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Together for a Shared Future, and a Shared Future for Together (Space)!

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Abstract:"The very sun irradiates their gorgeous palace, but never bypasses our tatty hut: sunshine is equal." -Shakespeare
Equity is the common desire of all people in this world, and it is also a silently tacit agreement between countries and the strategic balance they want to pursue. However, the recent asteroid mining craze seems to be quietly influencing the existing equity degree around the globe. We developed the World Resource Equity Assessment Model (WREAM) and other related models in order to measure the equity degree of the earth as a regional system and to propose policies to regulate it.In this paper, we reviewed the relevant literature, then collected the required data and performed data pre-processing. Next, for the problem we faced, we developed a model that can assess the degree of equity of any regional system. In this model, we combined subjective hierarchical analysis with objective entropy weighting to obtain the weights of each indicator, and then calculated the IP and OP (Input and Output) for each country using the TOPSIS integrated evaluation method. By introducing the Pearson correlation linear coefficients fitted with the one-dimensional linear regression, the degree of global equity was judged by judging the magnitude of the one-dimensional linear regression coefficients. Then, we applied this World Resource Equity Assessment Model to 10 countries. we made predictions for possible future visions of asteroid mining for pre-policy interventions and post-policy interventions.
Keywords: TOPSIS; Entropy weight method; Time series prediction; World Resource Equity

1. Introduction

In 1967, most of the world's States signed the United Nations Treaty on Outer Space, agreeing that "exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind"[1]. At the same time, the United Nations aims to promote global peace and reduce inequalities. As the basis of international space law, the Outer Space Treaty provides the legal basis for promoting space exploration projects in many countries, such as the International Space Station and the use of satellites to browse the Internet in the most remote areas.

But as humanity seeks access to space-based resources, this equitable international commitment seems to face many challenges. There are many unanswered questions about asteroid mining, but we assume that asteroid mining is viable in near future, that humans will be able to bring valuable minerals (such as platinum and palladium metals) back to Earth in a relatively safe way, and that it will be economically worth the investment.

2. Assumption

To simplify our problems, we make the following basic hypotheses.

● We assume that the environment in which the country is located is relatively stable, the situation of the detected resources is also relatively stable.

This means that when we measure and predict the resource allocation situation of a country, the country we choose will not undergo dramatic changes. For example, major financial crises and global public health emergencies which will influence countries' related situation such as the COVID-19 will not occur in the next few decades. In order to avoid this kind of influence, the data we selected are all the data of 2017 for analysis. By the way, some extreme cases about resources, like the drastic change in asteroid conditions effected by Yarkovsky effect, we will not discuss it here.

● We select some representative countries to train our evaluation model, and the results of the model can be applied to all countries.

Due to the large number of private enterprises, it is difficult to complete statistics. Relative to national data, it is easy to obtain accurate data, and the sample size corresponding to the country is large, which is more universal. Therefore, we choose national data to build the model.

● We assume that a specific country can be regarded as a macroscopic Strategic Business Unit.

Similar to an independent business or department, the development of a specific country is relatively independent. The resource situation of other countries does not have a great influence on one country, and we ignore this influence. Therefore, the status of a specific country in the international environment is similar to the positioning of a company or department in the market, so the country

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can be regarded as a macroscopic Strategic Business Unit.

3. World Resource Equity Assessment Model

According to Palgrave, "Equity does not refer to the average number of resources, but takes into account the subjectivity of equity, defining fairness as the average of the utility that each allocator feels through access to resources."[2] When each assignee has the same satisfaction with the result of the resource allocation, this achieves a fair distribution. We introduced the concept of equity. The equity degree is based on equity as the first criterion, which is used to measure the rationality of the allocation of resources within a regional system. If we believe that a system is fair, the system should not only reach a high level in all aspects, but also be sustainable and balanced in these aspects. The World Resource Equity Assessment Model that we will establish should meet the following requirements:

- The model should be universal and applicable to regional systems under any resource scale in the universe. Therefore, the indicator we have chosen should be suitable for most geographies.
- The pattern should be comprehensive and occupy all dimensions of resource allocation.
- The model should develop appropriate criteria to assess the use of the entity's resources at the entity level (e.g., state, private enterprise) in order to fairly assess the fairness of the regional system of these entities.
- The model should be robust. The evaluation results of this model are relatively stable, and there may be uncertainty interference.

4. ED Indicator System

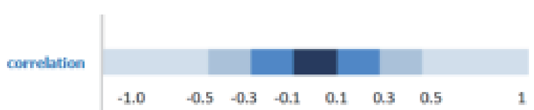
4.1 Determination of indicators and Data Collection

We need to use representative indicators to create an index system to assess the degree of equity. We have read and studied several different indicator systems for gauging equity in prior study. The Gini coefficient system, for example, can accurately depict the economic disparity within a region, but it is limited to a certain area. Because Chinese farmers own land and buildings, they are a viable option. A large portion of their income is uncollected. They don't even commercialize the money they've amassed. As a result, using monetized income alone to determine China's wealth disparity is unable to achieve accurate conclusions.[3] Furthermore, China's geographical conditions are diverse, and the country is large. The rich-poor divide in Tibet, the northwest, and the coastal regions is unlikely to occur, but the rich-poor divide in these two regions does not create a particularly urgent social interaction. The evaluation model developed by our team can be used to examine regional systems over a wide range of spatial distances. As a result, the equity index methodology we built is more universal and logical. We devised two macro criteria for measuring entity behavior and effect in order to better achieve our goal: input and expenditure. And will focus on the examination of equity using more than ten distinct indicators. Our indicator framework is as follows:

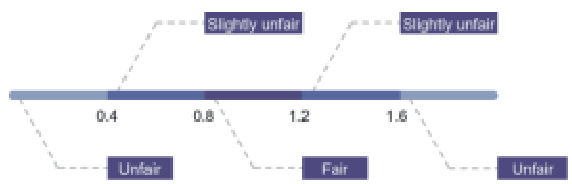
Input: Financial and human resources invested in resource allocation.

Output: The benefits of resource allocation.

ED: After obtaining the scores of IP and OP, we build scatter plots with IP as the X-axis and OP as the Y-axis for the selected countries, and first determine the magnitude of linear correlation by performing Pearson's linear correlation coefficient calculation (which has been hypothesis tested to prove significance), and perform one-dimensional linear regression fitting under the premise of strong linear correlation, so as to obtain the value of the fitted one-dimensional function coefficient, which is used as an indicator to judge global equity.



(a)Meaning of Pearson correlation coefficient



(b) Meaning of different ED values

After determining the indicator framework, we collected data from authorized sources, including World Bank data [4], UNESCO

LEVEL1	LEVEL2	Abbreviation	Unit
Input	Resource import volume	RIV	100t
	Conversion efficiency of resource processing	CER	%
	Science and Technology Input Index	STII	—
	Environmental pollution index	EPI	—
	Proportion of labor force in resource-consuming industries	PLF	%
	Proportion of secondary industry in all industries	PSI	%
	Resources per capita	RPC	—
	Growth rate of Gross Domestic Product	GDP	%
	Happiness index	HI	—
	Employment rate	ER	%
	Urbanization rate	UR	%

Institute for Statistics [5], Trading Economics[6], Kaggle[7], Forward-looking Database [8], Heywhale[9]. Given that we are talking about the allocation of resources, we mainly choose countries with a level of resource input. In the end, we have 11 inferior indicators. Here we introduce our indexsystem.

4.2 Data Normalization

We need to normalize the data of different indicators so that they may be compared on the same scale now that we have a complete and accurate dataset. There are two types of indicators among the 11. We use a variety of normalization approaches.Benefit Attributes: the larger, the better,Cost Attributes: the smaller, the better.

4.3 Calculate the IP, OP and ED

We selected 10 countries with different continents and different development situations as research objects to calculate their IP and OP.We use TOPSIS comprehensive evaluation method to evaluate IP and OP of 10 countries, and obtain the IP and OP scores of 10 countries. We collect data from 10 countries and calculate.From the above calculations we can get a standardized A/B matrix, and now we determine the optimal scheme and the worst scheme for each indicator:

Calculate the proximity of each indicator to the optimal scheme and the worst scheme:

$$A^{+} = (\max\{a_{11},a_{21},a_{n1}\ldots\},\max\{a_{12},a_{22},a_{n2}\ldots\},\ldots\max\{a_{1m},a_{2m},a_{nm}\ldots\}) = (A_1^{+},A_2^{+},\ldots,A_m^{+})$$

The worst scheme A^+orB^+composed of the maximum value of each column element in the A or B:

$$A^{-} = (\min\{a_{11},a_{21},a_{n1}\ldots\},\min\{a_{12},a_{22},a_{n2}\ldots\},\ldots\min\{a_{1m},a_{2m},a_{nm}\ldots\}) = (A_1^{-},A_2^{-},\ldots,A_m^{-})$$

Calculate the proximity of each indicator to the optimal scheme and the worst scheme:

$$D_i^{+} = \sqrt{\sum_{j=1}^{m} \omega_j (A_i^{+} - a_{ij})^2} \quad D_i^{-} = \sqrt{\sum_{j=1}^{m} \omega_j (Z_i^{-} - a_{ij})^2}$$

Calculate the closeness of each indicator to the optimal scheme:

$$IP_i = \frac{D_i^{-}}{D_i^{+}+D_i^{-}} \quad OP_i = \frac{D_i^{-}}{D_i^{+}+D_i^{-}}$$

Application of the World Resource Equity Assessment Model(regional analyses).

Before using Pearson correlation coefficient as the index of ED, linear correlation test should be carried out. We chose the matrix scatter diagram generated by SPSS for judgment.Figure 1.

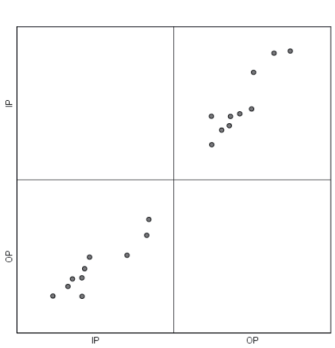
It can be observed that the two have an obvious linear correlation.

Now we have obtained the World Resource Equity Assessment Model, and we will apply it to ten countries including the United States, China, Japan, Germany, South Korea, France, Switzerland, Sweden, Canada and Russia, and analyze their IP, OP and ED. The results are as follows:Figure 2.

5. The Future of Asteroid Mining

In the case of asteroid mining by nations. We assign new meanings and abbreviations to 11 indicators in the World Resource Equity Accessment Model, as shown in the table below:

5.1 Trends in asteroid mining



Country	Input	Output
America	0.1974	0.2113
China	0.1934	0.1743
Japan	0.1576	0.1277
Germany	0.0893	0.1233
Korea	0.0803	0.0963
France	0.0754	0.0751
Switzerland	0.0582	0.0726
Sweden	0.05	0.0551
Canada	0.0227	0.0326
Russia	0.0757	0.0318

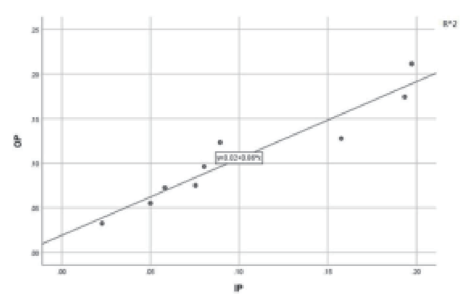


Figure 1: Rectangular scatter plote

Figure 2: Linear relationship between OP and IP

LEVEL1	LEVEL2	Abbreviation	Unit
Input	Imports of rare resources from space	A1	100t
	Space Rare Resource Processing Conversion Efficiency	A2	%
	Science and Technology Input Index	A3	—
	Environmental Pollution Index due to Space Resource Extraction	A4	—
	Share of labor force engaged in space mining operations and related activities	A5	%
	Share of space mining industry in all industries	A6	%
Output	Per capita share of rare resources in space	B1	—
	Growth rate of Gross Domestic Product	B2	%
	Happiness index	B3	—
	Employment rate	B4	%
	Urbanization rate	B5	%

According to the country's resources, science situation, we divide space mining into three stages.

5.2 Quantification of asteroid impacts

After the analysis of likely Vision for the Future of Asteroid mining, we can know the impact of asteroid mining on global equity at different times. How can we quantify this impact? Based on the prediction of asteroid mining prospect by experts, we established a pyramid impact index to quantify the impact of IP indexes of STII, PLF and PSI on OP. This principle will also be reflected in the subsequent prediction model.

After the influence conditions were confirmed, we brought the affected data of the first stage back into our evaluation model and analyzed the fairness again.(**At the 0.01 level (two-tailed), there is a significant decrease relative to the value before the start of space mining.)We can found that the Pearson correlation coefficient is significantly reduced, and the fitting coefficient of linear function is reduced to 0.62, it shows that at the early stages of the asteroid mining is not fully mature, the rate of return on investment (equity) may not meet expectations of all countries, it also accord with our set for the first stage the asteroid mininginfluence.As for the impact of the second stage of asteroid mining, after the subsequent prediction model for each group of indicator data, we find that the ED of the second stage is generally greater than 1 in countries with high initial investment, which is also in line with our expectations. It is not hard to see that, after the verification of the evaluation model, our assumptions about the impact of asteroid mining are reasonable.

6. Conclusion

First of all, we reviewed the relevant literature, then collected the required data and performed data pre-processing. Next, we developed a model that can assess the degree of equity of any regional system. In this model, we combined subjective hierarchical analysis with objective entropy weighting to obtain the weights of each indicator, and then calculated the IP and OP (Input and Output) for each country using the TOPSIS integrated evaluation method.

By introducing the Pearson correlation linear coefficients fitted with the one-dimensional linear regression, the degree of global equity was judged by judging the magnitude of the one-dimensional.linear regression coeffients. Then, we applied this World Resource Equity Assessment Model to 10 countries.

Moreover, after referring to many papers and journals on asteroid mining, we reasonably conceptualized the asteroid mining event. Since there is no human data on asteroid mining. Thus, we bring the changes in some of the metrics generated by asteroid mining into our World Resource Equity Assessment Model and assess the changes in ED (Equity Degree) from asteroid mining.

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