

# Research on the Impact of Asteroid Mining on Global Equity Based on Entropy Weight Method and Polynomial Regression

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**Abstract.** It has been 60 years since humankind first entered outer space. Looking back, aerospace workers have made countless sweat and efforts on the way to visit the universe. In the future, if asteroid mining becomes a reality, the resources and wealth contained in it will be enormous. Only by rational distribution and efficient utilization of resources can we fairly benefit the people of the world. In this paper, we define "global equity" as the negative effect of the degree of discretization of the comprehensive strength index of all countries in the world. The global equity index model is established. The model selects the indicators such as economy, politics, education, military strength, and scientific research investment, obtains the weight by using the entropy weight method, calculates the comprehensive strength index of each country, calculates the standard deviation of the comprehensive strength of each country after interval processing, and then negative processing to obtain the global equity index. Then, we verify the model by region. Finally, a prediction model is established for the scale development of the asteroid mining industry, and it analyzes and calculates the profitability of three types of countries after the exploitation of outer space resources. It is included in the calculation of the national strength index to calculate the global equity index in the base year (2020) and 2034-2039. The least-squares cubic polynomial regression fitting is used to show the future trend of the global equity index intuitively. It is concluded that the development of the space mining industry will deteriorate global equity.

**Keywords:** Global equity index model, entropy weight method, polynomial regression.

## 1. Introduction

Why are people so interested in asteroid mining? The answer is resources and money.[1] Just as human beings explored California or participated in any commercial speculation in the 1850s, someone would pursue them as long as there were economic interests.[2] The United States recently established a law on asteroid mining, which allows individuals and private enterprises to explore asteroid minerals and pave the way to develop outer space resources. Although Americans who have experienced the era of great navigation issued the bill, the focus of the bill is to prevent American companies from killing each other in space and keep consistent with the outside world.[3] However, this legislation may lead to a worldwide "space gold rush." The "asteroid reorientation program" of the United States is recently a project with high attention. It is not challenging to doubt how much benefit the asteroid mining program can obtain from its description.[4] For example, unmanned detectors with huge launch costs can only bring back up to 5 tons of water in one mission. From an economic point of view, it is evident that it is reasonable to obtain water resources from the earth. However, this paradigm of using space resources will become an influential pioneer in large-scale asteroid mining in the future. American scientists have just calculated that one of the two metal asteroids floating near the earth may contain precious metals worth about 116.5 trillion US dollars. This expensive "golden ball" may contain more iron, nickel, and cobalt than the total metal reserves of the whole earth. These two metal-rich near-earth asteroids have rare and abundant mineral deposits 1.6km wide. One of the metal veins is labeled 1986 DA, and the other is labeled 2016 ed85. According to the latest analysis published in the Journal of planetary science on October 1, these two planets "may become the targets of asteroid mining in the future." In addition, there is a large asteroid that will start exploration in 2022.[5] Elon Musk, the world's richest man, has signed a contract with

NASA. Once a large amount of capital flows into the research and development of asteroid mining, in the foreseeable future, resource collection across space will completely change the international situation and even the fate of humankind.[6] Only by rational distribution and efficient utilization of resources can we somewhat benefit the people of the world.

Fairness has always been a core topic in human morality, and it is also a common concern of many disciplines such as psychology, sociology, and economics. We believe that fairness is a strategy that comprehensively considers the interests of self and others in people's social communication.[7]

## 2. Global Equality Index Model Based on Entropy Weight Method

Since we want to quantify global equity, and since the world's political system is based on the premise of distinguishing countries, we have decided to define global equity as the reverse effect of the dispersion of the comprehensive strength of countries around the world.

We first established the comprehensive strength evaluation model of various countries. The model is divided into six first-class indicators: the gap between the rich and the poor, scientific and technological indicators, economic indicators, educational indicators, military indicators, and political influence indicators. In addition to military indicators, each primary indicator has a second indicator corresponding to it. Military indicators are composed of nuclear weapon level, number of troops, number of weapons, number of military satellites, and military budget.[8]

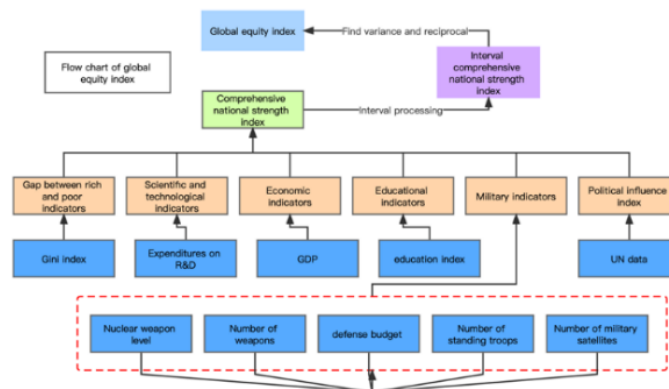
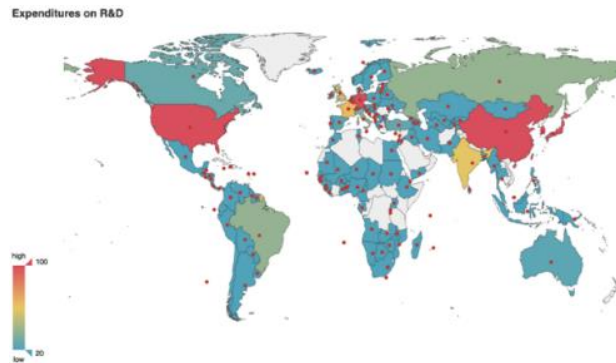


Figure 1 Model hierarchy diagram

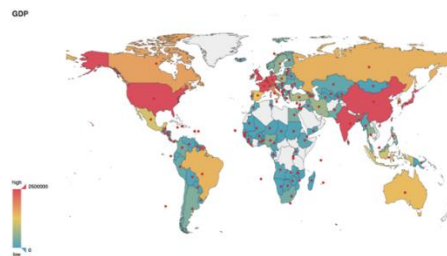
Scientific and technological indicators are an important part. They are not only the country's primary productivity but also the main driving force leading the development of the times. Its secondary indicators are used research and development expenditure (R&D) data to include basic research, experimental research, and applied research. In terms of scope, it almost includes universities, laboratories, enterprises, research institutes, governments, and other activity subjects. Therefore, R&D ranking can fully reflect a country's overall investment in scientific and technological research and development.

We use Python pyechart library to draw a global thermal map of scientific and technological index data, which intuitively displayed the scientific and technological situation of the countries worldwide.



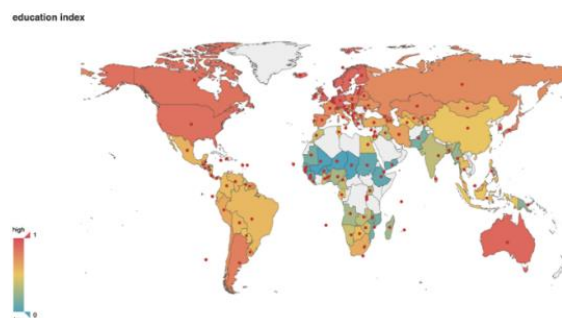
**Figure 2** Global thermal map of scientific and technological indicators

The economic indicator is the GDP of each country. Its economic representativeness has been recognized worldwide so that it can be used to summarize the economic strength of a country or region.



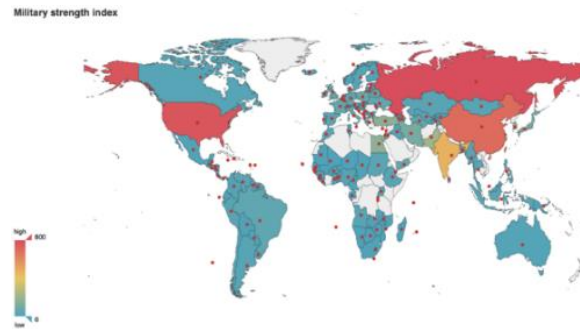
**Figure 3** Thermodynamic diagram of global economic indicators

The education index is one of the three component indicators of the human development index published by the United Nations Development Programme. It is measured by the adult literacy rate (2/3 weight) and the comprehensive enrollment rate of primary school, middle school, and University (1/3 weight). It is believed that the penetration rate of basic education is indeed the best factor to measure a country's education level. Meanwhile, education also directly affects and promotes the development of national science and technology, so it is the top priority of comprehensive national strength.



**Figure 4** Thermodynamic diagram of global education indicators

Under the current world system, military indicators are a strong supporting condition for formulating the world pattern and rules. Although we do not want the occurrence of war and expect humankind to maintain peace for 70 years for a longer time, the improvement of the force of various countries still affects everyone's nerves. Only with strong military strength can we avoid bullying in the international community and have the right to speak. It is an eternal principle.



**Figure 5** thermodynamic diagram of global military strength indicators

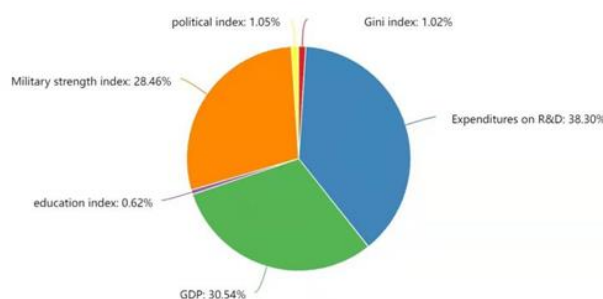
Political influence indicators mainly summarize the status of countries in the international community. This indicator is made up of three categories of countries. The first category of countries as permanent members of the United Nations. We give them 3 points; The second category is the developed countries recognized by the United Nations except for the permanent members, which we give them 2 points; The third category is developing countries other than permanent members. We give them 1 point.

The indicator of the gap between the rich and the poor is composed of the Gini coefficient. We believe that the Gini coefficient can be used as a part of the national strength system against the economic indicators, so this indicator is used as a reverse indicator.

**Table 1.** Describes statistics

Item	Sample size	average value	standard deviation
Gini index	137	0.632	0.212
Expenditures on R&D	137	15.634	70.885
GDP	137	584852.692	2259338.545
education index	137	0.669	0.181
Military strength index	137	39.237	131.752
political index	137	1.248	0.497

Next, the entropy weight method is used to calculate the secondary indicators of military indicators, which obtains their weights and calculates the military indexes of various countries. It is used the entropy weight method model to calculate the weights of each node together with the other five primary indicators.[9]

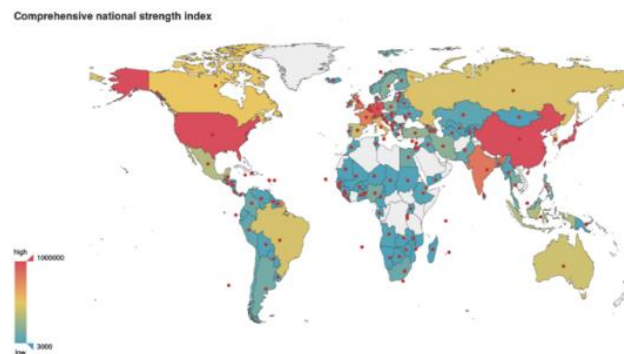


**Figure 6** Weight pie chart

After obtaining the index weight of the comprehensive national strength index model, substitute the relevant data of each country in 2020 into the model to calculate the comprehensive strength index of each country. Then process these data in intervals and then calculate the standard deviation of the comprehensive strength index of all countries with the Python mathematical module. Finally, after

subtracting nine from the standard deviation, take the reciprocal to obtain the global equity index = 0.557606538 because we believe that the greater the gap in strength between countries, the more unfair the world will be.

In order to verify the reliability of the model, we extract the comprehensive strength index of various countries in calculating the global equity index, which compares it with the mainstream national strength ranking in the world. It is used to judge the accuracy of the intermediate value of the model according to the comprehensive strength heat map of different continents.



**Figure 7** Heat map of national comprehensive strength index

From the heat map, we can roughly see the comprehensive strength of each continent. For example, in North America, most of the regions with red and yellow colors are strong and relatively uniform; South America, which is next to it, is very different. Yellow and green account for the central part. Although there is little difference in national strength, the overall strength is not good. There are several kinds of colors in Asia, and the national strength of each region varies greatly and is also related to the vast land of Asia. It is found that Europe has a small area, primarily warm colors and strong overall strength, which is related to the EU system to a certain extent. Then, Oceania is a single country with medium strength in the world. The theme color of Africa is the cool blue-green color. The strength gap between countries is small, which is mainly caused by the overall economic backwardness of Africa.

To sum up, the global equity model has high accuracy and can make accurate comparisons and predictions.

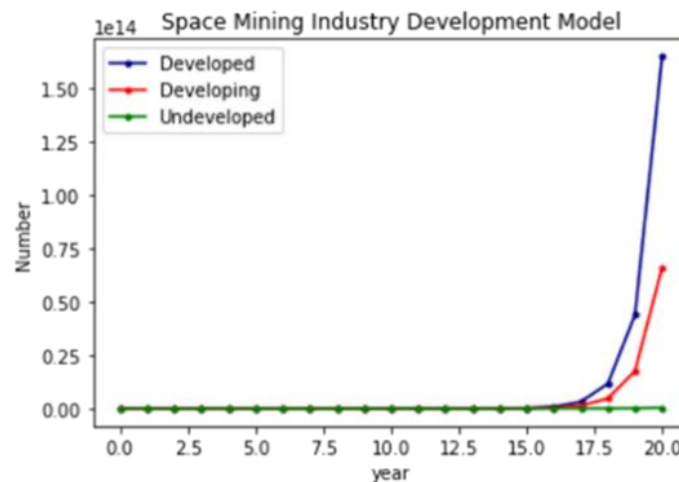
### 3. Prediction of Asteroid Mining Scale Development Based on Polynomial Regression

The original intention of establishing this model is to quantify the impact of asteroid mining on the economies of all countries from the perspective of industrialization. We have built a relatively simple business model for future space mining: mining companies are divided into private enterprises and state-owned enterprises, which are listed companies. Based on the rules, the income obtained from asteroid mining is distributed to individuals, companies, and countries but ultimately belongs to the domestic economic system.

Profit is an important part of the "asteroid mining industry development prediction model." Part of the annual profits will be distributed as dividends, and part will be invested as scientific research funds for the next year. The remaining profits will be distributed according to formal procedures. According to the Research Report of Goldman Sachs on asteroid mining, we set the dividend yield in the model as 0.1; The proportion of R & D expenditure in profit is set as 0.3; The profit margin is set at 1.7. We have predicted the industrial scale of the three countries classified by cluster analysis and obtained the time series trend chart of their space mining industry scale.

$$V_n = V_{n-1} \cdot p \cdot (1 - r - tech) \cdot (1 + tech) \quad (1)$$

$$\text{profit}_n = \frac{V_{n-1} \cdot p \cdot r + \text{profit}_{n-1} \cdot d}{d^n} \quad (2)$$



**Figure 8** Industrial-scale prediction

It can be seen that with the outbreak of the development of the asteroid mining industry, the industrial scale of the first type of countries, such as the United States and China, will show a geometric leap in growth. The second category of countries, such as Britain and France, will also see a significant increase. However, the third kind of countries can only struggle in the mire. It is difficult for them to put space mining into practice and compete with other powerful countries. From this point of view, the countries with the highest strength will get very considerable benefits, but the countries at the bottom may only become the material suppliers of space mining or the manufacturing and processing plants of spacecraft in theory. Stronger beneficiary countries bring resources back to earth from space. Although weaker countries will benefit from the economic radiation of increasing overall resources, they are too insignificant compared with the high profits of leading countries. Given that the economy is relative since the economic benefits are gradually enlarged, the world pattern and world equity will also face great challenges.

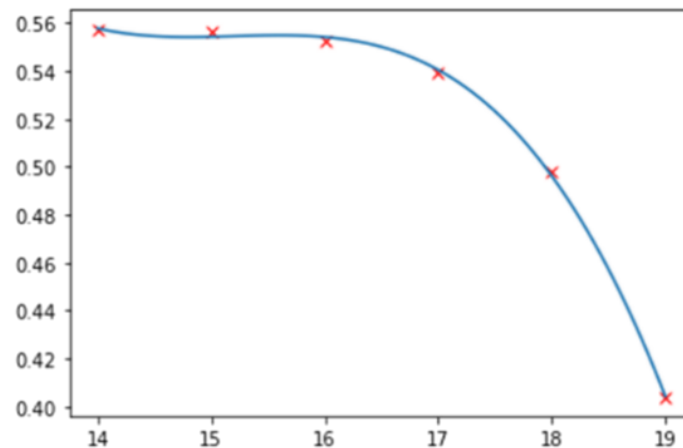
Next, we discount the residual profit in the "asteroid mining industry scale prediction model" to the starting year (the discount rate is the yield of 30-year treasury bonds of the Federal Reserve). Then, we substitute it into the economic indicators of various countries in the starting year (2020) in the form of increasing GDP and substitute it into the previous global equity index model to calculate the change in global equity with the gradual growth of asteroid mining.

In the industrial scale prediction model, the asteroid mining industry in the first 15 years is not active and has no considerable economic benefits. Therefore, the global equity index is shown from the starting year (2020), 2034, to 2039.

The calculation result is:

- Global equity index in the starting year (2020) = 0.557606538
- Global equity index in 2034 = 0.557221608
- Global equity index in 2035 = 0.556268284
- Global equity index in 2036 = 0.552677274
- Global equity index in 2037 = 0.539695182
- Global equity index in 2038 = 0.497745898
- Global equity index in 2039 = 0.403747005

Next, the least-squares cubic polynomial regression is used to make the fitting curve of the global equity index over time and provides the corresponding function expression.[10]



**Figure 9** Least-squares cubic polynomial regression fitting diagram

$$y = -2.83e - 0.3 \cdot x^3 + 1.29e - 0.1 \cdot x^2 - 1.96x + 1.04e + 0.1 \quad (3)$$

It can be seen from the figure that the global equity index decreases with the scale of the asteroid mining industry, the slope is larger and larger, and the decline rate of the global equity index is faster and faster, which also proves our conjecture that space mining will aggravate the gap between countries. According to the previous correlation analysis, we regard the impact of economic indicators as one of the essential conditions. Such huge economic benefits cannot be distributed fairly to all countries under the existing distribution system. The gap between economies gradually widens and radiates to all aspects of comprehensive national strength. Finally, the Matthew effect is still formed, and the strong are always strong.

#### 4. Conclusion

In this paper, we built a global equality index model. The model selects indicators such as economy, politics, education, military strength, and scientific research investment, uses the entropy weight method to obtain weights and calculates the comprehensive strength index of each country. Secondly, we established a prediction model for the scale development of asteroid mining, analyzed, predicted, and calculated the profitability of the three types of countries after mining resources in outer space, and incorporated it into the calculation of the national strength index to calculate the future of the global equity index. It is concluded that the development of space mining will lead to a deterioration in global equity.

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