The Influence Degree of Minimum Purchase Price Policy on Grain Production Efficiency

Zheng Yao1, *, Pu Xuan2
1College of Science, China Jiliang University, Hangzhou Zhejiang, 310018, China
2College of Mechanical and Electronic Engineering, Northwest A&F University, Yangling, Shaanxi, China, 712100, China

*Corresponding author e-mail: 1345817359@qq.com

Abstract. China has made a major controversy since the beginning of the implementation of the minimum purchase price policy in the main grain producing areas in China in 2005. In order to evaluate the effect of the implementation of the minimum purchase price policy, this paper chooses the population of agricultural industry, agricultural production capacity, the lowest purchase price and the fertilizer input, these four indicators as the input and the planting area, the per capita income of farmers and grain yield per mu, these three indexes as the output to establish the data envelopment analysis based on the Manquist index evaluation model, and the model operation and analysis are carried out in Anhui, Hubei and Jiangsu province.

1. Introduction

Food is not only the necessary of daily life, but also the maintenance of national economic development and political stability of the strategic material and food security issues have become a worldwide strategic issue. In order to promote grain production, increase farmers’ income and avoid the sharp fluctuation of grain prices, China has started to implement the minimum purchase price policy in the main grain producing areas since 2005 and raised the minimum purchase price for many years.

In the case of grain varieties and regional differences, we use data from the main grain producing areas, apply linear programming based on EDA and input-output-oriented Manquist productivity index to evaluate the changes in China’s Grain Productivity Index in the main grain producing areas to measure the impact of the minimum purchase price policy on food production efficiency before and after the implementation of the minimum purchase price policy.

2. The establishment of evaluation model

Using the Panel Data of the main grain producing areas and applying the DEA-based linear programming and input-output-oriented Manquist productivity index to measure the changes of China's grain productivity index after 2005, and explore the extent of the minimum purchase price policy to food production efficiency.

Based on the DEA-Malmquist index method, the multi-input and multi-output data sets can be processed well. This method can not only analyze the efficiency evolution of decision-making units in different periods, but also decompose the Malmquist index into technical progress index and technical efficiency change index. The technical efficiency represents the distance between the actual output and...
the optimal output (production frontier) under the given input factors. The greater the distance is, the lower the technical efficiency is. Technical efficiency can be also decomposed into pure technical efficiency (mainly reflected in the institutional arrangements, technological innovation and management efficiency changes, etc.) and scale efficiency (mainly in the scale of expansion and other aspects); technological progress that the production of cutting edge along with the movement of time changing. Thus we can understand more detailed information of the impact of the specific factors to industrial technology innovation efficiency.

In this paper, a factor-intensive industry can be seen as a production decision-making unit (DMU), firstly we determine the each year of factor-intensive manufacturing production of the best frontier, and then compare each of the production frontier with the best frontier so that we can measure the technical efficiency and productivity changes of the various factor-intensive manufacturing industries. Finally we derive the Malmquist productivity change index with input as an indicator.

Mainly from the perspective of output to study the total factor productivity changes, assuming that in each period \( t = 1, \ldots, T \), in the area \( k = 1, \ldots, K \), using the quantity \( n = 1, \ldots, N \) of the input \( x_{k,n} \), getting the quantity \( m = 1, \ldots, M \) of the output \( y_{k,m} \). The reference technology for each period in the case of a fixed-scale remuneration and a strong input requirement is defined as:

\[
\left\{ \begin{array}{l}
C, S : 
\sum_{k=1}^{K} \sum_{n=1}^{N} \sum_{m=1}^{M} x_{k,n} 
\leq z M, z N \leq x, z \in R^K, x \in R^K
\end{array} \right.
\]

\( z \) represents the weight of each cross-sectional observation. The nonparametric programming model for calculating the Farrell technical efficiency of each region based on output is:

\[
F^0_t \left( x', y' \mid C, S \right) = \max_{\theta_z} \theta^k
\]

\[
\left\{ \begin{array}{l}
\theta^k y_{k,m} ' \leq \sum_{k=1}^{K} z_{k} y_{k,m}' \\
z_{k} \geq 0
\end{array} \right.
\]

Among them, \( m = 1, \ldots, M \), \( n = 1, \ldots, N \), \( k = 1, \ldots, K \)

In order to derive the Manquist productivity function with the change of productivity over time, we introduce the Distance Function.

According to Fare, the Distance Function is the reciprocal of Farrell’s technical efficiency, which can define the output distance function of reference technique \( L' \left( x \mid C, S \right) \):

\[
D^0_t \left( x', y' \right) = 1 / F^0_t \left( x', y' \mid C, S \right)
\]

The Output Distance Function can be seen as a production point \( (x', y') \) to the ideal maximum output point, which means the ratio of an output and the maximum possible output. If and only if \( D^0_t \left( x', y' \right) = 1 \left( x', y' \right) \), it is on the production boundary, production is technically efficient. If \( D^0_t \left( x', y' \right) > 1 \left( x', y' \right) \), it is in the production boundary, production is technically ineffective. When the time is \( t + 1 \), We can get the distance function \( D^0_t \left( x'^{t+1}, y'^{t+1} \right) \) at this time by substituting \( t \) in the formula as \( t + 1 \).
In the case of $t$-technology $T^t$, the Malmquist index based on the output angle can be expressed as:

$$M_0^t\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = d_0^t\left(x^{t+1}, y^{t+1}\right) / d_0^t\left(x^t, y^t\right)$$

This index measures the technological efficiency changes from $t$ to $t+1$ during the $t$ time technical conditions. Similarly, to the $t+1$ period technology $T^{t+1}$ as a reference, based on the output angle of the Malmquist index can be expressed as:

$$M_0^{t+1}\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = d_0^{t+1}\left(x^{t+1}, y^{t+1}\right) / d_0^t\left(x^t, y^t\right)$$

In order to avoid the possible differences in the arbitrariness of the period selection, the geometric mean of the two Malmquist productivity indexes can be used to measure the change in productivity from $t$ to $t+1$. When the index is greater than 1, it is shown that the total factor productivity is increasing from $t$ to $t+1$:

$$M_0\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \left[\frac{d_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{d_0^t\left(x^t, y^t\right)} \times \frac{d_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{d_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2}$$

Further, the Malmquist index obtained by the above-mentioned treatment can be decomposed into constant scale payout and the technical efficiency change index ($EC$) and technological progress index ($TP$) under the condition of factor free disposal. The decomposition process is as follows:

$$M_0\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \frac{d_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{d_0^t\left(x^t, y^t\right)} \times \left[\frac{d_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{d_0^{t+1}\left(x^t, y^t\right)} \times \frac{d_0^{t+1}(x^t, y^t)}{d_0^t(x^t, y^t)}\right]$$

The $EC$ index measures the degree of succession of each decision-making unit to the probability boundary of production from period $t$ to $t+1$; the $TP$ index measures the movement of the technical boundary periods between $t$ to $t+1$. According to Fare the study, the technical efficiency change index ($EC$) can be further decomposed into pure technical efficiency index ($PC$) and scale efficiency index ($SC$), which are:

$$M_0\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = EC \times TP = PC \times SC \times TP$$

An index being greater than 1 indicates that it is the source of productivity gains. Reversely, an index being lower than 1 indicates it is the root cause of reduced productivity.

### 3. Variable selection and data processing

Significant changes in the area of grain cultivation can effectively reflect the effect of the minimum purchase price policy of grain, but it can not just rely on the index to evaluate the effect of the implementation of the policy. After consulting the relevant information and contacting the actual situation, we have selected the following indicators to measure:

1. Planting area. The change of planting area is more obvious, and reflect steady growth trend shows that the implementation of the policy has a good effect.
(2) Yield per mu. To a certain extent, the greater the yield per mu is, correspondingly, in the case of a certain planting area, the greater the total output is, that is to say, to meet the supply and demand relationship, to ensure that people's food and clothing problems, to protect the national food security. It will be able to reflect the Policy has a positive effect.

(3) Income per capita. Income per capita income is reflected in the social benefits, farmers' income is improved, to meet their own supply needs. It will be able to ensure social stability, but also show the implementation of the policy effect. From the consumer's point of view, the rate of growth of food prices should not be higher than the growth rate of urban resident’s income, otherwise it will increase the consumer's economic pressure and living pressure. This angle can also reflect the indirect effect of policy implementation.

(4) Number of agricultural employees. The better the policy is, the more number of farmers who are willing to cultivate is.

Based on the condition of grain varieties and regional differences, we selected the rice in Hubei and Anhui provinces, wheat in Shandong and Henan provinces respectively, and analyzed the data from the Chinese Statistical Yearbook and the National Agricultural Product Cost Data. The data interval was From 1995 to 2014 (data can be seen in annex), which concludes agricultural industry population, agricultural production capacity, the lowest purchase price and fertilizer inputs as input variables; planting area, income per capita, yield per mu as an output variables, each year as a decision-making unit. The effect of the minimum purchase price of grain in the main grain producing areas was evaluated by comparing the values of the annual output variables with the time span and the vertical comparison of the regional span.

| Food varieties | Regional options |
|----------------|------------------|
| Rice           | Hubei, Anhui     |
| Wheat          | Shandong, Henan  |

| Input variable                  | Output variable    |
|---------------------------------|--------------------|
| Agricultural industry population| Planting area      |
| Agricultural production capacity| Income per capita  |
| The lowest purchase price       | Yield per mu       |
| Fertilizer input                | /                  |

4. The solution and analysis of the model
We use each year as a decision-making unit, at the same time to the agricultural industry population, agricultural production capacity, the lowest purchase price and fertilizer input as input variables; planting area, income per capita, yield per mu as output variables. Anhui rice, for example, as shown in the following table:
Table 3. Each decision unit input and output index value

| Serial number | Making Unit | Planting Area | Yield per mu | Income per capita | Agricultural industry population | Agricultural production capacity | The lowest purchase price | Fertilizer input |
|---------------|-------------|---------------|--------------|------------------|----------------------------------|-------------------------------|-----------------------|----------------|
| 1             | 1995        | 645           | 320.31       | 1302.82          | 2719.36027                       | 1829.51143                   | /                     | 203.3          |
| 2             | 1996        | 666.9         | 242.47       | 1607.72          | 2696.9962                        | 1952.53887                   | /                     | 248.5          |
| 3             | 1997        | 627           | 335.41       | 1808.75          | 2664.34338                       | 2128.24098                   | /                     | 240.6          |
| 4             | 1998        | 595.5         | 324.1        | 1863.06          | 2635.28544                       | 2289.9323                    | /                     | 253.8          |
| 5             | 1999        | 558.6         | 259.58       | 1900.3           | 2605.40489                       | 2481.82836                   | /                     | 255.7          |
| 6             | 2000        | 544.35        | 281.25       | 1934.57          | 2582.15843                       | 2663.04158                   | /                     | 253.2          |
| 7             | 2001        | 466.35        | 315.86       | 2020.04          | 2552.29561                       | 2794.66493                   | /                     | 280.7          |
| 8             | 2002        | 414.15        | 313.9        | 2117.56          | 2517.24434                       | 2934.3574                    | /                     | 270.5          |
| 9             | 2003        | 390.15        | 307.57       | 2127.48          | 2480.55797                       | 3058.79301                   | /                     | 281.3          |
| 10            | 2004        | 433.95        | 332.53       | 2499.33          | 2458.05916                       | 3243.243                     | /                     | 277.6          |
| 11            | 2005        | 440.55        | 347.52       | 2640.96          | 2442.96895                       | 3464.59412                   | 70                    | 285.7          |
| 12            | 2006        | 420.9         | 352.58       | 2969.08          | 2429.45458                       | 3691.9173                    | 70                    | 305            |
| 13            | 2007        | 414.45        | 355.65       | 3556.27          | 2375.47558                       | 3894.5114                    | 70                    | 307.4          |
| 14            | 2008        | 399           | 352.88       | 4202             | 2351.96269                       | 4163.23933                   | 75                    | 312.79         |
| 15            | 2009        | 410.9         | 366.1        | 4504             | 2341.93328                       | 4431.99158                   | 90                    | 319.77         |
| 16            | 2010        | 395.1         | 355.1        | 5285             | 2293.99978                       | 4699.66439                   | 93                    | 329.67         |
| 17            | 2011        | 384.29        | 356.97       | 6300             | 2281.52887                       | 4950.6114                    | 102                   | 333.53         |
| 18            | 2012        | 356.31        | 370.46       | 7161             | 2261.89047                       | 5194.97951                   | 120                   | 338.4          |
| 19            | 2013        | 353.25        | 370.28       | 8098             | 2243.14                          | 5400.03                      | 132                   | 341.39         |
| 20            | 2014        | 338           | 379.5        | 9016             | 2222.93                          | 5613                         | 135                   | 338.69         |

View the effect of policy implementation from the perspective of horizontal
We use DEAP2.1 software to solve, the results are as follows:
(1) View the effect of policy implementation from a vertical perspective with time as a span
We used DEAP2.1 software to calculate the Malmquist productivity index and its decomposition results for total factor productivity of wheat cultivation before the minimum purchase policy was implemented. We integrated the situation in Hubei Province and selected the data from 2007 to 2014.

Table 4. Changes in production efficiency after the implementation of the minimum grain purchase price policy

| Year | TE  | TP  | SE  | PC  | Malmquist index |
|------|-----|-----|-----|-----|-----------------|
| 2007 | 1.009 | 1.031 | 1.009 | 1 | 1.041 |
| 2008 | 1.012 | 1.12 | 1.012 | 1 | 1.134 |
| 2009 | 1.007 | 1.117 | 1.007 | 1 | 1.125 |
| 2010 | 0.996 | 1.09 | 0.996 | 1 | 1.085 |
| 2011 | 1.007 | 1.142 | 1.007 | 1 | 1.149 |
| 2012 | 1.004 | 1.147 | 1.004 | 1 | 1.151 |
| 2013 | 0.999 | 1.116 | 0.999 | 1 | 1.115 |
| 2014 | 0.957 | 1.158 | 0.954 | 1.003 | 1.108 |
| Average | 0.998875 | 1.115125 | 0.9985 | 1.000375 | 1.1135 |
From the table, we can find the wheat production efficiency increased by 11.36% in the implementation of the policy nine years. We further decompose the total factor change into technical efficiency \( TE \) and technological progress \( TP \), and have found their impact on total factor productivity. Technical efficiency refers to the fact that the input-output and the maximum output ratio of an enterprise are a relative concept when the input factor is constant. (The introduction of literature here)

It can be seen, therefore, that China's food production efficiency is mainly dependent on technological and policy changes, the average size efficiency index of 0.99, but has a negative impact. And from the data we can also see that wheat acreage has been decreasing trend.

Similarly, we also selected the data before the implementation of the 1996-1995 data, data envelopment analysis, and after the implementation of the policy comparison, making the following figure:

![Figure 1. Contrast of Production Efficiency before and after Implementation of Minimum Purchase Price](image)

As can be seen from the figure, the minimum purchase price policy for wheat production efficiency has been significantly improved, and production efficiency in a stable state of growth.

(2) View the effect of policy implementation from the perspective of horizontal

In order to explore the effect of policy implementation in different provinces, we compared the changes in the production efficiency of six wheat producing areas.

| Area     | \( TE \) | \( TP \) | \( SE \) | \( PC \) | \( Malmquist \) |
|----------|----------|----------|----------|----------|-----------------|
| Anhui    | 1.002    | 1.048    | 1.002    | 1        | 1.151           |
| Henan    | 1.003    | 1.135    | 1        | 1        | 1.135           |
| Hebei    | 1.019    | 1.053    | 1.019    | 1        | 1.073           |
| Jiangsu  | 1.004    | 1.147    | 1.004    | 1        | 1.151           |
| Shandong | 1.007    | 1.117    | 1.007    | 1        | 1.125           |
| Hubei    | 0.998875 | 1.115    | 0.9985   | 1.000375 | 1.1135          |

From the above table can be drawn to the policy for the production efficiency of six provinces have a catalytic role, which promoted the most effective in Anhui, Jiangsu, Hubei to enhance the efficiency.
of smaller. This is because the wheat production in Hubei Province is low and the technical efficiency change index is low, so when the same minimum purchase price is used, the production efficiency is low.

(3) Comparison of different food varieties

In order to study the effect of the policy on the effect of different varieties, we chose the Hubei wheat and rice as indicators to compare with each other.

| Variety | TE  | TP  | SE   | PC     | Malmquist index |
|---------|-----|-----|------|--------|-----------------|
| Rice    | 1.025 | 1.14 | 1.025 | 1      | 1.168           |
| Wheat   | 0.998875 | 1.115125 | 0.9985 | 1.000375 | 1.1135          |

It can be concluded that the policy of minimum purchase price has a positive effect on the productivity of early rice and wheat, but the income for rice is greater. The implementation of the policy has brought them technical progress, but the gap between the two mainly comes from the scale efficiency index, Hubei wheat planting area showed a downward trend, while the rice planting volume has stabilized.

5. Conclusion

In this paper, we firstly compare the vertical time factors, and draw the conclusion that the minimum purchase price policy greatly improves the efficiency of grain production. Secondly we compare the effects of different provinces in the same background. We find that the effect of Anhui and Jiangsu is obvious, while Hubei the results are flat. We analyzed because of the unit yield in Hubei Province is slightly lower, the need for a higher care market price to have a good effect. Finally, we compared the effectiveness of the policy among different food breeds and found that the results achieved in early rice were better, and we observed that this was because the crop had a better scale efficiency index.

References

[1] Research on Influencing Factors of Technological Progress in China (1981-2006) - Empirical Analysis Based on Vector Autoregressive Model [J]. Soft Science, 2008, 22 (7): 24-2
[2] National Development Planning Commission. National Compendium of Cost and Income of Agricultural Products [M]. China Price Publishing House, 2014.
[3] Journal of Wuhan University of Technology, 2011 (1): 20-24 .Analysis of Innovation Efficiency of Different Factor-intensive Manufacturing Industry Based on DEA-Malmquist Index [J].
[4] Seiford L M, Thrall R M. Recent developments in DEA: The mathematical programming approach to frontier analysis [J]. Journal of Econometrics, 1990, 46 (1-2): 7-38.
[5] He Wei. Minimum purchase price policy for grain in China: status quo, problems and countermeasure of China [J]. Macroeconomic research, 2010 (10): 32-36.