Analysis of Factors Influencing Comprehensive Productivity of Agriculture in Henan Province on the Basis of Grey Correlation

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Abstract According to the data from *Henan Statistical Yearbook* from 2002 to 2008, from production capital, production conditions, labour inputs and financial support, this paper selects 11 variables influencing comprehensive productivity of agriculture in Henan Province. Through calculation and analysis of grey correlation of variables and comprehensive productivity of agriculture, this paper determines the impact of different variables on comprehensive productivity of agriculture. The results show that the agricultural capital has become the most important factor influencing comprehensive productivity of agriculture in Henan Province, while the impact of production conditions, labour inputs and financial support on comprehensive productivity of agriculture in Henan Province diminishes in turn. Corresponding countermeasures and suggestions are put forward to promote the sustainable development of comprehensive productivity of agriculture in Henan Province as follows: strengthen agricultural financial system building, and ensure agricultural production expenditure; scientifically arrange allocation of agricultural resources, and improve agricultural production conditions; carry out training of agricultural skills, and elevate the quality of agricultural labour forces; increase financial expenditure for agricultural production, and optimize financial expenditure structure.

Key words Comprehensive productivity of agriculture, Grey correlation analysis method, Influencing factors, Henan Province, China

Comprehensive productivity of agriculture is the output capacity integrating comprehensive inputs of various factors of agricultural production and the corresponding relations of production. In the process of advancing new socialist countryside building, promoting comprehensive productivity of agriculture is necessary requirement of ensuring national food security, increasing farmers' income, developing modern agriculture, and boosting rural economic prosperity. The researches of China's scholars on comprehensive productivity of agriculture primarily focus on capital inputs to agriculture, production conditions, labour inputs and financial support. In terms of agricultural production capital, Chen Ming' en *etc.* point out that continuous supply of funds is an important measure for achieving continuous growth of agriculture[1]. Wei Wei and other scholars, through the establishment of economic model, put forward drive of inter-industry comparative advantage. Under conditions of limited endowments, China's rural households increase investment in non-agricultural industries, which not only restricts non-agricultural output, but also makes investment in agriculture insufficient, impacting the improvement of comprehensive productivity of agriculture in China[2]. In terms of production conditions, due to different resource endowments and economic conditions in various regions, as well as different analysis time of researchers, the impact of production conditions on comprehensive productivity of agriculture varies. In terms of labour inputs, Dang Xianing proposes that promoting the overall quality of the agricultural labour force is the premise of enhancing the marginal productivity of other factors[3]. Shen Jingyu *etc.* also point out that promoting the quality of labour force is the key to adjustment of the agricultural structure[4]. In terms of financial expenditure, Li Xiangyun *etc.* evaluate the scale of China's financial expenditure on agriculture through establishing the second relative benefit model, and point out that the scale of China's fiscal expenditure on agriculture is relatively small, and the structure is irrational, affecting China's agricultural output[5]. There are few literatures of analysing the factors influencing comprehensive productivity of agriculture comprehensively. As to the overall consideration of influencing factors, it can be conducive to grasping the factors influencing comprehensive productivity of agriculture on the whole. Henan is a major agricultural province in China, so the analysis of factors affecting comprehensive productivity of agriculture has a great significance to the promotion of sustainable agricultural development in Henan Province. From production capital, production conditions, labour inputs and financial support, this paper selects 11 variables influencing comprehensive productivity of agriculture in Henan Province. Through calculation and analysis of grey correlation of variables and comprehensive productivity of agriculture, this paper determines the impact of different variables on comprehensive productivity of agriculture. And this paper proposes countermeasures and suggestions for continuous development of comprehensive productivity of agriculture in Henan Province.

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1 Variable selection, data source and research method

1.1 Overview of study area Henan Province is located in

east-central China, the middle and lower reaches of Yellow River, where plenty of light and heat resources, abundant water resources and fertile land resources provide good natural conditions for agricultural development. In 2008, Henan Province had 7.926 4 million hm^2 of farmland, accounting for 6.51% of China's farmland area. Henan is one of China's main grain producing areas. In 2008, the total grain output of Henan Province reached 53.655 million tons, ranking first in China. The wheat yield was 30.51 million tons, ranking first in China; the corn yield was 16.15 million tons, ranking third in China. In addition, oil output reached 50.53 million tons, ranking first in China; fruit yield was 21.296 million tons, ranking second in China; output of cotton and tobacco is 0.651 million tons and 0.267 million tons respectively, both ranking third in China. Henan is also China's important producing base of poultry products and animal products, and the output of poultry products and animal products is at the top of list of China's output of poultry products and animal products. In 2008, the total meat output of Henan Province reached 5.848 million tons, the total milk output of Henan Province reached 2.986 million tons and the total poultry and egg output of Henan Province reached 3.717 million tons, ranking second, fourth and second respectively in China's output of poultry products and animal products. Agriculture is the main source of income for farmers in Henan Province. In 2008, the value-added of agriculture, forestry, animal husbandry and fishery reached 265.877 billion yuan, and agricultural income per capita of rural residents reached 3 577 yuan. Researching the factors influencing comprehensive productivity of agriculture in Henan Province, is of great significance to promoting continuous development of agriculture in Henan Province and formulating related agricultural policies.

1.2 Variable selection Considering the availability and representation of data, we select 11 variables as the factors influencing continuous development of comprehensive productivity of agriculture in Henan Province (Table 1).

Table 1 Variable selection and analysis of factors influencing comprehensive productivity of agriculture in Henan Province

Variable sequence	Classification of variable	Name of variable	Definition of variable
Parent sequence	Agricultural income	Agricultural income	Operation income of household per capita in the primary industry Yuan
Subsequence	Production capital	Production capital	Operation expenditure of household per capita in the primary industry // Yuan
	Production conditions	Machinery	Total power of agricultural machiery // $\times 10^4$ kW
		Power consumption	Rural power consumption // $\times 10^8$ kW · h
		Chemical fertilizer	The net amount of chemical fertilizer // $\times 10^4$ t
		Agricultural pesticide	Application rate of agricultural pesticide // $\times 10^4$ t
		Irrigation	Effective irrigation area of farmland // $\times 10^3$ hm^2
		Plastic film	Consumption of agricultural plastic film // $\times 10^4$ t
		Farmland	The area of farmland in common use at the end of year $\times 10^3$ hm^2
	Labour inputs	Amount of labour forces	Workers in farming, forestry, animal husbandry, and fishery $\times 10^4$ people
		Educational level	The proportion of quantity of people with educational level of the junior secondary school to quantity of agricultural labour forces %
	Policy support	Financial expenditure	Financial expenditure for affairs of agriculture, forestry, and aquaculture // $\times 10^8$ yuan

1.3 Data source The data are from *Statistical Yearbook of Henan Province*. As in 2001 and the previous years, the farmland area is often used as old caliber, so we select the data in the period 2002 –2008. In 2006, China began new rural construction, and we select the year 2006 to conduct interval division.

1.4 Research method Grey correlation analysis is a method of factor analysis. Grey correlation analysis, through comparison of the time series variation trend between factors, determines the impact of subsequence on parent sequence. If the curve shape of subsequence is in close proximity to the curve shape of parent sequence, then the correlation between the two is large, and the impact of subsequence on parent sequence is great; similarly, If the curve shape of subsequence is not in close proximity to the curve shape of parent sequence, then the correlation between the two is small, and the impact of subsequence on parent sequence is small. The complexity and uncertainty of factors influencing comprehensive productivity of agriculture make grey correlation analysis more suitable than regression analysis for analysis of factors influencing comprehensive productivity of agriculture.

The calculation method of grey correlation analysis is as follows:

First, we determine parent sequence $X_0(t)$ and $X_i(t)$ subsequence $X_i(t)$, where $X_0(t) = \{x_0(1), x_0(2), \cdots, x_0(m)\}$ $X_i(t) = \{x_i(1), x_i(2), \cdots, x_i(m)\}$, $t = 1, 2, \cdots, m$, $i = 1, 2, \cdots, n$.

Second, we calculate the correlation coefficient $\xi_i(t)$ of $X_0(t)$ and $X_i(t)$ at time point t, where ξ is identification coefficient, and the value of coefficient is in between 0 –1.

$$\xi_i(t) = \frac{\min_i \min_t |x_0(t) - x_i(t)| + \xi \max_i \max_t |x_0(t) - x_i(t)|}{|x_0(t) - x_i(t)| + \xi \max_i \max_t |x_0(t) - x_i(t)|}$$

Third, we calculate the mean value r_i of mean correlation coefficient of subsequence $X_i(t)$ at all time.

$r_i = \frac{1}{m}\sum_{i=1}^{m}\xi_i(t)$, where r_i is correlation between subse-

quence $X_i(t)$ and parent sequence $X_0(t)$.

Fourth, according to size of correlation r_i, in descending order, the impact of $X_i(t)$ on $X_0(t)$ diminishes in size in turn.

2 Results and analysis

By using Excel software, we select identification coefficient $\xi = 0.5$, to conduct grey correlation calculation on parent sequence and subsequence, and the calculation results of grey correlation of factors influencing comprehensive productivity of agriculture in Henan Province can be seen in Table 2.

Table 2 Calculation results of grey correlation of factors influencing comprehensive productivity of agriculture in Henan Province

Variable	In the period 2002 – 2005		In the period 2006 – 2008	
	Correlation	Sequencing	Correlation	Sequencing
Production capital	0.744 1	8	0.964 7	1
Machinery	0.849 4	2	0.806 0	4
Power consumption	0.852 4	1	0.917 6	2
Chemical fertilizer	0.790 0	3	0.799 5	5
Agricultural pesticide	0.772 4	5	0.783 5	6
Irrigation area	0.748 0	7	0.735 3	7
Farmland area	0.744 0	9	0.727 1	8
Plastic film	0.776 4	4	0.806 4	3
Amount of labour forces	0.729 9	10	0.689 9	10
Educational level	0.759 8	6	0.695 7	9
Financial expenditure	0.633 1	11	0.630 7	11

According to Table 2, the ranking of correlation of factors influencing comprehensive productivity of agriculture and analysis of the status quo of agricultural production in Henan Province are as follows.

2.1 Production capital Agricultural production capital directly restricts the inputs of material elements of agricultural production, which is the guarantee for continuous development of comprehensive productivity of agriculture. The correlation between farmers' agricultural production expenses in Henan Province and agricultural income rises from No. 4 from the bottom before the new rural construction, to NO. 1, becoming the most important factor impacting comprehensive productivity of agriculture. From 2003 to 2008, agricultural spending maintained the average annual growth rate of 17.84%. In the case of limited funds, farmers choose to input limited funds into the sectors with high marginal returns, and the marginal returns of the secondary and tertiary industries are better than the returns of agriculture. The risks and uncertainties of the secondary and tertiary industries are greater than those of agriculture. In addition, farmers' level of knowledge is low, and the experience and ability are limited, so the non-agricultural investment of rural households is limited. In 2008, the agricultural production spending in Henan Province still accounted for 87.88% of household operation expenses. Agriculture is the main investment industry for rural residents in Henan Province.

2.2 Production conditions

2.2.1 Inputs of agricultural machinery. The impact of agricultural machinery inputs on agricultural income declines slightly compared to the impact prior to the construction of new rural areas, but the impact of agricultural machinery inputs on agricultural income is still big. Henan Province is China's most populated province, and China's main producing areas of agriculture. It is a vast plain with great population density. The land management is decentralized; the arable land per household is limited; the land transfer system is not perfect; it is difficult to achieve mechanized large-scale production under effective centralized supply of land. Under the support policies of benefiting agriculture and subsidizing agriculture, such as providing subsidy for the purchase of agricultural machinery, the agricultural mechanization process in Henan Province accelerates. In the period 2002 – 2008, the agricultural machinery inputs maintained an average annual growth rate of 6.28%. There are some problems existing in the process of mechanization, such as imperfect supporting agricultural machinery and irrational structure. In 2008, there were 6.395 2 million supporting farm implements of small tractors owned by rural households in Henan Province, and only 0.431 6 million supporting farm implements of large and medium-sized tractors. The wide application of machinery to the whole process of agricultural production, the liberation of agricultural productivity, and improvement of workforce productivity, is a necessary requirement for the modernization of agriculture.

2.2.2 Agricultural power consumption. It is mainly in irrigation, breeding of livestock and poultry, processing of agricultural crops and so on. Agricultural power consumption has high correlation with agricultural income, which is the most important factor impacting agricultural output of Henan Province. With the development of benefit agriculture, agricultural power consumption grows incessantly, and there are diversified ways of using power. Large-scale breeding, processing of agricultural crops and so on, consume considerable power. The gradual improvement of power grid and other infrastructure, and the growing number of electrical equipments, promote continuous growth of comprehensive productivity of agriculture in Henan Province.

2.2.3 Chemical fertilizer. The correlation between chemical fertilizer inputs and agricultural income drops two in ranking, and ranks No. 5 from the implementation of new rural construction. Under limited supply of arable land, increasing inputs of chemical fertilizer and improving soil fertility, is an important measure to increase unit yield of agricultural crops. The amount of chemical fertilizer inputs of Henan Province, maintains growth rate of 6%, the impact of which on agricultural output is declining. The utilization rate of agricultural chemical fertilizer in China is not high, and marginal contribution of chemical fertilizer decreases progressively. When the use of chemical fertilizer goes to a certain extent, its impact on agricultural output gradually weakens. The use of chemical fertilizer will contaminate soil, reduce yield and harm human health.

2.2.4 Agricultural pesticide. Agricultural pesticide can kill pests, grass, bacteria and so on, which is a major measure to ensure and promote the growth of crops. The impact of agricultural pesticide on agricultural income decreases as against that before the construction of new countryside. The use of agricultural pesticide contaminates soil, and once the bacteria and pesticide are resistant to drug, we must increase inputs to agriculture, thus forming a vicious cycle. The pesticide kills pests along with the beneficial organisms, which may cause an increase in pests, affecting agricultural production and endangering human health. Low cost and convenient use result in the widespread use of highly toxic pesticide.

2.2.5 Irrigation area. The correlation between effective irrigation area and agricultural income remains in the seventh place before implementation of new rural construction. Henan Province is a a big producing province of agriculture in China, lacking water. In the period 2002 – 2008, the irrigation conditions of farmland in Henan Province were gradually improved. There is newly-added 6% irrigation area annually on the average, and 32% of the arable land still lacks effective irrigation. Part of the mountainous areas, and hills, lack irrigation conditions. The water use of crops is largely dependent on rainfall, water storage capacity of soil is poor, and the ability to resist drought is poor, so water shortage related to crop growth has seriously affected agricultural output.

2.2.6 Inputs of agricultural plastic film. The correlation between agricultural plastic film inputs and agricultural income rises from No. 4 to No. 3, so the impact of agricultural plastic film on comprehensive productivity of Henan Province is big. Pastic film in agriculture is mainly used in the film, plastic greenhouses and livestock breeding. The plastic film can keep warm and humid, improve use efficiency of fertilizer, and reduce pests and diseases, which is widely used in flower, vegetable cultivation in slack season, with good economic benefits. Driven by great benefits of cash crops, more and more farmers in Henan Province turn to planting of cash crops. Agricultural operation can be regarded as full competition. Under the conditions of failing to price, the farmers adopt thin-film technology to improve agricultural production conditions, reduce the risk of agricultural production, and improve agricultural production gains. The use of film increases the yield of crops, ensure the supply of fresh vegetables, effectively improve the farmers' agricultural income, and improve people's quality of life.

2.2.7 Farmland area. The correlation between farmland area and agricultural income is low. The farmland is affected by the geographical situation, soil and water conservation, reclamation methods , improvement measures and other factors, with limited amount, and the spatial location can not be moved. Arable land is means of production for agricultural production that can not be replaced, having a direct impact on agricultural output. According to the detailed survey data in 2000, the first-class arable land of Henan Province is alluvial soil arable land in East and North Henan; drab soil and red clay arable land in mountains of West and North Henan; rice paddy arable land in West Henan. The first-class arable land only accounts for 13.49% of total farmland area. With economic development, agricultural land is squeezed by non-agricultural land, and the common farmland area decreased by 85 330 hm^2 from 2002 to 2004, and then maintained at about 7.202 2 million hm^2 under the farmland protection policy afterwards. The marginal returns of agricultural production are low, the conditions for cultivating land are inclement, and the national policies support the secondary and tertiary industries, resulting in the occurrence of rural farmland being wasted through disuse, and waste of limited arable land.

2.3 Labour inputs The correlation between agricultural labour forces and agricultural income is the last but one, having little effect on agricultural income of rural households, therefore, it is not the main factor affecting comprehensive agricultural productivity. The amount of labour forces engaging in agricultural production in Henan Province, decreased at an average annual rate of 2.93% in the period 2002 – 2008. With the quickened pace of industrial structure adjustment and urbanization, the labour forces engaging in agricultural production continuously transfer to non-agricultural sectors. In 2008, The share of agricultural labour forces in total labour forces in Henan Province decreased to 72.5%. From the dual structure model, we can know that the real income gap between urban and rural areas is an important factor responsible for migration of rural residents to the city. Labour is an essential element of agricultural production, and we need to maintain a certain amount of labour forces to ensure continuous development of agriculture.

The correlation between the educational level of labour forces engaging in agricultural production, and agricultural income, drops from No. 6 to No. 9. The educational level of labour forces in rural areas of Henan Province is low, and the agricultural labour forces with educational level of junior high school are the most. In 2008, the proportion of the agricultural labour forces with educational level of junior high school was 37.22%. The non-agricultural transfer of agricultural labour forces causes the rural labour forces with high quality to transfer to non-agricultural sectors continuously, which further makes the agricultural labour forces in Henan Province fail to be effectively improved. Low educational level makes the farmers incapable of effectively using and giving play to the technology advantage to improve output and quality of agricultural products, in the process of acquiring information, purchasing technology, learning and adopting new technology. If the farmers abuse and overuse factors of production, this will increase the cost of factor inputs, and damage agricultural production environment, detrimental to the improvement of comprehensive productivity of agriculture.

2.4 Financial support The correlation between financial expenditure and agricultural income always ranks last. The financial expenditure can be considered as the input of agricultural capital factor. Compared to the impact of farmers' agricultural inputs on agricultural income, the impact is small. After the implementation of new rural construction, the financial expenditure of Henan Province for agriculture, forestry and aquaculture, maintains an average annual growth rate of 37%. And in 2008, the financial expenditure reached 20.959 billion yuan. The financial expenditure structure is not reasonable, non-production expenses are too high, and the expenditure for agricultural infrastructure construction, ecological environment protec-

tion of agriculture, and agricultural industrialization is too insufficient. In addition, financial expenditure lacks effective supervision, resulting in inefficient use of funds, which has a poor effect in promoting comprehensive productivity of agriculture of Henan Province.

3 Policy suggestions

Based on the above calculation results and analysis, agricultural capital has become the most important factor influencing comprehensive productivity of agriculture of Henan Province. The degree of influence of production conditions, labour inputs and financial support to comprehensive productivity of agriculture of Henan Province decreases progressively. In the process of continuous development of agriculture in Henan Province, we need to strengthen the financial system building of agriculture, scientifically arrange the allocation of resources, carry out agricultural skills training, and increase financial expenditure for agricultural production, to improve comprehensive productivity of agriculture of Henan Province.

3.1 Strengthen agricultural financial system building and ensure agricultural production expenditure Since the establishment of the household contract responsibility system, the rural household has been the major bearer of agricultural production capital inputs. With the restructuring of agricultural production, the agricultural industry chain, which takes agricultural products as the center, gradually takes shape. The capital needed for upstream and downstream industry chain is higher than the fund for pure farming and breeding of agricultural products. Limited income of farmers, dramatic increase in living and production costs, and insufficient capital inputs needed by agricultural industrial chain, affect the improvement of comprehensive productivity of agriculture. A major obstacle to the promotion of new technology is also the restriction of agricultural production capital. We should strengthen the building of agricultural financial system, make up for the lack of agricultural production capital, and guide adjustment of agricultural expenditure structure for farmers, so that the farmers gradually abandon the traditional agricultural production method characterized by high input and low output, and develop soilless agriculture, specialty agriculture, tourism agriculture and other emerging agriculture.

3.2 Scientifically arrange allocation of agricultural resources and improve agricultural production conditions Agricultural production conditions directly affect agricultural output. We should strictly implement the existing land protection policy, improve land transfer system under the premise of protection of existing arable land, promote the transfer of land, and achieve the scale merit of agricultural production. And we should further strengthen the building of electricity used for agriculture and irrigation facilities, increase inputs of large and medium-sized agricultural machinery, ensure the basic conditions for agricultural production and reduce losses caused by agricultural disasters. The benefit of input of chemical fertilizer, agricultural pesticide and other production factors diminishes marginally. Low inputs cannot produce the desired effect, and high inputs will waste production factors. Reasonable arrangement of agricultural resources allocation is an important measure to increase output of agricultural products under the condition of limited supply of arable land.

3.3 Carry out training of agricultural skills and elevate the quality of agricultural labour forces Technological progress reduces the demand for labour forces, but poses high requirement on the quality of labour forces. Agricultural labour forces are the main body of agricultural production. Expenditure of production capital, inputs of materials and means of production, and selection of agricultural production mode are the behavioral results of agricultural labour forces, with a close relationship with the quality of labour forces. The generally low quality of agricultural labour forces in Henan Province, restricts continuous growth of the comprehensive agricultural production capacity. We should carry out agricultural skills training, improve skill and knowledge level of agricultural workers, and achieve maximization of agricultural output under limited inputs of resources. The improvement of quality of agricultural labour forces, can make the farmers scientifically use material and production factors of agriculture, and reduce the costs of searching new technologies, learning and application, so as to lay solid foundation for the promotion of new technologies. The spillover effect brought by the technology can drive holistic improvement of comprehensive productivity of agriculture.

3.4 Increase financial expenditure for agricultural production and optimize financial expenditure structure The basic role and feebleness of agriculture determine the need for financial support for agriculture. Continuous and stable financial expenditure is an important guarantee for the government to regulate agricultural production. We should optimize the financial expenditure structure in agriculture, increase financial inputs to agricultural infrastructure, environmental protection of agriculture, and agricultural technology research, and comprehensively enhance economic, social and ecological benefits of agricultural production. Moreover, we should strengthen the management level of financial fund use, establish long-term effective financial expenditure control mechanism and ensure the efficiency of financial expenditure.

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