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Analysis of Maize Production Efficiency Based on DEA-Malmquist Indexes: A Case Study of Henan Province

Bingjun Li, Xiaoxiao Zhu*

College of Information and Management Science, Henan Agricultural University, Zhengzhou, China
Email: zzlbjun@163.com, *zhu_xiaoxiao113@163.com

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Abstract

In order to improve the production efficiency of maize in Henan, China, the HP (High-Pass) filter method is used to obtain the maize trend yield. Secondly, the Malmquist index method is used to analyze the changes of TFP (Total Factor Productivity) of maize in 18 cities in Henan Province in the past 11 years. Finally, the amount of slack in maize input and output is analyzed. The results show that the research and development level of advanced technology of maize production in Henan Province has been improved to some extent in recent years; the advanced technology in various regions has not been fully promoted and utilized; there is a certain degree of relaxation in the input of various elements of maize; the resource allocation is unreasonable, and there is a certain amount of space for saving.

Keywords

DEA-Malmquist Index Method, HP Filter Method, Henan Province, Maize

1. Introduction

Henan Province is located in the center of Huang-Huai Maize dominant industrial belt, and its light and heat resources are abundant, forming the cultivation system of wheat and maize cropping twice a year. Located in the continental monsoon climate zone, Henan Province is an important grain producing area in China. The summer maize planting area and output account for about 10% of the country, but the summer maize yield is high and unstable. As a big grain planting province, Henan planted 3316.86 thousand hectares of maize in 2016, with a total yield of 17.5297 million tons. In fact, the yield per unit area of maize in Henan Province is 5638 kg/ha in 2012 and decreased to 5285 kg/ha in 2016, while the planting area of maize in 2012 is 3100 thousand hectares, and by 2016 it had increased to 3316.86 thousand hectares. The input of other controllable elements is also in the state of growth; the input gradually increases and the output decreases, which indicates that the production efficiency of maize in Henan Province is low, so it is necessary to adjust the input of production factors to increase the yield of maize.

Data Envelopment Analysis (DEA), Malmquist Index Method, Stochastic Frontier Analysis (SFA), and DEA-Tobit models are widely used in productivity studies in the agricultural sector. Many scholars have studied the production efficiency of maize, and most scholars' research mainly concentrates on the above methods to study the maize production efficiency in the country or in some provinces and cities, mainly the following parts.

For the study of maize production efficiency in China: Yang Guoqing *et al.* [1] used the Malmquist index analysis method in DEA to analyze the growth of maize production efficiency in China's main maize producing areas from the perspective of time gradient and regional difference. Yan Yijun *et al.* [2] used the stochastic frontier analysis (SFA) method to calculate the maize production efficiency in 20 provinces and regions of China, and analyzed the output elasticity of each input factor. Wang Jun *et al.* [3] analyzed the total factor productivity of maize production in China's core producing areas from 2001 to 2008 using Stochastic Frontier Analysis (SFA) method. Liu Nian *et al.* [4] used the DEA-Malmquist index method to measure the total factor productivity (TFP) of China's maize from 2002 to 2013. Based on DEA model, Malmquist index method and ESDA analysis method, Zhang Lina *et al.* [5] analyzed the temporal and spatial characteristics of the change of comprehensive technical efficiency and total factor productivity of maize production in 20 major maize provinces (regions) of China from 2005 to 2015.

Studies on maize production efficiency in individual provinces and cities: Huang Yong [6] decomposed the Malmquist index and analyzed the internal driving force of agricultural total factor productivity growth in Hubei Province. Wang Zhidan *et al.* [7] used DEA-Malmquist index method to analyze the total factor productivity (TFP) of maize and its composition change in Xinmin City, Shenyang, Liaoning Province from 2013 to 2014 from the overall situation, different regions and different scale levels and analyzed the investment optimization direction of maize production factors. Jiang Yubo *et al.* [8] took the modern agricultural machinery cooperative in the core maize producing area of Heilongjiang Province as the research object and used the data envelopment analysis to analyze the influencing factors of the typical samples production efficiency. Using the method of data envelopment analysis, Jiang Xiusheng *et al.* [9] analyzed the technical efficiency of spring maize production in five main spring maize production areas in North China from 2006 to 2014. Yang Chun *et al.* [10] used DEA to analyze the production efficiency and inpu-output slack of Shanxi maize from 1978 to 2011. Chen Suqiong *et al.* [11] analyzed the technical efficiency of maize production of different types of labor transfer farmers in Liaoning Province. The results showed that there is no significant difference in the technical efficiency of maize production among different types of labor transfer farmers. Taking the three counties of Ganzhou, Linze and Gaotai in Zhangye City as examples, the DEA-Tobit model is used to analyze the production efficiency and influencing factors of different types of farmers field maize [12]. On the basis of using DEA to measure the production efficiency, Yang Xiao *et al.* improved the simulation of redundant input elements based on the calculation results. On the basis of using DEA to measure the production efficiency, Yang Xiao *et al.* [13] improved the redundant input elements based on the calculation results. Qian Jinxia [14] used maize per unit yield and meteorological data from 39 counties (cities) in Shanxi Province from 1991 to 2000 to analyze the regional distribution characteristics of maize climate resource utilization efficiency and maize climate resource utilization efficiency in Shanxi Province. Liu Xiaoying *et al.* [15] studied the utilization efficiency of light and heat resources of winter wheat and summer maize in northern Henan. Wang Xueqiu [16] used correlation analysis to analyze the relationship between the scale of maize management and production efficiency in Jilin Province.

The above scholars have used the actual production as the output index of maize, and the actual production of maize is affected by other factors, the actual yield could not be used as the exact output corresponding to the input of each element of maize. The analysis using actual production does not accurately reflect maize production efficiency. In this paper, the HP filter method is used to process the yield data of maize, and the trend yield is obtained as the output index of maize. The Malmquist index method of DEA is used to study the growth of maize TFP in 2006-2016 in various cities of Henan Province. The change of total factor productivity of maize is decomposed into technical efficiency and technological progress, and further decomposed into pure technical efficiency, scale efficiency and technological progress. Then the influence of efficiency change is analyzed concretely.

2. Theory and Method

2.1. DEA-Malmquist Index Method

Data Envelopment Analysis (DEA) is first proposed by A.Charnes and W. W. Cooper [17] in the United States in 1978. The DEA model can be divided into CCR model and BCC model. It is a systematic analysis method for the relative effectiveness or benefit evaluation of the same type of units (departments) based on multiple indicator inputs and multiple indicator outputs and the concept of "relative efficiency".

The Malmquist productivity index is first proposed by Swedish economist and statistician Malmquist (1953) and can be used to investigate the variation of production efficiency in different periods. The nonparametric Malmquist exponent method based on data envelopment analysis defines the Malmquist exponent by the distance function (distance function) and calculates the total factor productivity (total factor productivity, (TFP) by using the mathematical linear programming model. Decompose the Malmquist index while analyzing the efficiency changes of production decision-making units in different periods to find the root cause of total factor productivity change [18]. Fareetal (1994) defined an output-based Malmquist productivity index [19], which uses panel data to decompose total factor productivity into two parts: technical efficiency change (effch) and technological progress (techch). The technological progress index reflects the "frontier movement effect" from the period t to the $t+1$, and the technical efficiency change under the Constant Return Scale (CRS) can be further decomposed into pure technical efficiency changes (pech) and scale efficiency (sech) changes under variable-scale compensation (VRS). The Malmquist exponent calculation formula based on DEA can be expressed as follows:

$$
\begin{aligned}
&M_0^{t+1}\left(x^{t+1},y^{t+1},x^t,y^t\right)\\
&=\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\middle|VRS\right)}{D_0^{t}\left(x^{t},y^{t}\middle|VRS\right)}\left[\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\middle|CRS\right)}{D_0^{t}\left(x^{t},y^{t}\middle|CRS\right)}\cdot\frac{D_0^{t}\left(x^{t},y^{t}\middle|VRS\right)}{D_0^{t+1}\left(x^{t+1},y^{t+1}\middle|VRS\right)}\right]\\
&\cdot\left[\frac{D_0^{t}\left(x^{t+1},y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}\cdot\frac{D_0^{t}\left(x^{t},y^{t}\right)}{D_0^{t+1}\left(x^{t},y^{t}\right)}\right]^{\frac{1}{2}}\\
&=\text{pech}\times\text{sech}\times\text{techch}
\end{aligned}
\tag{1}
$$

Among them, $D_0^t\left(x^t,y^t\right)$ and $D_0^{t+1}\left(x^{t+1},y^{t+1}\right)$ represent the distance function of two periods. $M_0^{t+1}\left(x^{t+1},y^{t+1},x^t,y^t\right)>1$, that is, TFP > 1, indicates that the total factor productivity is in the growth stage, and the resource allocation efficiency of maize is improved. $M_0^{t+1}\left(x^{t+1},y^{t+1},x^t,y^t\right)<1$, that is, TFP < 1, indicates that the total factor productivity is in the declining stage, and the resource allocation efficiency of maize is decreased. The change of technical efficiency is used to measure the ratio of the actual output to the theoretical maximum output under the same input condition or the ratio of the actual input to the theoretical maximum input under the same output condition, effch > 1, which indicates that the decision making unit is close to the technical frontier. Technological progress reflects the fact that during the implementation of the policy, through technological transformation or other means to achieve the same amount of output to reduce input or the same amount of input to improve output, pech > 1, indicating that the decision-making unit has technological progress or innovation.

2.2. HP Filter Method

The HP filtering method is a decomposition method of time series in state space. It assumes that the time series consists of two parts, namely: long-term trend component and short-term fluctuation component. The HP filter method can be considered as a high-pass filter, which can separates high-frequency components with periods below 8 years [20].

Maize yield sequence $\{y_t\}$ is divided into trend yield g_t and fluctuating yield c_t by HP filter, in which g_t is a stable high frequency trend signal and c_t is an unstable low frequency disturbance signal. The principle is to remove the low frequency signal c_t by filtering, thereby detecting the high frequency signal g_t from the production sequence. HP filter decomposes y_t into: $y_t = g_t + c_t$.

The detection method of high frequency signal g_t is often defined as the solution of the following minimization formula, namely:

$$\min\left\{\sum_{t=1}^{T}\left(y_t - g_t\right) + \lambda\sum_{t=1}^{T}\left[\left(g_{t+1} - g_t\right) - \left(g_t - g_{t-1}\right)\right]^2\right\} \quad (2)$$

In the formula, λ is the HP filter parameter. When $\lambda = 0$, the minimized solution of the function is $\{y_t\}$ sequence. With the increase of λ value, the trend of minimum solution estimation is smoother. The general experience of λ is as follows:

$$\lambda = \begin{cases} 100, & \text{annual data} \\ 1600, & \text{quarterly data} \\ 14400, & \text{monthly data} \end{cases} \quad (3)$$

3. Data Collection

According to the scientificity, comprehensiveness and availability of data and the accuracy and rigor of data calculation, this paper selects the trend yield of maize per unit area (kg/ha), the number of people engaged in maize production (10,000 people), the effective irrigation area of maize (1000 ha), the sowing area of maize (1000 ha), the corn fertilizer application (ton), and the total power of maize machinery (10,000 kilowatts) in Henan Province from 2006 to 2016, data obtained from the Henan Provincial Bureau of Statistics [21]. The yield per unit area of maize in Henan Province is shown in **Table 1**. The trend yield of maize per unit area is taken as the output index; the number of people engaged in maize production, the effective irrigation area of maize, the sowing area of maize, the amount of corn fertilizer applied, and the total mechanical power of maize are taken as input indexes. The input-output index system of maize production efficiency is constructed, and the efficiency is analyzed by DEA-Malmquist exponent method.

4. Efficiency Analysis

4.1. Time Dimensional Analysis

Using DEAP2.1 software to calculate the overall situation of maize production efficiency during the period of 2006-2016 in Henan Province is shown in **Table 2**.

Observing **Table 2** it was found that in 2012-2016, the average of technical efficiency change, technological progress change, pure technical efficiency change, scale efficiency change and total factor productivity change index of maize production in 18 cities of Henan Province are 0.970, 0.997, 0.975, 0.994, 0.967, the

Table 1. Maize per unit production of Henan Province in 2006-2016 (Unit: kg/ha).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Zhengzhou	4969.27	4935.21	4900.85	4866.43	4831.83	4797.38	4763.37	4729.37	4695.52	4662.22	4628.57
Kaifeng	5560.78	5551.61	5541.42	5529.64	5515.33	5496.57	5474.96	5450.85	5424.47	5396.69	5367.69
Luoyang	5049.09	4984.07	4918.17	4852.78	4790.00	4732.85	4680.49	4631.31	4585.01	4542.53	4500.70
Pingdingshan	4920.42	4876.89	4831.38	4782.33	4730.47	4676.18	4619.90	4562.23	4506.25	4457.83	4411.48
Anyang	6456.62	6471.13	6482.48	6488.76	6490.05	6487.20	6480.74	6470.20	6455.76	6438.09	6417.97
Hebi	6832.33	6865.44	6895.62	6921.14	6942.13	6959.32	6972.99	6982.87	6988.98	6992.31	6994.01
Xinxiang	6048.98	6072.57	6093.78	6110.55	6121.47	6125.41	6120.87	6105.91	6080.80	6047.24	6008.41
Jiaozuo	7323.62	7323.37	7321.33	7316.80	7309.13	7297.57	7281.18	7258.73	7230.56	7198.47	7164.22
Puyang	6580.71	6579.54	6576.12	6569.27	6559.56	6547.90	6534.72	6519.34	6501.04	6477.37	6450.43
Xuchang	6403.64	6387.96	6370.61	6348.99	6323.68	6295.58	6266.83	6238.26	6210.74	6185.63	6161.09
Luohe	6215.70	6211.42	6209.28	6212.66	6224.70	6245.69	6274.00	6306.06	6340.04	6375.55	6411.91
Sanmenxia	4528.95	4493.19	4455.89	4417.62	4378.75	4339.34	4299.33	4258.07	4216.21	4175.16	4134.48
Nanyang	5550.92	5524.99	5496.50	5463.45	5424.54	5378.83	5325.77	5264.84	5197.75	5128.20	5057.20
Shangqiu	6581.23	6587.49	6589.99	6586.03	6573.91	6553.04	6523.20	6484.98	6440.35	6392.01	6341.76
Xinyang	4661.81	4606.40	4559.51	4533.03	4533.37	4564.72	4627.59	4720.70	4841.45	4984.98	5142.45
Zhoukou	6127.30	6069.38	6017.31	5977.44	5954.25	5946.95	5950.13	5958.43	5969.71	5983.04	5996.11
Zhumadian	5241.99	5221.88	5207.79	5203.07	5208.34	5221.91	5240.59	5261.22	5282.03	5302.66	5322.51
Jiyuan	5214.63	5224.97	5233.02	5237.70	5239.02	5236.92	5231.04	5220.82	5206.82	5190.95	5174.11

Table 2. Indicators of maize production efficiency in Henan Province from 2006 to 2016.

Years	Comprehensive technical efficiency change index (Ech)	Technological progress change index (Tch)	Pure technical efficiency change index (PEch)	Scale efficiency change index (SEch)	Total factor productivity change index (TFPch)
2006-2007	0.961	1.035	0.962	0.999	0.994
2007-2008	0.941	0.948	0.919	1.024	0.892
2008-2009	1.002	0.966	1.018	0.984	0.968
2009-2010	0.996	0.965	0.990	1.006	0.961
2010-2011	0.943	1.025	0.963	0.980	0.967
2011-2012	1.003	0.967	0.993	1.011	0.970
2012-2013	0.994	0.991	0.982	1.012	0.986
2013-2014	0.995	0.978	0.996	0.999	0.974
2014-2015	0.953	1.026	0.974	0.979	0.978
2015-2016	0.915	1.074	0.960	0.952	0.982
Average	0.970	0.997	0.975	0.994	0.967

value of each efficiency did not exceed 1, which indicated that these five efficiency have not improved. Among them, the average total factor productivity (TFP) decreased by 3.3% (the average index is 0.967, less than 1), indicating that the maize production efficiency in these 18 cities showed a downward trend in 2006-2016. Total factor productivity (TFP) of maize has been fluctuating from 2006 to 2016, which is mainly affected by the change of comprehensive technical efficiency (the overall technical efficiency has decreased by 3.0% annually), and the comprehensive technical efficiency is affected by pure technical efficiency and scale efficiency. Moreover, it is greatly affected by the pure technical efficiency (the average value of pure technical efficiency is 0.975, while the average efficiency of scale is 0.994). The reason for this phenomenon is that it fails to effectively promote the use of advanced technology or the unreasonable configuration of agricultural implements and low utilization efficiency.

From 2006 to 2016, the comprehensive technical efficiency change index of the annual maize production in 18 cities of Henan Province is greater than 1 in 2 time periods (2008-2009, 2011-2012), indicating that the input and output of these years are in the best allocation, and all resources have been fully utilized. The comprehensive technical efficiency change index of the remaining years is less than 1, especially in 2015-2016, the comprehensive technical efficiency change index is 0.915, which is the lowest level in the study period, and the allocation efficiency of input and output is the lowest during the study period.

From 2006 to 2016, the average value of technological progress in the studied cities is 0.997 (less than 1), and the technological progress of these years in 2006-2007, 2010-2011, 2014-2015, 2015-2016 is greater than 1, and is in a state of technological progress, and the progress is relatively large, 3.5%, 2.5%, 2.6% and 7.4%, while the technical progress changes of the remaining years are less than 1, indicating that these annual technologies have not improved.

The period of corn production pure technical efficiency change index greater than 1 is only in 2008-2009, and only the annual technology use efficiency is rising. The change in pure technical efficiency in 2013-2014 (0.996) basically tended to be 1, indicating that the efficiency of technology use in this year is basically the same as the previous year. The pure technical efficiency changes for the remaining years are all less than 1, indicating that the efficiency of technology use in these years has decreased from the previous year.

The average of maize production scale efficiency change in Henan Province is 0.994, and the scale efficiency change value of four time periods is greater than 1, which are 2007-2008 (1.024), 2009-2010 (1.006), 2011-2012 (1.011), 2012-2013 (1.012). These years scale returns are declining. In the remaining years, the scale efficiency change values are all less than 1, indicating that these years scale returns are increasing.

4.2. Spatial Dimension Analysis

Using DEAP2.1 software to calculate the overall situation of maize production efficiency in the 18 cities of Henan Province during 2006-2016 is shown in Table 3.

The total factor productivity of Hebi, Xinxiang, Jiaozuo, Puyang, Xuchang, Luohe, Sanmenxia, Shangqiu, Xinyang, Zhoukou and Jiyuan is much higher

Table 3. Maize production efficiency in Henan Province from 2006 to 2016.

Area	Comprehensive technical efficiency change index (Ech)	Technological progress change index (Tch)	Pure technical efficiency change index (PEch)	Scale efficiency change index (SEch)	Total factor productivity change index (TFPch)
Zhengzhou	0.957	1.000	0.963	0.994	0.956
Kaifeng	0.962	0.977	0.956	1.006	0.940
Luoyang	0.957	1.000	0.967	0.989	0.956
Pingdingshan	0.944	1.000	0.953	0.990	0.943
Anyang	0.968	1.000	0.993	0.975	0.968
Hebi	1.001	0.998	1.000	1.001	0.998
Xinxiang	0.975	1.000	0.986	0.989	0.975
Jiaozuo	0.984	1.000	1.000	0.984	0.984
Puyang	0.972	1.000	0.964	1.008	0.972
Xuchang	0.977	1.000	0.995	0.983	0.977
Luohe	0.980	1.000	1.010	0.970	0.980
Sanmenxia	0.973	1.000	0.981	0.992	0.973
Nanyang	0.920	1.000	0.910	1.012	0.920
Shangqiu	0.977	0.999	0.967	1.010	0.976
Xinyang	0.997	0.981	0.987	1.011	0.978
Zhoukou	0.969	1.000	0.970	0.999	0.969
Zhumadian	0.947	1.000	0.958	0.989	0.947
Jiyuan	1.000	0.993	1.000	1.000	0.993
Average	0.970	0.997	0.975	0.994	0.967

than the average level, showing a positive growth, while Anyang (0.968) is basically the same as the average (0.967). Nanyang City (0.920) is well below the average level, and the rest of the cities are slightly below the average level. Total factor productivity is less than 1, indicating a negative growth.

In terms of technical efficiency, Hebi (1.001) is more than 1, Jiyuan is 1. The maize planting technical efficiency in these cities is relatively effective, the resources are fully utilized, the input and output are in the best allocation state. Xinxiang, Jiaozuo, Puyang, Xuchang, Luohe, Sanmenxia, Shangqiu and Xinyang are above the average level, Zhoukou (0.969) is close to the average level (0.970), Nanyang (0.920) is far below the average level, and the other cities are slightly lower than the average level. Below average, it indicates that the technical efficiency of maize planting in these areas is relatively ineffective, resources are not fully utilized, input and output allocation is unreasonable, and efficiency is low, so it needs to be improved.

In terms of technological progress, Zhengzhou, Luoyang, Pingdingshan, Anyang, Hebi, Xinxiang, Jiaozuo, Puyang, Xuchang, Luohe, Sanmenxia, Nanyang, Shangqiu, Zhoukou, Zhumadian is above the average level (0.997), indicating that these areas are in the leading level of Henan Province in the field of propaganda and application of advanced technology. The technological progress change indicators in other cities are lower than the average level, which indicates that these cities should strengthen the propaganda and application of advanced technology.

Among the 18 cities studied, 6 cities have scale efficiency values greater than 1. These cities have diminishing returns on scale, which should reduce the input of factors and avoid unnecessary waste to achieve the optimal scale. The scale efficiency value of Jiyuan is 1, which is in the optimal scale, while the remaining cities have a scale efficiency value of less than 1, in the case of increasing returns to scale, the input of factors should be increased to achieve optimal scale.

The pure technical efficiency of Hebi, Jiaozuo and Jiyuan is 1. The maize planting is in a technically effective state, and there is no input and output slack. The pure technical efficiency of the other areas is not equal to 1, indicating that the maize planting in these areas is in a technically inefficient state. There are different degrees of input and output irrational, and the input and output should be adjusted based on the effectiveness of DEA to achieve technical effectiveness.

5. Input and Output Relaxation Analysis

5.1. Analysis of Maize Production Output

If the comprehensive technical efficiency of maize in the cities of Henan Province is the best, the average yield of maize in 2016 can be increased by 176.099 kg/hm^2, and in 2006, the yield of maize can only increase by 107.978 kg/hm^2, which fully reflects the improvement of maize production technology in Henan Province in recent years.

5.2. Analysis of Maize Production Factors Input

In addition, there are some relaxations in the input factors of maize in Henan Province. If the technical efficiency is optimized while maintaining the same output, the input of factors can be saved to a certain extent.

Input of the number of maize producers

In 2006, the number of slack people engaged in maize production in Henan Province is 257170, but by 2016 it had fallen to 161640. This shows that the phenomenon of surplus labor input in Henan Province has been effectively alleviated, mainly because of the progress of science and technology, and the improvement of the mechanization level of maize production, which led to the accumulation of labor to the secondary and tertiary industries, thus reducing the slack in the production labor of maize. This is consistent with the research by Zhang Lina *et al.* [5].

Input of effective irrigation area and sowing area

The effective irrigation area of maize is 50.123 thousand hectares in 2006 and 37.855 thousand hectares in 2016, which indicated that the irrigation facilities of maize are fully and reasonably used, and the amount of relaxation is reduced. The maize sowing area increased from 8.911 thousand hectares in 2006 to 9.250 thousand hectares in 2016.

Input of chemical fertilizer application

The relaxation rate of chemical fertilizer application is 5511.475 tons in 2006 and increased to 7588.712 tons in 2016. This indicates that with the improvement of science and technology, the use cost of chemical fertilizers is lower, and the use of chemical fertilizers is gradually increasing, resulting in increased relaxation of chemical fertilizer application.

Input of total mechanical power

The total power input of agricultural machinery increased from 21.495 kilowatts in 2006 to 21.784 kilowatts in 2016, mainly due to the improvement of mechanization level and the increase in machinery investment in Henan Province, which resulted in a certain amount of relaxation in the total power of agricultural machinery.

From 2006 to 2016, the relaxation of various inputs in Henan Province is in an optimized state, mainly due to the advancement of science and technology, which resulted in a certain cost savings for maize production in Henan Province. It is of great significance to increase the enthusiasm of farmers to grow grain and ensure national food security.

6. Conclusion

In this paper, considering the effect of other factors on maize yield, the HP filter method is used to deal with the actual yield of maize, and the trend yield corresponding to the input of maize is obtained. The DEA Malmquist index method is used to analyze the efficiency of maize production in 18 cities of Henan Province from 2006 to 2016. The results show that: From the time dimension, the comprehensive technical efficiency change, the technological progress change, the pure technical efficiency change, the scale efficiency change and the total factor productivity change have not improved. From the perspective of spatial dimension, the total factor productivity of maize in all cities is less than 1, which is in the declining stage, showing negative growth, mainly because the production technology of each area is not reasonable and fully utilized. There is a certain degree of relaxation in the input and output of maize production factors, but the relaxation of input in 2016 is better than that in 2006, mainly due to the advancement of technology and the improvement of mechanization level. Strengthen the research and development and promotion of advanced agricultural technology, rationally adjust the allocation of production factors, improve the production efficiency of maize in Henan Province through technological progress and efficiency improvement, and ensure the food security of the country.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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