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Dynamic mechanism of non-ferrous metal processing industry transfer in Qinghai province based on production function

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Abstract. Non-ferrous processing industry is related to all aspects of residents' life and has a prominent industrial position in Qinghai Province. The driving force of industry transfer is closely related to the production function of enterprises. The OP method established by Olley and Pakes, the LP method established by Levinsohn and Petrin have guiding significance for the estimation of the production function of enterprises. In this paper, OP method and LP method are used to estimate the production function of the non-ferrous metal processing industry in Qinghai province based on the statistical data of industrial economy over the years, calculate the total factor productivity of the industry, and summarize the transfer power mechanism of the non-ferrous metal processing industry in Qinghai province.

Keywords: Non-ferrous metal processing industry; Industry transfer; Dynamic mechanism; Production function.

1. Introduction

Non-ferrous metals smelting and calendaring industry is an important industry in China, which is related to all aspects of residents' lives. Moreover, non-ferrous metals smelting and calendaring industry plays an important role in the regional economy of Qinghai Province and has a prominent industrial status. Research on the total factor productivity of non-ferrous metals smelting and calendaring industry can help to analyze and solve the problems encountered in non-ferrous metals smelting and calendaring industry in China. Next, this paper will estimate the production function of China's non-ferrous metals smelting and calendaring industry based on the industrial economic statistics over the years, calculate the total factor productivity of the industry, and analyze the realistic development of Qinghai's non-ferrous metals smelting and calendaring industry.

2. Fitting and model establishment of enterprise production function

Total factor productivity comes from the promotion of industrial output by factors such as technological progress and policy system optimization. The most common understanding of total factor productivity is that the part of economic growth in economic production activities that cannot be explained by factors such as labor and capital, that is, the "residual value" in economic growth accounting. That is to say, total factor productivity is the part of total output that cannot be explained by all input factors. Based on this understanding, the estimation of total factor productivity should be based on the production function, and the production function of industrial enterprises in the economic system should be fitted.

Since we need to fit the production function, we need to set up a form of production function, and then use statistical principles and methods and statistical tools to calculate the specific expression of the function. The most widely used form of production function is Cobb Douglas production function, which is as follows:

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} \tag{1}$$

Among them, Yit represents the industrial output value, Ait is the total factor productivity brought by factors such as technological progress and policy system optimization, Kit and Lit respectively represent capital factor and labor factor input, α and β are the elastic coefficients of capital and labor factors for output, respectively.

The logarithm of both sides of formula (1) can be changed as follows:

$$y_{it} = \alpha l_{it} + \beta k_{it} + u_{it} \tag{2}$$

Where y_{it}、l_{it}、k_{it} are the logarithmic forms of Y_{it}, K_{it}, L_{it}, respectively, and u_{it} is the logarithmic form of total factor productivity.If the coefficients in equation (2) can be estimated, the corresponding total factor productivity can also be calculated.However, if the parameter estimation of the above formula is simply carried out using linear regression, the technical deviation due to correlation bias and selectivity bias in production activities will not be eliminated, and the influence of correlation bias is particularly prominent.And in the actual production process, in order to achieve optimal production, the enterprise will make decisions based on the market information it observes, and make certain adjustments to the input of production factors.If the error term of the linear regression is directly used as the total factor productivity, then some of them will affect the input of the production factor, that is, the residual term is related to the regression term, then the coefficients of the regression results will be erroneous. In order to eliminate such errors as far as possible, the residual items can be divided into two parts:

$$u_{it} = f_{it} + w_{it} \tag{3}$$

Where f_{it} is the part of the original residual that is observable by the manufacturer and related to the factor input, and w_{it} is a pure residual term, including the unobservable productivity impact and measurement error of the researcher. Formula (2), the deformation is:

$$y_{it} = \alpha l_{it} + \beta k_{it} + f_{it} + w_{it} \tag{4}$$

The so-called selective bias refers to whether the production enterprises in the industry continue to produce or withdraw from the market is related to the impact of productivity. While when the enterprises with large capital stock face the impact of productivity on the ground, the probability of choosing to stay in the market and continue their production activities is higher than that of enterprises with small capital stock, which is due to their stronger ability to anticipate future earnings. That is to say, when enterprises are faced with choices, the probability of remaining in the market to continue production activities is positively correlated with their capital stock. In the process of estimation, the coefficient of capital item is easy to be underestimated, while the coefficient of labor item is easy to be overestimated.

In response to the above two errors, Olley and Pakes proposed a semi-parametric estimation method in 1996, which was later called OP method. They assumed that firms decide the scale of investment according to the specific size of productivity, and used current investment as the indicator variable of productivity shocks to eliminate the correlation bias. The concrete realization is accomplished in two steps:

The first step is to establish the equation of the relationship between capital stock and investment scale

$$K_{it+1} = (1-\delta)K_{it} + I_{it} \tag{5}$$

Where K_{it} denotes the capital stock of enterprises in period t, I_{it} denotes the investment scale of enterprises in period t, δ denotes capital depreciation, and K_{it+1} is the capital stock of enterprises in period t+1.

The investment scale is positively correlated with productivity shocks and has a relationship with capital stock. Therefore, investment scale is a function of productivity shocks and capital stock, and it's a monotonic incremental function about productivity shocks.

$$I_{it} = I(f_{it}, k_{it}) \tag{6}$$

Then productivity shocks can be written as an inverse function of investment scale

$$f_{it} = g(i_{it}, k_{it}) \tag{7}$$

Furthermore, we can get the following equation

$$y_{it} = \alpha l_{it} + \beta k_{it} + g(i_{it}, k_{it}) + w_{it} \tag{8}$$

We can rewrite equation (8) as

$$\phi_{it} = \beta k_{it} + g(i_{it}, k_{it}) \tag{9}$$

Therefore, the production function can be divided into two parts, the labor contribution part and the capital contribution part.

$$y_{it} = \alpha l_{it} + \phi_{it} + w_{it} \tag{10}$$

The elasticity coefficient of labor force in the above equation (10) can be estimated.

The second step is to estimate the coefficients of investment scale and capital stock by using the estimated coefficients.

$$y_{it} - \hat{\alpha} l_{it} = \beta k_{it} + g(i_{it}, k_{it}) + w_{it} \tag{11}$$

At the same time, in order to eliminate selectivity bias, Olley and Pakes used survival probability to characterize the process of enterprise's birth and death, and set the criteria for enterprises to decide whether to withdraw from the market or continue to produce, used Bellman equation to control, and combine the decision-making mechanism with formula (11), and then estimated the capital factor unbiased.

OP method can eliminate correlation and selectivity errors and estimate production function under a series of assumptions. Among them, the scale of investment is used as a characterization variable, and the relationship between investment scale and productivity shocks is monotonous. However, if some investment amount is zero, which makes the assumption unsatisfactory, this part of the data will be excluded. In addition, because of the cost of investment adjustment, it can not be used as a complete reflection of productivity changes. Based on this defect, Levinsohn and Petrin improved OP in 2003, using intermediate investment rather than investment scale as the characterization variable of productivity. The intermediate input is basically not zero, which can greatly improve the efficiency of data use. The adjustment cost of intermediate input is relatively low. It can reflect the impact of productivity more quickly, and the change of intermediate input can more effectively reflect the impact of productivity.

The LP method sets the following production functions

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + w_{it} + \eta_{it} \tag{12}$$

Where m_{it} denotes the intermediate input in period t, w_{it} the productivity shocks, η_{it} the error term. And the intermediate input is related to capital stock and productivity shocks.

$$m_{it} = m(k_{it}, w_{it}) \tag{13}$$

The LP method assumes that the intermediate inputs increase monotonously with respect to productivity, and that there exists an inverse function in the upper formula, which can be expressed as

$$w_{it} = w(k_{it}, m_{it}) \tag{14}$$

Thus, productivity is expressed as a function of capital stock and intermediate input, then formula (12) can be expressed as

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + w(k_{it}, m_{it}) + \eta_{it} \tag{15}$$

We can rewrite equation (15) as

$$v_{it} = \beta_0 + \beta_k k_{it} + \beta_m m_{it} + w(k_{it}, m_{it}) \tag{16}$$

Then formula (15) can be written as

$$y_{it} = \beta_l l_{it} + \upsilon_{it} + \eta_{it} \tag{17}$$

LP method also needs two steps to complete parameter estimation:
The first step is to construct a third-order polynomial of capital stock and intermediate input, which is used to substituted the v_{it} in the formula (17).

$$y_{it} = \delta_0 + \beta_l l_{it} + \sum_{h=0}^{3}\sum_{j=0}^{3-h} \delta_{ij} k_{it}^h m_{it}^j + \eta_{it} \tag{18}$$

We can get estimation coefficients of v_{it} by using the ordinary least squares method to estimate the parameters of formula (18),

$$\hat{v}_{it} = \hat{y}_{it} - \hat{\beta}_l l_{it} = \hat{\delta}_0 + \sum_{h=0}^{3}\sum_{j=0}^{3-h} \delta_{ij} k_{it}^h m_{it}^j \tag{19}$$

The second step is to estimate the coefficient of capital stock and intermediate input. Using $\hat{v}_{it}$ and capital stocks and intermediate inputs, we can structure the follow equation to estimate the w_{it}.

$$\hat{w}_{it} = \hat{v}_{it} - \beta_k^{\ *} k_{it} - \beta_m^{\ *} m_{it} \tag{20}$$

Using the estimated value obtained by formula (20), and considering that the change of productivity is a first-order Markov process, the equation is constructed to calculate the estimated value of the expected value, namely $\hat{E}[w_{it} | \hat{w}_{it-1}]$.

$$\hat{w}_{it} = \gamma_0 + \gamma_1 w_{it-1} + \gamma_2 w_{it-1}^2 + \gamma_3 w_{it-1}^3 + \varepsilon_{it} \tag{21}$$

The residuals of formula (21) are recorded as $\hat{\eta}_{it} + \hat{\xi}_{it}$, we can get the follow equation

$$\hat{\eta}_{it} + \hat{\xi}_{it} = y_{it} - \hat{\beta}_l l_{it} - \beta_k^{\ *} k_{it} - \beta_m^{\ *} m_{it} - \hat{E}[w_{it} | \hat{w}_{it-1}] \tag{22}$$

Given this definition of Z, $Z_{it} \equiv (k_{it}, m_{it-1}, l_{it-1}, m_{it-2}, k_{it-1})$ .The coefficients of capital stock and intermediate input are estimated by solving the following optimization problems:

$$\min_{(\beta_k^*, \beta_m^*)} \sum_h \left\{ \sum_t \left(\hat{\eta}_{it} + \hat{\xi}_{it} \right) Z_{hit} \right\}^2 \tag{23}$$

3. Data samples and empirical research

This part of the empirical data comes from the database of China's industrial enterprises from 2001 to 2017, as well as the relevant statistical data of the National Bureau of Statistics. Relatively comprehensive statistics of China's manufacturing industry are made in the database of China's industrial enterprises, Considering the integrity requirements of data and the empirical needs of this paper, relevant statistics from 2001 to 2017 are selected in the database of China's industrial enterprises. At the same time, through the data of the National Bureau of Statistics to query the price index within the corresponding time, and use the price index to convert production output, fixed capital and intermediate input. The steps for processing the data are as follows:

Step1: Delete data items in which statistical incomplete data, such as production value, fixed assets, intermediate input and the number of employees missing in the statistics;

Step2: Excluding data items in which production value, fixed assets, intermediate inputs, and the number of employees is zero;

Step3: Logical processing, excluding data items with employee number less than 8, excluding data items in the state of suspension, preparation and revocation of business in that year;

Step4: Adjust some industry classifications according to current industry classification criteria;

Step5: Based on 2001, the factory price of industrial products used for production value was converted to 2001 price index, the investment price of fixed assets used for fixed assets was converted to 2001 price index, and the purchase price of intermediate input fuel and power industry was converted to 2001 factory price index.

In this paper, the LP method is used to estimate the corresponding coefficients of the production function of non-ferrous metals smelting and calendaring industry. The main variable statistics are described as follows:

Table 1. Statistical Description Information of Major Variables

variable	Variable name	Mean	Std.Error	Min.	Max.
Gross output Value	lny	10.27867	1.439472	0.6926473	16.67936
Labor Force	lnl	4.578579	1.230028	2.197225	10.45579
Intermediate Input	lnm	9.919096	1.496	-0.4592586	16.29326
Capital Level	lnk	8.415795	1.978065	-0.001998	16.25994

The precondition for estimating total factor productivity is the estimation of the production function. The following tables are used for estimating the coefficients of the production function:

Table 2. Coefficient Estimation of Production Function

VARIABLES	lny
lnl	0.229***
	(0.0135)
lnk	0.437***
	(0.0395)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The total factor productivity of non-ferrous metals smelting and calendaring industry in some provinces of China from 2001 to 2007 is estimated as follows:

Table 3. Total Factor Productivity Estimation in Some Provinces

Province	2001	2004	2007	2010	2013	2016
Jiangsu	1.24	1.28	1.30	1.32	1.34	1.24
Zhejiang	1.27	1.28	1.30	1.32	1.33	1.23
Henan	1.25	1.20	1.27	1.32	1.34	1.17
Shandong	1.21	1.21	1.24	1.25	1.29	1.15
Ningxia	1.02	1.15	1.17	1.11	1.06	0.83
Gansu	1.09	1.16	1.07	1.18	1.24	1.00
Neimenggu	1.04	1.09	1.14	1.18	1.19	0.96
Qinghai	1.00	1.01	1.07	1.11	1.08	1.01

The total factor productivity in the table above is standardized by referring to the total factor productivity in Qinghai Province in 2001.

4. Conclusion

The following conclusions can be drawn from the table above:

From 2001 to 2017, the total factor productivity of non-ferrous metals smelting and calendaring industry in Qinghai Province was not in the leading position in the whole country, This was because the non-ferrous metals smelting and calendaring industry in Qinghai Province was mainly concentrated in the production of basic products., such as electrolytic aluminum, with low added value. While calendaring of non-ferrous metals with high added value, such as aluminum were mainly developed in Jiangsu and Zhejiang areas, so the total factor productivity is higher.

It is in recognition of the above facts that, in the course of its subsequent development, Qinghai Province should accelerate the development of non-ferrous metal calendaring industry, promote the transformation of non-ferrous metal smelting and calendaring industry from producing primary products such as electrolytic aluminum to producing new alloy materials, and transform the growth mode of non-ferrous metal industry with emphasis on structural adjustment, according to the foundation and advantages of non-ferrous metal smelting industry, and in accordance with the requirements of relevant national industrial policies. Through the adjustment of industrial structure and the introduction of advanced technology, the target total factor productivity of non-ferrous metals smelting and calendaring industry in Qinghai Province will be improved, the actual total factor productivity of the industry in Qinghai Province will be promoted, more production factors will be attracted, and the spatial allocation of factor resources will be realized.

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