Research on the Factors Affecting Wheat output in China

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Abstract: Wheat is rich in elements, and its demand market is huge. Studying the factors affecting wheat output is of great significance to the stable development of the wheat industry. This article firstly analyzes the factors affecting wheat output from three aspects: technical factors, planting growth factors, economic and social factors .Eleven relevant indicators from 2000 to 2019 are selected to establish an AHP model and calculate the weights of each indicator and rank them. Secondly, the fuel ethanol output, corn output, soybean output are introduced, and the data from 2005 to 2019 are used for Granger causality analysis. According to the results of empirical analysis, it is concluded that the most important factors affecting wheat output are the sown area over the years and rural electricity consumption in the planting growth factors. Fuel ethanol output and corn output also have an impact on wheat output. Adjust measures to local conditions, protect the environment, increase innovation, introduce talents and technologies, and transform agricultural scientific research results into reality， deepen the reform of the agricultural supply side, increase the fuel ethanol output, and stabilize the corn output, these are currently the main development direction to improve wheat planting efficiency and increase output.

1. Introduction

As one of the three major grains, wheat is widely used for food. Then, wheat is the feed for breeding and animal husbandry, and it is also the main raw material for wine, medicine, and condiments. At the same time, wheat can also be used in the output of chemical raw materials. Wheat is one of China's most important food rations, and the development of the wheat industry is directly related to national food security and social stability.

In recent years, our country pays more and more attention to agriculture, and pointed out to accelerate the advancement of agricultural modernization, including the expansion of the pilot scope of full cost insurance and income insurance for the three major food crops of rice, wheat, and corn. It is observed that the important position of wheat in China’s agricultural development.

Due to the impact of agricultural policy reforms, economic globalization and the new crown virus epidemic, wheat output fluctuates greatly. It is of great significance for ensuring the stable and healthy development of the wheat industry to study the influencing factors of wheat output.

2. Literature review

2.1 Research on the influencing factors of grain output

In terms of factors affecting grain output, most scholars have carried out corresponding researches on this through the establishment of various models. Li Haoru et al. (2018) used the HP filter method to analyze the fluctuation characteristics of my country's grain output since the reform and opening up, and used the combination of Grey Relation Analysis and AHP model to analyze the degree of influence of each influencing factor on my country's grain output. Li Xinhui et al. (2016) selected 8 indicators and used Principal Component Analysis to analyze the main factors affecting grain output,

and found that the grain output in Henan Province was significantly linearly correlated with the first principal component, and there was no obvious correlation with the second principal component. Li Zilin et al. (2020) constructed a structural equation model to analyze the influencing factors of cultivated land productivity in Gao'an City, and concluded that soil nutrients, farmland water conservancy and soil properties have a direct or indirect positive influence on cultivated land productivity.

2.2 Literature review

In summary, there are many researches on the influencing factors of grain output that provide the basic theories and ideas for this article. In recent years, most scholars have carried out corresponding researches on soybeans, rice, cotton and other crops, but relatively few researches on wheat. Some researches related to wheat are relatively long ago, and a series of changes brought about by certain policy changes could not be reflected in previous studies. Therefore, based on the country's emphasis on the "three rural issues" and the promotion of agricultural supply-side structural reforms and other policies, this article uses various models to get the ranking of the importance of the various factors affecting wheat output, and then introduces the wheat related product index and its substitute output to conduct Granger causality test. Finally summarizes the conclusion, puts forward the correlation proposal.

3. Research data and statistics

3.1 Data sources

The object of this research is the wheat output in China. The data collected online is adopted, and the relevant data needed for this research can be found in the *China Rural Statistical Yearbook* and *China* Statistical *Yearbook*. This article selects the data of eleven indicators from 2000 to 2019 for analysis.

3.2 Descriptive statistics of factors influencing wheat output

For the research on the factors affecting wheat output, this paper selects 11 indicators, of which the national fiscal agricultural expenditure data are data from 2008 to 2019, and the remaining 10 variables are data from 2000 to 2019. Select wheat output as the dependent variable and 11 indicators as independent variables. The descriptive statistics of each variable are as follows:

Table 1. Descriptive statistics of indicators affecting wheat output

Variable	Obs	Mean	Std. Dev.	Min	Max
Wheat output	20	19487.35	1553.079	16066.0	21268.0
Effective irrigation area	20	60313	5416.214	53820.3	68678.6
Amount of chemical fertilizer used in rural area	20	5258.44	642.2811	4146.4	6022.6
Large and medium tractor ownership.	20	3425965	2048593	829900	6700800
Sown area over the years	20	34020.2	7851.494	23056	44968
Rural employed population.	20	41806.9	5132.824	33224	48934
Rural electricity consumption.	20	6366.785	2512.812	2421.3	9524.4
Plastic film usage amount in rural areas.	20	2087595	423396.9	1335000	2603561
National fiscal agricultural expenditure	12	5216.85	1354.506	2278.9	6554.7
Damaged area of crops	20	35960.3	12177.23	18478	54688
Average temperature	20	9.8285	0.4402305	9.1	10.09
Total output value of wheat per mu.	20	693.5630	269.9293	283.48	1052.96

Table 2 Correlation coefficient table of wheat output and each index

Wheat output	Correlation coefficient	Wheat output	Correlation coefficient
Average temperature	0.5455	Damaged area of crops	-0.8602
Rural electricity consumption	0.9230	Rural employed population	-0.9157
Amount of chemical fertilizer used in rural area	0.8943	National fiscal agricultural expenditure	0.9645
Effective irrigation area	0.9292	Plastic film usage amount in rural areas	0.9112
Total output value of wheat per mu	0.9281	Sown area over the years	0.9419
Large and medium tractor ownership	0.9246		

This paper uses eviews software to calculate the correlation coefficients between each index and wheat output. It can be seen from the correlation coefficient table that the average temperature and wheat output have a relatively obvious positive correlation. Rural electricity consumption, amount of chemical fertilizer used in rural area, effective irrigated area, total output value of wheat per mu, large and medium tractor ownership, national fiscal agricultural expenditure, plastic film usage amount in rural areas and sown area over the years were positively correlated with wheat output. The damaged area of crops and rural employed population are obvious negatively correlated with wheat output.

4. An Empirical Analysis of Factors Affecting Wheat output

4.1 Analytic Hierarchy Process

AHP is a theory of operations research that combines qualitative and quantitative methods. It is often used in multi-plan or multi-objective decision-making.In the face of unstructured and complex problems, it is divided into multiple levels, and its elements are analyzed in a hierarchical manner and comprehensively evaluated according to the objectives, which is practical.

4.1.1 Establishment of Indicators

The eleven indicators that affect wheat output are classified into each criterion level, and a hierarchical model of the factors affecting wheat output is established. Its hierarchical structure is shown in the following table:

Table 3. Index system of the factors affecting wheat output

Target layer	Criterion layer	Scheme layer
Influencing factors of wheat output (I)	Technical factors (T)	Effective irrigation area (T1)
		Amount of chemical fertilizer used in rural area (T2)
		Large and medium tractor ownership (T3)
		Plastic film usage amount in rural areas(T4)
	Planting growth factors (G)	Sown area over the years (G1)
		Rural electricity consumption (G2)
		Damaged area of crops (G3)
		Average temperature (G4)
	National fiscal agricultural expenditure (S1)	

	Economic and social factors (S)	Rural employed population (S2)
		Total output value of wheat per mu (S3)

4.1.2 Indicator calculation

After determining the indicators, according to the principles of the AHP model, the indicators are compared in pairs to construct a judgment matrix. First, assign values to the elements in the pairwise judgment matrix with a scale of 1-9, make group decision based on expert scores and data obtained from literature review, and calculate the results through related formula calculations and Matlab corresponding programs to obtain the weights of each indicator , and multiply the weights of each level to get the comprehensive weight ranking. The higher the weight, the higher the influence of this indicator on wheat output. Calculated as follows:

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(QW)_i}{W_i} \tag{1}$$

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{2}$$

$$CR = \frac{CI}{RI} < 0.1 \tag{3}$$

Where Q is the m*m order matrix, Qm*m=qij, n represents the dimension, λmax represents the maximum eigenvalue of the judgment matrix Q, Wi represents the degree of influence of each index, W is the normalized eigenvector corresponding to λmax, CI is the consistency index. CR is the random consistency ratio. When it is less than 0.1, the judgment matrix can be considered to have satisfactory consistency. When calculating the weight of each index, this paper uses the arithmetic average method, geometric average method and eigenvalue method to calculate the weight respectively, and the final weight takes the average of the results obtained by the three methods.

Table 4 Nine-point scale table

Scale aij	definition
1	Indicates that compared to two factors (i and j), i and j are equally important
3	Indicates that compared to two factors (i and j), i is slightly more important than j
5	Indicates that compared to two factors (i and j), i is obviously more important than j
7	Indicates that compared to two factors (i and j), i is more important than j
9	Indicates that compared to two factors (i and j), i is extremely important than j
2，4，6，8	The median value of the above adjacent judgment
Reciprocal of scale value	Inverse comparison of i and j

Table 5 Consistency inspection index RI

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

4.1.3 The process of analytic hierarchy process of factors affecting wheat output

Table 6 Target layer-criterion layer judgment matrix and weight

I	T	G	S	W1	W2	W3	W
T	1	1/4	5/2	0.2172	0.2137	0.2137	0.2149
G	4	1	5	0.6729	0.6786	0.6786	0.6767
S	2/5	1/5	1	0.1099	0.1077	0.1077	0.1084

After constructing the judgment matrix, check it through the related program of Matlab software, and get CI=0.0268, CR=0.0516, so the consistency test is passed, the consistency test of the judgment matrix is acceptable, and the same is true for the following judgment matrix tests. In the table, W1, W2, and W3 represent the results of arithmetic average method, geometric average method, and eigenvalue method respectively, and W represents the average of the results obtained by the three methods.

Table 7 T-TL judgment matrix and weight

T	T1	T2	T3	T4	W1	W2	W3	W
T1	1	2	3	1/3	0.2346	0.2334	0.2332	0.2337
T2	1/2	1	5/3	1/4	0.1329	0.1326	0.1315	0.1323
T3	1/3	3/5	1	1/5	0.0885	0.0878	0.0876	0.0880
T4	3	4	5	1	0.5441	0.5462	0.5477	0.5460

CI=0.0126, CR=0.0142<0.10

Table 8 G-GL judgment matrix and weight

G	G1	G2	G3	G4	W1	W2	W3	W
G1	1	2	3	5	0.4658	0.4690	0.4681	0.4676
G2	1/2	1	5/2	4	0.2984	0.2997	0.2998	0.2993
G3	1/3	2/5	1	3	0.1627	0.1594	0.1600	0.1607
G4	1/5	1/4	1/3	1	0.0731	0.0720	0.0721	0.0724

CI=0.0256, CR=0.0288<0.10

Table 9 S-SL judgment matrix and weights

S	S1	S2	S3	W1	W2	W3	W
S1	1	1/2	3	0.3202	0.3196	0.3196	0.3198
S2	2	1	4	0.5571	0.5584	0.5584	0.5580
S3	1/3	1/4	1	0.1226	0.1220	0.1220	0.1222

CI=0.0091, CR=0.0176<0.10

4.1.4 Result analysis

All the above matrix consistency tests have passed, and it can be considered that the importance of the index weights in each level is consistent. Multiply the weights of each level to get the final weight, the final weight is as follows:

Table 10 The total ranking of target layer index weights

Target layer	Criterion layer	Index layer	Total score (ranking)
Influencing factors of wheat output (I)	Technical factors (T) (0.2149)	Effective irrigation areaT1(0.2337)	0.05022213(6)
		Amount of chemical fertilizer used in rural areaT2(0.1323)	0.02843127(9)
		Large and medium tractor ownership T3(0.0880)	0.01891120(10)
		Plastic film usage amount in rural areasT4(0.5460)	0.11733540(3)
	Planting growth factors (G) (0.6767)	Sown area over the years G1(0.4676)	0.31642492(1)
		Rural electricity consumptionG2(0.2993)	0.20253631(2)
		Damaged area of cropsG3(0.1607)	0.10874569(4)
		Average temperatureG4(0.0724)	0.04899308(7)
	Economic and social factors (S) (0.1084)	National fiscal agricultural expenditureS1(0.3198)	0.03466632(8)
		Rural employed populationS2(0.5580)	0.06048720(5)
		Total output value of wheat per muS3(0.1222)	0.01324648(11)

It can be seen from the above table that planting growth factors have the greatest impact on wheat output. Among the eleven indicators, the sown area has the largest impact on wheat output, followed by rural electricity consumption. Compared with other industries, agriculture is more dependent on the natural environment, and proper planting and growth conditions are more beneficial to the growth of crops.

4.2 Granger causality analysis of factors affecting wheat output

In the case of time series, the Granger causality between the two variables X and Y is defined as: if the past information of the variables X and Y is included, the predictive effect of the variable Y is better than that of Y alone. The predictive effect of the past information on Y, that is, the variable X helps explain the future changes of the variable Y, and then the variable X is considered to be the Granger cause of the variable Y.

4.2.1 Unit root test

Before the Granger causality test, it is necessary to ensure that the time series must be stable. According to the existing research, this paper takes the logarithm of the corn output, soybean output and fuel ethanol output to process.The unit root test results of the processed series show that the first-order difference series of wheat output, soybean output, and fuel ethanol output are all stable at the 1% significance level，and the first-order difference sequence of corn output is stable at a significance level of 10%, and each variable is a first-order single integer sequence.

Table 11 Unit root test results of each variable

Variate	ADF Statistics	P value	conclusion
Wheat output	**-5.555891**	**0.0008**	**steady**
Corn output	**-3.619309**	**0.0686**	**steady**
Soybean output	**-8.699134**	**0.0001**	**steady**
Fuel ethanol output	**-4.137568**	**0.0005**	**steady**

4.2.2 Granger causality test

This paper selects wheat output, corn output, fuel ethanol output, and soybean output data from 2005 to 2019. Firstly, the lag period is determined according to the minimum principle of AIC or SC. It can be seen from Figure 1 that the unit roots all fall within the unit circle. It shows the rationality of lagging 2 periods,passed the stability test of the model.

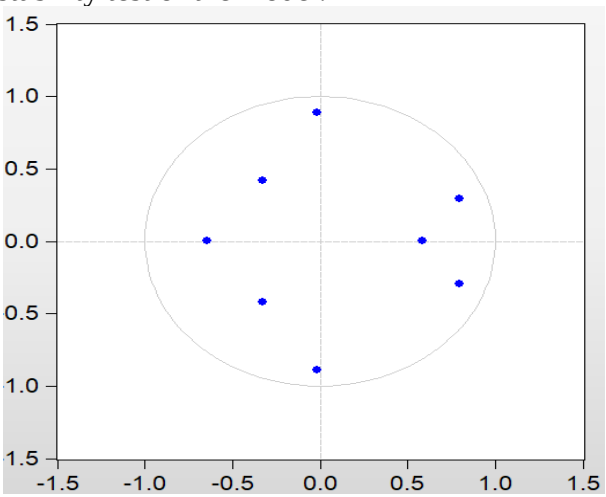

Figure 1 AR unit root test results

Table 12 Granger test of each variable

Null hypothesis	F value	P value
Fuel ethanol output is not the Granger reason for wheat output.	6.85561	0.0184
Wheat output is not the Granger reason for fuel ethanol output.	1.95978	0.2029
Corn output is not the Granger reason for wheat output.	5.87155	0.0270
Wheat output is not the Granger reason for corn output.	1.74143	0.2356
Soybean output is not the Granger reason for wheat output.	1.09234	0.3807
The Granger reason that wheat output is not soybean output.	0.46234	0.6456

The above table shows the results of the Granger causality test with 2 lags. It can be seen from the above table that fuel ethanol output is a one-way Granger causality of wheat output, and corn output is a one-way Granger causality of wheat output. The Granger causality of other variables and wheat output is not very strong.

5. Relevant recommendations

This article argues for several countermeasures to the research results, the main countermeasures are as follows:

Provide the most suitable environment for wheat growth, adjust measures to local conditions, increase protection of the environment, especially land and water resources, increase investment in farmland water conservancy, and ensure sufficient water resources for irrigation.

Scientific farming, increasing innovation, accelerating agricultural modernization and improving planting efficiency. Introduce relevant technical talents, rationally use chemical fertilizers and pesticides, provide technical guidance to farmers, prevent rust, prevent pests, prevent bunting, total rot and powdery mildew, etc., and enhance protection against climate change and natural.

Increase the emphasis on agriculture, formulate relevant agricultural product price protection policies, transform agricultural scientific and technological achievements into actual farming, formulate incentive policies, encourage the participation of various universities and scientific research units, promote agricultural development, and increase crop output.

Do a good job in the adjustment of the planting area of wheat and other alternative crops, deepen the structural reform of the agricultural supply side, and maintain the stability of the grain planting area.

Fuel ethanol output has an impact on wheat output. As corn is a substitute for wheat, changes in its output may also cause fluctuations in wheat output. Increasing fuel ethanol output and stabilizing corn output will be more conducive to wheat output growth.

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