International Rare Earth Supply and Demand Forecast Based on Panel Data Analysis

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Abstract. Rare earth supply and demand forecasting plays a crucial role in the development of the rare earth industry, but there are some problems in common prediction methods, such as big error and insufficient authenticity. Through the use of panel data analysis methods to predict and analyze international rare earth supply and demand can greatly improve the authenticity and reliability. Spatially analyze the positive correlation between international rare earth supply and national GDP, rare earth production, and rare earth imports, while negatively correlated with the price of rare earth. From the time analysis, the international rare earth consumption presents the general trend of decline. At the same time, the supply and demand forecast of rare earth in China is analyzed and compared and strive to provide an important reference for the comprehensive development and utilization of rare earth resources in China through the analysis of panel data.

1. Introduction

About 23% of the world's rare earth resources are in China [1]. The world's most rare earth rare earth is the Bayan Obo light rare earth mine in Inner Mongolia. It is the most popular rare earth mine in the world except the heavy rare earth mines located in the six southern provinces of China. It has simple mining technology, extensive distribution and no radioactivity [2]. China's rare earth quota has a high proportion of heavy rare earths, and is the world's largest and most important producer of heavy rare earth, holding a significant position in the global rare earths market. International rare earth supply and demand forecast is particularly necessary for the comprehensive development and utilization of rare earth resources in China. How to develop rare earth resources reasonably and effectively has become a resource issue that researchers attach great importance to. Panel Data is an efficient statistical method [3], which can be applied to rare earth supply and demand forecast to obtain more real Data. Rare earth industry has a very broad development prospects.

2. The panel data model and analysis method

2.1 Panel data

Panel data, also known as parallel data, has two-dimensionality of cross-sectional data and time series data. Panel data refers to the sample data in which multiple cross sections taken from time series and sample values combined from multiple sections [4]. Panel data can solve problems that cannot be solved by simple time series, and the panel data model considers both cross-sectional data and time...
series for more relevant variables. Compared with the commonly used methods of time series model, BP neural network analysis and other methods, the model is possible to simulate the closer to the real value and better predictive analysis [5].

2.2 Panel data analysis method
The general form of panel model is \( y_{it} = \alpha_i + \sum b_{kt}x_{it} + u_{it} \), \( x \) for explanatory variables, the parameter \( \alpha \) represents the intercept term of the model, and \( k \) is the number of explanatory variables, \( t = 1,2,3,4 \ldots \), \( i = 1,2,3,4 \ldots n \).

The fixed effect model can be expressed as \( y_{it} = \alpha_i + \sum b_{kt}x_{it} + u_{it} \), \( t = 1,2,3 \ldots , i = 1,2,3,4 \ldots n \) There are individual effects in the fixed effect model that do not take into account structural changes. Intercept terms \( (i = 1,2, \ldots ) \) \( \alpha_i \) can represent different individual influences. That is, in the sub-equation, the intercept term of each equation is different [6]. The intercept term, although not observable, is related to the changes of observable explanatory variables. Panel data analysis method steps: panel data can be fixed effect and random effect estimation method, that is, if the fixed effect model is selected, the least squares method of dummy variable is used for estimation; if the random effect model is selected, the feasible generalized least square method is used for estimation [7].

Panel data model unit root test:
If the established panel data model is stable, regression analysis, Huasman test and F test are performed by Eviews software; if the panel root unit root test is not stable, it needs to be transformed into a sequence of the same order through sequence difference [8].

3. Panel data independent variables and model selection
Although rare earths account for a small proportion of the total national economy, rare earths are an indispensable resource in traditional industrial production and today's high-end manufacturing, so rare earths play an important role in national economic production. The global rare earth consumption is affected by many factors, and the analysis of rare earth demand factors is the premise of rare earth prediction.

The main influencing factors are as follows:
- GDP reflects a country's economic strength and level of economic development, and national GDP has a direct impact on domestic rare earth consumption. Rare earth production (OU), rare earth imports (IM), and rare earth prices (PR) all have important impacts on rare earth consumption (CO). This paper temporarily selects the fixed effect model to predict and analyze the global rare earth demand, and then through data processing to verify whether the established model is reasonable. “Econometric Analysis” by William H. Greene and Damodor N. Gujarati & Dawn C. Porter’s "Basic Econometrics" consumption function econometrics promotes the unification of theoretical quantitative methods and empirical quantitative methods, It is the combination of statistics, economic theory and mathematics and mainly considers the application of mathematical statistics and statistical inference tools in the empirical relationship explained by economic theory [9].

Imitation Quantity = \( \beta_1 \cdot price \times \beta_2 + income \times \beta_3 + \varepsilon \) build a model.

Imitation build: \( CO_i = \alpha_i + \beta_1IM_{i,t} + \beta_2OU_{i,t} + \beta_3price_{i,t} + \mu_{i,t} \), the intercept term in the model is \( \alpha^*_i = \alpha_i + \alpha \cdot i = 1,2,3 \ldots n \cdot t = 1,2,3 \ldots T \). It is assumed that random error terms \( \mu_{i,t} \) are independent of each other while satisfying a mean of 0.

4. International supply and demand forecast.
In this paper, Eviews6.0 was used to conduct fixed effect regression analysis on rare earth data. Cross-section weights were selected as weights item in the regression to avoid cross-section heteroscedasticity caused by unbalanced regional development. ZG stands for China, MG stands for the US, RB stands for Japan, and QT stands for other countries. The results of the fixed effect model regression are shown in Table 1.
Table 1. Eviews6.0 Input data

|       | Consumption (CO?) | GDP? | Import (IM?) | Output (OU?) | Price (PR?) |
|-------|-------------------|------|--------------|--------------|-------------|
| ZG-2008 | 69680             | 46000| 3041         | 120000       | 8.45        |
| ZG-2009 | 73000             | 50700| 3894         | 129000       | 9.28        |
| ZG-2010 | 87025             | 58900| 4013         | 130000       | 9.33        |
| ZG-2011 | 83110             | 69900| 1479         | 105000       | 45.18       |
| ZG-2012 | 64797             | 82300| 1381         | 100000       | 33.96       |
| ZG-2013 | 78200             | 83000| 1100         | 115000       | 43.15       |
| MG-2008 | 7410              | 143300| 21188       | 0            | 8.45        |
| MG-2009 | 7000              | 143300| 16605       | 0            | 9.28        |
| MG-2010 | 8000              | 146700| 17559       | 0            | 9.33        |
| MG-2011 | 7000              | 150600| 12702       | 0            | 45.18       |
| MG-2012 | 6000              | 156800| 10201       | 8000         | 33.96       |
| MG-2013 | 7000              | 158300| 10000       | 40000        | 43.15       |
| RB-2008 | 34700             | 48400| 34317        | 0            | 8.45        |
| RB-2009 | 29970             | 49000| 18262        | 0            | 9.28        |
| RB-2010 | 33030             | 54700| 28564        | 0            | 9.33        |
| RB-2011 | 23280             | 58600| 22505        | 0            | 45.18       |
| RB-2012 | 22075             | 59600| 13829        | 0            | 33.96       |
| RB-2013 | 23000             | 53000| 10000        | 0            | 43.15       |
| QT-2008 | 1800              | 342000| 25874       | 3730         | 8.45        |
| QT-2009 | 1800              | 357000| 18360       | 3600         | 9.28        |
| QT-2010 | 2000              | 359300| 22247       | 3380         | 9.33        |
| QT-2011 | 1010              | 420900| 15842       | 5530         | 45.18       |
| QT-2012 | 700               | 428000| 12771       | 6750         | 33.96       |
| QT-2013 | 600               | 445700| 9800        | 6550         | 43.15       |

Dependent Variable: CO?

Method: Pooled EGLS (Cross-section weights)
Date: 05/26/15   Time: 23:44
Sample: 2008 2013
Included observations: 6
Cross-sections included: 4
Total pool (balanced) observations: 24
Linear estimation after one-step weighting matrix

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 18598.23    | 4478.074   | 4.153176    | 0.0007|
| GDP?     | 0.033054    | 0.018978   | 1.741738    | 0.1007|
| IM?      | 0.239662    | 0.109850   | 2.181713    | 0.0444|
| OU?      | 0.055037    | 0.046023   | 1.195850    | 0.2492|
| PR?      | -47.56815   | 38.65026   | 1.230733    | 0.2362|

Fixed Effects (Cross)

_ZG–C 49394.27
_MG–C -19264.01
According to the F test and the hausman test selected by the fixed effect model, the corresponding P value is 0.0000, and the null hypothesis is rejected at the significance level of 1%, so the fixed effect model is adopted.

It can be seen from the above figure that the fitting degree of the model is relatively high, with the adjusted R2 reaching 98%, the value of the F statistic is 144.6949, and the corresponding P value is 0.0000; the t statistic scale indicates that all variables of the model established at the 10% level basically passed the test.

\[ C_{it} = \alpha_i + 0.033GDP_{it} + 0.240IM_{it} + 0.055OU_{it} + 47.568PR_{it} + 18598.23 \]

The intercept term \( \alpha_i \) is as shown in Table 2.

| ZG--C | MG--C | RB--C | QT--C |
|-------|-------|-------|-------|
| 49394.27 | -19264.01 | 3388.681 | -33518.93 |

Table 3. Actual and predicted values of rare earth demand in 2008-2013

| Rare earth demand (tons) | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   |
|-------------------------|--------|--------|--------|--------|--------|--------|
| Actual value            | 113590 | 111770 | 130055 | 114400 | 93572  | 108800 |
| Panel data predictor    | 107375 | 118640 | 146530 | 122784 | 82985  | 108078 |
| Panel data predictor    | 0.05   | 0.06   | 0.12   | 0.07   | 0.11   | 0.02   |

It can be seen from the model that global rare earth consumption is positively correlated with GDP of each country, rare earth production, and rare earth imports in various countries, but negatively correlated with rare earth prices, which means that global rare earth consumption as the growth of the GDP. The increase in output, the increase in rare earth imports promotes the consumption of rare earths in the country, which in turn increases the global consumption. As the price of rare earths increases, the demand for rare earths will decrease, which is consistent with the law of price changes in Chapter 3. According to the model, the coefficient of GDP is 0.033, that is, for every 100 billion US dollars of GDP increase, the consumption of rare earth will increase by 33 tons, while every 1 increase in price will lead to an increase of 47.568 tons of rare earth consumption. From Table 4-4, the simulation effect of the model is OK. The absolute
percentage error is kept within 0.15. Due to the relatively difficult data acquisition and time relationship, at the same time, the Chinese government has cancelled the rare earth tariff at the beginning of 2015 and handed the rare earth supply and demand to the market. This has led to a more confusing supply and demand situation of rare earths. The paper analyzes relevant data from 2008 to 2013 and provides basic reference significance.

5. China’s rare earth consumption forecast based on panel data model
Using the panel data analysis method, the US, Japan and other rare earth consumptions are used as explanatory variables to establish a model to analyze and predict the consumption of rare earths in China. The data processing is shown in Table 4:

Table 4. Eviews6.0 sorting up the consumption of rare earths in various countries

| Year | CO_MG | CO_QT | CO_PR | CO_ZG |
|------|-------|-------|-------|-------|
| 2008 | 7410  | 1800  | 34700 | 69680 |
| 2009 | 7000  | 1800  | 29970 | 73000 |
| 2010 | 8000  | 2000  | 33030 | 87025 |
| 2011 | 7000  | 1010  | 23280 | 83110 |
| 2012 | 6000  | 700   | 22075 | 64797 |
| 2013 | 7000  | 600   | 23000 | 78200 |

Figure 1. Global rare earth consumption (tonnes)

| Year | CO_MG | CO_QT | CO_PR | CO_RB | CO_ZG |
|------|-------|-------|-------|-------|-------|
| 2008 | 3763.720 | 7434.437 | 0.506255 | 0.6630 |
| 2009 | 10.57124 | 2.433249 | 4.344495 | 0.0491 |
| 2010 | 18.16426 | 1.178281 | 15.41590 | 0.0042 |
| 2011 | 2.533710 | 0.279229 | -9.073939 | 0.0119 |
The world market is a whole. As can be seen from Figure 2, China's rare earth consumption accelerated significantly in 2009, reaching a peak in 2010, and then the consumption of rare earth began to decline, and from 2011 to 2012, rare earth consumption plunging, and then the rare earth Consumption is picking up. At the same time, as shown in Figure 1, the trend of Japan's rare earth consumption curve as the second largest consumer of rare earths is similar to that of China. The consumption of rare earths peaked in 2010 and then declined, and began to rise slowly. According to the model results, China's rare earth consumption is positively correlated with the United States and others, while negatively correlated with Japan's rare earth consumption. For every additional ton of Japanese rare earth consumption, China's rare earth consumption will fall by 2.5 tons. Therefore, it can be known that the increase of rare earth consumption in Japan will have a large inhibitory effect on China's rare earth consumption, and it is known that Japan and the United States have a great influence on China's rare earth consumption.

| obs | Actual | Fitted | Residual |
|-----|--------|--------|----------|
| 2008 | 69680.0 | 69469.4 | 210.596 |
| 2009 | 73000.0 | 74006.5 | -1006.500 |
| 2010 | 87025.0 | 86531.9 | 493.139 |
| 2011 | 83110.0 | 82605.7 | 504.258 |
| 2012 | 64797.0 | 64217.5 | 579.483 |
| 2013 | 78200.0 | 78981.0 | -780.973 |

Figure 2. curve fitted by computer
6. The time and space law of the international rare earth market

The 2008 financial crisis has had a violent impact on the global economy, making the demand for rare earths sluggish. Although the global macro-environment market has gradually improved since 2010, the global economic situation has shown a downturn and began to decline in 2012, especially, countries like Japan, the United States, Europe and other countries that consume more rare earth, their national economic growth rate was less than 2%, which seriously affected the demand for rare earth. The soaring price of rare earths in 2011 is another important factor restricting the sales of international rare earths. As the price of rare earths is far beyond the bottom line of the cost of users, many rare earth users actively seek alternatives or suspend project operations. Based on the above double strikes, the international rare earth consumption in 2012 fell below 100,000 tons of REO. Although the total international consumption of rare earths has declined from 2008 to 2013, the global proportion of China's rare earth consumption still increased by nearly 10 percentage points [10].

7. Conclusion

Through the use of panel data analysis method for international rare earth prediction analysis, it is found that from the spatial analysis, the international rare earth demand is positively correlated with national GDP, rare earth output and rare earth import, while negatively correlated with the price of rare earth. The demand for rare earth decreases with the rise of the market price of rare earth. From the time analysis, the international rare earth consumption has shown a downward trend. Through the panel data analysis method, using the rare earth demand of the United States, Japan and other countries to predict China's rare earth demand, from the spatial analysis, China's rare earth consumption is positively correlated with the United States and other countries, but negatively correlated with Japan's rare earth consumption. For every additional ton of Japanese rare earth consumption, China's rare earth consumption will be reduced by 2.533 tons. Therefore, it can be known that the increase of rare earth consumption in Japan will have a large inhibitory effect on China's rare earth consumption, and the result shows that Japan and the United States have a greater impact on China's rare earth consumption. From the analysis of time, the proportion of China's rare earth consumption in the world is increasing, and the consumption of rare earths gradually showed an upward trend.

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