Research on Resource Evaluation Mapping and Asteroid Mining Based on HFSE Model and Entropy Weight Method

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Abstract. In view of the scarcity of resources, we analyze the mapping process from existing resources to expected production value from a humanitarian point of view. After analyzing the fairness index from six different angles, we propose a solution and establish an HFSE model that reflects the difference between a country's economic structure and expectations. In addition, we also synthesize six aspects of the fairness index through the entropy weight method and get the overall fairness of a country. According to the current global situation, the policy of asteroid mining has been put forward. These recommendations enhance global competitiveness promptly and ensure that industries with national characteristics can give full play to their advantages and develop productive forces in an all-around way.

Keywords: Global equity, Entropy weight method, Asteroid mining.

1. Introduction

The development and utilization of external control resources is a new field of human space activities. On 13 December 1963, the United Nations General Assembly unanimously adopted resolution 1962, entitled Declaration on legal principles of the activities of States in the Exploration and Use of Outer Space, recognizing the legality of the development of externally controlled resources. The Outer Space Treaty, signed by most countries at the United Nations in 1967, aims to use outer space resources to benefit all countries, promote global peace and reduce inequality. However, as technological advances make asteroid mining possible, it raises questions: can resources be fairly distributed? What is the impact of different ways of distribution on fairness? How do they give full play to the humanitarian spirit under the condition of rational distribution? What policies can improve global equity? We believe that global equity is an essential value and development evaluation standard that runs worldwide. It refers to the fair and reasonable allocation of resources in a particular historical and regional environment. Therefore, many factors determine the fair and rational distribution of mineral resources.

For example, Pan Kun (2021) proposed that promoting the improvement of the supervision system of space activities is the embodiment of fulfilling international obligations. The Outer Space Convention imposes an obligation on sovereign States to regulate space activities undertaken by their non-governmental sectors. In the aspect of land value index (ARE): Chen Lei (2022) put forward in a review on the efficiency of land use that the evaluation value of land resources usually has the characteristics of the multi-factor compound, multi-level differences, multi-angle objectives, etc. Wang Zhendong (2015) proposed that measuring the economic connotation of mineral resources mainly considers two aspects: inherent assets and intangible assets, which can evaluate the intrinsic economic value of mineral resources in a region. Therefore, it can be used as an index parameter of economic evaluation. According to Wang Zhendong's theory, the mineral resources index = total mineral resources x mineral market price x utility coefficient. Sanjaya Lall proposed that scientific and technological capabilities in the industry refer to technical, management, and institutional skills that enable production enterprises to use equipment and technical information effectively. This energy development can be defined as industrial technology development (SCI). This paper draws lessons from the comprehensive evaluation index system of regional scientific and technological progress put forward by tension (1999). The first-level evaluation indicators include scientific and technological

investment, scientific and technological output, achievement transformation, economic development, and social progress.

2. Humanitarian Fairness Standard Evaluation Model

2.1. Model flow

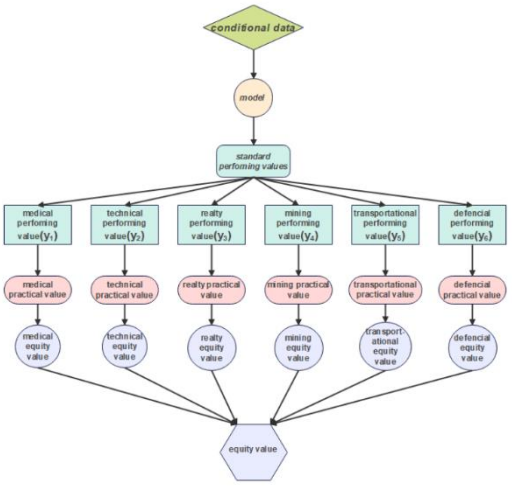


Figure 1 The operation relationship of the model

The model is as follows: first, we collect data on each country's land area, population, and mineral reserves. According to the model established by us, each aspect's corresponding predictive performance values are calculated. We compare the predicted performance values with the actual performance values (GDP, etc.). Moreover, calculate the equality index. Health, technology, real estate, mining, and transport determine a country's equality index.

2.2. Introduction of Index

Demographic data (PEO): The total population of a country.

Land value Index (ARE): Chen Lei (2022) stated that the evaluation value of land resources usually has the characteristics of the multi-factor compound, multi-level difference, multi-angle goal, etc. Land area∗ Land value coefficient, the value coefficient of land, is determined by the exploitable degree of land. Generally speaking, the value coefficient of rainforest and mineral resource-rich areas is higher, while the value coefficient of desert areas is the smallest.

Ore deposits (RES): Wang Zhendong (2015) proposed that the economic connotation of mineral resources should be measured in two aspects: inherent assets and intangible assets, which can be used to evaluate the intrinsic economic value of mineral resources in a region. Therefore, it can be used as an index parameter of economic evaluation. According to Wang Zhendong's theory, the mineral resources index = total mineral resources x mineral market price x utility coefficient.

Science and Technology (SCI): Scientific and technological strength represents a country's ability to develop knowledge-intensive industries. Sanjaya Lall proposed that scientific and technological capabilities in the industry refer to technical, management, and institutional skills that enable production enterprises to use equipment and technical information effectively. This energy development can be defined as industrial technology development (SCI). This paper draws lessons from the comprehensive evaluation index system of regional scientific and technological progress put forward by tension (1999). The first-level evaluation indicators include scientific and technological investment, scientific and technological output, achievement transformation, economic development, and social progress.

WAT: The evaluation of water resources is mainly based on the reserves of freshwater resources. The European Drought Observatory (EDO 2016) provides continental-scale monitoring and modeling

of soil water resources. The impact of fresh water on the bioclimate and agroforestry industry is significant.

2.3. Index of Performing Value

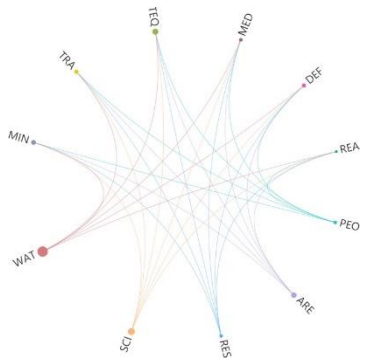


Figure 2 Relationship Net Graph

We should use a uniform measurement scale to study the global ideal of different countries and regions under ideal conditions. Subsequent redistribution would tilt each country's six outcome indices towards the global ideal, respecting objective facts.

Medical index (MED):

$$MED = \ln(1 + ARE + RES) + \exp(SCI) + \alpha_1 * PEO \tag{1}$$

The medical index reflects how well a country is protecting the life and health of its citizens, especially since the global outbreak of COVID-19 in late 2019. Medical resources are increasingly becoming an irreplaceable decisive factor in judging social equality.

Science and technology index (TEQ):

$$TEQ = \ln(1 + PEO) + \exp(SCI) + RES \tag{2}$$

Real estate index (REA):

$$REA = \exp(PEO + ARE) + (RES + SCI)^2 \tag{3}$$

Mining index (MIN):

$$MIN = PEO + \exp(ARE + RES) + \sqrt{WAT} \tag{4}$$

Traffic index (TRA):

$$TRA = SCI * \exp(RES * PEO) + ARE^2 + 0.5 * WAT \tag{5}$$

Defense index (DEF):

$$DEF = \sqrt{PEO * ARE} + \sqrt{(RES + SCI)} + 0.2 * WAT \tag{6}$$

Practical value: the actual output of GDP in each part.

3. Sigmoid-II Algorithm

We will compare the predicted data with the result data, and the direct ratio may have extreme data, which is not conducive to our comprehensive evaluation of fairness. Meanwhile, the model can only express linear mapping. We use the idea of activation function in the neural network to introduce

nonlinear modeling ability and map the ratio η to $y=\frac{2}{1+e^{-x}}$ function, x refers to the ratio of practical value to performing value ($x=\frac{practical_value}{perfor\min g_value}$). It is provided us with a function between 0 and 1

$$EV_i=\frac{2}{1+e^{-x}}-1(x>0;i=1,2,3,4,5,6) \tag{7}$$

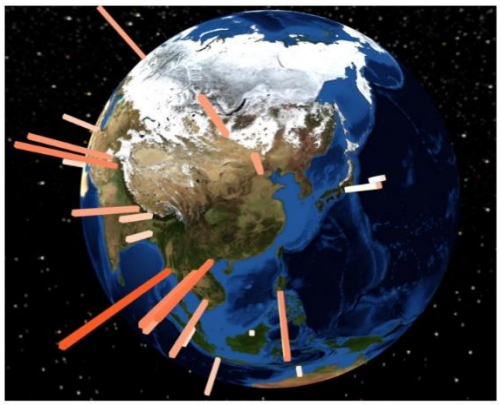


Figure 3 ER distribution chart

ER distribution chart:

$$ER=\sum_{i=1}^{n}\beta_i*\left|EV_i-1\right| \tag{8}$$

Equity Rank (ER):

$$GER=\sum_{g=1}^{m}\sum_{i=1}^{n}EV_i(i=1,...,6;g=1,2,3,...) \tag{9}$$

Where i represents the number of each result data, and g represents the number of each country in the world. Finally, we graphically represent EV of various aspects.

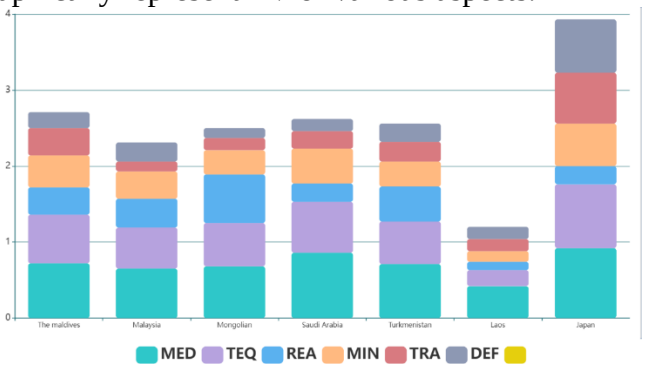


Figure 4 ER Index of Each Country

4. Example Verification

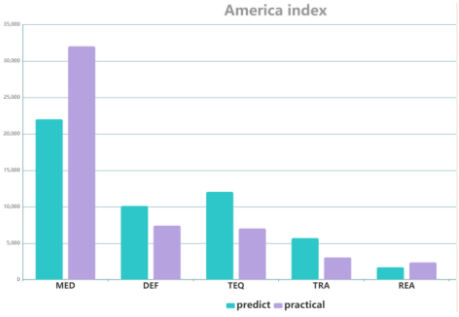
The specific content is shown in table 1.

Table 1. Statistical tables of conditional data and practical data(2021)

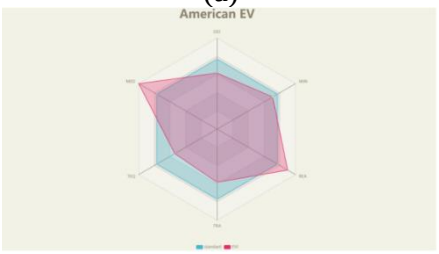
	USA	Russia	India	Unit
Land area	30071	14289	109535	10^4 km^2
Ore deposits	936.4	1707.5	328.8	-
Oil	8.25	5.17	6.04	10^8 t
Natural gas	1291.9	777	258.1	10^8 m^3
Coal	5.79	4.84	7.89	10^8 short ton
Non-ferrous metals	5043.8	7125.6	4938.7	10^4t
Number of patents filed	59570	34984	56771	-
Number of papers published	57.74	35.26	18.73	10^8 m^3
WAT	30690	45080	18930	10^8 m^3
GDP	23.03	1.55	2.66	10^{12} dollar
DEF	7405.0	432.1	736.5	10^8 dollars
MED	32000	978	1947	10^8 dollars
TEQ	7021	474	57.6	10^8 dollars
TRA	1047.6	108.6	32.8	10^8 dollars
REA	236	75	14	10^8 dollars
MIN	1142.3	213.5	26.7	10^8 dollars

4.1. The USA

As can be seen from the bar chart, the medical GDP (MED) and real estate GDP (REA) of the United States are higher than the predicted value, which is called "fair spillover." The remaining four indicators still have a large room for improvement. For the radar chart, blue is the baseline and red is the objective, and the U.S. economy is uneven compared to its projected targets.



(a)



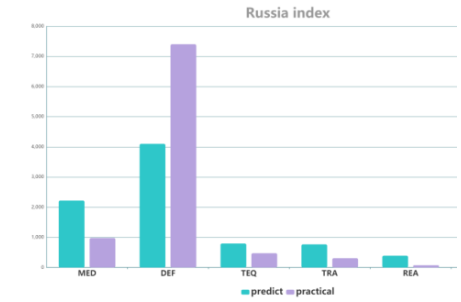
(b)

Figure 5 USA data

4.2. Russia

As can be seen from the chart, Russia's DEF and MIN are higher than predicted. Between 1999 and 2008, the rapid growth of the Russian economy benefited from structural and institutional reforms in the 1990s, as well as a boom in global energy trade (high oil prices). Therefore, the main body of

the Russian economy is over-dependent on the energy and resources industry. Among them, hydrocarbons play a leading role in the energy industry. Russia's arms exports have consistently accounted for half of the country. In addition, the issue of Ukraine has become another focus of the Russian economy. The conflict in Ukraine has directly or indirectly led to higher military spending and loss of troops. Therefore, closer economic and political cooperation with the European Union and the United States, as well as the rational resolution of conflicts in neighboring countries, will enable Russia to divert some of the budget resources currently spent on military and security spending to infrastructure, education, research, and public health projects to promote equitable global development.



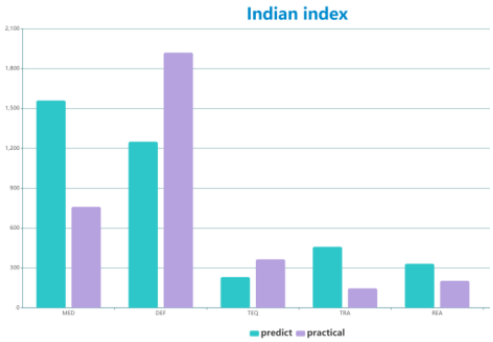
(a)



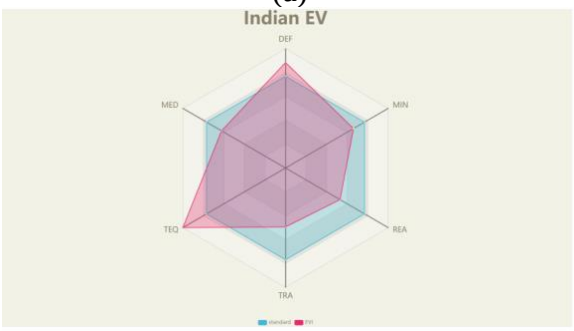
(b)

Figure 6 Russia data

4.3. India



(a)



(b)

Figure 7 India data

As can be seen from the chart, Russia's DEF and MIN are higher than predicted. Between 1999 and 2008, the rapid growth of the Russian economy benefited from structural and institutional reforms in the 1990s, as well as a boom in global energy trade (high oil prices). Therefore, the main body of the Russian economy is over-dependent on the energy and resources industry. Among them, hydrocarbons play a leading role in the energy industry. Russia's arms exports have always accounted for half of the country. In addition, the issue of Ukraine has become another focus of the Russian economy. The conflict in Ukraine has directly or indirectly led to higher military spending and loss of troops. Therefore, closer economic and political cooperation with the European Union and the United States, as well as the rational resolution of conflicts in neighboring countries, will enable Russia to divert some of the budget resources currently spent on military and security spending to infrastructure, education, research, and public health projects to promote equitable global development.

5. The future vision

So far, no country has successfully mined an asteroid due to limited scientific and technological capabilities and the high cost involved, but the benefits and possibilities of asteroid mining are enormous. Because asteroid mining needs strong science and technology backing in the future period. Human exploitation of objects is mainly near-earth asteroids, and mining asteroids has two main ways, one is human through its technological fly to asteroid mining, the other is to capture the asteroid, re-use solar propeller moving asteroid orbits in recent months.

As for the benefits obtained from these minerals, most of the minerals with significant scientific research value will be occupied by the mining countries and applied in frontier science and technology. These mining countries are already in a leading position in science and technology. With the support of the resources, the advantages of the countries will be further expanded. Moreover, because of their scarcity, those sold minerals also make a considerable profit. From the perspective of maintaining fairness, we advocate that the investment value of each sector in a country should follow a certain proportion when investing. The government needs to guide the macro-control to a certain extent. Only in this way can we optimize the economic structure and accelerate the economic construction of weak sectors. The economic structure can be realized through the transmission mechanism of the change in investment ratio. Thereby, the overall fairness of the country is improved, and the ER value expectation is minimized.

6. Policy SuggestionS

In order to promote global equity and ensure that asteroid mining is powerful for all human beings, we have formulated the following policies based on our conclusions:

6.1. Build a public mining business:

Due to the differences in countries' economic and technological strengths, some countries have particular difficulties in mining and even cannot carry out space mining. Therefore, we propose establishing a public mining enterprise to help countries in need.

a. The funds needed to establish public construction are allocated according to the economic strength of each country.

b. Countries should extract 5% to 10% of the benefits obtained through mining to spend on public mining.

6.2. The distribution method adopts a combination of various methods:

The unfair distribution of the benefits from asteroid mining is the main cause of global quality. If the developed countries gain much more benefits from asteroid mining than the backward countries,

global inequality will be aggravated. Therefore, the backward countries must be considered in the distribution problem. We believe that the distribution should include:

a. Distribution according to capital: countries distribute benefits according to their capital contributions, and those who contribute more get more.

b. distribution on demand: according to the strength of each country, take care of the backward countries. The weaker ones should be allocated more accordingly.

c. investment in public facilities: This promotes the development of public mining, which is beneficial to all countries. From our conclusions, we recommend 75.44% for allocation by capital, 14.39% for distribution on demand, and the remainder to promote public mining.

6.3. Guarantee the uniqueness of each country's mining rights to asteroids.

Due to different levels of science and technology, developed countries have great advantages in asteroid mining, and some countries may even be unable to carry out asteroid mining. To prevent the rapid expansion of inequality through asteroid mining, we believe that the policies should be formulated as follows:

a. All nations own asteroids, and one or more nations may not occupy them by any means.

b. All nations have the freedom to conduct scientific investigations of asteroids, but not mine them. Mining rights to an asteroid would be allocated to each country, and only mining rights to an asteroid would be allowed.

c. Countries that do not have the resources to carry out mining operations or that wish to carry out mining operations on planets where they do not have mining rights may, on their own, negotiate with other countries to cede some or acquire some of the mining rights.

6.4. Strengthening the Management of Enterprise Mining

Private capital has entered the field long ago, so corporate mining should be regulated.

a. The scope of mining enterprises is the asteroid that their own country has mining rights. If they want to mine that other country has mining rights on the planet, they need to obtain permission from other countries.

b. Each country should regulate mining by its enterprises and be punished if its enterprises violate the relevant regulations.

7. Conclusions

To aim at the problems of global equity and asteroid mining, we have constructed a standard evaluation model of humanitarian equity, which measures all aspects of a country through a comprehensive index. It can analyze a country's economy from a micro three-dimensional structure. Meanwhile, we can summarize the macro fair distribution among countries in the world. Our profit chain model measures the reasonable investment of each sector of a country. At the same time, we are considering the economic strength of the sector and global equity. After analyzing the fairness index from six different angles, we propose a solution and establish an HFSE model that reflects the difference between a country's economic structure and expectations. In addition, we also synthesize six aspects of the fairness index through entropy weight, get the overall fairness of a country, and put forward relevant policy recommendations.

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