Asteroid Mining in a Global Equitable Environmente

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Abstract. With the advancement of human technology and the continuous development of society, asteroid mining has entered people's field of vision. In order to better solve a series of problems caused by asteroid mining, firstly, we use the equitable distribution of resources and opportunities to explain what global equity is, and create a global equity model using Analytic Hierarchy Process (AHP). Secondly, we establish a linear model and demonstrate the economic feasibility of this model by introducing data. Finally, we build an elastic demand curve model and a Quantitative model of financial investment papers to vary the amount of mined and the allocation rate of mined ore in the asteroid mining sector, respectively, to analyze their impact on global equity.

Keywords: Global Equity, AHP, Linear model, Asteroid Mining.

1. Introduction

Nowadays, with the development of human science and technology, the exploration and development of outer space is essential for human beings. According to the existing treaties on outer space that most countries have signed, outer space is regarded as the territory of all mankind and does not take into account the economic and scientific development of each country. On the issue of asteroid mining, it is difficult to rely on the strength of only one country. In asteroid mining, it requires the cooperation of multiple countries and even all human beings to complete it.[1]

Since there is cooperation, it will inevitably involve the issue of resource allocation. There are many mineral resources on asteroids, and there is a high probability that there will be some rare mineral resources on the earth and even unknown minerals that are not on the earth. These resources are of great help to a country's economic and technological development. At this time, it is difficult to ensure the fairness of resource distribution.[2]

Although there are still many unknown and intractable problems about asteroid mining, now we assume that asteroid mining is feasible and that humans can bring mineral resources back to Earth and be of great help to human development.

2. Definition and Measurement of Global Equity

We believe that the definition of fairness in the world is a fair distribution of resources and opportunities. The resources here include but are not limited to minerals, oil, food, water, etc. To achieve this distribution, the world should abandon the boundary between some countries and countries can only be achieved by making the world closer to a whole. This does not mean that we will completely lose the form of countries, but the boundaries between countries will become more blurred. Only in this way is it possible to achieve global equity. And for the distribution of opportunities, we consider the opportunity assistance provided by the United Nations. The opportunities here include but are not limited to funds, education, environmental governance subsidies, etc. Under the assumption of this major premise, we can begin to measure how to carry out global equity.

2.1. A Global Equity Model for Resource Allocation

When determining global equity, we believe that this reasonable allocation should be handled by considering three factors: the population of the allocated country [3], the level of science and

technology (innovation ability or resource acquisition ability) [4] [5], and the resources originally held by the country [6].

Under this kind of world fairness as we define it, these three factors are prioritized when allocating a resource. In the allocation process, we will normalize these three factors respectively, and use the method of AHP [7] to finally obtain a score for the proportion of a certain resource that the country deserves. Here are the detailed steps:

$$\Theta = \frac{Reserves\ of\ a\ Certain\ Resource\ Owned\ by\ a\ Country}{All\ the\ Reserves\ of\ a\ Certain\ Resource\ in\ the\ World} \tag{1}$$

$$\Lambda = \frac{Total\ \ Population\ \ of\ \ a\ \ Country}{Total\ \ World\ \ Population} \tag{2}$$

$$\Phi = \frac{All\ \ the\ \ Technologies\ \ a\ \ Country\ \ has}{All\ \ the\ \ Technology\ \ in\ \ the\ \ World} \tag{3}$$

We will give a scale to their mutual importance according to the relevant literature and some subjective judgments and establish a judgment matrix, as shown in Table 1.

Table 1. judgment matrix for Resource Allocation

Rated First	Native Population	Indigenously Held Resources	Indigenous Access to Resources
Native Population	1	3	6
Indigenously Held Resources	1/3	1	2
Indigenous Access to Resources	1/6	1/2	1

We will first normalize the judgment matrix by column to get the following Table 2.

Table 2. Normalize the judgment matrix

Rated First	Native Population	Hndigenously Held Resources	Indigenous Access to Resources
Native Population	2/3	2/3	2/3
Indigenously Held Resources	2/9	2/9	2/9
Indigenous Access to Resources	1/9	1/9	1/9

Finally, we sum each row separately, and divide the result of the sum by n to obtain the weight vector, as shown in Table 3.

Table 3. Weight vector for Resource Allocation

Rated First	Weight Vector
Λ	0.67
Θ	0.22
Φ	0.11

$$x = 0.67\lambda + 0.22\theta + 0.11\varphi \tag{4}$$

We finally allocate resources fairly based on the total score ratio.

According to the world population data map, considering the population and development level, the world is divided into eight regions, including Europe, North America, East South America (Chile, Colombia and other countries), South America West (Brazil and other countries), Oceania , Africa, East Asia (especially the four countries of China, South Korea, Japan, India), and other regions in Asia, but due to the variety and complexity of resources, this model is mainly based on the BP Statistical Review of World Energy countries' oil reserves and Global Innovation The country rankings of Index 2021 are established [8], and the number of people, resource holdings, and resource acquisition

capabilities in the eight regions are given corresponding weights of 2/3, 2/9, and 1/9 by using the AHP method, which is realized by MATLAB. Evaluation of global equity in different regions of the world.

After reviewing the data and arranging the data, we get the results as shown in Table 4.

Table 4. Evaluation of global equity in different regions of the world

Region	Europe	North America	Eastern South America	South America West
Population	0.0947	0.0745	0.0158	0.0455
Resource Holdings	0.0080	0.1400	0.0300	0.1800
Resource Acquisition Ability	0.1600	0.1800	0.1000	0.1200
Region	Oceania	East Asia	Rest of Asia	Africa
Population	0.0053	0.3789	0.2122	0.1730
Resource Holdings	0.0020	0.0680	0.5000	0.0720
Resource Acquisition Ability	0.1400	0.1600	0.0800	0.0600

The final calculation result as shown in Table 5.

Table 5. The final calculation result

Europe	North America	Eastern South America	Western South America
0.0827	0.1008	0.0283	0.0836
Oceania	East Asia	Rest of Asia	Africa
0.0195	0.2855	0.2615	0.1380

From these values, from the perspective of the average population's possession of oil resources and the ability to obtain oil, the larger the total score, the more oil resources should be allocated to the region.

2.2. A Global Equity Model for Allocation of Opportunities

when determining global fairness, we believe that a reasonable distribution of opportunities takes into account the environmental pollution index, per capita GDP, and education level of the assigned countries. We believe that countries with lower indexes should get more opportunities to improve their environment. Raise their GDP and raise their education levels. We will also use AHP to get a score for the opportunity this country deserves.

We will scale their mutual importance according to the relevant literature and some subjective judgments and build a judgment matrix, as shown in Table 6.

Table 6. A Judgment matrix for the Allocation of Opportunities

Rated First	GDP Per Capita	Environmental Index	Education Level Index
GDP Per Capita	1	2	3
Environmental Index	1/2	1	2/3
Education Level Index	1/3	2/3	1

After normalizing the rows and columns of the matrix and dividing by n we get the weight vector, as shown in Table 7.

Table 7. Weight vector for the Allocation of Opportunities

Rated First	Weight Vector
AG	0.55
Ψ	0.27
ED	0.18

$$x = 0.55AG + 0.27\Psi + 0.18ED \tag{5}$$

We will allocate this opportunity in the form of funding or international assistance based on the score.

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For example, let's take South Africa and the United States as examples. In order to better evaluate global equity, the team decided to build a model before that, with different weights of 0.55, 0.27 and 0. 18 respectively assigned to the three variables of per capita GDP, environmental index and education index. In addition, because the environmental index is not easy to measure. Instead, we decided to use 1 minus the death rate due to environmental pollution. According to the literature search and calculation, the education index was obtained, so as to judge the level of education in a region and obtain the per capita GDP data of each country to evaluate whether it is fair. In addition, this model differs from the previous one in that it uses only two regions, the United States and South Africa, for comparison, illustrating the feasibility of the model in a simpler way.

After modeling with MATLAB, the result is in Table 8 and Fig.1.

Table 8. The result of USA and South Africa

America	South Africa
0.7823	0.2177

From this we can get a higher score for the United States, so we would prefer South Africa in the opportunity allocation, and show that in terms of GDP per capita, environ- ment, and educational attainment, South Africa should be allocated more opportunities to improve these factors.

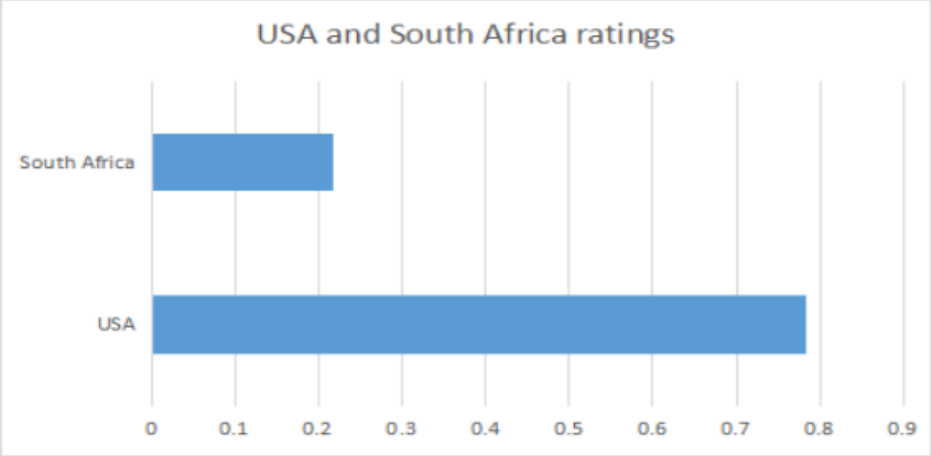


Figure 1. USA and South Africa Ratings

3. Future Asteroid Mining

3.1. Asteroid Mining of the Future

Based on the relevant literature and our thinking, we propose the following three feasible solutions for asteroid mining:

1) Directly bring raw materials back to earth for processing.

2) Processed on asteroids to extract valuable minerals.

3) Transport the asteroid from its original orbit to a safe orbit near the Earth, and proceed to option 2.

Because the cost of transportation is now too expensive, according to the literature, the cost of transporting one ton of water to space is as high as 50 million US dollars. In addition to the cost of launch and fuel, the cost will be too high. If we implement plan 1 or plan 2, we will inevitably use the spacecraft to travel for a long time, and we have to repeat this process. In this way, the transportation cost is very huge, and the earth's environment has been damaged to a great extent. If we put a large

amount of raw materials from asteroids on the earth for processing, it will undoubtedly damage the earth's environment. Therefore, after comprehensive consideration, we believe that the third option is the most suitable for people to conduct asteroid mining in the future.

However, there are still many difficulties in the implementation of the third plan. The biggest difficulty is how to transport the celestial bodies to a safe location, and capture and control them when mining asteroid ore. Some asteroids may tumble and spin, and we must try our best to stabilize them in orbit around the Earth.

According to the literature and data, we have put forward the following general ideas for the third plan, as shown in Fig.2 First, we will launch multiple spacecraft and load them with high- power thrusters to find suitable asteroids. After locking on the target, we will collect a certain amount of rock formation samples from the asteroid for analysis to check its valuable mineral content. After determining its value, multiple spacecraft will fix the asteroid from different angles and push it to the Lagrangian point of the Earth-Moon. After the asteroid is stabilized, we will send the mining spacecraft to mine. After the valuable minerals on the planet have been mined, we are using propulsion spacecraft to send them out of the vicinity of Earth's orbit. If the propulsion spacecraft is not damaged too much, it will be recycled and used for the next mission.

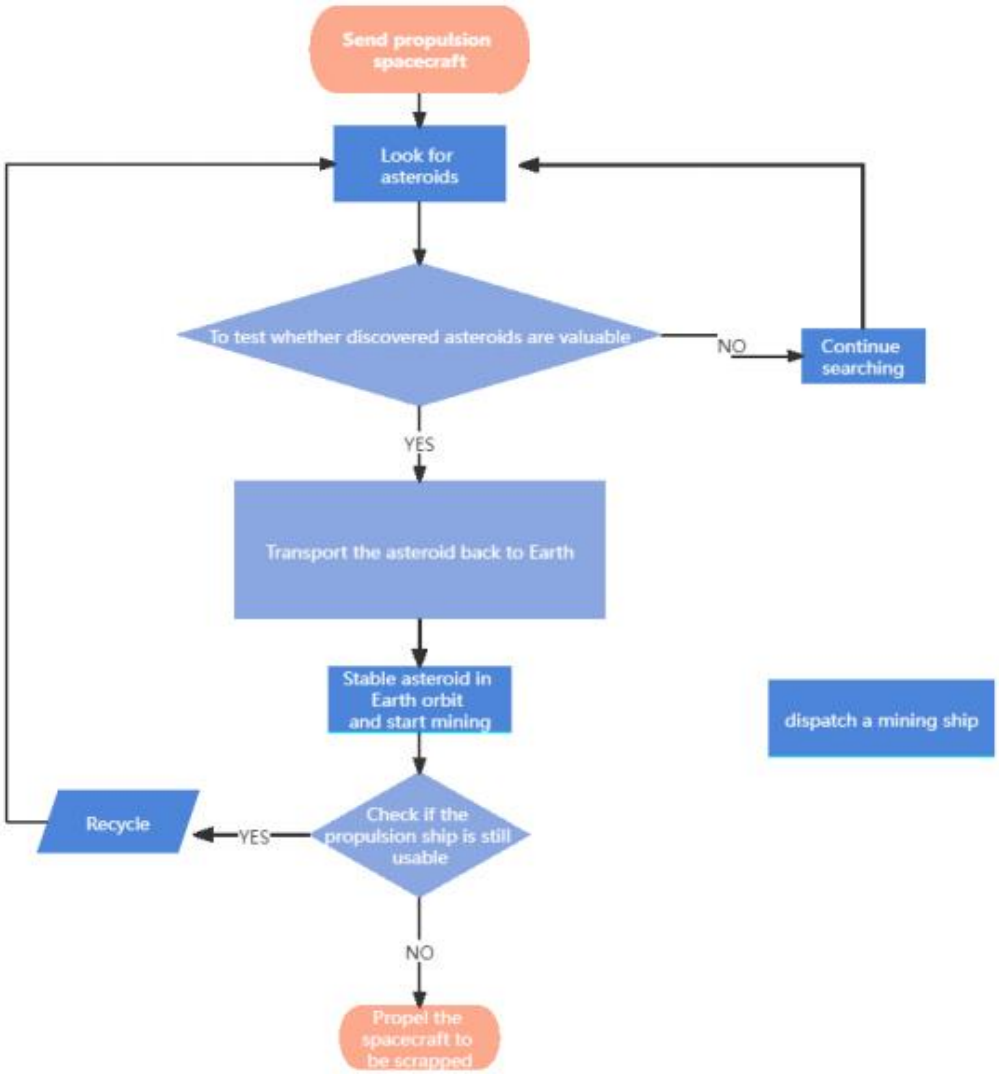


Figure 2. Asteroid Mining Process

Since the cost and risk of asteroid mining are too great, under the premise of our global fairness and the United Nations Outer Space Treaty in 1967. [4-1] Our assumption is that this responsibility is shared globally. We can assume a UN asteroid mining agency. Each country needs to invest a certain percentage of its annual GDP in this institution, and the money invested serves as a fund for a series

of required matters such as asteroid mining, and the ore obtained is partly used by the United Nations to sell as funds. The other part is distributed to countries according to the initial funding contribution. Specific steps are as shown in Fig.3.

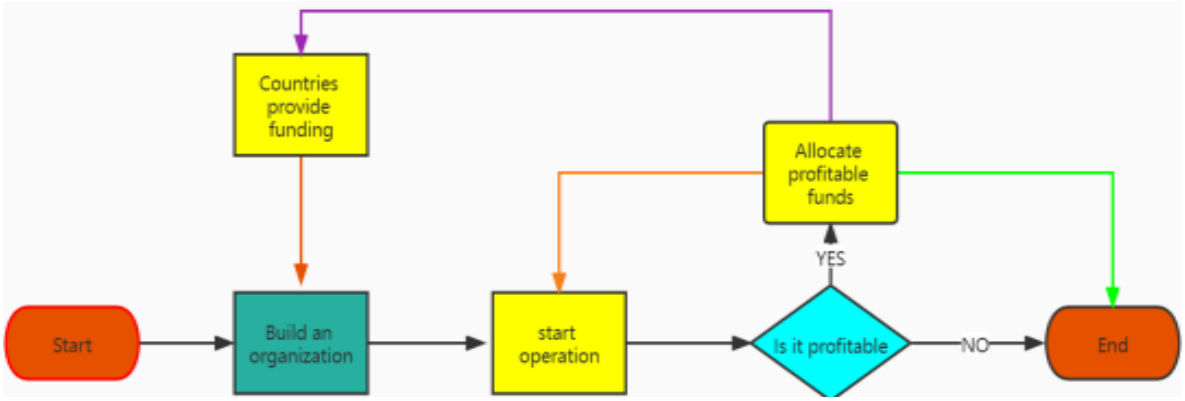


Figure 3. Asteroid Mining Process

In order to demonstrate the feasibility of the plan we take the mining of platinum as an example; we built the following models [12] by searching the literature:

$$P(t) = H - S - K(t) \tag{6}$$

$$S = Cspc * B + Co \tag{7}$$

$$H = Ppl * B * t * I \tag{8}$$

$$K(t) = Cstc * B \tag{9}$$

By reviewing the literature, we obtained the reference data [9] as shown in Table 9.

Table 9. Reference data

	Conservative Cost	Optimistic Cost (mass production)
Cspc	1000000	10000
Cstc	20000	20000
Ppl	37000	37000
Co	5700000	100000

We assume that the total mining time is twenty years. Based on the model developed we derive the Fig.4.

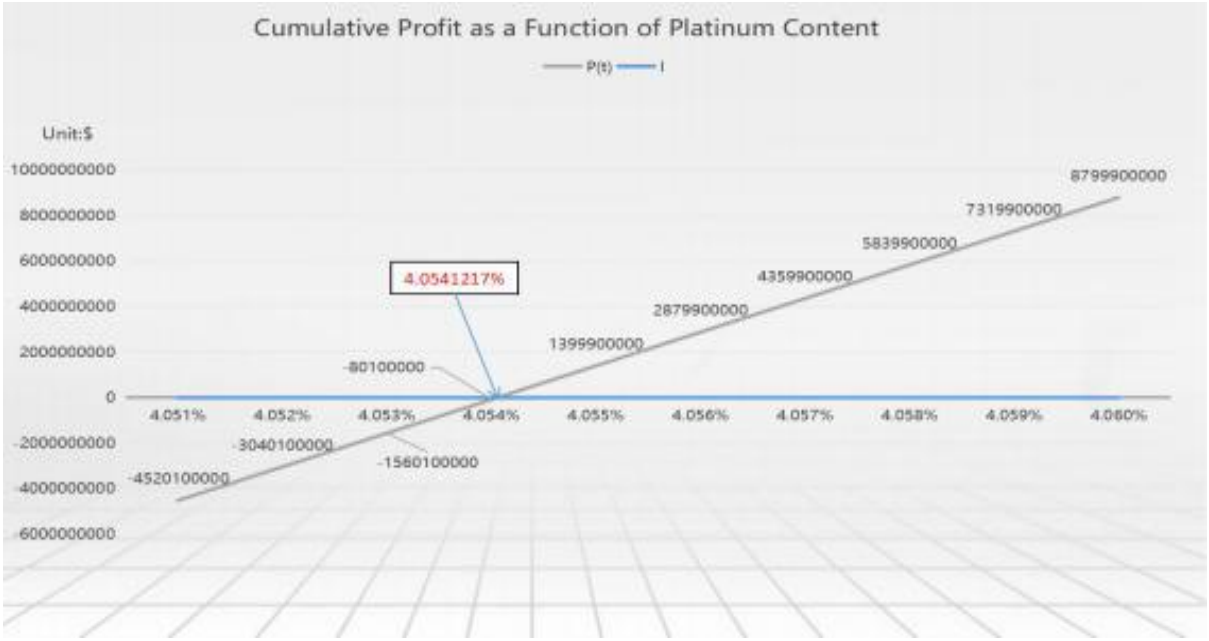


Figure 4. Cumulative Profit as a Function of Platinum Content

According to the model we established, considering only the mining of platinum, it is concluded that when the platinum content of the asteroid is 4.054%, the project will be profitable, which shows that this plan is feasible when the technology is mature. very feasible.

3.2. Impact of Asteroid Mining on Global Equity

As far as building an organization is concerned, there are limited access opportunities due to the small number of countries with mining potential. This means that many capitalist countries may not want to establish a global organization to jointly develop asteroid mining, but prefer countries with fast enough technological development to share the water resources and mineral resources brought by asteroid mining. Increase the gap between countries.

These substances include cobalt, neo-iodine and platinum. Due to worldwide low carbon emission policies, the industry of similar materials continues to grow, and many of these low carbon energy technologies use key metals to function. There are many risks associated with the side effects of mining, processing, recycling and disposing of these metals, including environmental hazards and public health concerns, in addition, rocket fuels such as unsymmetrical dimethyl hydrazine (ADH) pose a significant threat to the environment and human health, especially in the case of a burnt rocket stage falling. It may cause human health problems and may have carcinogenicity, mutagenicity, convulsion, teratogenicity and embryotoxicity. As a global problem, it will inevitably have a negative impact on global equity.

In addition, due to the imperfection of space law now, it is likely to lead to many intra-planetary conflicts and some national conflicts in the future. But asteroid mining could mitigate global warming, and in the future the mined asteroid material could be used to create a giant, stationary sunshade, and the resulting shadow could be reduced if these “Earth Sunglasses” are designed and positioned correctly solar energy, thus having a positive effect on the environment, is more conducive to global equity.

As far as whether asteroid mining can be profitable, the financial feasibility report’s answer is yes. As far as Mars is concerned, more than 50 years of Mars exploration has helped researchers to gradually deepen their understanding of Mars. Bit resource utilization technology to convert Martian material resources into consumables required for missions, greatly reducing the dependence on the earth, thereby reducing the cost of Mars exploration. However, as a new marketing concept, space travel will attract many investors. Since the earth is not yet in global equity, if this investment can be

determined to be profitable, it will definitely bring about a larger gap between people. Thus, affecting global equity.

In addition, the economic impact of asteroid mining also needs to be considered. For example, after a large amount of a certain ore enters the market, it will inevitably cause the price of the ore market to change dramatically. This economic change will also affect the world. fair.

4. Impact of Changing Conditions on Global Equity

4.1. Change in the Percentage of Profit Earned

In order to illustrate the impact on global equity when the proportion of profits shared by each country changes when distributing benefits, we will give an example. First, let's assume a country A, which is involved in all aspects of asteroid mining. For some reason, its share of profit distribution has increased, which may be caused by technological breakthroughs. Before starting the analysis, we first assume that the proportion of country A's investment in scientific research in the country's fiscal revenue remains unchanged. Next, we will explain the next step.

In order to illustrate the impact of the state's financial investment in scientific re- search on scientific research, we simplify scientific research into the number of papers produced by all universities in a country, so as to reflect the development of science and technology in a country. We will put major financial investment and human investment, we will mainly focus on financial investment.

Based on this we build the following model:

$$\log(Y) = \log(A) + \alpha \log(K) + \beta \log(L) + \gamma \log(E) + \varepsilon \tag{10}$$

In order to make the relevant conclusions more realistic, our main data here comes

from the profiles of Chinese universities and their financial data, the relevant websites of the Chinese Ministry of Education and the book Compilation of Science and Technol- ogy Statistics of Higher Education Institutions. These include the number of papers, the number of projects approved, the number of technology transfer contracts, the number of awards, human input and national financial input. However, because we mainly discuss the relationship between financial investment and scientific research output, we only analyze the financial investment in scientific research.

After the correlation test and regression analysis of the individual fixed effect model, we got the results as shown in Table 10.

Table 10. Regression analysis results

Variable Name	Y
E	0.7893

We can see that the correlation coefficient between financial investment and the number of papers, that is, the output of colleges and universities, is positive, which indicates that a country's investment in scientific research has a great and positive correlation with the number of papers published in that country. To a certain extent, the number of papers represents a country's scientific research capabilities and technological development level, and the same is true for asteroid mining, so we make the following summary.

An increase in the proportion of profits distributed by a country in asteroid mining will increase its investment in scientific research, which will make the country's techno- logical level develop faster, which will inevitably make the country's ability to acquire resources stronger. That is to say, it will have an impact on the o variable in the global fairness model we have established, which will then have an impact on global fairness.

4.2. The Impact of Resource Accumulation on Global Equity

When distributing minerals on asteroids, we have to consider a question, that is, whether the excess minerals will affect the market price of above-ground minerals. Taking platinum as an example, in order to simplify the model, we assume that platinum is an independent market. The price of platinum is only affected by the market volume. If a large amount of platinum collected from asteroids flows into the market, it will inevitably lead to a serious impact on the price of platinum. At present, the world's platinum re- serves are 14,000 tons. The average price in the past two decades is about 34,440 US Dollars/Kg [10], and the total supply in recent years is only about 180 tons per year.

Considering the effect of quantity on price alone, according to the literature we searched, platinum from 30-meter-long (98-foot) asteroids may be worth $2.5-50 billion. If all the platinum on these asteroids flows into the market, we assume that there are 100 If there is an inflow of platinum of $100 million, then according to the market price and calculation, it can be concluded that an inflow of 290.36 tons of platinum is equivalent, which will bring a lot of fluctuations to the market. If these platinums enter the market in the same year, the market price of platinum will only be about 40% to 50% of the original price.[11]

Not only that, the devaluation of such a large amount of minerals in other mining industries will lead to a sharp drop in the GDP of many countries that rely on minerals as their main income, such as South Africa, Russia, etc. Therefore, in our previous distribution situation, it is undoubtedly a negative impact on the economy of such countries. On the contrary, these countries are not only not getting the benefits they deserve, they are also being deprived of their original benefits, which obviously affects the global equity model we have established. The resources they hold will be relatively reduced, and the per capita GDP will also decrease accordingly. Taking South Africa as an example, we only consider the output of asteroid platinum. Assuming that the price of platinum is only affected by quantity, we know that the annual platinum mining volume in South Africa is about 124 tons. By setting the annual platinum mining volume of different asteroids, Let's look at the impact on South Africa's GDP.

We first need to calculate the price elasticity of demand for platinum [12]. According to the data, the total demand for platinum in 2020 is 215.2 tons, and the price is about 28,000$/kg. The total demand in 2019 is 263. 1 ton, and the price is about 22,000$/kg. It is assumed that there will be market demand for all platinum produced.

Firstly, we will calculate the current price elasticity of platinum [9].

$$E_d = \frac{(Q_2 - Q_1)/(Q_2 + Q_1)/2}{(P_2 - P_1)/(P_2 + P_1)/2} \tag{11}$$

Secondly, we will estimate the current price of platinum through the demand curve model.

$$P = \frac{(W_a \times h + W_{sa})}{E_d} + \frac{P_1 \times P_2 - P_1 \times P_1 - Q_1 \times Q_2 + Q_1 \times Q_1}{(P_2 - P_1)} \tag{12}$$

Finally, we will calculate South Africa's expected earnings from platinum exports based on current platinum prices.

$$P_{nf} = P \times W_{sa} \tag{13}$$

After calculation we get the following model as shown in Fig.5.

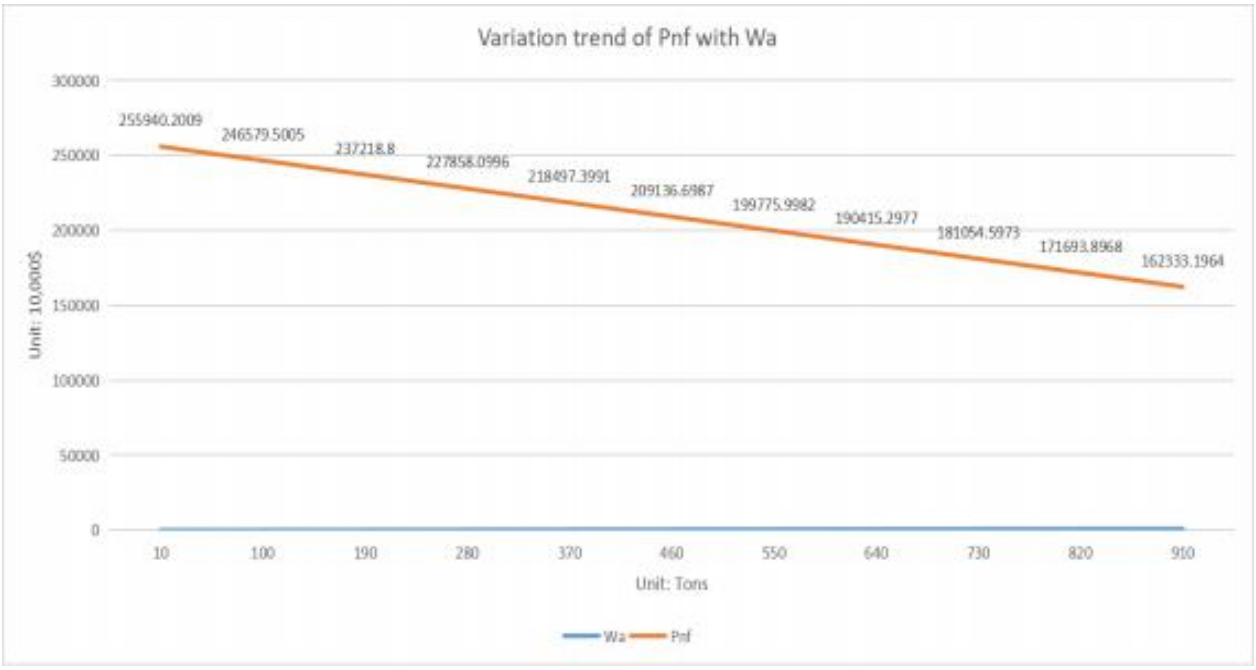


Figure 5. Variation trend of P_{nf} with W_a

It can be seen that with the increase of asteroid mining platinum, the expected total revenue of South African platinum will be lower and lower. Therefore, we conclude that changes in the condition of mining volume will obviously affect global fairness.

5. Policies and Recommendations Proposed

Countries that have mastered asteroid mining technology should share the technology with the world, and the technology that can improve mining efficiency should be shared with the world.

Only organizations established by the state have the right to explore and mine asteroids, and private companies have no right to mine asteroids for profit.

The resources acquired by the planet must be reported to the United Nations, and each country cannot violate the interests of other countries for its own interests.

The United Nations should consider as many factors as possible, including a country's population, development level, resource reserves, environment, education, technological development, and industrial structure, etc. We will evaluate the scoring of each country and set up a corresponding number of asteroid resources to ensure global equity.

For those big and powerful countries in the world, the United Nations needs to establish laws to share good environmental governance programs, scientific and technological development programs, and national development programs with other countries, so as to make the world as fair as possible.

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