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Analysis of the Influence Factors of Grain Supply-Demand Gap in China

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Abstract

Based on the analysis of the grain supply and demand gap's current situation in China, this paper establishes an indicator system for the influence factors of grain supply and demand gap. Then this paper calculates the correlation degree between the main grain varieties' supply and demand gap and its influence factors. The results show that sown area and unit yield have the greatest impact on wheat supply and demand gap; per capita disposable income and unit yield have the greatest impact on corn supply and demand gap; per capita disposable income and agricultural mechanization level have the greatest impact on the supply and demand gap of soybean and rice. From the analysis results, we can obtain the difference between the factors affecting the grain supply and demand gap, and provide a certain theoretical basis and new ideas for the balance of grain supply and demand in China.

Keywords

Entropy Method, Grey Correlation Analysis, Demand and Supply Gap, Influence Factors

1. Introduction

As a big grain country, the grain issue has always been a foundation for the stable development of the country's economy and social stability, a significant issue concerning the international people's livelihood. In recent years, many scholars have studied the balance of supply and demand of grain. Yu [1] analyzed the changes of grain supply and demand in China in recent years. Jiang [2] studied the structural characteristics and spatial distribution of grain supply and demand in China based on ArcGIS. Xie [3] predicted the new situation and challenges of grain supply and demand in the new era. Hu [4] established a grain supply and

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demand model to study the structural characteristics and spatial distribution of China's grain supply and demand. Gao and Teng [5] [6] analyzed the grain supply and demand relationship and grain security situation in Tibet and Chongqing respectively. It can be seen from the above scholars' research that most scholars focus on the study of the relationship between supply and demand of grain; few scholars studied the gap between supply and demand and its influence factors. Based on these, this paper firstly analyzes the current situation of China's grain supply and demand gap, and then studies the influence factors of China's grain supply and demand gap based on the improved grey combination model. The data can be fully utilized based on the grey combination model and the government can formulate relevant policies to ensure grain security based on the analysis results.

2. Research Methods

2.1. Grey Correlation Analysis

The grey system theory is a new method proposed by Professor Deng Julong to study the problem with less data and poor information uncertainty [7]. It is based on the "small sample" and "poor information" uncertainty system with "some information is known and some information is unknown". It realizes the correct description and effective monitoring of the system's operational behavior and evolution law by generating and developing the "partial" known information. Grey correlation analysis is an important branch of the grey system. Its basic idea is to determine whether the connection is close by determining the degree of similarity between the reference series and several comparison series, which reflecting the degree of association between the curves. The steps of the grey correlation analysis method are introduced as follows [8]:

Step 1: Determine the analysis sequence.

Set as the reference sequence:

$$X_0 = \left(x_0(1), x_0(2), \cdots, x_0(n)\right) \tag{1}$$

Set as the comparison sequence:

$$X_i = \left(x_i(1), x_i(2), \cdots, x_i(n)\right) \quad \left(i = 1, 2, \cdots, m\right) \tag{2}$$

Step 2: Nondimensionalize the original data.

The initialized reference sequence is:

$$X_0' = x_0(k)/x_0(1) = \left(x_0(1), x_0(2), \cdots, x_0(n)\right) \quad \left(i = 1, 2, \cdots, m\right) \tag{3}$$

The initialized comparison sequence is:

$$X_i' = X_i(k)/x_i(1) = \left(x_i'(1), x_i'(2), \cdots, x_i'(n)\right) \quad \left(i = 1, 2, \cdots, m\right) \tag{4}$$

Step 3: Calculate difference sequence.

The calculation formula of sequence difference is:

$$\Delta_{0i}(k) = \left|x_0(k) - x_i(k)\right| \quad \left(i = 1, 2, 3, \cdots, m, k = 1, 2, 3, \cdots, n\right) \tag{5}$$

The maximum and minimum calculated by the Formula (5) are:

Maximum: $M = \max_i \max_k \Delta_i(k) = \Delta_{\max}$

Minimum: $m = \min_i \min_k \Delta_i(k) = \Delta_{\min}$

Step 4: Calculate grey correlation coefficient.

The calculation formula of grey correlation coefficient is:

$$\gamma_{0i}(k) = \frac{m + \rho M}{\Delta_{0i}(k) + \rho M} \tag{6}$$

where, $\rho \in (0,1), i = 1,2,3,\cdots,m$, ρ is called resolution coefficient, set $\rho = 0.5$ usually.

Step 5: Calculate grey correlation degree.

The calculation formula of grey correlation degree is:

$$\gamma_{0i} = \frac{1}{n}\sum_{k=1}^{n}\gamma_{0i}(k) \tag{7}$$

The γ_{0i} is the comparison sequence x_i to reference sequence x_0, which can reveal the degree of their association.

Record the grey correlation degree of the comparison sequence to the parameter sequence as $\gamma(X_0, X_i)$, the weight of each feature information should be different due to the different importance of each feature information when calculating the target grey correlation degree. Let the weight be $a(k), k = 1,2,\cdots,n$, n is the weight coefficient of each feature information and $\sum_{i=1}^{n} a(k) = 1, a(k) \geq 0$, the Weighted correlation degree is $\gamma_i = \sum_{j=1}^{M} \varepsilon_i(j)a(j), i = 1,2,\cdots,m_k$. The larger the γ_i, the greater the degree of association, and vice versa.

2.2. Entropy Weight Method

The concept of entropy comes from thermodynamics. The entropy weight method is to calculate the weight by using the amount of information contained in the indicator monitoring value. If the information entropy of an evaluation index is larger, it indicates that the amount of information provided by it is greater, and the greater the role played in the comprehensive evaluation. If there are n objects, m evaluation index, the original data matrix is $X = [x_{ij}]_{n\times m}, x_{ij} \geq 0 (i = 1,2,\cdots,n; j = 1,2,\cdots,m)$. Since the variable in entropy has a value range of [0, 1], in order to ensure compliance with the requirements, the original evaluation data needs to be processed by normalization, *i.e.* $P_{ij} = x_{ij} \Big/ \sum_{j=1}^{m} x_{ij}$. The processed matrix is $P_{ij} = [p_{ij}]_{n\times m}$, relative to an indicator x_{ij} in the system. Information entropy is $E_j = -k\sum_{i=1}^{n}[p_{ij} \ln p_{ij}]$, and in the equation $k = 1/\ln n$. The entropy weight of the indicator j is $W_j = (1 - E_j) \Big/ \left(m - \sum_{j=1}^{m} E_j\right)$. The entropy weight method not only has the advantage of objectivity, but also the evalua-

tion problem with a large degree of difference in indicators, which can lead to the weight with higher accuracy [9].

2.3. Grey Correlation Analysis Model Based on Entropy Weight Method

The weight of each indicator indicates the importance and status of the feature in the judgment decision, and also reflects the reliability of different features in the signal characteristics. The grey correlation analysis algorithm based on entropy weight can objectively weight each index according to the entropy value of the data sample; it does not overly rely on the subjective judgment of the expert.

3. Grey Correlation Analysis of Grain Supply and Demand Gap in China

3.1. The Current Situation of Grain Supply and Demand Gap in China

According to experts' opinion a Chinese consumes about 370 kilograms of grain one year. Among them, 250 kg of rations, 2 kg of grain for food industry, 5 kg of grain for alcoholic beverages, and 110 kg of feed grain are included. According to this standard, 1.4 billion people in China consume about 1.04 trillion catty of grain per year [10] [11] [12] [13]. China's grain yield has exceeded 1.2 trillion catty for five years consecutively, but the import amount has risen year after year. This shows that there is an imbalance between the varieties of grain production in China. This paper analyzes the influence factors of supply and demand gaps of main grain varieties. We can find out the differences in the influence factors among the varieties in this paper. The data on grain production is obtained by the statistical yearbook, and the grain demand data is calculated by the estimate. The rations were obtained from the statistical yearbook, and the feed grain was calculated using the feed return rate of various livestock and poultry products and aquatic products proposed by the Ministry of Agriculture Information Center. The feed return rate of each livestock and poultry and aquatic products is: pork 1:2.8, beef 1:1.0, lamb 1:0.3, poultry meat 1:2.0, poultry egg 1:1.8, milk 1:0.4, aquatic product 1:0.8. In this way, the amount of feed for various livestock, poultry products and aquatic products are calculated. Industrial grain mainly includes the demand for grain in industries such as brewing, alcohol, starch processing, and biscuit biscuits. In this paper, the coefficient of consumption of white wine is 1:2.3, the beer is 1:0.15, the starch is 1:1.5, and the alcohol is 1:3. With the advancement of farming science and technology, the grain use of grain crops in China has generally declined. According to the National Agricultural Products Cost-benefit Data Compilation, the seed dosage per mu of rice, wheat and corn in China is 3.50 kg, 15.70 kg and 3.00 kg respectively. In light of the calculation and data review, the statistics on the supply and demand gap of main grain crops in China are shown in **Table 1**.

It can be seen from **Table 1** that China's total grain supply and demand can

reach a balance. But supply and demand of major grain varieties can't reach equilibrium between supply and demand. The demand of wheat in 2011 is greater than yield, but between 2012 and 2016, the supply is gradually increasing, and the gap between supply and demand is rapidly changing from negative to positive and gradually increasing. However, according to the recent import situation of high-quality wheat, it can be seen that its import quantity is increasing year by year but the export quantity is not large, indicating that there is a large amount of wheat stock every year. The remaining production of corn is always large, and the gap between supply and demand in 2014 reached 60.29 million tons. As the country's supply-side reform policy' regulation of corn production, its yield and inventory has declined in 2015 and 2016. As far as soybean is concerned, its demand has been growing rapidly, but its yield can not keep up with the demand. The gap between supply and demand is increasing year by year due to its increase of yield.

3.2. Establishment of Indicators for Influence Factors of Supply and Demand Gap

Select China's grain supply and demand gap (Y_0) as the main research object from 2011 to 2016. At the same time, based on the current social and economic development in China, this paper selects the following factors from the perspective of supply and demand as the correlation factors affecting the fluctuation of grain supply and demand gap. X_1 is the sown area of main grain varieties, which reflecting the planting area of wheat, corn, soybean and rice in a certain period of time. It is the most direct influence factor for the change of grain supply. X_2 is the yield per unit area of major grain varieties. It is a comprehensive reflection of various factors such as technological progress, investment changes, institutional innovation, and disaster climate. X_3 is disaster area of crops. It is a direct factor affecting crop production and has a direct impact on grain supply in the short term. X_4 is the total power of agricultural machinery. It reflects the level of mechanization of agriculture during a certain period of time; it is a direct influencing factor of grain supply. X_5 is the population quantity of China, which is a directly impact factors of grain demand. X_6 is per capita disposable income, which is a symbol of the level of social development and represents people' living standards. The living standards of people will affect the consumption structure of grain, which is an important factor influencing grain demand. Refer to the existing literature and the availability of data. The influence factors index selected in this paper are shown in **Table 2** [14] [15] [16].

3.3. Grey Correlation Analysis of Supply-Demand Gap and Influence Factors

The correlation degree of influences factors and the supply-demand gap are calculated by the grey combined correlation model and the results are shown in the following **Table 3**.

Table 1. Supply and demand gap of major grain varieties in China (unit: million tons).

Variety	Year	Yield	Demand	Supply-Demand Gap
wheat	2011	11740.09	12465.00	−724.91
	2012	12102.32	11765.00	337.32
	2013	12192.64	11600.00	592.64
	2014	12620.84	11780.00	840.84
	2015	13018.52	10960.00	2058.52
	2016	12884.50	11400.00	1484.50
corn	2011	19278.11	18155.00	1123.11
	2012	20561.41	18585.00	1976.41
	2013	21848.90	18775.00	3073.90
	2014	21564.63	15535.00	6029.63
	2015	22463.16	16855.00	5608.16
	2016	21955.15	19030.00	2925.15
soybean	2011	1448.53	7320.00	−5871.47
	2012	1301.09	7335.00	−6033.91
	2013	1195.10	7650.00	−6454.90
	2014	1215.40	8730.00	−7514.60
	2015	1178.50	9220.00	−8041.50
	2016	1225.00	9630.00	−8405.00
rice	2011	20100.09	19585.00	515.09
	2012	20423.59	19590.00	833.59
	2013	20361.22	19625.00	736.22
	2014	20650.74	19685.00	965.74
	2015	20822.52	19495.00	1327.52
	2016	20707.51	19470.00	1237.51

Table 2. Influence factors index of supply and demand gap.

Primary Indicators	Secondary Indicators	Code	Unit
yield	sown area	X_1	thousand hectare
	yield per unit area	X_2	kilogram/hectare
	disaster area	X_3	thousand hectare
	total power of agricultural machinery	X_4	ten thousand kilowatts
demand	population quantity	X_5	ten thousand people
	per capita disposable income	X_6	yuan

Table 3. Grey correlation degree of influence factors and supply and demand gap.

Variety	X_1	X_2	X_3	X_4	X_5	X_6
wheat	0.8473	0.8438	0.8375	0.8435	0.7805	0.8333
corn	0.7969	0.793	0.7777	0.7951	0.7406	0.8108
soybean	0.9643	0.9776	0.9595	0.9833	0.8724	0.9953
rice	0.9115	0.9125	0.895	0.9169	0.8264	0.9347

From Table 3 we can find that the ranking of influence factors of wheat supply-demand gap is: $\gamma_{11} \succ \gamma_{12} \succ \gamma_{14} \succ \gamma_{13} \succ \gamma_{16} \succ \gamma_{15}$. It can be seen that the biggest influence factor on the supply-demand gap of wheat is the sown area, followed by the yield per unit area. Sown area and yield per unit area are the most direct factors directly affecting grain production. This also shows that the change in the supply-demand gap of wheat is dominated by grain production. The ranking of influence factors of corn supply-demand gap is $\gamma_{26} \succ \gamma_{21} \succ \gamma_{24} \succ \gamma_{22} \succ \gamma_{23} \succ \gamma_{25}$. From the ranking of the influence factors we can see that the living level and sown area of the residents have the greatest impact on the change of corn' supply-demand gap. It shows that with the improvement of people's living standards and the changes in dietary structure, the demand of chicken, duck, fish and meat has increased. As a coarse grain, corn plays an important role in feed demand, so per capita disposable income has the greatest impact on corn's supply-demand gap. The ranking of influence factors of corn's supply-demand gap is $\gamma_{36} \succ \gamma_{34} \succ \gamma_{32} \succ \gamma_{31} \succ \gamma_{33} \succ \gamma_{35}$. The most influence factors are the people's disposable income and the total power of agricultural machinery. With the improvement of people's living standards and the demand for nutrition, the demand for soybean is increasing rapidly. As the main producing areas of soybeans, the three northeastern provinces are geographically sparsely populated, so they are affected by the level of mechanization. The ranking of influence factors of rice's supply-demand gap is $\gamma_{46} \succ \gamma_{44} \succ \gamma_{42} \succ \gamma_{41} \succ \gamma_{43} \succ \gamma_{45}$. Similarly, with the improvement of people's living standards, the demand of high quality rice is increasing rapidly. The distribution characteristics of the main rice producing areas makes the per capita disposable income and agricultural mechanization level have the greatest impact on the change of rice's supply-demand gap.

The sown area and yield as the main influence factors of wheat and corn's supply and demand gap, are mainly reflected in the grain supply. However, as the world's forefront in grain production, the improvement is not so large. In case that production can not be significantly increased, expanding the cultivated area is a practical adjustment method. Per capita disposable income is the biggest influence factor in the supply and demand gap of corn, soybean and rice. It can be seen that the people's living standards play a vital role in the supply and demand of China's grain. It is mainly reflected in the demand for grain. With the improvement of people's living standards, the demand for grain has changed. As

the main influence factor of soybean and rice supply-demand gap, the total power of agricultural machinery plays a significant role in the production of grain. It can pay attention to the improvement of agricultural mechanization level and increase the attention to mechanization level. We can pay attention to the improvement of agricultural mechanization level and increase the attention to the level of mechanization.

4. Conclusions

From the grey correlation degree analysis of the influence factors and the supply-demand gap, we can find that the biggest impact on the supply and demand gap of wheat is the sown area and yield per unit area. The most influence factors on corn are per capita disposable income and sown area. The biggest influence factors on soybean and rice are per capita disposable income and the total power of agricultural machinery. The supply and demand balance of main grain varieties can be improved from the following aspects.

1) Mobilize the enthusiasm of grain farmers through effective incentive mechanisms. As a major factor affecting grain production, sown area plays a vital role in the improvement of grain yield. Various grain subsidy policies can be introduced to encourage farmers to increase the grain sown area. At the same time, it is necessary to guide the moderate scale operation of cultivated land for different varieties. 2) The government should optimize the consumption structure, increase investment in scientific research, strengthen the scientific and technological research on the staple food, overcome the shortcomings of poor grain taste and easy gelatinization, and process coarse grain staple food to meet the needs of residents. 3) Strengthen the level of mechanization in agricultural development. On the one hand, it is necessary to increase the subsidy policy for agricultural machinery and mobilize the enthusiasm of farmers to purchase agricultural machinery. On the other hand, it is vital to actively promote land transfer, accelerate the scale operation of grain production, and provide a basic land platform for agricultural mechanization. In addition, we ought to develop the agricultural machinery leasing market to solve the mechanized operation of small farmers and migrant workers. Last but not least, the government should focus on cultivating large agricultural machinery service and agricultural machinery cooperation organizations to promote the promotion and application of large-scale and multi-type agricultural machinery.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this pa-

per.

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