

The Research on Total Factor Productivity of Soybean in China

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ABSTRACT

This paper uses the panel stochastic frontier model to study the total factor productivity of Chinese soybean. The research shows that the impact of direct cost and labor cost on yield is positive and significant, the impact of indirect cost on yield is not significant, and the impact of cash cost on yield improvement is negative.

1. Literature Review

In terms of agricultural total factor productivity, the main methods to study the growth rate of total factor productivity are so low residual method, envelope analysis and stochastic frontier method. There are many literature applying these three methods to agriculture. Fu Xiao-xia and Wu Li-xue^[1] reviewed the development of stochastic frontier production function model and its application in China's productivity analysis; Zhang Yong-xia^[2] used the index method to calculate the growth rate of China's agricultural total factor productivity and the growth rate of provincial agricultural total factor productivity, and analyzed the growth factors of agricultural total factor productivity by using panel data model and production function method; Zhang Le, Cao Jing^[3] introduced the change of allocation efficiency into the stochastic frontier production function as a variable to measure China's agricultural total factor productivity from 1991 to 2010; Zhu Xuehong, Zeng Yi, Feng Chao^[4] analyzed China's total factor productivity (TFP) from

the national, regional and provincial levels by using the framework of "environmental technology" in combination with the directional distance function and the three-level production frontier function. The research shows that China's TFP is at a low level, and the gap between regions and industries is obvious; Hao Xiao-yan, Zhang Yi, Han Yi-jun^[5] used time-varying decay SFA model and double threshold model to test the impact of China's import and export trade of agricultural products on agricultural total factor productivity; Gong Bin-lei^[6] integrated five productivity analysis models by using the knife cutting model average method to obtain a more comprehensive and accurate productivity estimation method, and analyzed the internal structure of China's agricultural growth from 1990 to 2015; Yang Qian, Wang Yu, Li Chao and Liu Xinpeng^[7] believed that the progress of China's agriculture can't be completely measured only by agricultural total factor productivity, and the impact on the environment should also be considered. Through the research on agricultural green total factor productivity,

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this paper empirically analyzed the driving factors of lawyer TFP differentiation. In this paper, the stochastic frontier method is used for analysis.

2. Theoretical Models and Data Sources

(1) Theoretical model

The panel stochastic frontier model is used to study the total factor productivity of soybean:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^k \beta_k \ln x_{kit} + v_{it} - u_i \quad u_i \geq 0 \quad (1)$$

Where, $u_i \geq 0$ is the invalid rate item, v_i refers to the specific error. According to whether the invalidity item u_i changes over time, the panel random frontier model is divided into the following two categories:

(2) Technical efficiency don't change with time

Then equation (1.1) can be transformed into:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^k \beta_k \ln x_{kit} + v_{it} - u_i \quad u_i \geq 0 \quad (2)$$

If u_i is related to x_i , it is a fixed effect model, and the equation is as follows:

$$\ln y_{it} = \beta_{0i} + \sum_{k=1}^k \beta_k \ln x_{kit} + v_{it} \quad (3)$$

Here, $\beta_{0i} \equiv \beta_0 - u_i$ is the unique intercept item of enterprise i.

If u_i is not related to x_i , it is a random effect model, which can be estimated according to Equation (2).

(3) Technical efficiency changes over time

Due to the rapid development of science and technology in recent years and the obvious progress of science and technology in soybean production, the invalid rate terms in different regions and at different times are constantly changing. The formula is as follows:

$$u_{it} = e^{-\eta(t-T_i)} u_i$$

Where, T_i is the time dimension of enterprise i, η is the parameter to be estimated, and $u_i \sim N^+(\mu, \sigma_u^2)$. Equation (4) becomes a time-varying attenuation model. The above three cases basically cover all cases of SFA, and stata14 is used for estimation below. The data comes from the cost-benefit statistical yearbook of China's agricultural products(2005-2018).

3. Empirical Research

Since the input factors in the actual soybean production include manpower, chemical fertilizer, pesticide, machinery, technology, etc., for convenience of explanation and limited to the availability of statistical data, the data used in this paper comes from the cost-benefit statistical yearbook of China's agricultural products over the years, and the relevant input items are also subject to the statistical data, The items of these statistics may be omitted or can't be obtained, but the items that have been obtained have covered the main

influencing factors of soybean production. Therefore Equation (2) can be rewritten as:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^k \beta_k \ln x_{kit} + v_{it} - u_i$$

Here t refers to the time span from 2005 to 2018; i refers to various provinces, including 1 Hebei, 2 Shanxi, 3 Inner Mongolia, 4 Liaoning, 5 Jilin, 6 Heilongjiang, 7 Anhui, 8 Shandong, 9 Henan, 10 Chongqing and 11 Sanxi. K refers to each sub cost breakdown item. This refers to the gross output value. The impact of inflation isn't taken into account here.

$$\ln y_{it} = \beta_0 + \beta_1 \ln x_{1it} + \beta_2 \ln x_{2it} + \beta_3 \ln x_{3it} + \beta_4 \ln x_{4it} + \beta_5 \ln x_{5it} + v_{it} + u_i \quad (4)$$

Here k represents the input cost, where 1 represents direct cost, 2 represents indirect cost, 3 represents labor cost, 4 represents land cost and 5 represents cash cost. The unit here is 50 kg, not mu, that is, the relationship between soybean output per 50kg and relevant input cost is studied here, and the corresponding data is obtained by conversion.

Table 1. Statistics of Regression Results by Different Methods

	Fixed effect model	Random effect model	Time varying attenuation model of random effects
β_1	0.7361 (0.2184)	0.6176 (0.1333)	0.2617 (0.0866)
β_2	-0.0266 (0.085)	0.002979 (0.01797)	0.0292 (0.01014)
β_3	0.06204 (0.03274)	0.1303 (0.02322)	0.0699 (0.01623)
β_4	0.1793 (0.05124)	0.1951 (0.03721)	0.0456 (0.029)
β_5	-0.5782 0.1829	-0.6457 (0.12669)	-0.4026 (0.08562)
β_0	3.8751 (0.2777)	4.3787 (0.2241)	5.5544 (0.17494)
η	/	/	0.5535

As can be seen from the above Table 1, the coefficients estimated by various methods are partially significant. And the time span is 14 years, and η is 0.5535, indicating that the technical efficiency changes with time. From the above estimate, we can see the coefficient of direct cost β_1 , the impact on yield is positive and significant. Direct costs mainly include seed costs, the use of various fertilizers and the use of machinery. Obviously, the increase of these direct costs has a positive effect on the improvement of yield, which is in line with basic common sense. Coefficient of overhead β_2 , the estimates are not significant and the symbols are different. Indirect costs mainly include depreciation and financial costs. These

costs basically change little every year. The continuous increase of indirect costs will not have a great impact on the output. Coefficient of labor cost β_3 is significant. It is obvious that the strength is not so large, because the improvement of technology has replaced labor to a certain extent. Coefficient of cash cost β_5 , the impact on the increase of output is negative, and the greater capital cost does not result in the increase of output. Through the above analysis, we can know that the technical efficiency of soybean in China has been improved in recent years, but the speed of improvement is different due to different regions. Because the northeast is a plain area, which is suitable for the development of large-scale machinery, the technical efficiency is a little higher, while Chongqing is in mountainous areas, which is not suitable for large-scale mechanization, so the technical efficiency is not easy to improve.

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