Analysis of the Factor Input Constraint on China's Grain Production

Jing HAN，Xin-hai LU and Xi YANG，China

Key words: grain production; factor input; influencing factors; cultivated land; food security

Summary

The purpose of this paper is to analyze China’s grain production factor inputs since its reform and opening-up，find out the factors that affect China's food production at different stages. Methods applied in this paper include Say’s Three Elements Theory and Grey Correlation Model. The result shows that the influencing factors in different phases are distinctly different. In the phase of household contract responsibility system effect from 1978 to 1989, the agricultural fiscal expenditure has the greatest effect on the grain production than food production; in the phase of the smoothly running institution from 1990 to 2001, the effective irrigation area has the greatest impact on the grain production; In the phase after China's joining the World Trade Organization from 2002 to 2011, the grain acreage has the greatest influence on the grain production. In conclusion，from the perspective of factor input, China's grain production has been heavily dependent on the element of land, and the cultivated land is the most significant factor input that constraining China's grain production since the reform and opening up. Therefore, the most effective means is to break constraining effect of the cultivated land on grain production. It is considered helpful to reduce production factor's constraining effect on food supply by releasing the internal pressure of the cultivated land through the establishment of overseas farmland investment strategy in the implementation of the agriculture “going out” strategy.

摘要

研究目的：对中国改革开放以来粮食生产的要素投入情况进行了分析,揭示不同阶段影响中国粮食生产的要素。研究方法：本文借鉴萨伊三要素理论，构建灰色关联模型。研究结果:在改革开放以来的不同阶段，影响中国粮食生产的要素呈现出明显差异。在1978-1989 的家庭联产承包责任制效应阶段，农业财政支出额对粮食生产影响最大，在1990-2001 的制度平稳阶段，有效灌溉面积影响最大；在 2002-2011 的加入世贸组织后阶段，粮食播种面积影响最大。研究结论：从要素投入角度看，中国改革开放来的粮食生产对土地要素的依赖非常大，耕地是约束中国粮食生产最为重要的要素投入。因此，中国保障粮食供应量的最有效手段就是破解耕地对粮食生产的约束，可以考虑在农业“走出去”战略实施过程中，通过建立海外耕地投资战略以释放中国内部耕地承载压力，缓解粮食供给的生产要素约束。

关键词：粮食生产；要素投入；影响因素；耕地；粮食安全

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1. INTRODUCTION

Food is the first necessity of the people. At all times and in all countries, food security has always been the chief strategic issue for the rulers to ensure social stability. Since the reform and opening up, China's total grain production increased from 3.21 billion tons in 1980 to 6.02 billion tons in 2013, the net growth was 2.81 billion tons. However, the food security situation in China is not optimistic because of the rapid reduction of arable land, the continuous decline of farmland quality, the worsening of environmental pollution, the tightening of water resources constraints and the increasing trend of grain finance. In fact, China's net food imports have been expanding in recent years, and the rate of self-sufficiency in grain has frequently fallen below 95% of the national food security cordon. Starting with the year of 2012, China's three major grain varieties are rice, wheat and corn that have all been converted into net importers. The latest data show that China's net food imports are 18.747 million tons in 2014 which increase 33.8%, the net imports of rice, wheat and corn are normalized, and the internal resource support for food security is obviously weak. In January 2015, the Ministry of Agriculture leaders said for promoting the potato become China's fourth staple food, but also aroused the general concern of the people. In the context of the continuous increase in global food prices and the growing scale of Chinese net food imports, it is necessary to re-examine the issue of grain production and food security in China, in the face of the reality of double growth in domestic grain production, net food imports, and the dire food security situation.

China's food security has always been the focus of academic circles, especially the source of grain production increase is a concern of academia. It is believed that the factors affecting China's grain production can be divided into three aspects, the one is institutional factors, such as the household contract responsibility system, agricultural tax reform, accession to the WTO and so on,once determined, it has long term and stability; The two is natural factors such as climate change, which often have wide range and uncontrollable nature ;The three is the input of production factors, such as land, capital, labor, etc, which has obvious quantifiable and controllability [1-4]. Therefore, on the basis of institutional analysis, this paper divides grain production since China's reform and opening-up into three time periods :a household contract responsibility system effect stage (1979-1989) ,a stable stage (1990-2001) and the post-WTO stage (2002-2011), then using the Say's Three Elements Theory and Grey System Theory, the Grey Relational Analysis Model is applied to the key analysis of the input of production factors in China's grain production in 1979-2011 years.In order to clarify the restriction of the dominant

factor of production to the grain production in China, the article focuses on the production factor input of grain production, and provides a reference for formulating the macro grain security policy.

2. LITERATURE REVIEW

The effect of production factors such as land, capital and labor force on grain production in China has been paid more attention by relevant researchers, and the academic circles have made a relatively deep research on this problem. Fu Zeqiang and other scholars believe that arable land is the fundamental resource to support China's grain production, and the large amount of cultivated land has had an important impact on China's grain production, so it is necessary to pay great attention to the maintenance and quality improvement of arable land.[5-7]. Liu Yansui thinks water and soil resources jointly restrict the increase of grain production in China, both shortage and spatial mismatch are the important factors that affect China's grain yield [8]. There are also studies that the decline of land quality in China has a significant negative impact on grain production in China, under the existing Chinese land fertility decline trend, this problem will lead to reduce 9% Chinese grain production in 2030[9,10] . The research on the labor force shows that the non-agricultural transfer of rural labor force has a significant positive effect on the improvement of grain production technology efficiency, especially in the balance zone of grain production and marketing, the labor force transferring has a great effect on the improvement of grain productivity, and the surplus phenomenon exists in Chinese rural labor force [11]. In fact, the decline in the quantity and quality of arable land has seriously affected China's food production capacity, and China must ensure its food security by supplementing the element input method [12].

The decrease of arable land caused by urbanization and the influence of related factors of production from agricultural sector to non-agricultural sector on China's food security have also attracted the attention of scholars [13,14]. The expansion of irrigation area is important to the increase of Chinese grain production, the output is about 75% in China originates from irrigated arable land, but every cubic meter of agricultural water in China produces food only 0.85KG, only half of the developed countries, increasing the utilization rate of water resources is very important for China's grain production[15]. Research on the relationship between grain production and irrigation area in China,there are absolute three kinds of relations: absolute decoupling, quasi relative decoupling and coupling. In the contribution rate of arable land, quasi-relative decoupling provinces are higher than the coupled provinces; In the contribution rate of fertilizer dosage, quasi relative decoupling provinces are lower than the coupled provinces. The relationship between the input of agricultural labor force and grain yield are negatively correlated[16].

In the research methods, various research methods such as C-D production function model, multiple regression model, panel analysis model and ridge regression analysis have been applied to the analysis of the influencing factors of grain production in China [17-19]. In the selection of factors of production, scholars mostly use the quantitative method to analyze the time-series data of grain production in China. The main use of grain yield, grain sown area, arable land, irrigated area, disaster area, fertilizer application, agricultural mechanical power and other variables to build a measurement model to analyze its impact on China's grain production.

Judging from the current research progress, considerable achievements have been made in the academic input into the key elements of grain production in China. The impact of resource constraints on food security in China is increasingly spuring academic attention [20]. However, there are also some scholars who dispute the impact of relevant factors on food production. For example, Chen and Baixue think that the change of arable land area has little effect on the grain output in China [11,21]. The reason are mainly in the following two points: firstly the model set the lack of theoretical support; secondly the National Bureau of Statistics released a leap in cultivated land area data. For the first point, its performance mainly has two aspects: (1) quantitative analysis pursues long-time span, ignores the theoretical analysis of the impact of institutional inputs on food production; (2) the model construction itself ignores the theoretical support, thus reducing the accuracy of the model. The second point is mainly due to the significant jump in the official cultivated area data between 1995 and 1996, which leads to a decrease in the model adaptability of the data and a large analysis error. Therefore, based on the analysis of relevant systems, this paper intends to use Say theory and gray system theory to analyze the input and constraint of China's grain production in three phases ,in order to base on the existing grain production and factor input in China What elements of data and system deconstruction have constrained China's grain production.

3. THEORETICAL ANALYSIS AND MODEL CONSTRUCTION

3.1 Theoretical Analysis

Modern western economics believes that the factors of production consist of four elements: land, capital, labor and entrepreneurial talent.This section mainly analyzes the impact of factor inputs on food production and takes the fact that grain production in China is mainly dominated by peasants into account. We excluded the factor of entrepreneurial ability in the model construction that is adopting Three Elements of Production Theory of Say, building an analytical framework only containing the three elements : land, capital and labor, the production function is as follows:

$$Q = f(\mathrm{T}, \mathrm{C}, \mathrm{L}) \qquad (1)$$

Among them, Q represents grain output; T represents land element; C represents capital element; L represents labor element.

3.2 Data Sources

According to the reality of food production, the land elements used in this study include five variables in two aspects: (1) In terms of quantity, cultivated area (X1, unit: thousand ha), sown area of grain (X3, unit: thousand ha); (2) In terms of quality, chemical fertilizer application (X4, unit: million t), effective irrigation area (X5, unit: thousand ha). The capital elements include the following three variables: the average production expenditure of rural residents (X6, unit: yuan / person), the average net income of rural residents (X7, unit: yuan / person), the state fiscal agricultural expenditures (X8, unit: one hundred million yuan); The labor force factor includes the following three variables: labor inputs for food production (X9, unit: ten thousand people), rural electricity consumption (X10, unit: 0ne hundred million KW-h), the total power of agricultural machinery (X11, unit: 0ne hundred million W); Grain yield (Y, unit: ten thousand t) as dependent variable. Of the above variables, the cultivated land area data from 1979 to 2005 were derived from the reconstruction data of Wu Qun (2006). From 2006 to 2008, the data came from *China Statistical Yearbook 2012* and from 2009 to 2011 in the UN Food and Agriculture Organization database[1]. The average production expenditure of rural residents is calculated according to the following formula:

$$X_6 = RLAI(1-r\%) - RLALC \qquad (2)$$

Among them, RLAI represents the average net income of rural residents; r% represents average saving rate for farmers; RLALC represents average living expenses for rural residents spending; The above three sets of data were obtained from China Statistical Yearbook over the years.

The amount of grain production labor input is calculated according to the following formula:

$$X_9 = \frac{CPA}{TPA} \times AL \qquad (3)$$

Among them, CPA represents the sown area of food crops; TPA represents agricultural population; The above three sets of data were obtained from China Statistical Yearbook over the years. The remaining variables are derived from the *China Statistical Yearbook*, *China Rural Statistical Yearbook* and *China Agricultural Statistics Compilation (1949-2004)* and *China Rural Development Report*.

3.3 Model Building

[1] In order to overcome in the statistics of cultivated area of 1995-1996 years of "cliff" statistical data is not complete defects, multiple data sources are used here.

This paper uses the grey system theory to construct the model to analyze the factor input of grain production in China. The grey system theory which is parallel with probability statistic and fuzzy mathematics is the research method of analyzing uncertainty system, the maximum advantage of this method is applicable to arbitrary distribution of variable, and it can find out the reality rules through excavating small amount of data. According to the above production function theory, there is a functional relationship between input of each factor and grain production, but this function relation is not definite. Therefore, we can regard grain production as a grey system, using grey relational analysis to analyze the above problems. The basic idea of grey relational analysis judges whether the relationship is close by the similarity degree of the geometric shape of the sequence curve, the closer the curve, the greater the association degree between the corresponding sequences.

In this study, the grey relative relational degree measurement model is used to analyze the problem. The idea of grey relative relational degree is to characterize the interrelationship between the rate of change of different data series groups relative the starting points, the closer the rate of change between the two sets of data, the greater the grey relative relational degree, the smaller the other hand. In this study, we construct grey relational degree model between grain yield data sequence and each factor input index sequence in the three stages of research design, and analyze the influence of each factor input index on grain yield by comparing its grey relative degree. Because of the same time interval between the variables, it do not consider the time-distance transformation, and the grey relative relational degree analysis model building steps are as follows:

The first step：find the initial value image

$$X_i^{'} = \left(\frac{x_0(1)}{x_0(1)}, \frac{x_0(2)}{x_0(1)}, \cdots, \frac{x_0(n)}{x_0(1)}\right) \quad (4)$$

Among them， $x_0(n)$ is a sequence， n is the number of sequence elements

The second step：find the starting point of zero image

$$X_i^{'0} = (x_i^{'}(1) - x_i^{'}(1), x_i^{'}(1) - x_i^{'}(2), \cdots, x_i^{'}(n) - x_i^{'}(1)) \quad (5)$$

Among them， $x_i^{'}(n)$ is the initial value of the sequence element

The third step：calculate the relative degree of gray relative

$$\left|s_0^{'}\right| = \left|\sum_{k=2}^{n-1} x_0^{'0}(k) + \frac{1}{2} x_0^{'0}(n)\right| \quad (6)$$

$$\left|s_i^{'}\right| = \left|\sum_{k=2}^{n-1} x_i^{'0}(k) + \frac{1}{2} x_i^{'0}(n)\right| \quad (7)$$

$$\left|s_i^{'} - s_0^{'}\right| = \left|\sum_{k=2}^{n-1} (x_i^{'0}(k) - x_0^{'0}(k)) + \frac{1}{2}(x_i^{'0}(n) - x_0^{'0}(n))\right| \quad (8)$$

$$\gamma_{0i} = \frac{1 + \left|s_0^{'}\right| + \left|s_i^{'}\right|}{1 + \left|s_0^{'}\right| + \left|s_i^{'}\right| + \left|s_i^{'} - s_0^{'}\right|} \quad (9)$$

Among them， k is the Kth element of the sequence， γ_{0i} is the relative degree of gray relative

4 RESULT ANALYSIS

4.1 The effect Stage of Family Contract Responsibility System

According to the calculation result of grey relative relational degree, it can be found that there are obvious differences in the factors that influence Chinese grain production in different stages since reform and opening-up (table 1). In the period of household contract responsibility, there are 5 important factors affecting the grey relative correlation degree between the selected factor input index and grain yield over 0.7, namely, fiscal agricultural expenditure, grain sown area, grain production labor force, disaster areas and cultivated area, one of the most influential factors for grain production is fiscal agricultural expenditure which grey relative degree is over 0.8reaching 0.8432. During1979-1989 China's grain production increase from 330 million tons to 410 million tons, the state's total investment in agricultural funds is 184.264 billion yuan, and average annual investment is about 16.751 billion yuan. From the results of grey relational analysis, it can be inferred that the capital investment in this stage has greatly promoted the increase of grain production in China. From the point of view of land, capital and labor factor input, and at this stage the differences between the factors that have an important impact on China's grain production is not obvious. According to the results of current theoretical research and the grey relational analysis of this study, in addition to the factors of institutional change it can be inferred that the resultant forces from the above three factors contribute to the improvement of grain production in China.

Tab. 1 Relative degree of grey incidence between factor input indicator and grain production

Stage 1 （1979-1989）	γ_{0i}	Stage 2 （1990-2001）	γ_{0i}	Stage 3 （2002-2011）	γ_{0i}
Fiscal agricultural	0.8432	Effective irrigation	0.9569	Sown area of grain	0.9942

expenditure**		area**		**	
Grain sown area*	0.7962	Cultivated area**	0.8549	Disaster area **	0.9083
Grain production labor force*	0.7756	Grain production labor force **	0.8440	Grain production labor force **	0.8754
Disaster area*	0.7113	Sown area of grain**	0.8250	Fertilizer application**	0.8587
Cultivated area*	0.7003	Agricultural machinery total power	0.6223	Effective irrigation area **	0.8387
Effective irrigation area	0.6777	Fertilizer application	0.6171	Cultivated area *	0.7544
Agricultural machinery total power	0.6582	Disaster area	0.5926	Production expenditure of rural residents	0.6297
Fertilizer application	0.6395	Rural electricity consumption	0.5478	Net income of rural residents	0.6044
Rural electricity consumption	0.6066	Net income of rural residents	0.5372	Rural electricity consumption	0.6033
Net income of rural residents	0.5683	Fiscal agricultural expenditure	0.5349	Fiscal agricultural expenditure	0.5376
Production expenditure of rural residents	0.5665	Production expenditure of rural residents	0.5204	Agricultural machinery total power	0.5268

** Indicates that the effect of this factor on grain yield is over 0.8； * Indicates that the effect of this factor on grain yield is over 0.7

4.2 System Stable Stage

In the steady stage of the system, four factors have an important impact on the grain production of China，and the gray correlation degree of these four factors to the grain yield all exceeded 0.8: effective irrigated area was 0.9569, arable land area was 0.8549, grain production labor force was 0.8440, grain sown area was 0.8250.Moreover, the gray relative relativity values of the various factors at this stage and the grain yield showed a strong clustering difference.In addition to the above important factors, the relative gray level of other factors and grain yield did not exceed 0.63, this shows that the effect of different indicators of inputs on grain production at this stage has obvious differences. According to the data of China's grain output and each factor input from 1990 to 2001,the input of effective irrigation area, cultivated area, food production labor force and grain sown area at this stage, all above have a significant impact on the protection of China's grain production capacity, taking the effective irrigation area that

has the greatest impact on food production .For example, China's effective irrigated area expanded by 6.84636 million hectares between 1990 and 2001.It can be inferred that an improvement in the basic conditions of production in agriculture strongly contributes to an increase in food production at this stage. At this stage, the relative relativity of gray level more than 0.7 also changes obviously compared with the first stage: the importance of effective irrigated area increased rapidly from 6th in stage 1 to 1st in stage 2, and the relative gray level increased from 0.6777 to 0.9569; The influence of arable land on food production also significantly increased from No. 5 in the first phase to No. 2 in the second phase, and the gray relative correlation degree increased from 0.7003 to 0.8549 which also reflects the importance of cultivated area in the second stage of food production. The order of the labor force for food production has not changed, but the relative gray relation has been raised from 0.7756 to 0.8440.Although the importance of the sown area of grain to food production declined from the second place in the first stage to the fourth in the second stage, its relative gray relation increased from 0.7962 to 0.8250; It is noteworthy that the importance of fiscal agriculture spending decrease rapidly, the relative gray level dropped from 0.8432 to 0.5349; The order of disaster area also declined and the relative gray relation also dropped from 0.7113 to 0.5926.

From the perspective of land, capital and labor input, the land and labor forces in the second phase have the most obviously impact on food production. In particular, the importance of the land factor is clearly highlighted. Among the four factors with a relative gray correlation are more than 0.8, there are three factors that can be attributed to land elements. Therefore, it can be inferred that in the second stage of grain production, the land factor has an important impact on grain production, followed by the labor factor, indicating that China still relies on land and labor input to ensure food production and is still in extensive mode food production stage.

4.3 After Entering the WTO Stage

In the post-WTO accession phase, six factors have had a significant impact on China's grain production, among them five factors have a gray correlation degree above 0.8. Respectively, the sown area of grain was 0.9942, disaster area was 0.9083, grain production labor was 0.8754 and fertilizer use was 0.8587, and the gray relative degree of cultivated land was 0.7544. Since 2002, China's grain output has been steadily increasing. By the end of 2011, China's grain output has reached 570 million tons, a net increase of 110 million tons over 2002. Combined with the common sense of economics, this stage of China's grain production input data and gray correlation analysis results can be inferred: during this period, the positive effect of grain sown area, food production labor force, chemical fertilizer application and cultivated area on the improvement of grain output in China, if the area of grain sown with the greatest impact on grain output during this period will be expanded from 104 million hectares in 2002 to 162 million in 2011, a net increase will be achieved 588 million hectares in 9 years, reflecting the

importance of sown area for increased grain production at this stage; The affected area had an inhibitory effect on food production in China at this stage. Statistics show that the 2011 national disaster area reached 33 million hectares, a net increase of 6 million hectares over the 27 million hectares in 2002. At this stage, the relative relativity of gray level more than 0.7 also changed obviously compared with the second stage: The importance of sown area of grain was once again raised from No. 4 in Phase 2 to No. 1 in Phase 3, and the relative gray level increased from 0.8250 to 0.9942. The impact of the disaster area at this stage also highlighted, from the second phase of the seventh substantial increase to the second of this stage, the relative relativity of gray from 0.5926 substantial increase to 0.9083, it also reflects the inadequacy of China's agricultural anti-disaster capability. The order of the labor force for food production has not changed, but its relative gray relation has been raised again from 0.8440 in the second stage to 0.8754 in the third stage; The importance of chemical fertilizer application has also been highlighted, from the sixth phase of the second phase to the fourth of this phase the gray relative correlation increased from 0.6171 to 0.8587; The order of effective irrigated area decreased, from the first stage of the previous stage to the fifth stage of this stage, and the relative gray level also dropped from 0.9569 to 0.8387; The importance of arable land also declined. From the second place in the previous stage to the sixth in the current stage, the relative gray level also dropped from 0.8549 to 0.7544. In terms of land, capital and labor input, the impact of land and labor forces on food production is still the most obviousin the third phase.The importance of land factor is further highlighted. When the relative gray correlation degree exceeds 0.7 is six factors,and five factors are attributed to land elements. Therefore, it can be concluded that in the third phase of food production, land has become the most important factor that affects China's grain production,followed by the labor force, and also reflects the key element is the land element that China's current dependence on land inputs for grain production to crack the current grain production constraints.

5. RESEARCH CONCLUSIONS AND ENLIGHTENMENT

Comprehensively examining the gray analysis results of various stages from the perspective of factor input can clearly find that China is facing constraints on the input of grain production. That is China is facing a shortfall in production factors in terms of supply. From the mean value of relative degree of grey incidence of various factors like supporting land, capital and labor forces and their changing rules at all phases, Since China's reform and opening up, land has become the most important factor of grain production, followed by labor, and finally capital, especially the land element, the mean value of relative degree of grey incidence of its supporting factors remained above 0.7 (Table 2).

Tab. 2 Relative degree of grey incidence among factors of different phases

Stage 1			Stage 2			Stage 3		
Indicator	Mean	Value of	Indicator	Mean	Value of	Indicator	Mean	Value of

	relative degree of grey incidence		relative degree of grey incidence		relative degree of grey incidence
land	0.7050	land	0.7693	land	0.8709
#quantity	0.7359	#quantity	0.7575	#quantity	0.8856
#quality	0.6586	#quality	0.7870	#quality	0.8487
labor	0.6801	labor	0.6714	labor	0.6685
capital	0.6593	capital	0.5308	capital	0.5906

It can also be seen from the above results that the important role of land elements in food production in China is still gradually evolving over time, the mean value of relative degree of grey incidence of its supporting factors increase from 0.7050 in the first phase to 0.7693 in the second phase, and finally to 0.8709 in the third phase. This also reflects that the importance of cultivated land to grain production in China is also becoming increasingly clear. In addition, the change of the mean value of relative degree of grey incidence of quantity and quality in the two dimensions of land elements confirms the above point of view once again. In terms of quantity, the mean value of relative degree of grey incidence reflecting the quantity of land increased from 0.7359 in the first phase to 0.7575 in the second phase, especially enlarged to 0.8856 in the third phase, reflecting that as the decrease of the amount of cultivated land in China, its binding force on grain production in China also converged; As quality, the mean value of relative degree of grey incidence of the factor which reflected the land quality increased from 0.6586 in the first stage to 0.7870 in the second stage, reaching 0.8487 in the third stage finally. Its value expanded nearly 20 percentage points in the three stages. On the one hand, it reflects that the quality of cultivated land has been significantly improved since China's reform and opening up, and it had an important impact on food production. On the other hand, it also reflects that the dependence of gain production on the quality of cultivated land is also growing. The change of the mean value of relative degree of grey incidence of labor force showing a gradually decreasing characteristics, from 0.6801 in the first stage to 0.6714 in the second stage, then improved to 0.6685 in the third stage, which reflected that since the reform and opening up, the contribution of labor input to food production is gradually reduced, that is, the binding force of labor on food production in China is gradually relaxed. The mean value of relative degree of grey incidence of capital elements shows a change characteristic of decreasing first and then promoting, decreasing from 0.6593 in the first phase to 0.5308 in the second phase and promoting to 0.5906 in the third phase, which is also related to the investment in China's agricultural finance. Since the beginning of the reform and opening up, capital investment in rural areas has risen, and capital investment has been gradually declining. Since 2001, with the reform of rural taxes ,fees and the implementation of the strategy of agricultural modernization, investment in agricultural capital has been gradually increased, which has obviously promoted the development of grain output enhance.

In fact, since the reform and opening up, China has made great achievements in both national income and grain production. However, due to the influence of the factors like rapid reduction of cultivated land, the continuous decline of the quality of cultivated land, the worsening of environmental pollution, the tightening of water resources constraints and the trend of food finance continues to strengthen, China's food security situation is not optimistic. As a matter of fact, the net import of food in China has been expanding in recent years. The rate of food self-sufficiency has begun to fall below the national food security warning line, which is often below 95% of the self-support rate of food. In 2012, China's three major grain varieties of rice, wheat and maize have all been converted into net imports. In the same year, net cereal imports also reached a historic 13.169 million tons. In the first seven months of 2014, China's food imports surged on a year-on-year basis by 80.7%, the net imports of rice, wheat and maize in China have become normalized. The dependence of China's food security on external resources has obviously increased. In January 2015, the leader of the Ministry of Agriculture even said that to promote the potato as the fourth largest staple food in our country has aroused widespread public concern. As it pointed out in "National Medium and Long-Term Plan for Food Security (2008-2020)", agriculture is the weakest link in China's national economy. With the advancing industrialization and urbanization, China's food security situation will face such prominent problems as increasing production difficulty and long-term tight supply and demand of balance of power. In view of the long-term development trend, due to changes in population, cultivated land, water resources and the international market, the above trends are hard to reverse. China's food and food security will face severe challenges.

An important policy enlightenment of this study is to re-examine the constraints of China's grain production and provide references for improving the national food security strategy. The paper finds that the three main elements of land, labor and capital, the key to the relationship with China's food production is the land factor. That is, since the reform and opening up, the change of grain output in China depends very much on the elements of land. In other words, the cultivated land is the most important factor of investment to restrain the grain production in China. In addition, from the aspect of factor substitutability, land investment has the worst substitutability, its input is also the most difficult to effectively improve. However, on the one hand, labor force and capital input are more substitutable, and on the other hand, the input amount is also relatively easy to increase. Therefore, in the face of China's increasingly severe food security situation and the constraints of domestic agricultural resources, the most effective way to ensure food supply is to solve the constraints of cultivated land factors on China's grain production, and to improve the quality of cultivated land and the amount of cultivated land as much as possible. Under the objective reality that the tightening of domestic cultivated land resources is tight, it is a reference way to follow the practice of food shortage countries such as

Japan and South Korea and to look for cultivated land resources in the world. Since the 21st century, the Central Rural Economic Work Conference has repeatedly emphasized that we must make good use of the two markets and two kinds of resources and speed up the pace of agriculture going out. In 2015, the document No. 1 of the Central Government also explicitly proposed the "ability to make co-ordination and utilization of the two resources in both domestic and international markets" and demanded that "pay close attention to formulating plans for agricultural cooperation with foreign countries", "innovative modes of agricultural cooperation with foreign countries" , "supporting the development of overseas agricultural cooperation" ," perfect support for agricultural cooperation with foreign investment, taxation, financial, insurance, trade, customs clearance, inspection and quarantine policy". Obviously, in China deeply involved in global economic activity and further promote the background of agricultural "going out" strategy, in the face of reality constraints of land to Chinese grain production, the relevant departments should consider the use of "two resources and two markets", and "The Belt and Road" initiative in the process of construction, establish cooperation and in other countries the development and utilization of cultivated land resources strategy, so as to effectively release China internal land bearing pressure, alleviate the constraints of production factors in food supply, and make a greater contribution to world food security.

REFERENCES

[1] Scott D R,Bruce S, Li J G. Fluctuation of Grain Output and Agricultural Policy and Technological Progress in China[J]. Rural Economy and Society ,1990, (3):13-20.

[2] Lu W. Effects of Agricultural Market Policy on Crop Production in China[J]. Food Policy, 2002,27(5-6):561-573.

[3] Xiong W, Holman R, Lin E, etal.Climate Change, Water Availability and Future Cereal Production in China[J]. Agriculture, Ecosystems and Environment,2010, (135): 58-69.

[4] Zuo L J, Wang X, Zhang Z X, etal. Developing grain Production Policy in Terms of Multiple Cropping Systems in China[J]. Land Use Policy, 2014, (40):140-146

[5] Fu Z Q, Cai Y L ,Yan Y X, etal. Research on the relationship of cultivated land change and food security in China[J]. Journal of Natural Resources, 2001(4):313-319.

[6] Deng X Z， Huang J K, Rozelle S .Change of Cultivated Land and Its Impacts on Agricultural Bioproductivity in China:Implication to National Grain Security[J].China Soft Science, 2005(5):65-70.

[7] Han S S. Urban Expansion in Contemporary China: What Can We Learn from a Small Town? [J]. Land Use Policy, 2010,27(3):780-787.

[8] Liu Y S, Wu C X. Situation of Land-water Resources and analysis of Sustainable Food Security in China[J].Journal of Natural Resources, 2002(3):270-275.

[9] Chen B M, Zhou X P. Changes of Agriculture Resources and Grain Comprehensive Productive Capacity of China in Recent Years[J].Resources Science,2004,(9):38-45.

[10] Ye L, Ranst E V. Production Scenarios and the Effect of Soil Degradation on Long-term Food Security in China[J]. Global Environmental Change, 2009, (19): 464–481.
[11] Ma L J , Yan J Q , Wang Y P. The Influence of Evolvement of Rural Labor Resources on Grain Production Efficiency[J]. China Population, Resources and Environment,2014(09):103-109.
[12] Lichtenberg E, Ding C. Assessing Farmland Protection Policy in China[J]. Land Use Policy,2008, 25 (1): 59–68.
[13] Wang J X, Huang J K, Yan T T. Impacts of Climate Change on Water and Agricultural Production in Ten Large River Basins in China[J]. Journal of Integrative Agriculture, 2013, 12(7): 1267–1278.
[14] Yan T T , WangJ X, Huang J K. Urbanization, Agricultural Water Use, and Regional and National Crop Production in China[J]. Ecological Modelling, 2015, (1):1-10.
[15] Khan S, Hanjra M, Mu J X. Water Management and Crop Production for Food Security in China: a Review[J]. Agricultural Water Management, 2009,96(3):349-360.
[16] Yu F W. Analysis of the Decoupling Relationship Between Grain Production and Irrigation Water in China[J]. Chinese Rural Economy,2008, (10):34-44.
[17] Le L X. Estimation of Rice Production Function in Rice Farming Area in Southern China[J]. Chinese Rural Economy, 2005, (6):12-18.
[18] Xie J, Construction and Econometrical Analysis of China 's Grain Production Function[J]. Statistics and Decision, 2007(20):74-76.
[19] Huang Z. Analysis of Influencing Factors of Grain Production in China —Based on C-D Production Function and Ridge Regression [J].Taxation and Economy, 2014(05):50-54.
[20] Li G X. The Analysis of China's Grain Production Capacity and the Degree of National Food Security in 2020[J]. Chinese Rural Economy, 2014(05):4-12.
[21] Qu X B, Zhao H P. Changes of Agriculture Resources and Influence of Grain Production Capcaity of China in Recent Years [J]. Anhui Agricultural Sciences, 2011(11):4-7.

BIOGRAPHICAL NOTES

CONTACTS

Title Given name and family name: Jing Han
Institution: College of Public Administration, Central China Normal University
Address: No. 152, Luoyu Road, Hongshan District
City: Wuhan
COUNTRY: China
Tel. + 13618633203
Fax + 027-67863765
Email: hanjing@mail.ccnu.edu.cn
Web site: