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# Evaluation of the Execution Effect of the Minimum Grain Purchase Price in Rural Areas

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***Abstract*****—**This paper uses the analytic hierarchy process to study the execution effect of the minimum purchase price of grain in different regions and various grain crops. Firstly, for different regions, five indicators including grain yield, grain sown area, gross agricultural production, grain consumption price index, and disposable income of rural residents were selected to construct an evaluation index system. We collect data of six provinces including Hebei Province, Heilongjiang Province and Shandong Province from 2006 to 2017. Then, the judgment matrix is constructed, and the hierarchical single ordering and consistency test are carried out to determine the scoring standard for the minimum purchase price of grain. The ranking of the execution effect from high to low is: Heilongjiang Province, Shandong Province, Hebei Province, Guizhou Province, Shaanxi Province, and Guangdong Province. Secondly, taking Shandong Province as an example, we collect the relevant data of sown area and yield of cereals, beans, potatoes and other crops from 2006 to 2017. The weight of area and yield index is determined by expert scoring method. And the average sown area and yield of cereals, beans and potatoes in 2006-2017 were calculated, respectively. On this basis, according to the sum of products of weights and mean values, the execution effects of different grain crops are determined. It turns out that among the cereals, the minimum purchase price had the best execution effect on paddy, followed by wheat and finally maize. Moreover, among major categories of crops, cereals perform best, followed by beans and finally potatoes. Lastly, countermeasures are proposed for different regions, various categories of crops, and different crops of the same category.

***Keywords*****—**Analytic hierarchy process, grain yield, grain sown area, minimum grain purchase price.

## I. Introduction

THE minimum purchase price of grain was launched in 2004, mainly targeting major grain crops such as wheat and rice. In 2005, the minimum purchase price plan for rice was launched in the south, aiming to protect the income and enthusiasm of the farmers. This paper mainly studies the execution effect of the minimum purchase price of grain in different regions and varieties of grain crops, finds out possible problems, and puts forward countermeasures for relevant departments.

## II. Literature Review

Grain is the most basic survival material of human beings. The minimum purchase price policy plays an important role in promoting farmers' income and ensuring grain production. The reform of the minimum purchase price policy is also an important part of agricultural structural reform. Grain security issues affect the stable development of the country [1]. In recent years, domestic scholars have conducted in-depth research on food issues. The following is a summary of domestic scholars' research on grain sown area, grain subsidy policy, grain yield situation, grain price and so on.

### *A. Research on the Factors Affecting Grain Sown Area*

There are many factors affecting grain sown area. Different scholars have made different levels of exploration.

Lili and Shaomin believe that the factors determining grain sown area include natural factors, the population of agriculturally available labor, the degree of mechanization in rural areas, and the use of chemical fertilizers [1].

Shuang and Xinliang proposed that the factors affecting grain sown area include natural factors and import and export volume. The relationship between these factors is complicated and there may be differences in grain varieties and regions [2].

Ling and Chaoyi put forward that the establishment of the index system of grain sown area is based on the three perspectives of grain input, output and sustainable development. Input refers to the cost needed to grow grain, output refers to the income obtained from planting grain, and sustainable development refers to other factors affecting grain planting [3].

Sulong obtained the data of grain sown area and related influencing factors in 31 provinces and municipalities directly under the Central Government from Wind information and China Statistical Yearbook. He used EViews software to build a panel model and determined the index system of grain planting area. The study found that grain price index, per capita income in rural areas, fertilization and other factors have a great impact on grain planting area [4].

### *B. Research on the Problems of Food Policy*

Using provincial panel data from 2005 to 2014, Libo established a double difference model, and used counterfactual simulation method to evaluate the effect of the minimum purchase price of grain in each region. The study found that the minimum purchase price of grain has regional and varietal heterogeneity. He proposed that differential pricing should be executed according to the region and crop varieties, and the minimum purchase price of grain should be stripped out to play its bottom role [5].

Haonian studied the variance of different crops in different regions before and after the execution of the minimum purchase price of grain. It was found that for wheat, executive provinces had better effect than non-executive provinces; for

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paddy, there were differences among executive provinces; and there was no significant difference among different grain crops [6].

Jinting et al. regarded wheat planting area as the criterion to measure the minimum purchase price of grain. Fixed coefficient effect model was used to study the effects of various factors on the minimum purchase price of grain. The results show that the influencing factors are different for different provinces. In Shandong Province, the per capita income of rural areas and the level of agricultural mechanization have a great impact; in Hubei Province, the income gap between urban and rural areas has a great impact. Thus, he put forward suggestions on formulating differential supporting measures [7].

Zhongzhong and Haifeng sorted out the subsidy modes and standards of agricultural protection subsidy support policies in various provinces and cities. Based on the agricultural survey data of four counties in Shandong Province and Zhejiang Province, they evaluated the agricultural support and protection intensity, and put forward countermeasures for improving the agricultural support and protection policies in China [8].

Zhongyuan et al. sent questionnaires to grain planting bases in major grain-producing areas and rape-producing areas in Hubei Province. They found that after the transformation of the three government subsidy policies into government-supported subsidy policies, there are still some problems, such as diminishing marginal effects and difficulty in financing. They put forward relevant recommendations on improving the agricultural credit system and increasing protection of arable land [9].

### *C. Research on the Situation of Grain Production*

Hanbin studied the sustainable growth of grain in Jilin Province. In view of the problems of over-digging groundwater and over-fertilization in Jilin Province, he put forward concrete suggestions on the construction of grain production funds, technology and legal system [10].

In view of problems existing in grain production, such as the decrease of farmers' enthusiasm to grow grain, the low quality of cultivated land and the serious pollution of land environment, Jing et al. put forward suggestions of strictly dividing crop planting areas, promoting scientific fertilization, watering, medication [11].

Yating et al. studied the evolution law of crop cultivation in urban suburbs from a micro-perspective based on examples, found that under the influence of social economic environment and institutional policies, crop selection changing to intensive, high-profit cash crops [12].

Xia collected the data of total grain production, unit yield, main grain crop production, unit yield and population in Sichuan Province from 2005 to 2016, and analyzed the structural characteristics of grain production and supply side in Sichuan Province [13].

Zhenyan studied the changes of grain production and sown area in Henan Province, divided the grain production structure of Henan Province into four stages based on different periods, and studied the evolution of grain production structure in Henan Province [14].

### *D. Impacts of Grain Prices*

Xiangqin researched the main influencing factors and price transmission mechanism of domestic grain price changes, and proposed some suggestions [15].

Bo et al. studied the relationship between the factors affecting the minimum purchase price of grain and the area of grain planting, and put forward relevant policy recommendations from the aspects of supply-demand relationship and net profit [16].

## III. Minimum Grain Purchase Price Comprehensive Evaluation Model

### *A. Minimum Grain Purchase Price Regional Evaluation Model*

The evaluation is mainly to analyze the change of grain yield and farmers' income after the adoption of the minimum purchase price of grain. This paper mainly uses the analytic hierarchy process (AHP), and the main indicators involved are: grain yield, grain sown area, gross agricultural production, grain consumption price index, and disposable income of rural residents. The evaluation system of the execution effect of the minimum grain purchase price is shown in Fig. 1.

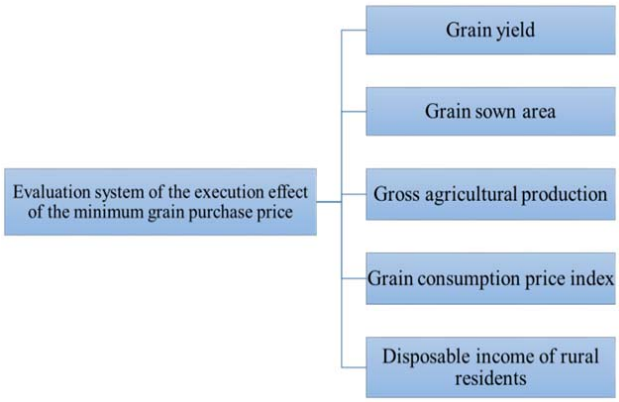


Fig. 1 Evaluation system of the execution effect of the minimum grain purchase price

1. Data Collection

According to the classification of geographical regions in China Statistical Yearbook [17], the main grain producing areas in different geographical regions were selected as the research objects. Hebei Province is chosen in North China, Heilongjiang Province in Northeast China, Shandong Province in East China, Guangdong Province in South China, Guizhou Province in West China and Shaanxi Province in Northwest China. Relevant statistics are shown in Tables I-V.

2. Construction of Judgment Matrix

A scale of “1-9” is used to indicate the importance of the index. The higher the scale is, the greater the importance of the former index is. The judgment matrix between the indexes

is obtained, as shown in Table VI.

TABLE I
GRAIN YIELD (10,000 TONS) IN 2006-2017

| Province Year | Hebei Province | Heilong jiang Province | Shan dong Province | Guang dong Province | Guizhou Province | Shaanxi Province |
|---|---|---|---|---|---|---|
| 2006 | 2702.8 | 3346.4 | 4048.8 | 1387.6 | 1122.8 | 958.9 |
| 2007 | 2841.6 | 3462.9 | 4141.8 | 1284.7 | 1100.9 | 1067.9 |
| 2008 | 2905.8 | 4225 | 4230.5 | 1243.4 | 1158 | 1111 |
| 2009 | 2910.2 | 4535 | 4316.3 | 1314.5 | 1168.3 | 1131.4 |
| 2010 | 2975.9 | 5012.8 | 4335.7 | 1316.5 | 1112.3 | 1164.9 |
| 2011 | 3172.6 | 5570.6 | 4426.3 | 1361 | 876.9 | 1194.7 |
| 2012 | 3246.6 | 5761.5 | 4511.4 | 1396.3 | 1079.5 | 1245.1 |
| 2013 | 3365 | 6004.1 | 4528.2 | 1129.2 | 1030 | 1215.8 |
| 2014 | 3360.2 | 6242.2 | 4596.6 | 1171 | 1138.5 | 1079.8 |
| 2015 | 3363.8 | 6324 | 4712.7 | 1358.1 | 1180 | 1226.8 |
| 2016 | 3460.2 | 6058.5 | 4700.7 | 1360.2 | 1192.4 | 1228.3 |
| 2017 | 3829.2 | 7410.3 | 5374.3 | 1208.6 | 1242.4 | 1194.2 |

TABLE II
GRAIN SOWN AREA (1000 HA) IN 2006-2017

| Province Year | Hebei Province | Heilong jiang Province | Shan dong Province | Guang dong Province | Guizhou Province | Shaanxi Province |
|---|---|---|---|---|---|---|
| 2006 | 6199.4 | 9023.7 | 6797.5 | 2767.1 | 3108.5 | 3295 |
| 2007 | 6168.2 | 10820.5 | 6936.5 | 2479.2 | 2821.8 | 3099.8 |
| 2008 | 6158.1 | 10988.9 | 6955.6 | 2499.9 | 2919.6 | 3126 |
| 2009 | 6216.5 | 11391 | 7030.1 | 2538.5 | 2984.7 | 3134 |
| 2010 | 6282.2 | 11454.7 | 7084.8 | 2531.9 | 3039.5 | 3159.7 |
| 2011 | 6286.1 | 11502.9 | 7145.9 | 2530.4 | 3055.6 | 3134.9 |
| 2012 | 6302.4 | 11519.5 | 7202.3 | 2540.2 | 3054.3 | 3127.5 |
| 2013 | 6315.9 | 11564.4 | 7294.6 | 2507.6 | 3118.4 | 3105.1 |
| 2014 | 6332 | 11696.4 | 7440 | 2507 | 3138.4 | 3076.5 |
| 2015 | 6392.5 | 11765.2 | 7492.1 | 2505.8 | 3114.9 | 3073.5 |
| 2016 | 6327.4 | 11804.7 | 7511.5 | 2509.3 | 3113.3 | 3068.7 |
| 2017 | 6658.5 | 14154.3 | 8455.6 | 2169.7 | 3052.8 | 3019.4 |

TABLE III
GROSS AGRICULTURAL PRODUCTION (RMB 100 MILLION) IN 2006-2017

| Province Year | Hebei Province | Heilong jiang Province | Shan dong Province | Guang dong Province | Guizhou Province | Shaanxi Province |
|---|---|---|---|---|---|---|
| 2006 | 1394.7 | 532.4 | 2221.4 | 1261.1 | 354.6 | 531.6 |
| 2007 | 1639.1 | 971.9 | 2604.1 | 1328.7 | 392.2 | 629.3 |
| 2008 | 1760.7 | 1142.3 | 2895.7 | 1481.7 | 464.8 | 775.9 |
| 2009 | 1927.8 | 1206.8 | 3224 | 1551 | 501.5 | 823.6 |
| 2010 | 2470.1 | 1369.2 | 3670.1 | 1760.2 | 587.3 | 1107.2 |
| 2011 | 2775.3 | 1057.8 | 3843.6 | 2042.2 | 655.3 | 1360.7 |
| 2012 | 3095.3 | 2315.6 | 3960.6 | 2229.3 | 864.9 | 1526.3 |
| 2013 | 3473.3 | 2856.3 | 4509.9 | 2444.7 | 997.1 | 1714.8 |
| 2014 | 3453.4 | 3015.6 | 4765.8 | 2613.2 | 1321.9 | 1870.8 |
| 2015 | 3441.4 | 2911.9 | 4929.9 | 2793.8 | 1772.6 | 1910.7 |
| 2016 | 3459.4 | 2873.9 | 4641.3 | 3134.4 | 1888.6 | 2027.6 |
| 2017 | 2890.6 | 3471.3 | 4403.2 | 2890.0 | 2077.0 | 2095.3 |

3. Hierarchical Single Ranking and Consistency Test

Hierarchical single ranking refers to obtaining the eigenvector corresponding to the maximum eigenvalue of the judgment matrix, and obtaining the weight ranking of the same layer elements corresponding to the upper layer elements after normalization.

TABLE IV
GRAIN CONSUMPTION PRICE INDEX, 2006-2017

| Province Year | Hebei Province | Heilong jiang Province | Shan dong Province | Guang dong Province | Guizhou Province | Shaanxi Province |
|---|---|---|---|---|---|---|
| 2006 | 103 | 104.9 | 102.8 | 101.8 | 102.9 | 103.2 |
| 2007 | 109 | 107.1 | 108.1 | 104.4 | 106.7 | 107.7 |
| 2008 | 106.7 | 104.5 | 106.3 | 108.1 | 107.6 | 107.7 |
| 2009 | 105.9 | 110.7 | 104.4 | 104.3 | 103 | 104.6 |
| 2010 | 112 | 113.6 | 113 | 107.5 | 120.5 | 114.8 |
| 2011 | 112.2 | 111.2 | 108.7 | 112.7 | 116.8 | 109.8 |
| 2012 | 109.4 | 104.6 | 102.5 | 105 | 104.5 | 103.3 |
| 2013 | 108.1 | 104.6 | 107.3 | 101.9 | 103.3 | 107.9 |
| 2014 | 102.4 | 103.2 | 104.2 | 102.7 | 102.6 | 103.3 |
| 2015 | 101.2 | 102.3 | 101.7 | 101.8 | 102.6 | 102.7 |
| 2016 | 99.0 | 101.0 | 99.7 | 100.8 | 100.9 | 100.3 |
| 2017 | 101.7 | 101.1 | 102.8 | 101.4 | 101.1 | 101.6 |

TABLE V
DISPOSABLE INCOME OF RURAL RESIDENTS (RMB) 2006-2017

| Province Year | Hebei Province | Heilong jiang Province | Shan dong Province | Guang dong Province | Guizhou Province | Shaanxi Province |
|---|---|---|---|---|---|---|
| 2006 | 3801.82 | 3552.43 | 4368.33 | 5079.78 | 1984.62 | 2260.19 |
| 2007 | 4293.43 | 4132.29 | 4985.34 | 5624.04 | 2373.99 | 2788.2 |
| 2008 | 4795.46 | 4855.59 | 5641.43 | 6399.79 | 2796.93 | 3136.46 |
| 2009 | 5149.67 | 5206.76 | 6118.77 | 6906.93 | 3005.41 | 3437.55 |
| 2010 | 5957.98 | 6210.72 | 6990.28 | 7890.93 | 3471.93 | 4104.98 |
| 2011 | 7119.69 | 7590.7 | 8342.1 | 9371.7 | 4145.4 | 5027.9 |
| 2012 | 8081.39 | 8603.8 | 9446.5 | 10542.8 | 4753 | 5762.5 |
| 2013 | 15189.6 | 9634.1 | 10619.9 | 11669.3 | 5434 | 6502.6 |
| 2014 | 16647.4 | 10452.2 | 11882.3 | 12245.6 | 6671.2 | 7932.2 |
| 2015 | 18118.1 | 11095.2 | 12930.4 | 13360.4 | 8242.1 | 8688.9 |
| 2016 | 11919.4 | 11831.9 | 13954.1 | 14512.2 | 8090.3 | 9396.4 |
| 2017 | 12880.9 | 12664.8 | 15117.5 | 15779.7 | 8869.1 | 10264.5 |

TABLE VI
JUDGMENT MATRIX AT CRITERIA LEVEL

| A | B1 | B2 | B3 | B4 | B5 |
|---|---|---|---|---|---|
| B1 | 1 | 2 | 3 | 1/3 | 1/4 |
| B2 | 1/2 | 1 | 2 | 1/3 | 1/4 |
| B3 | 1/3 | 1/2 | 1 | 1/4 | 1/4 |
| B4 | 3 | 3 | 4 | 1 | 1/2 |
| B5 | 4 | 4 | 4 | 2 | 1 |

TABLE VII
THE EIGENVALUES OF THE JUDGMENT MATRIX

| | | | | |
|---|---|---|---|---|
| 5.1771 | 0 | 0 | 0 | 0 |
| 0 | -0.0116 + 0.9397i | 0 | 0 | 0 |
| 0 | 0 | -0.0116 - 0.9397i | 0 | 0 |
| 0 | 0 | 0 | -0.0770 + 0.1564i | 0 |
| 0 | 0 | 0 | 0 | -0.0770 - 0.1564i |

a. Calculating the Maximum Eigenvalues and Eigenvectors of Judgment Matrix

The maximum eigenvalues and eigenvectors of the judgment matrix in Table VI are calculated, as listed in Tables VII and VIII.

From Table VII, we find that the maximum eigenvalue is 5.1771, and the corresponding eigenvectors are 0.2597,

0.1772, 0.1201, 0.5225 and 0.7834. Therefore, the corresponding target weights of these five indicators are obtained respectively:

$$w_0 = [\,0.1394, 0.0951, 0.0645, 0.2805, 0.4206].$$

TABLE VIII
THE EIGENVECTORS OF THE JUDGMENT MATRIX

| | | | | |
|---|---|---|---|---|
| 0.2597 | -0.2142+ 0.1974i | -0.2142 - 0.1974i | -0.1121 + 0.1979i | -0.1121 - 0.1979i |
| 0.1772 | -0.1172 - 0.0525i | -0.1172 + 0.0525i | -0.0865 - 0.2374i | -0.0865 + 0.2374i |
| 0.1201 | -0.0093 - 0.1403i | -0.0093 + 0.1403i | 0.0765 + 0.1010i | 0.0765 - 0.1010i |
| 0.5225 | 0.2686 + 0.3743i | 0.2686 - 0.3743i | 0.6111 - 0.1761i | 0.6111 + 0.1761i |
| 0.7834 | 0.8165 | 0.8165 | -0.6811 | -0.6811 |

b. Consistency Test

First, the consistency index $CI$ is calculated with:

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

Secondly, according to the corresponding average random consistency index $RI$, the consistency ratio $CR$ is calculated.

$$CR = \frac{CI}{RI}$$

Then, bringing the corresponding data into $CR$, and get: $CR = 0.0395 < 0.10$. It demonstrates that the judgment matrix is reasonable and the final target weight $w_0$ is reasonable.

TABLE IX
AVERAGE VALUES OF RELEVANT INDEXES IN SIX PROVINCES FROM 2006 TO 2017

| Index Province | Grain consumption price index | Gross agricultural production | Disposable income of residents | Grain sown area in each province | Grain yield in each province |
|---|---|---|---|---|---|
| Hebei | 105.88 | 2648.43 | 7861.52 | 6303.27 | 3177.83 |
| Heilongjiang | 105.73 | 1977.08 | 7985.88 | 11473.85 | 5329.44 |
| Shandong | 105.13 | 3805.80 | 9199.75 | 7278.88 | 4493.61 |
| Guangdong | 104.37 | 2127.53 | 9948.60 | 2507.22 | 1294.26 |
| Guizhou | 106.04 | 989.82 | 4915.23 | 3043.48 | 1116.83 |
| Shaanxi | 105.58 | 1364.48 | 5775.20 | 3118.34 | 1151.57 |

4. Determination of Index Scores

The average values of each index in Hebei, Heilongjiang, Shandong, Guangdong, Guizhou and Shaanxi provinces in 2006-2017 are calculated, as shown in Table IX.

For the grain consumption price index, gross agricultural production, disposable income of rural residents and other grain evaluation indexes, the scoring criteria are determined, as shown in Table X.

With reference of the scoring standard, the scoring status of relevant indexes in each province is obtained, as shown in Table XI. Therefore, the total score of the execution effect of grain price policy in each province can be obtained by the formula:

$$G_j = \sum_{i=1}^{n} \omega_i \cdot X_i \ .$$

where $i$ denotes the number of indicators, $j$ denotes provinces, $\omega_i$ denotes the weight of indicators corresponding to the target level, and $X_i$ denotes the specific scoring status of indicators. The total scores of grain price policy execution in Hebei, Heilongjiang, Shandong, Guangdong, Guizhou and Shaanxi provinces are 61.739, 87.236, 73.464, 30.399, 31.51 and 31.067, respectively. Therefore, the execution effect of the minimum grain price policy in these six provinces ranks from high to low as: Heilongjiang Province, Shandong Province, Hebei Province, Guizhou Province, Shaanxi Province and Guangdong Province.

TABLE X
GRAIN INDEX SCORING CRITERIA

| Grain consumption price index | Gross agricultural production | Disposable income of residents | Grain sown area in each province | Grain yield in each province | Score |
|---|---|---|---|---|---|
| 100~101 | 500~1000 | 0~1000 | 0~2000 | 0~1000 | 10 |
| 101~102 | 1000~1500 | 1000~2000 | 2000~3000 | 1000~1500 | 20 |
| 102~103 | 1500~2000 | 2000~3000 | 3000~4000 | 1500~2000 | 30 |
| 103~104 | 2000~2500 | 4000~5000 | 4000~5000 | 2000~2500 | 40 |
| 104~105 | 2500~3000 | 5000~6000 | 5000~6000 | 2500~3000 | 50 |
| 105~106 | 3000~3500 | 6000~7000 | 6000~7000 | 3000~3500 | 60 |
| 106~107 | 3500~4000 | 7000~8000 | 7000~8000 | 3500~4000 | 70 |
| 107~108 | 4000~4500 | 8000~9000 | 8000~9000 | 4000~4500 | 80 |
| 108~109 | 4500~5000 | 9000~10000 | 9000~10000 | 4500~5000 | 90 |
| > 110 | 5000~5500 | > 10000 | > 10000 | > 5000 | 100 |

TABLE XI
SCORES OF RELEVANT INDEXES IN EACH PROVINCE

| Index Province | Grain consumption price index | Gross agricultural production | Disposable income of residents | Grain sown area in each province | Grain yield in each province |
|---|---|---|---|---|---|
| Hebei | 60 | 40 | 70 | 60 | 60 |
| Heilongjiang | 60 | 30 | 70 | 100 | 100 |
| Shandong | 60 | 70 | 90 | 70 | 80 |
| Guangdong | 50 | 40 | 90 | 20 | 20 |
| Guizhou | 70 | 10 | 40 | 30 | 20 |
| Shaanxi | 60 | 20 | 50 | 30 | 20 |

*B. Minimum Grain Purchase Price Evaluation Model for Different Crops*

Taking Shandong Province as an example, the specific data of the area and yield of cereals, beans and potatoes in Shandong Province are obtained, as shown in Table XII.

In the light of the expert scoring method, the weight of area and yield for the execution effect of the minimum grain purchase price are determined as follows:

$$\omega = (\overline{\omega_1}, \overline{\omega_2}) = (0.4, 0.6)$$

TABLE XII
AREA AND YIELD OF DIFFERENT GRAIN CROPS IN SHANDONG PROVINCE FROM 2006 TO 2017

| Year | Area | | | | | Yield | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cereals | | | Beans | Potatoes | Cereals | | | Beans | Potatoes |
| | Paddy | Wheat | Maize | | | Paddy | Wheat | Maize | | |
| 2006 | 125.7 | 3354.5 | 2753.6 | 236.1 | 282.2 | 106.6 | 1889.8 | 1761.3 | 65.6 | 209.1 |
| 2007 | 130.5 | 3519.1 | 2854.2 | 176.4 | 231.8 | 110.2 | 1995.6 | 1816.5 | 42.5 | 176.5 |
| 2008 | 130.7 | 3525.2 | 2874.2 | 175 | 225.8 | 110.4 | 2034.2 | 1887.4 | 41.9 | 179 |
| 2009 | 134.6 | 3545.2 | 2917.3 | 171 | 238.4 | 112 | 2047.3 | 1921.5 | 41.9 | 186.3 |
| 2010 | 128.2 | 3561.9 | 2955.3 | 166.9 | 247.3 | 106.4 | 2058.6 | 1932.1 | 41.1 | 189.3 |
| 2011 | 124.5 | 3593.5 | 2995.9 | 166.2 | 240.7 | 104 | 2103.9 | 1978.7 | 43.3 | 188.1 |
| 2012 | 123.9 | 3625.9 | 3018.1 | 163.6 | 245 | 103.4 | 2179.5 | 1994.5 | 39.9 | 185.8 |
| 2013 | 123.1 | 3673.3 | 3060.7 | 164.5 | 248.5 | 103.6 | 2218.8 | 1967.1 | 40.4 | 190.6 |
| 2014 | 122.4 | 3740.2 | 3126.5 | 168.7 | 256.9 | 101 | 2263.8 | 1988.3 | 41.7 | 193.4 |
| 2015 | 116.3 | 3799.8 | 3173.8 | 152.4 | 227 | 95.1 | 2346.6 | 2050.9 | 38.8 | 173.9 |
| 2016 | 105.8 | 3830.3 | 3206.9 | 143.8 | 201.4 | 88.1 | 2344.6 | 2065 | 38.4 | 157.2 |
| 2017 | 108.9 | 4083.9 | 4000.1 | 125 | 102.6 | 90.1 | 2495.1 | 2662.2 | 33.6 | 81.5 |
| Average | 122.88 | 3654.40 | 3078.05 | 167.47 | 228.97 | 102.58 | 2164.82 | 2002.13 | 42.43 | 175.89 |

1. Comparisons of Execution Effect of the Minimum Grain Purchase Price for the Same Category of Crops

The average area and yield of paddy, wheat and maize in cereals from 2006 to 2017 were calculated respectively, as shown in Tables XIII and XVI. Thus, the following formula can be used to obtain the evaluation value of the execution effect of the minimum grain purchase price for these three kinds of cereals.

$$G_i = S_i \cdot \overline{\omega_1} + P_i \cdot \overline{\omega_2} \ (i = 1,2,3),$$

where $S_i$ denotes the area of type $i$ cereals, $P_i$ denotes the yield of type $i$ cereals. By substituting the relevant data, the evaluation values of paddy, wheat and maize are obtained respectively:

$$G = [1.15, 0.68, 0.47]$$

Therefore, it can be learned that the minimum purchase price execution effect of paddy is the best, followed by wheat, and finally maize.

TABLE XIII
AVERAGE AREA AND YIELD OF PADDY, WHEAT AND MAIZE IN CEREALS FROM 2006 TO 2017

| Average Value of Indexes | Paddy | Wheat | Maize |
|---|---|---|---|
| Area | 122.88 | 3654.40 | 3078.05 |
| Yield | 102.58 | 2164.82 | 2002.13 |

TABLE XIV
DATA STANDARDIZATION

| Average Value of Indexes | Paddy | Wheat | Maize |
|---|---|---|---|
| Area | 1.14 | 0.72 | 0.42 |
| Yield | 1.15 | 0.65 | 0.50 |

2. Execution Effect of Minimum Grain Purchase Price for Cereals, Beans and Potatoes

The average sown area and yield of cereals, beans and potatoes were calculated, as shown in Table XV. Therefore, the average value of the execution effect of the minimum purchase price of cereals, beans and potatoes can be obtained by:

$$G_j = S_j \cdot \overline{\omega_1} + P_j \cdot \overline{\omega_2} \ (j = 1,2,3).$$

where $S_j$ denotes the area of type $j$ grains, $P_j$ denotes the yield of type $j$ grains. By substituting the relevant data, the evaluation values of the execution effect of the minimum purchase price of cereals, beans and potatoes are obtained.

$$G = [1.15, 0.64, 0.51]$$

Therefore, it can be seen that the minimum purchase price execution effect of cereals is the best, followed by beans, and finally potatoes.

TABLE XV
AVERAGE SOWN AREA AND YIELD OF CEREALS, BEANS AND POTATOES IN 2006-2017

| Average Value of Indexes | Cereals | beans | Potatoes |
|---|---|---|---|
| Area | 2285.11 | 167.47 | 228.97 |
| Yield | 1423.17 | 42.43 | 175.89 |

TABLE XVI
DATA STANDARDIZATION

| Average Value of Indexes | Cereals | beans | Potatoes |
|---|---|---|---|
| Area | 1.15 | 0.60 | 0.55 |
| Yield | 1.15 | 0.66 | 0.49 |

## IV. POLICY RECOMMENDATIONS

(1) For different regions, the minimum grain purchase price policy should be formulated differently.
In view of the above research results, we find that the execution effect of the minimum purchase price of grain is different in different regions. Among the six provinces selected in this paper, the execution effect of the minimum grain price policy ranks from high to low as: Heilongjiang Province, Shandong Province, Hebei

Province, Guizhou Province, Shaanxi Province and Guangdong Province.

Therefore, when formulating the minimum purchase price of grain, it is necessary to set different prices for different regions, highlight the differences, and make certain policy inclination to some regions to promote the development of regional grain industry.

(2) For different categories of crops, a comprehensive consideration should be made, and different minimum purchase price policies should be formulated.

In the light of our research, among different categories of grain crops, the minimum purchase price had the best execution effect on beans, followed by potatoes, cereals.

Therefore, when formulating policies, taking into account sown area, yield and other factors, the relevant department can make a certain degree of policy inclination for grain, so as to improving the execution effect of the minimum purchase price of grain.

(3) For different crops of same category, the minimum purchase price of grain should be as precise as possible.

For different crops of the same category, there are also some differences in sown area and yield in different regions. In accordance with the above research results, among the cereals in Shandong Province, the minimum purchase price had the best execution effect on wheat, followed by maize and finally paddy.

Therefore, it is advisable to improve the minimum purchase price of paddy on the original basis, thereby improving the execution effect of the minimum purchase price of grain.

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