j)$ and $min(Xj)$ represent the maximum and minimum value of the j^{th} index in the index system respectively.

The first and second level indicators are weighted using AHP. By comparing the importance of each indicator in the same layer to measure the national per capita contribution, the judgment matrix is constructed and the consistency test is carried out to obtain the weight of different indicators.

The AHP model is as follows:

By comparing the importance degree of each index at the same level, the judgment matrix is obtained: $A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$,

The weights of the AHP methods are averaged by arithmetic average method (Formula (5)), geometric average method (Formula (6)), and eigenvalue method (the eigenvector corresponding to the maximum eigenvalue of the normalized matrix).

$$\omega_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \ (i = 1,2,\mathrm{L}\ ,n) \tag{5}$$

$$\omega_i = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{k=1}^{n}(\prod_{j=1}^{n} a_{kj})^{\frac{1}{n}}} \ (i = 1,2,\mathrm{L}\ ,n) \tag{6}$$

The objective entropy weight method is used to weight the three-level indicators. The entropy weight method calculates the entropy weight of each index by using the information entropy according to the dispersion degree of the data of each index, then the index weight is obtained.

The entropy weight method to model as described below:

For a nonnegative matrix that's already positive turned: $\mathrm{Y} = \begin{bmatrix} y_{11} & y_{12} & \mathrm{L} & y_{1n} \\ y_{21} & y_{22} & \mathrm{L} & y_{2n} \\ \mathrm{M} & \mathrm{M} & \mathrm{O} & \mathrm{M} \\ y_{n1} & y_{n2} & \mathrm{L} & y_{nn} \end{bmatrix}$,

Each element of the probability matrix *P* is calculated by Formula (7), and the corresponding information entropy of the index is obtained by Formula (8) and (9), and the entropy weight is further obtained.

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{n} y_{ij}} \tag{7}$$

$$e_j = -\frac{1}{\ln n}\cdot\sum_{i=1}^{n} p_{ij}\ln(p_{ij})\ (j = 1,2,\mathrm{L}\ ,m) \tag{8}$$

$$W_j = (1-e_j)\Big/\sum_{j=1}^{m}(1-e_j)\ \ (j = 1,2,\mathrm{L}\ ,m) \tag{9}$$

The final weight of each index is obtained by multiplying the weights of the first, second and third level indexes obtained by the AHP and entropy weight method. The weights are multiplied and summed with the corresponding standardized indicators to obtain an index of national per capita contribution for each country.

2.2. Measurement of national per capita welfare Y

Maslow, an American psychologist, proposed that human beings have five levels of needs (Physiological, Safety, Social, Esteem and Self-Fulfillment), which develop from low to high. When the basic needs are satisfied, the next level of needs will be generated, until the peak of the need level, that is, self-realization [10] (as shown in Figure 1).

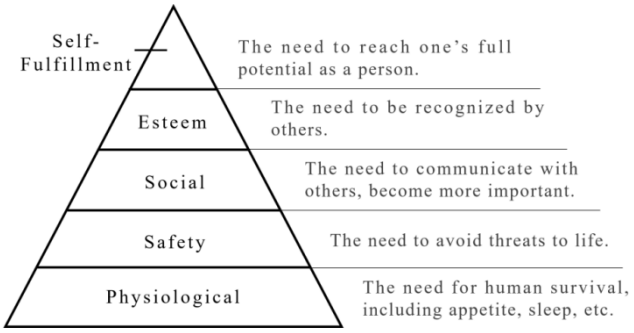


Figure 1 Maslow's Hierarchy of Needs

Based on the analysis of Maslow's hierarchy of needs theory, a welfare evaluation system is constructed for each country, which comprehensively covers related indicators of food and clothing, safety, environmental quality, education level, income level and happiness. The system includes the following three first-level indicators: Self-fulfilling, Self-promotion, Personal survival; The corresponding second-level indicators and third-level indicators are selected to measure the welfare of each country.

The selected indicators to measure the welfare level are shown in Table 2. The above method of calculating the national contribution index per capita is adopted, and the weight of the corresponding index is obtained by integrating the analytic hierarchy process and the entropy weight method, and the index of the welfare level of each country is obtained by weighted summation.

Table 2 Indexes to measure per capita welfare Y

	1st level	2nd level	3rd level
Welfare	Self-fulfilling	Happiness	Human rights index
			Happiness cantril ladder
	Self-promotion	Education	Total government expenditure on education gdp
			Duration of compulsory education
		Income	Gross national income per capita
	Personal survival	Military	Armed forces personnel percent
			Military expenditure share gdp
		Environment	Share without improved water
			Share without improved sanitation
			PM25 air pollution
		Poverty	Share of population in extreme poverty
		Health	Life expectancy
			Disability adjusted life years
			Total healthcare expenditure gdp
			Physicians per 1000 people
		Diet	Agricultural output dollars
			Prevalence of undernourishment

3. Results

3.1. Calculation of Contribution X

Sort by three tier-one metrics for measuring contributions: Yield>Creation>Unity. The first-level index judgment matrix Table 3 is obtained. The weights were obtained and averaged by arithmetic mean, geometric mean and eigenvalue methods to obtain the weights of the first-level indicators as shown in the Table 3 below.

Table 3 Judgment matrix of first-level contribution to measure welfare

	Yield	Creation	Unity
Yield	1	3	5
Creation	1/3	1	3
Unity	1/5	1/3	1

As the degree of importance is similar, the same weight is assigned to the secondary indicators. For the three-level index, the weight of each index is calculated by the entropy weight method . Based on the weights of the third-level indicators, the specific weight values of each indicator are calculated, as shown in Table 4. The weights are multiplied with each indicator to obtain the index of the contribution level of each country.

Table 4 The weight of each indicator in contribution index X

1st level	Weight	2nd level	Weight	3rd level	Weight
Yield	0.6358	Technology	0.3333	Scientific and technical journal articles per million people	0.0469
				Patent applications per million people	0.0718
				Research and development expenditure (% of GDP)	0.0449
				Researchers in R&D (per million people)	0.0483
		Capital	0.3333	Land area per million people	0.0997
				GDP per capita, PPP (constant 2017 international $)	0.0447
				Electricity per capita (kWh)	0.0676
		Effective Labor	0.3333	Employers, total (% of total employment) ×Education	0.2119
Creation	0.2590	Technology	0.5	The same as Technology in Yield	0.1295
		Culture	0.5	Quantity of cultural heritage	0.1295
Unity	0.1052	Participation in international affairs	1	Total diplomatic posts	0.0258
				Embassies or High Commissions	0.0254
				Consulates or Consulates General	0.0286
				Permanent Mission	0.0254

3.2. Calculation of Welfare *Y*

According to Maslow's hierarchy of needs theory, the three first-level indicators to measure welfare are ranked, and Self-fulfilling>Self-promotion>Personal Survival is concluded. The first-level index judgment matrix is shown in Table 5. The weights were obtained and averaged by arithmetic mean, geometric mean and eigenvalue methods.

Table 5 Judgment matrix of first-level indicators to measure welfare.

	Fulfilling	Promotion	Survival
Fulfilling	1	1/3	1/5
Promotion	3	1	1/3
Survival	5	3	1

Then compare the importance of the secondary indexes, the "self improvement" two secondary indexes, education and income, assigned to the same weight; The five secondary indicators of "survival" were ranked in order of different importance: health>poverty=diet>military= environment. Table 6 shows the judgment matrix of secondary indicators.

Table 6 Judgment matrix of second-level indicators to measure welfare.

	Military	Environment	Poverty	Health	Diet
Military	1	1	1/5	1/6	1/5
Environment	1	1	1/5	1/6	1/5
Poverty	5	5	1	1/2	1
Health	6	6	2	1	2
Diet	5	5	1	1/2	1

For the three-level index, the weight of each index is calculated by the entropy weight method formula. By combining the weights of the third-level indicators, the weights of each indicator are obtained, as shown in Table 7. The weights are multiplied with the indicators to obtain the welfare level index for each country.

Table 7 The weight of each indicator in welfare index Y

1st level	Weight	2nd level	Weight	3rd level	Weight
Self-fulfilling	0.1052	Happiness	1	Human rights index	0.0823
				Happiness cantril ladder	0.0229
Self-promotion	0.2590	Education	0.5	Total government expenditure on education gdp	0.0949
				Duration of compulsory education	0.0346
		Income	0.5	Gross national income per capita	0.1295
Personal survival	0.6358	Military	0.0653	Armed forces personnel percent	0.0238
				Military expenditure share gdp	0.0178
		Environment	0.0653	Share without improved water	0.0093
				Share without improved sanitation	0.0194
				PM25 air pollution	0.0129
		Poverty	0.2372	Share of population in extreme poverty	0.1508
		Health	0.3948	Life expectancy	0.0023
				Disability adjusted life years	0.0286
				Total healthcare expenditure gdp	0.0365
				Physicians per 1000 people	0.1837
		Diet	0.2372	Agricultural output dollars	0.1269
				Prevalence of undernourishment	0.0239

3.3. Calculation of Equity index CW

This paper selects 56 sample countries in 2000 and 2020 and calculates their contribution index and welfare index. Figures 2 and 3 represent the contribution index and welfare index of the sample countries in 2000, while Figures 4 and 5 represent the contribution index and welfare index of the sample countries in 2020. It can be seen that regions with higher scores tend to have higher scores.

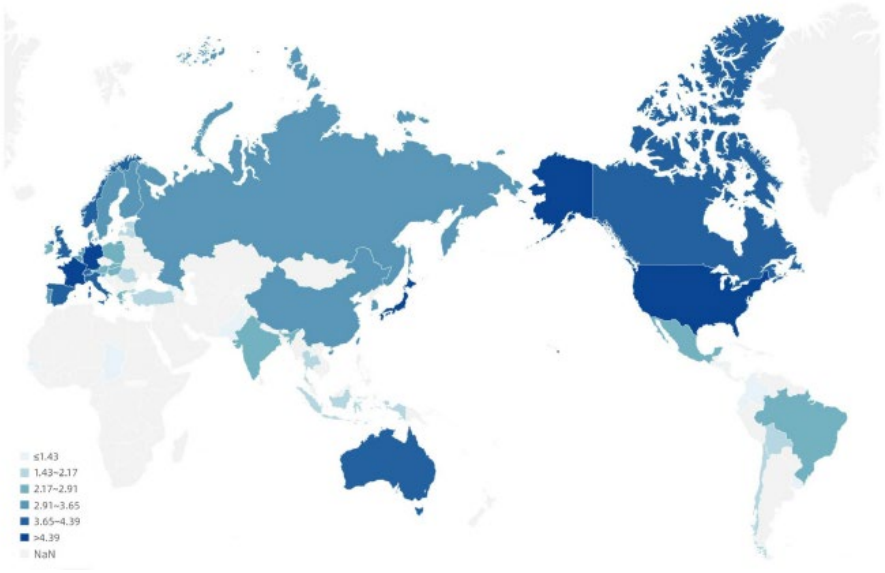


Figure 2 Heat map of global contribution in 2000

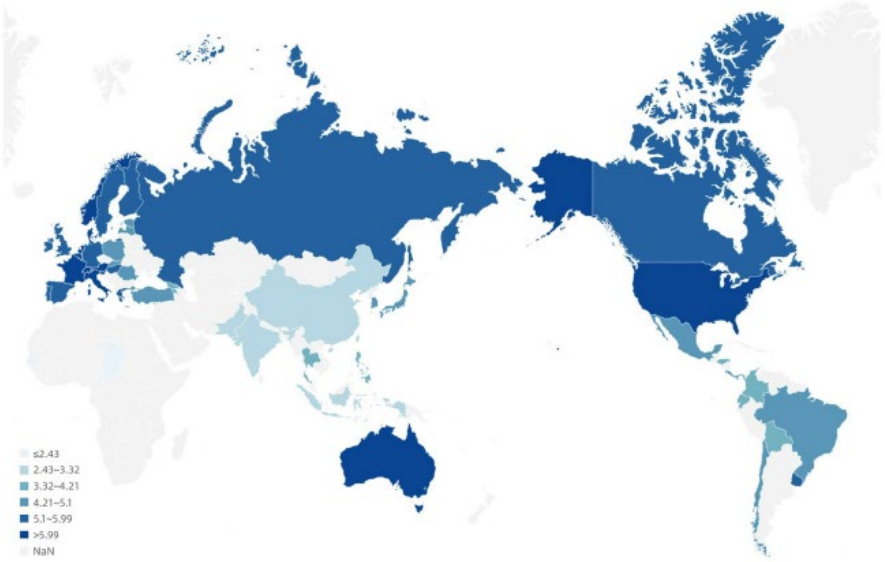


Figure 3 Heat map of global welfare in 2000

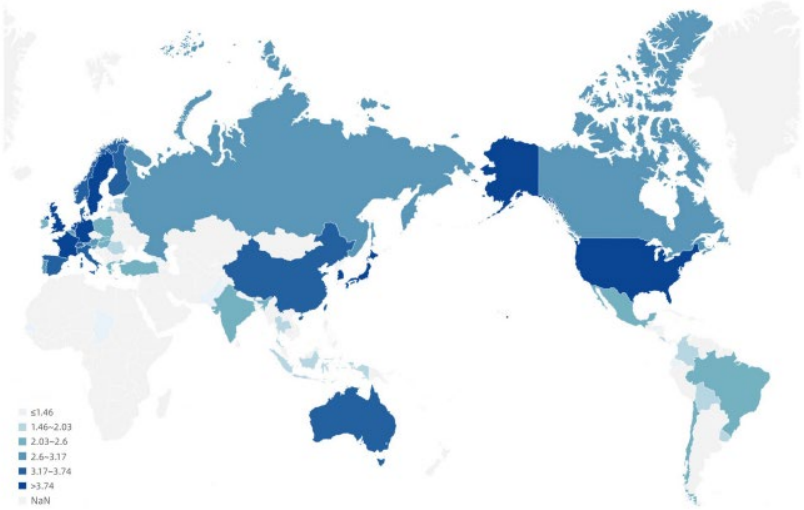


Figure 4 Heat map of global contribution in 2020

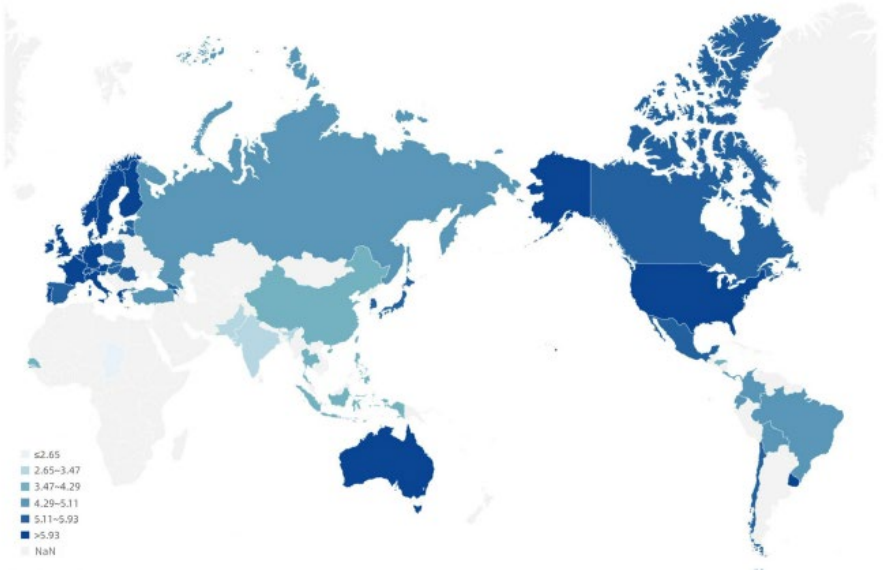


Figure 5 Heat map of global welfare in 2000

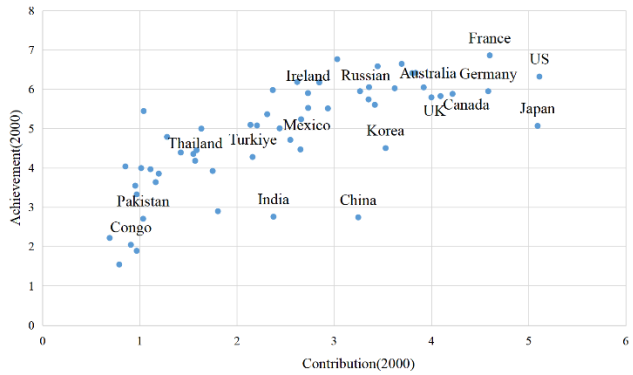
The correlation coefficient *CW* between contribution index and welfare index in 2000 and 2020 are calculated in Table 8 and 9.

Table 8 Equity Index *CW* for 2000 (calculated by Pearson correlation coefficient)

	Welfare	Contribution
Welfare	1	
Contribution	0.7303***	1
*, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively		

Table 9 Equity Index *CW* for 2020 (calculated by Pearson correlation coefficient)

	Welfare	Contribution
Welfare	1	
Contribution	0.6802***	1
*, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively		



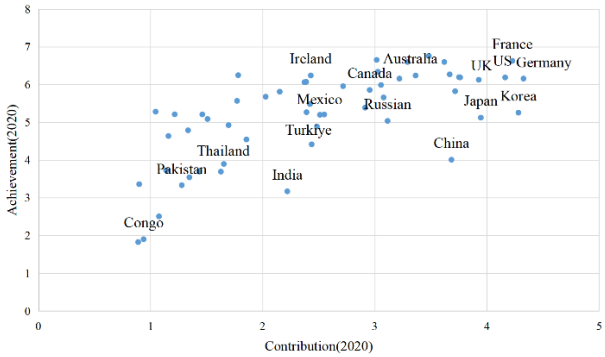


Figure 6 Scatter plot of global equity in 2000

Figure 7 Scatter plot of global equity in 2020

The scatter plots delineate the correlation between contribution index and the welfare index for each country. According to Figure 6 and 7, Nordic countries have a high rate of return on contribution, while Asian countries such as India and China have a low rate of return on contribution, showing obvious regional differences in world equity. Observed from Table 8 and Table 9, *CW*=0.7303 in 2000 and *CW*=0.6802 in 2020, indicating that the linear correlation between the two indexes becomes

smaller, and the global contribution does not correspond to the welfare, and the global inequality becomes more serious. According to the World Bank's 2020 World Development Report [11], the global gap between the rich and the poor is widening. Climate change, scientific and technological development, demographic change, information technology and other factors have exacerbated global inequality. This proves that the actual situation is consistent with the prediction of the model in this paper and verifies the credibility of the model in this paper.

3.4. Welfare-Contribution ratio analysis and global grants

In this paper, Formula (10) was regressed, which measures how many units of welfare each country can receive on average per unit of contribution. The coefficient β_1 represents the annual return contribution ratio of countries in the world.

$$Achievement = \beta_0 + \beta_1 Contribution + \varepsilon \tag{10}$$

It can be seen from Table 10 that the coefficient β_1 of Contribution in 2020 is smaller than that in 2000, which proves that the return to contribution ratio in 2020 is slightly less than that in 2000, and the level of world welfare status becomes worse. A larger constant term in 2020 May indicate an improvement in the overall welfare situation of all countries relative to the situation in 2000. Based on the results of heat map (Figure 2-5) and scatter diagram (Figure 6 and 7), in order to protect the rights and interests of people in backward countries, the United Nations should promote countries with more contributions and better welfare level (such as the United States, Japan, France and Germany) to provide subsidies to countries with lower welfare situation (such as Congo and Pakistan).

Table 10 Comparison of the annual Welfare-Contribution ratio in 2000 and 2020

	2000	2020
	Welfare	Welfare
(β_1)Contribution	0.8157***	0.8028***
	(7.8570)	(6.8180)
β_0	2.7898***	3.1692***
	(9.6599)	(9.9796)
N	56	56
R^2	0.5334	0.4626
Adj. R^2	0.5248	0.4527

4. Robustness

Only 56 countries are finally obtained in the global equity model due to missing data, so there may be errors in the measurement of global equity. In order to verify the robustness of the research, this paper uses the bootstrap method (a statistical method of augmented samples) to solve the problem of small samples. The test results are shown in Table 11, and the conclusions obtained by the bootstrap method are similar to those obtained by the original data, indicating that the results of this paper are robust.

Table 11 Bootstrap for 2000 and 2020

	2000	2020	2000	2020
	Original	Bootstrap	Original	Bootstrap
(β_1)Contribution	0.8157***	0.8157***	0.8028***	0.8028***
	(7.8570)	(7.4300)	(6.8180)	(6.0188)
β_0	2.7898***	2.7898***	3.1692***	3.1692***
	(9.6599)	(9.0258)	(9.9796)	(8.1264)
N	56	56	56	56
R^2	0.5334	0.5334	0.4626	0.4626

Adj. R^2	0.5248	0.5248	0.4527	0.4527

5. Conclusions

This paper aims to measure the global equity situation. From the perspective of production, innovation, cooperation and human civilization construction, based on Maslow's demand theory, this paper calculates the Pearson correlation coefficient *CW* to measure the global equity. The research indicates that the world is still far from perfect fairness. The decline in the global equity index and the welfare contribution ratio in the past 20 years proves that the equity of the international community has deteriorated in the past 20 years, and the welfare of people in the world with the same contribution has become worse.The model established can provide a scientific and reliable theoretical basis for global equity.

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