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Study on Global Equity and Asteroid Mining

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Abstract: *In this paper, we study the relationship between asteroid mining and global equity. Firstly, a comprehensive evaluation model of equity (CEME) is established. The entropy weight method is used to determine the weights of the seven indicators, and the tospsis algorithm is used to obtain the development indicators. In addition, the impact of changing the profit distribution conditions of asteroid mining on global fairness is discussed. Finally, in order to promote global fairness, we proposed the profit redistribution model (PRM).*

Keywords: *Comprehensive evaluation model of equity (CEME); Profit redistribution model (PRM); Tospsis algorithm; Asteroid mining*

1. Introduction

Asteroid mining is the use of launch vehicles to mine and utilize mineral resources from other planets. With the rapid development of human civilization, the earth's mineral resources can not meet the needs of human beings. Asteroid mining is getting more and more attention. The development and utilization of space resources is moving from science fiction to reality. The utilization of space resources is a major opportunity to benefit human society [1]. It carries the hope for the future development of mankind.

However, asteroid mining is also the focus of technological competition, which is related to national security and national interests. Some people think that space resources will become the focus of competition between countries and excessive competition will exacerbate the global gap between rich and poor. Others think that the use of outer space resources will promote distributive justice and global equity in the premise of equitable distribution of resources [2].

The organization structure of the paper is as follows. Firstly, we define global equity by selecting seven indicators to measure national development. Secondly, we established a comprehensive equity evaluation model. We analyzed the weights of seven indicators and defined a development index that measures the extent of a country's development. We then define a global stock index to measure global stocks based on the development index. Additionally, we explore the impact of post-asteroid mining profit distribution on global equity. The GDP of the country changes after the profit distribution. We built a model to measure the impact on global equity. We changed the conditions in the profit distribution model. We then conducted a sensitivity analysis to explore the impact of changes in the mining industry on global equity. Finally, we propose a profit redistribution policy.

2. Comprehensive evaluation model of equity

2.1. Model establishment

To measure national development, we used the topsis based on the entropy weight method to calculate each weight of the seven indicators and the score of each country under this weight [3]. We defined this score as the development index. The higher the index, the better the development of the country. We compare development index and build model for assessing global equity. We have selected seven indicators that we consider important from the perspective of national development: Gross domestic product (GDP), national territory (NT), population (PO), educational level (EL), competitive industrial performance reporting (CIP), poverty (POV) and technology (TE).

Step 1: Judge whether the criteria is beneficial, and forward the data;

Benefit criteria.

For non-benefit criteria, we calculate the difference between the maximum value and the value in the

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sample and use it to replace the original data.

$$x' = \max - x \tag{1}$$

Assuming that the number of countries is *n*, the seven evaluation indicators constitute the positive matrix as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{17} \\ x_{21} & x_{22} & \cdots & x_{27} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{n7} \end{bmatrix} \tag{2}$$

Step 2: Because these seven indicators to measure global equity are different dimensions, we standardize X, and denote the standardized matrix as Z, z_{ij} is each element in Z, $i = 1,2,\ldots,n; j = 1,2,\ldots,7$:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{3}$$

Step 3: Calculate the proportion of the sample i in index j to obtain the relative entropy p_{ij}, and regard it as a probability.

$$p_{ij} = \frac{z_{ij}}{\sqrt{\sum_{i=1}^{n} z_{ij}}} \tag{4}$$

Where $\sum_{i=1}^{n} p_{ij} = 1$.

Step 4: We introduce information entropy to measure the amount of information of each index and calculate the information entropy e_j of each index. In order to obtain a positive correlation measure, we process the data of information entropy to obtain the information utility value d_j .We normalize the value of d_j to obtain the entropy weight of each indicator. Information entropy of index j is:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \ (j = 1,2,\ldots,7) \tag{5}$$

Calculate the information utility value:

$$d_j = 1 - e_j \tag{6}$$

Normalizing the obtained information utility value, we obtain the entropy weight of each indicator to measure its weight in the global equity system

$$W_j = d_j / \sum_{i=1}^{7} d_j \ (j = 1,2,\ldots,7) \tag{7}$$

Step 5: Calculate the score and normalize. We select the largest sample value and the smallest sample value under each indicator as Z^+ and Z^-respectively:

$$Z^+ = (Z_1^+, Z_2^+, .. Z_7^+) = (m\{z_{11}, z_{21}, .., z_{n1}\}, m\{z_{12}, z_{22}, .., z_{n2}\}, \ldots, m\{z_{1m}, z_{2m}, .., z_{n7}\}) \tag{8}$$

$$Z^- = (Z_1^-, Z_2^-, .. Z_7^-) = (m\{z_{11}, z_{21}, .., z_{n1}\}, m\{z_{12}, z_{22}, .., z_{n2}\}, \ldots, m\{z_{1m}, z_{2m}, .., z_{n7}\}) \tag{9}$$

Define the positive ideal solution distance and negative ideal solution distance of the evaluation object $i, (i = 1,2,\ldots,n)$:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (Z_j^+ - z_{ij})^2} \tag{10}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j (Z_j^- - z_{ij})^2} \tag{11}$$

We can calculate the score for the evaluation object i:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{12}$$

Obviously, $0 \le S_i \le 1$.

Normalize the score:

$$\widetilde{S_i} = S_i / \sum_{i=1}^{n} S_i \tag{13}$$

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Where $\widetilde{S_i}$ represents the score value of the development capability of country i according to various indicators.

Differences in development index scores between countries reflect global equity. The smaller the development index gap, the higher the fairness. In order to quantify the level of global equity, we define the global equity index E according to the development index:

$$E = 1 - \frac{\tilde{S}_{max} - \tilde{S}_{min}}{\sum_{i=1}^{n} \tilde{S}_i^2} \tag{14}$$

2.2. Solution of the model

We substitute the corresponding data under the seven indicators into the model and calculate. By using matlab to display the development index statistics of 30 countries. It is shown in Figure 1. Then substitute the development index into formula (14) to obtain the global stock index E=0.3729.

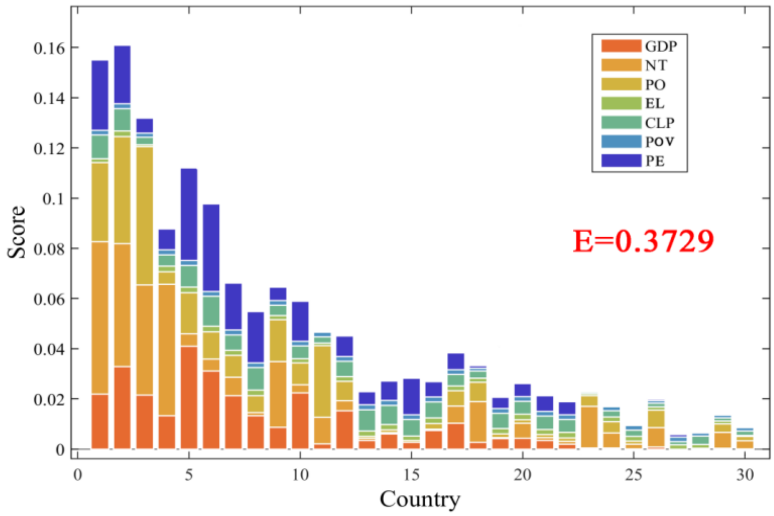

Figure 1: Develoment index chat

We defined global equity as the balance of national development in the comprehensive consideration of various indicators. So, we quantify global equity by establishing a Comprehensive Evaluation Model and defining Equity Index E. We believe that if the development gap between countries narrows, global equity will increase. In order to verify the rationality of the global equity model, we perform the following steps: firstly, we selected the bottom five countries in the ranking and increased the data under each indicator by 5% in the positive direction. Figure 2 shows the change in the development index. Then, we substituted the adjusted data into the model calculation to obtain a new development index. Then we calculated the new Equity Index E'= 0.3986.

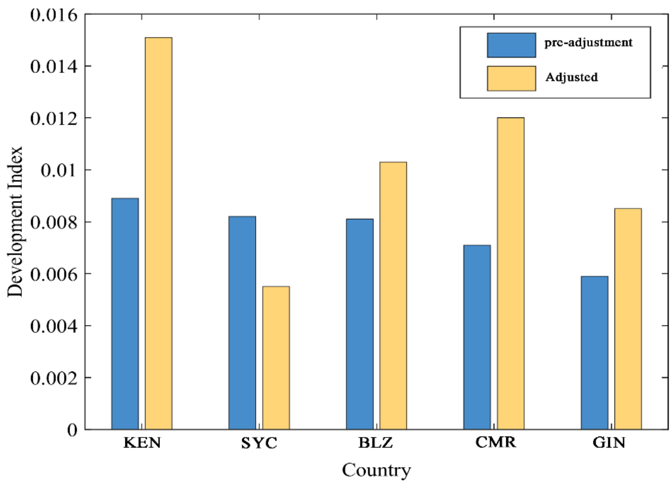

Figure 2: Development index change chart

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3. Measuring impact equity model

3.1. Model establishment

According to the above model, we have obtained an ideal profit distribution coefficient (a_i^*). In this case, the overall satisfaction is maximized. Asteroid mining profits are distributed according to the distribution coefficient. Among the indicators for measuring global equity, asteroid mining profits directly affects GDP and indirectly affects other indicators with a lag. Therefore, we will start with the indicator of GDP to analyze how asteroid mining profits affect global fairness.

Q represents the total profit of asteroid mining. a_i^* represents the distribution coefficient of the country i. Q_i represents the profit of country i after the asteroid mining.$Q_i = \{Q_{1,}Q_{2,} \dots, Q_i\}$

$$\mathrm{Q_i = Q \cdot a_i^*} \tag{15}$$

We consider Q_i as the increase in GDP and calculate the new GDP data of country i.This process updates the original data. Pluging the new data into the global equity index model, we get new global equity index values(E^*). In order to reflect the changes in global fairness, we define the equity index change rate P as:

$$\mathrm{P = \frac{E^* - E_0}{E_0} \times 100\%} \tag{16}$$

If $P > 0$, it means that global equity has increased. If $P < 0$, it means that global equity has declined [4].

3.2. Solution of the model

In order to intuitively demonstrate the impact of income distribution on global equity, we assumed the value of Q is \$10 trillion. We assumed that $\mathrm{a_i^*}$ obtained by the profit distribution model follows a normal distribution. Randomly generated a set of $\mathrm{a_i^*}$ which sum is one and obeys the normal distribution. Assumed that $\mathrm{a_i^*}$ is proportional to the initial development index. We substituted the value of a_i^* into the above model, then we got new development index $\widetilde{\mathrm{S_i}}$.Then we obtained new Global Equity Index $\mathrm{E^*}$=0.3769, Equity Index Change Rate P=1.07%.

3.3. Sensitivity analysis

In the profit distribution model based on nash negotiation, the contribution rate determines the distribution coefficient. We judge the contribution rate by three factors: Core technical factor(I_i), risk factor(R_i), invested capital factor(C_i). The distribution coefficient changes with the change of factors weights.

3.3.1. Increase the weight of invested capital factor ($\boldsymbol{C_i}$)

The level of economic development affects the invested capital. We believe that countries with higher GDP invest more in capital. After increasing the weight of the invested capital factor($\boldsymbol{C_i}$), the country with more capital invested increases the profit. Suppose the weight of the $\boldsymbol{C_i}$ is increased by 5%. We assumed \$10 trillion in profit from asteroid mining. Adjust the previous profit distribution coefficient $\mathrm{a_i^*}$according to changes in GDP:

$$\mathrm{a_i^{*\prime} = a_i^* \cdot \left(1 + \frac{GDP\ of\ country\ i}{Total\ GDP\ of\ all\ countries} \times 5\%\right)} \tag{17}$$

We normalized $\mathrm{a_i^{*\prime}}$ and got the new distribution ratio $\mathrm{a_i^*}$. We substituted $\mathrm{a_i^*}$ into the previous model, then we obtained new global equity index $\mathrm{E^*}$ =0.3610, equity index change rate P=-3.19%. P<0. Therefore, we can conclude that global equity decreases as the weight of $\boldsymbol{C_i}$ increases.

3.3.2. Increase the weight of Risk Factor (R_i)

We think countries that are economically backward are willing to take more risks. Countries with lower GDP take more risks. After increasing the weight of risk factor ($\mathbf{R_i}$), the country that bears more risks will gain more. Suppose the weight of the $\mathbf{R_i}$ is increased by 5%. We assume \$10 trillion in profit from asteroid mining. Adjust the previous profit distribution coefficient $\mathrm{a_i^*}$ according to changes in GDP:

$$\mathrm{a_i^{*\prime} = a_i^* \cdot \left(1 - \frac{GDP\ of\ country\ i}{Total\ GDP\ of\ all\ countries} \times 5\%\right)} \tag{18}$$

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We normalized $a_i^{*\prime}$ and we got the new distribution ratio a_i^*. We substituted a_i^* into the previous model, then we obtained new global equity index E^*=0.4142, equity index change rate *P*=11.07%. *P*>0. Therefore, we can conclude that global equity increases as the weight of Risk Factor (R_i) increases. Figure 3 showed the change in distribution coefficient. We concluded that the model is sensitive and the model is greatly affected by factors.

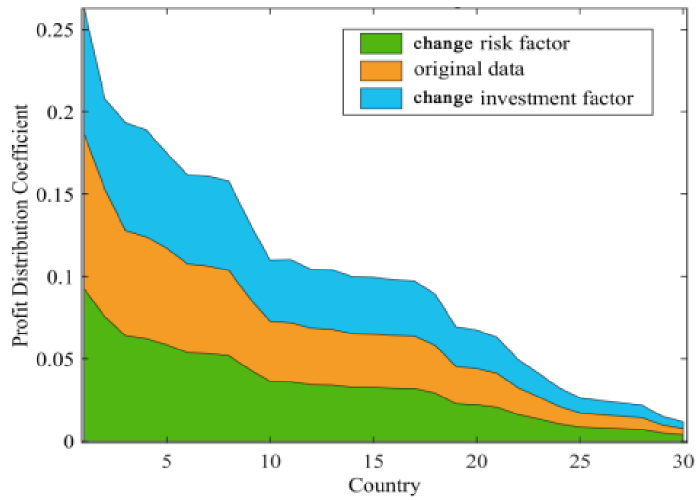

Figure 3: Distribution coefficient comparison chart

4. Profit redistribution model

It is an important measure to benefit mankind by improving the world equity index [5]. In order to enhance the rationality of mineral distribution and promote the balanced development of the world, our team proposed a profit redistribution policy. We took part of the funds from the profits and used them as subsidy funds. The role of the subsidy fund is to provide additional funds to less developed countries. It will help these countries develop. In this way, the economic situation of the underdeveloped country can be improved. And the development gapcan be reduced.

Assuming that after development, the total profit of the mine is Q. Draw a certain percentage of funds from Q for redistribution.

$$D = Q \cdot t \tag{19}$$

The extracted funds D are used to finance countries with smaller development index, thereby improving equity index. Funds of profit are allocated according to the development index obtained in the first model. The amount of profit redistribution required by the country is negatively correlated with the national development index. The lower the national development index, the more profit from redistribution.

Since the negative correlation of the data is inconvenient to deal with, we positively process the development index obtained by the first model: $\tilde{S}_i' = \tilde{S}_{max} - \tilde{S}_i$

Then, we normalized the resulting data to obtain each country's percentage of redistribution. normalized the resulting data to obtain the percentage of each country's share of the grant. Assuming that the proportion of subsidy received by a country is β_i, the subsidy that the country can obtain is $H_i = D \cdot \beta_i$.After profit redistribution, the GDP of each country will change, and the increment of each country's GDP is:

$$\gamma = Q \cdot t \cdot \beta_i + (1 - t) \cdot Q \cdot a_i \tag{20}$$

We substituteγinto the measuring impact equity model to get a new global equity index E* and equity index change rate P. We assume that the total profit Q is 10 trillion dollars, the redistribution ratio t = 20%, and the distribution ratio remains unchanged. After calculation by using this model, equity index E*=0.4457, and equity index change rate P=19.53%. The equity index has grown considerably, so the implementation of this policy can promote global equity.

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5. Conclusion

In this paper, we quantify the global fairness and propose a global fairness indicator E, which intuitively sees the degree of global fairness. The model we considered makes full use of the national data information of each country, and objectively determines the weight of the indicators according to the degree of change in the values of the seven indicators. In addition, we quantify the impact of conditional changes on equity by judging the rate of change of the stock index P. Finally, some fundamental and derived parameters are considered to build a global stock valuation model that reflects multiple impacts.

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