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Does the Agricultural Subsidy Policy Affect Chinese Grain Production?—Evidence from DID Model

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Abstract

Agricultural development in China has commanded much attention in the new era. This paper uses the DID model to analysis the relationship between agricultural subsidy policy and grain planting structure in China from two perspectives of macro and micro. The novelty of this paper is that we have developed a theoretical model to estimate effect of agricultural subsidy policy on the grain planting structure and explore its path of action. The empirical results of this paper show that the agricultural subsidy policy mainly changes the input of grain production of farmers from the aspects of technology and cost, which greatly motivates the farmers to increase the land input in grain production, and its grain planting area and its proportion will both increase.

Keywords

Agricultural Subsidy Policy, Grain Planting Structure, Grain Production; DID Model

1. Introduction

In the 21st century, China's agricultural development has undergone an important turning point. The situation of long-term shortage of agricultural products has gradually changed into a new stage of basically balanced supply and demand. The core of "three rural issues" has also become the issue of increasing farmers' income. The average income level of farmers is too low and the income gap is too large, which is threatening social harmony and food security in our country. Since China's grain output has increased continuously for 12 years, China has adopted a series of policies to benefit farmers in order to ensure national food security, continue to improve the agricultural support and protection system and promote agricultural policy reform. Since 2004, China has gradually abolished agricultural taxes and set up a series of agricultural subsidy systems aimed at promoting food production. The scope of reform has gradually expanded, covering more and more areas, and the intensity of subsidy has continuously increased. Among them, the agricultural tax exemption policy and grain direct subsidy policy are the two most important agricultural policies implemented in China's new "three rural" development strategy. The government hopes to develop various forms of agricultural policies to achieve a moderate scale operation, increase farmers' income and ensure national food security. However, for a long time, the production efficiency of grain has been relatively low, and the dual goals of increasing grain production and farmers' income are not consistent. Therefore, how to increase farmers' income under the premise of stabilizing agricultural development and protecting national food security is a problem that needs to be studied and solved urgently in a short period of time. This article is to study the effectiveness of China's agricultural subsidy system under the background of a large-scale food crisis, which has more theoretical value and practical significance.

A great deal of research has been carried out to evaluate the effect of agricultural subsidy policy, which is mainly from the aspects of farmers' income, grain production efficiency, grain production adjustment capacity, production cost, production behavior and factor productivity (Gao Ming & Michael Carter, 2017; Zhu Man De, 2015; Jean Joseph Minviel et al., 2017; Laure Latruffe, 2016; Li Jiangyi, 2016; Lin Wanlong, 2014; Zhong Funing et al., 2008; Kazukauskas et al., 2013; Huang Jikun et al., 2011; Chen Huiping et al., 2010; Long et al., 2019; Ivana & Rastislav, 2016; Thomas et al., 2018). Also, farm subsidies were associated with agricultural expansion (Lina & Huang, 2019). Liu (2010) report that the grain production subsidy policy has improved the enthusiasm of farmers in grain production, to a certain extent, will promote the expansion of grain planting area and optimize the structure of planting varieties. Koo and Kennedy (2006) used model simulations and reached a conclusion that farm subsidies in the United States can make agricultural intensification stimulate over-production and hence total cultivated area. Chung-Hui Lai et al. (2017) examine the effects of agricultural subsidy policies on long-run growth by distinguishing a land productivity conservation subsidy from an agricultural R&D subsidy and reveal the policy will generally enhance long-run growth when the balanced growth path is indeterminate. Chen Fei, Fan Qingquan and Gao Tiemei (2010) based on the adaptive expectations model put forward by Nerlove, from the perspective of China's grain production adjustment capability and the long-term effects of agricultural policies, conducted empirical research on China's grain production adjustment capability and the effects of agricultural policies. The research results found that increasing government investment in agriculture will gradually loosen various practical constraints on agricultural production, thus enhancing China's grain production adjustment capability. After comparing and analyzing the effects of different types of agricultural policies, it is found that various agricultural policies have a significant positive impact on grain production, of which the fiscal subsidy expenditure policy and the fixed investment policy are the most important (Sunil, 2006; Anthony & Rebecca, 2014).

Some scholars are skeptical about the sustainability and support of direct grain subsidy policy. Ma Yanli and Yang (2005), Cao Guangqiao et al. (2010) proposed that the direct grain subsidy policy has little impact on the expansion of farmers' grain planting area and the increase of farmers' income. The agricultural subsidy appears to exert significant effects on any of the land use decisions examined here and has little contribution to farmers' income, so the effectiveness of the direct subsidy policy cannot be overestimated (Wang et al., 2019). Fang and Wang (2009) studied China's agricultural subsidy policy against the background of the rapid rise of China's agricultural costs. The investigation shows that the current subsidy policy has marginal incentive effect, but the effect of subsidy to cope with cost changes has not been fully reflected. Zhong, Chen, and Xu (2013) proposed that subsidies can change the relative prices of factors, thus affecting the labor supply of farmers and allowing resources to be reallocated among different departments. Their empirical results show that agricultural subsidies can indeed improve the welfare of farmers, but their impact on agricultural production is limited. Agricultural subsidies can only partially improve factor inputs, unit output and farmers' welfare level, but have not significantly improved the technical efficiency of agricultural production. In addition, the relative income of factors cannot be compensated for the reason that the prices of agricultural products are generally relatively low and subsidies are not sufficient to fully compensate for the increase in the prices of farmers' means of production. Moreover, the existence of noticeable differences in the relative income of factors will affect the behavior of farmers, particularly, they still cannot greatly improve their investment in agricultural production (Mu, 2009; Wang & Yang, 2014; Ahearn et al., 2006; Key & Roberts, 2009). It deprived rural households of flexibility in making decisions, although the subsidies provide agribusiness enterprises that market agricultural inputs such as seeds, fertilizers and pesticides for farming households (Zhan, 2017). A large majority of existing research literatures are mainly focused on the effects of agricultural production subsidy policies. The effectiveness of agricultural subsidy policies, however, is still controversial. On the one hand, indicators for measuring the effects of agricultural production subsidy policies vary from each other. Furthermore, the few that do study the impact on grain production fail to account for the potential theoretical model mechanism systematically.

In this study, the novelty of this paper lies in its establishment of a theoretical model and research hypothesis of the impact of agricultural subsidy policies on agricultural production from the perspective of grain planting structure using DID model to empirically address the effects of agricultural production subsidy policies. This is helpful for us to analysis theoretically the effect of agricultural subsidy policy on agricultural product production, and we also can accurately evaluate the current situation of China's grain production better, clarify the direction of China's future agricultural policy and strategies for further implementing specific subsidy policies.

The rest of the paper is organized as follows: Section 2 presents the theoretical model of the impact of agricultural subsidy policies on grain production, revealing the two impact paths of farmers' grain production behavior. Section 3 describes the current situation of agricultural subsidy policy and grain production. Section 4 describes the data, introduces the empirical measurement of subsidy policy and the definitions of exogenous variables, and presents the empirical strategy derived from DID. The results of empirical are given in Section 5. In Section 6, I conclude by discussing the policy implications of my results for China.

2. Theoretical Models

We assume that farmers are rational economic people, and they aim to maximize profits through optimizing the allocation of basic production factors such as land, capital (including machinery, pesticides and fertilizers, etc.), labor, etc. Therefore, this paper establishes a production function for farmers:

$$Y = F(X, L_1, N) = AX^{\alpha} L_1^{\beta} N^{\gamma} e^{m_0} \tag{1}$$

In equation (1), Y represents grain output, A represents the level of agricultural technology production, X represents capital investment, L_1 represents the labor force engaged in agricultural production, $L=L_1+L_2$ denotes the endowment of household labor force, N represents the cultivated land area for agricultural production, and m0 represents the household characteristic variable.

$$C = p_1 X + \mathrm{w} L_1 + p_2 N \tag{2}$$

In equation (2), C represents the total cost of inputs for agricultural production, where p_1 is the price of capital inputs, w is the wage of non-agricultural labor, and p_2 is the rental cost of land. p_1, w and p_2 are exogenous variables determined by market externalities. Therefore, agricultural production cost C is jointly determined by capital input X, labor input L1 and cultivated land area N.

Considering the grain subsidies currently used in our country are basically the four main forms of subsidies, namely, direct subsidies for grain, subsidies for purchasing agricultural machinery, subsidies for improved varieties of crops and comprehensive direct subsidies for agricultural means, which are regularly distributed to the “one - card” accounts held by farmers. Hence, the grain subsidies implemented in our country are actually linked to the real planting area of farmers’ grain production, which is also called linked agricultural subsidies. In this paper , We regard the subsidy as a whole, accordingly, the amount of subsidy is determined by the actual grain planting area, and the subsidy rate s is an external variable determined by the government. Thus, an agricultural subsidy function can be established, and the subsidy rate s and the actual cultivated land area N jointly determine its quota:

$$S(N_{i,t}) = s \bullet N \tag{3}$$

Then, the cost of agricultural production can be rewritten into formula (4) with subsidies:

$$C = p_1 X + \mathrm{w} L_1 + p_2 N - sN \tag{4}$$

$$\underset{X,L,N}{Max}\ \pi(X, L_1, N) = p_0 Y - p_1 X - wL_1 + (s - p_2)N \tag{5}$$

The objective function of farmers who pursue profit maximization is shown in formula (5), in which p_0 is the market price level of grain. Based on Eqs(5), we can analyze the impact mechanism of agricultural subsidy policy on farmers’ grain production. According to equation (5), Lagrange function can be obtained:

$$Z(X, L, N) = p_0 A X^{\alpha} L_0^{\beta} N^{\gamma} e^{m_0} - p_1 X - w L_1 + (s - p_2) N + \lambda (L - L_1 - L_2) \quad (6)$$

By solving the first derivative of equation (6), the simplified behavior function of farmers' grain production can be obtained as follows:

$$N^* = \phi(p_0, p_1, p_2, s, w, L, m_0) \quad (7)$$

Equation (7) represents the partial equilibrium solution of the farmers' grain planting area, which means that the optimal planting area of farmers' grain production is influenced by the market price of grain, the wage level of non-agricultural employment, the price level of capital inputs, the rental cost of land, agricultural subsidies, the total labor endowment of the family and the other family characteristic variables together. In other words, agricultural subsidies and other exogenous variables will jointly determine the planting area of grain.

We further expound the impact direction of agricultural subsidies on farmers' grain planting structure through graphic analysis. As shown in the figure, when the agricultural subsidies are linked to the actual grain planting area, farmers will increase their investment in arable land, that is, for farmers who receive direct grain subsidy, the existence of s will reduce the marginal cost of farmers' grain production, thus increasing the marginal income of their grain production and directly promoting the expansion of farmers' grain planting area.

For farmers who receive subsidies for purchasing agricultural machinery and comprehensive direct subsidies for agricultural materials, s will not only decline the fixed investment cost of grain production and increase the marginal income of grain production, but also drive improvements in production-time reduction, technology innovation, production efficiency and material cost reductions, and further encourage farmers to expand the area of grain cultivation.

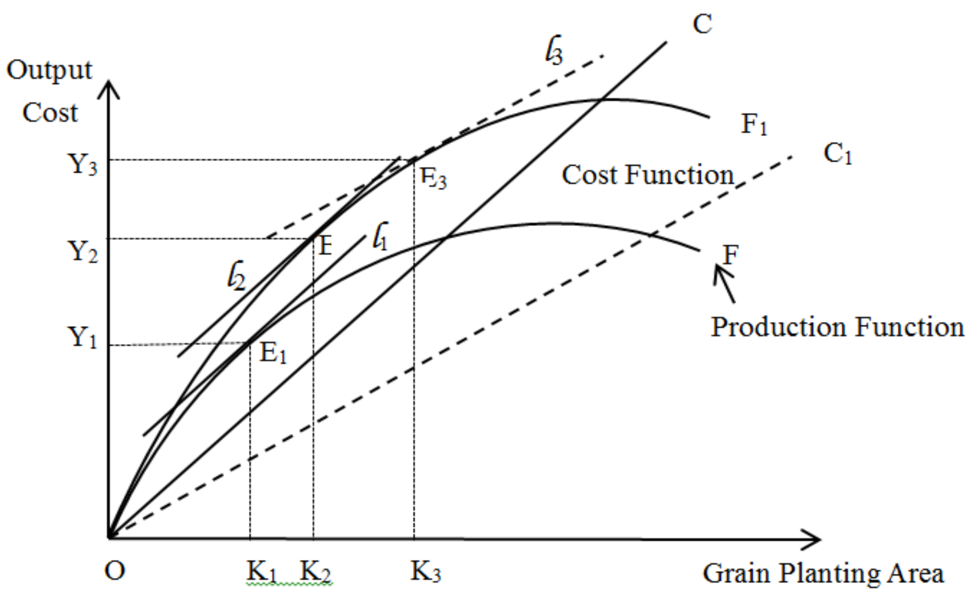

Figure 1. Theoretical Models

Therefore, agricultural subsidies mainly affect farmers' grain production behavior through two channels. First, it will influence farmers' production function by promoting technological progress. The other three subsidies except direct grain subsidy are subsidy policies for agricultural inputs, which can directly increase the quantity and improve the quality of agricultural capital inputs, thus expanding the production-possibility frontier of grain production technology. Figure 1 shows that the production function curve moves upward from OF to OF1, where the cost function is tangent to the new production function at point E2, thus the optimal equilibrium point changes from E1 to E2, and the optimal grain planting area increases from K1 to K2. Second, agricultural subsidies can change the cost function by reducing the cost, thus affecting the grain planting structure. The agricultural production costs will be greatly reduced when farmers acquire direct grain subsidy. The cost function, then, will move downward from OC to OC1. Its parallel line L3 is tangent to the new production function OF1 at point E3 in this period. The optimal grain planting area will be further increased to K3.

Hence, we assume that in the process of grain production, the implementation of the agricultural subsidy policy will promote farmers' families to increase the cultivation of grain crops; specifically, its sown area and its proportion in the whole sown area of crops will increase on the premise that other conditions remain equal.

3. Situation of Agricultural Subsidy Policy and Grain Production

3.1 Situation of Agricultural Subsidy Policy

Table 1. Total Power and Mechanization Level of Agricultural Machinery in China, 2006-2015 (Million Kilowatts)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total Power	7.25	7.66	8.22	8.75	9.28	9.77	10.26	10.39	10.81	11.17
Growth rate	6.03	5.6	7.33	6.46	6.04	5.34	4.94	1.31	3.99	3.4

Source: Author's own collations based on the Government website, the Ministry of Agriculture website, the China Economic Information Network, the Ministry of Finance website and network data.

At present, China's grain subsidies are basically four forms of subsidies, namely, direct subsidies for grain, subsidies for purchasing agricultural machinery, subsidies for improved varieties of crops and comprehensive direct subsidies for agricultural means(hereinafter referred to as comprehensive subsidies). The scope and scale of seed subsidy have been expanded year by year since the implementation of seed subsidy. Up to now, more than 10 crop varieties including rice, wheat and corn are covered. With the process of agricultural mechanization in recent years, as shown in Table 1, the total power of agricultural mechanization in China increases rapidly. In 2006, the total power of agricultural mechanization in China was only 725 million kilowatts; however, by 2015 it had increased to 1.117

billion kilowatts, which means that mechanized operation is becoming more and more popular. In order to compensate the negative impact of the increase in agricultural material prices on the cost of grain production and to ensure farmers' reasonable income from grain production, the central government, on the one hand, set up subsidies to support farmers to purchase agricultural machinery and improve the level of comprehensive mechanization. On the other hand, we implement comprehensive agricultural subsidy policy for capital inputs used by farmers in agricultural production such as chemical fertilizers and pesticides.

The scope, scale and fields of subsidies have been continuously expanding since the introduction of various agricultural subsidy policies in China in 2004, and the four subsidies are basically on a steady rise. In 2006 the early introduction of policies, the total amount of the four subsidies was only 30.95 billion yuan, accounting for 35.20 % of the central "three rural" expenditures. In 2015, the total amount of the four subsidies nationwide has rapidly reached 166.2 billion yuan, accounting for 69.70 % of the central government's expenditure on agriculture, rural areas and farmers (Table 2).

Table 2. Four Subsidies from the Central Government (Billion Yuan) and Proportion (%)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Direct subsidy	142	151	151	151	151	151	151	151	151	151	140.5
Machinery purchase subsidy	6.01	20.1	40.1	130	154.9	175	215	217.6	237	236.5	209
Seed subsidy	41.5	66.6	123.4	198.5	204	220	224	226	215	203.5	203.5
Comprehensive subsidies	120	276	716	716	716	860	1053	1071	1078	1071	1073
Total subsidy	309.51	513.7	1030.5	1195.5	1225.9	1406	1643	1665.6	1681	1662	1626
Proportion	0.352	0.377	0.446	0.475	0.537	0.636	0.655	0.674	0.691	0.697	0.649

Source: Author's own collations based on the Government website, the Ministry of Agriculture website, the China Economic Information Network, the Ministry of Finance website and network data.

According to Table 3, with strengthening the implementation of China's agricultural subsidies policies in 2004, various provinces have also adjusted their subsidy systems and increased agricultural subsidies. The blackbody part of Table 3 is the eastern provinces, including Henan, Shandong, Jiangsu and other major agricultural provinces. It can be found that since 2004-2013, the total amount of the four agricultural subsidies in each province has maintained an upward trend (Note 1).

Tabel 3. Four Agricultural Subsidies (Billion Yuan) by Province and Year

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Shandong	7.36	8.54	17.47	32.15	49.19	67.73	73.83	86.73	89.95	106.66

Henan	22.54	24.82	45.67	59.86	79.8	94.9	106.02	140.03	174.9	195.23
Hebei	6.04	6.5	19.43	30.53	59.53	61.77	66.53	72.65	78.58	90.03
Jiangsu	7.95	9.63	18.94	28.66	54.4	62.29	63.31	66.13	68.95	71.77
Sichuan	8.03	10.25	24.1	37.76	49.44	59.46	64.52	69.15	83.29	84.91
Hunan	11.38	12.95	18.96	27.61	40.24	47.86	49.98	53.82	58.24	64.67
Hubei	9.87	10.8	25.45	31.58	35.15	47.03	53.27	58.6	63.01	69.99
Heilongjiang	18.53	19.29	15.54	54.74	70.93	89.05	109.84	130.02	124.7	152.74
Anhui	11.62	13.19	22.38	34.09	62.96	69.23	76.28	81.89	88.12	92.73
Liaoning	5.59	6.73	20.19	27.85	32.7	37.75	42.81	47.69	53.02	63.93
Jilin	17.94	21.48	30.32	43.46	65.04	67.12	73.02	78.3	83.35	86.2
Jiangxi	6.12	7.56	14.02	21.49	29.11	35.545	42.26	47.98	57.72	58.22
Shanxi	2.58	3.67	8.76	15.42	20.38	27.72	30.38	33.12	40.51	45.28
Gansu	2.32	3.63	7.62	13.41	19.5	21.04	23.51	27.47	32.31	36.55
Guizhou	5.51	7.12	12.68	19.86	29.2	31.61	37.64	44.5	48.88	53.86
Shanxi	2.23	3.32	7.63	12.42	18.57	27.25	28.93	30.69	32.47	45.6
Ningxia	0.4	0.73	2.41	4	5.8	7.67	8.33	10.4	12.8	15.6
Yunnan	1.3	1.46	5.72	11.22	17.43	23.61	31.75	36.92	42.04	47.2

Source: Author's own collations based on the Provincial government websites.

We divide the 31 provinces in our country into the east and the west; thereby, a comparative observation shows that the total amount of the four agricultural subsidies in the eastern provinces far exceeds that of the western region (Figure 2), which means that the agricultural subsidies in the eastern region are far stronger than that in the western provinces. Two potential reasons can be given: first, the allocation of subsidy funds by the local government in the western provinces is mostly used to invest in township or county-run enterprises that are conducive to local economic construction, while less investment is made in agriculture and infrastructure.

Secondly, the four agricultural subsidies are mainly concentrated on food crops, while the industrial structure in most western provinces is unreasonable. Although there is a large number of rural labor force, agricultural production is mainly based on the cultivation of resource-intensive cash crops such as cotton, sugar and oil. Therefore, the agricultural subsidies in the western region are weak, resulting in obvious differences in agricultural subsidies between the eastern and western regions.

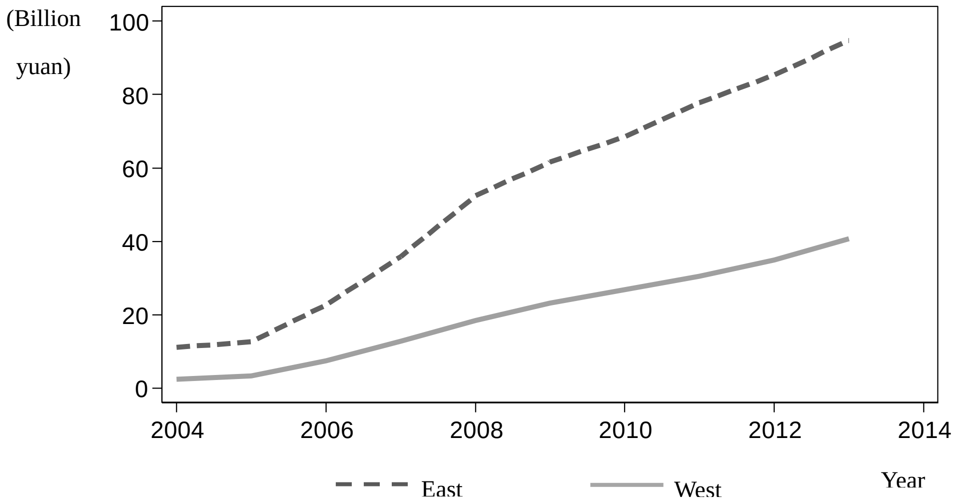

Figure 2. Four Subsidies for Agriculture in East and West, 2004-2013

Source: Author's own collations based on the Provincial government websites.

3.2 Situation of Grain Production

Table 4. Trends in China's Grain Planting Area from 1998 to 2016 (Thousands of Hectares)

year	mean	min	max	N	sd
1998	2761.63	58.10	7369.20	31	1995.45
1999	2781.51	59.30	7615.10	31	2021.84
2000	2775.61	58.70	7586.80	31	2035.56
2001	2570.08	56.07	7583.25	31	1929.45
2002	2508.38	51.47	7417.50	31	1886.34
2003	2475.60	49.96	7645.00	31	1899.30
2004	2341.19	46.51	7694.27	31	1839.76
2005	2433.89	44.99	7784.53	31	1887.90
2006	2516.07	46.36	7982.05	31	1962.48
2007	2555.71	45.86	8188.23	31	2011.57
2008	2648.94	44.59	8592.55	31	2190.98
2009	2668.50	42.34	8684.67	31	2191.43
2010	2745.22	41.78	8770.02	31	2232.87
2011	2794.56	42.25	8854.00	31	2289.23
2012	2834.64	42.75	8986.33	31	2342.31
2013	2887.19	43.05	9088.16	31	2409.90
2014	2929.88	43.08	9211.32	31	2460.47
2015	2970.58	42.07	9340.20	31	2474.06

2016	2983.74	41.80	9425.52	31	2533.33
Total	2693.84	41.78	9425.52	589	2122.92

Source: CHINA RURAL STATISTICAL YEARBOOK.

According to Table 4, the overall planting area of China's food crops appeared a downward tendency before 2004. And then the overall planting area of China's food crops began to increase year by year since the introduction of various agricultural subsidy policies in 2004, showing a V-shaped trend as a whole. The trend of grain planting area proportion in China is similar to that of planting area. It also declined year by year before 2004. After the implementation of various subsidy policies, it gradually picked up, showing a V-shaped trend (Table 5).

Table 5. Trends of Grain Planting Area Proportion in China from 1998 to 2016

year	mean	min	max	N	sd
1998	0.54	0.25	0.75	31	0.10
1999	0.54	0.26	0.74	31	0.10
2000	0.53	0.25	0.73	31	0.10
2001	0.49	0.24	0.63	31	0.09
2002	0.47	0.22	0.69	31	0.09
2003	0.47	0.21	0.70	31	0.09
2004	0.44	0.20	0.68	31	0.10
2005	0.46	0.19	0.72	31	0.11
2006	0.47	0.20	0.69	31	0.11
2007	0.47	0.20	0.70	31	0.12
2008	0.50	0.19	0.72	31	0.13
2009	0.49	0.18	0.72	31	0.13
2010	0.50	0.18	0.71	31	0.13
2011	0.50	0.18	0.71	31	0.13
2012	0.50	0.18	0.73	31	0.14
2013	0.50	0.18	0.76	31	0.14
2014	0.50	0.17	0.79	31	0.15
2015	0.52	0.17	1.04	31	0.18
2016	0.50	0.17	0.80	31	0.15
Total	0.49	0.17	1.04	589	0.12

Source: CHINA RURAL STATISTICAL YEARBOOK.

Same as the treatment method of subsidy policy, in order to more intuitively compare the difference between the grain planting area and its proportion in the eastern and western provinces, this paper respectively studies the trend of the grain planting area and its proportion in the eastern and western regions from 1998 to 2016. As presented in Figure 3 and Figure 4, it can be directly seen that both the grain planting area and its proportion are much higher in the eastern region, also, the trend of the grain planting area and the proportion of planting area in the eastern region are basically consistent with that of the whole country. The planting area and its proportion in eastern region have been declining until 2004, and subsequently began to recover year by year, showing a V-shaped trend as a whole.

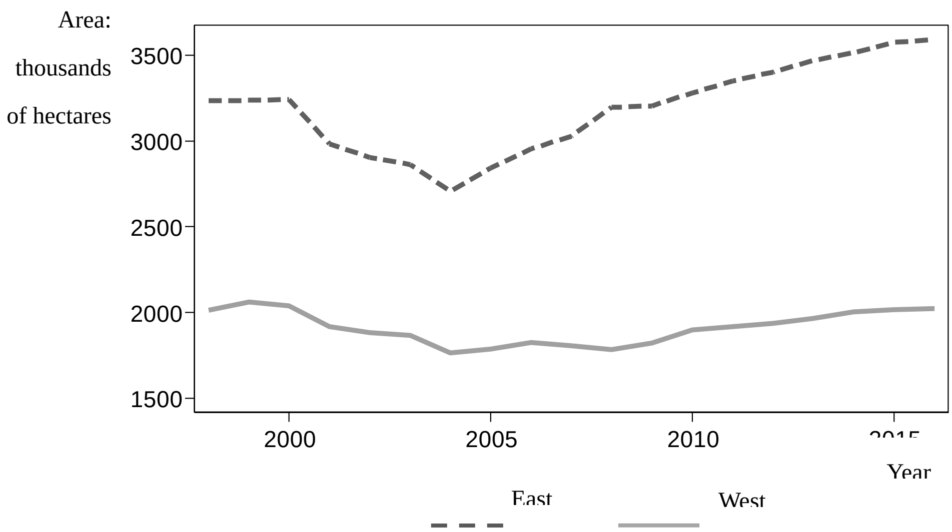

Figure 3. Trend of Grain Planting Area in East and West

Source: CHINA RURAL STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK FOR REGIONAL ECONOMY

However, this is not exactly the case in the western region. From the perspective of the planting area of food crops, although the planting area of grain has slightly rebounded after the implementation of the agricultural subsidy policy in 2004, the planting area of food crops is basically the same around 2004 with little fluctuation. Judging from the proportion of grain cultivated area, the proportion was in line with the overall change trend of the whole country before 2004, showing a downward trend, but it was still declining after 2004 with a slight descent.

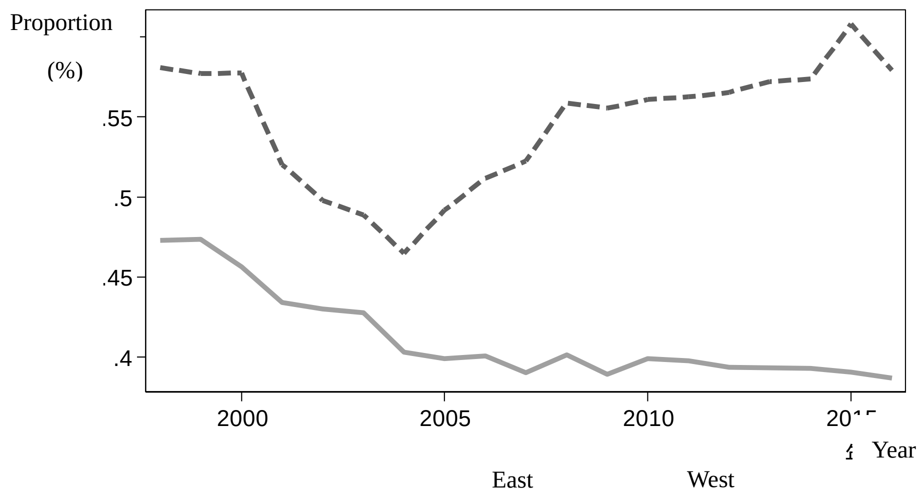

Figure 4. Trend of Grain Planting Area Proportion in the East and West

Source: CHINA RURAL STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK FOR REGIONAL ECONOMY.

4. Estimation Model

4.1 Methods

We mainly apply the DID method to explore the relationship between China's agricultural subsidy policy and grain planting structure. The DID method, is currently widely used in the field of policy evaluation, which is mainly used to evaluate the net impact of the implementation of a specific policy or the construction of government public works. Here, we regard the public policy as a natural experiment, then select the exogenous subjects, and divided all the investigation samples into the treatment group with policy effect and the control group without policy effect. The basic principle is to calculate the changes of the treatment group and the control group before and after the implementation of a certain policy respectively, and then compare the difference between the two changes to obtain a double difference estimate, that is, the net effect of the policy after deducting other relevant influencing factors.

$$y_{it} = \alpha_0 + \alpha_1 P_i + \alpha_2 T_t + \alpha_3 P_i T_{it} + u_{it} \tag{8}$$

A simple DID model is established to explain its specific meaning here. y_{it} represents the explained variable in formula (8), P_i is a grouping virtual variable. When P_i is 1, it indicates that the sample belongs to the treatment group; otherwise, it means it belongs to the control group. T_t is a time dummy variable, similarly, it indicates that the policy has not been implemented if T_t is 0; after the policy is implemented, T_t takes a value of 1. The double difference estimate is expressed by the coefficient α3 in front of the cross term P_iT_{it} and it is used to measure the net effect of the policy. Thus δ can be obtained by second order difference.

The index change models of the treatment group and the control group can be obtained from the above model. For the control group, when Pi =0, the model can be rewritten as:

$$y_{it} = \alpha_0 + \alpha_2 T_t + u_{it} \tag{9}$$

Therefore, the explained variables of the control group before and after the implementation of the policy can be simplified as follows:

$$y_1 \begin{cases} \alpha_0 (T = 0,\ \textit{before the implementation of the policy}) \\ \alpha_0 + \alpha_2 (T = 1,\ \textit{after the implementation of the policy}) \end{cases} \tag{10}$$

Apparently, the changes of the control group's explained variables are:

$$dif_1 = (\alpha_0 + \alpha_2) - (\alpha_0) = \alpha_2 \tag{11}$$

Also for the treatment group, when P_i =1, the model can be rewritten as:

$$y_{it} = \alpha_0 + \alpha_1 + \alpha_2 T_t + \alpha_3 T + u_{it} \tag{12}$$

The explained variables of the treatment group before and after the implementation of the policy can be simplified as follows :

$$y_2 \begin{cases} \alpha_0 + \alpha_1 (T = 0,\ \textit{before the implementation of the policy}) \\ \alpha_0 + \alpha_1 + \alpha_2 + \alpha_3 (T = 1,\ \textit{after the implementation of the policy}) \end{cases} \tag{13}$$

Then the changes of the treatment group's explained variables are:

$$dif_2 = (\alpha_0 + \alpha_1 + \alpha_2 + \alpha_3) - (\alpha_0 + \alpha_1) = \alpha_2 + \alpha_3 \tag{14}$$

The net impact of this policy on y_{it} can be directly calculated:

$$dif = dif_2 - dif_1 = (\alpha_2 + \alpha_3) - (\alpha_2) = \alpha_3 \tag{15}$$

That is, the coefficient α3 in front of $P_i T_{it}$ in the original model formula (8) represents the net effect of the implementation of a certain policy on the explained variables.

In the empirical analysis, we often add some control variables to control the influence of other relevant factors on the basis of equation (8).

We further adopt the fixed effect or the first-order difference method to establish a general DID model for the samples involved in the multi-phase panel data structure, then equation (8) can be further rewritten as follows:

$$y_{it} = \beta_0 + \delta D_{it} + \alpha X_{it} + \mu_{it} \tag{16}$$

D_{it} is a dummy variable, and it means that the individual i is affected by the policy during T period when it is 1. The coefficient δ in front of D_{it} is a double difference estimator, which reflects the effect of the policy.

Since the sample data in this paper belong to multi-period panel structure data, the general econometric model is more appropriate here.

4.2 Data and Descriptive Statics

The data used in this research are panel data of 31 provinces from 1998 to 2016. We mainly study the impact of agricultural subsidy policy on the grain production structure. Therefore, the explained variables are the grain planting area and its proportion of the total crop planting area. The core explanatory variable is the dummy variable, which indicates whether the agricultural subsidy policy is implemented. The definition and calculation of other control variables involved in models are shown in Table 6.

Table 6. Description of the Variables Used

Variable name	Description
Mechanization degree	The amount of agricultural machinery owned by each province (10,000 kilowatts), which is subjected to logarithmic processing
Agricultural acreage	The total amount of cultivated land in each province (thousand hectares), which is subjected to logarithmic processing
Number of agricultural labors(NAL)	The total number of agricultural laborers (10,000 people) in each province，which is subjected to logarithmic processing
Proportion of female	The total number of female agricultural workers in each province (10,000)
Proportion of elderly workforce	The total number of agricultural senior laborers over 60 years old in each province(10,000 people)
Local economic development level	The proportion of the second and tertiary industries in GDP of each province

Table 7 further gives descriptive statistical results of variables. The data of this article are collected from the official data and network data of China rural statistical yearbook, China statistical yearbook, China regional statistical yearbook, websites of provinces, central government, Ministry of agriculture, Ministry of finance and China economic information network statistical database from 1998 to 2016.

Table 7. Descriptive Statistics

Variable name	mean	min	max	sd	N
Mechanization degree	7.293	4.516	9.499	1.081	589
Agricultural acreage	7.908	5.403	9.57	1.078	589
Agricultural labors	8.295	5.503	11.594	1.124	589
Proportion of female	0.7	0.053	5.093	1.005	589
Proportion of elderly workforce	0.122	0.007	1.196	0.183	589

Local economic development level	0.859	0.621	0.996	0.075	589

Source: CHINA RURAL STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK; CHINA STATISTICAL YEARBOOK FOR REGIONAL ECONOMY.

4.3 Estimation Model

The different implementation intensities of agricultural subsidy policy to different provinces in China has made it possible to identify the impact of agricultural subsidy policy by DID method.

On the one hand, the allocation of subsidy funds by the local government in the western provinces is mostly used to invest in township or county-run enterprises that are conducive to local economic construction, while less investment is made in agriculture and infrastructure.

On the other hand, the four agricultural subsidies are mainly concentrated on food crops, while the industrial structure in most western provinces is unreasonable. Although there is a large number of rural labor force, agricultural production is mainly based on the cultivation of resource-intensive cash crops such as cotton, sugar and oil, so the agricultural subsidies in western regions are weak and negligible. In addition, according to the data of China's 1998 - 2016 rural statistical yearbook, the change trend of the grain planting area and its proportion in the eastern and western provinces were very close (see Figure 4 and Fugure 5) before the implementation of the agricultural subsidy policy in 2004. Based on the above analysis, we choose DID method to test the impact of agricultural subsidy policy on grain production structure, which is of certain applicability and accuracy.

Hence, this paper takes the provinces in the eastern region as the treatment group and the provinces in the western region as the control group, and uses DID method to study the impact of agricultural subsidy policy.

$$DID = \left[E(y_i \mid P_i = 1, T_t = 1) - E(y_i \mid P_i = 1, T_t = 0)\right] - \left[E(y_i \mid P_i = 0, T_t = 1) - E(y_i \mid P_i = 0, T_t = 0)\right] \tag{17}$$

Considering that the agricultural subsidy policy was implemented in 2004 and the lagging effect of the policy, this paper divides the implementation period of the policy into two parts: pre-implementation and post-implementation, thus the samples are divided into four groups: the grain planting structure of eastern provinces before and after 2005; the Grain planting structure of western provinces before and after 2005. The difference between the four groups of grain planting structure can be concluded as the impact of agricultural subsidy policy.

The specific regression model is set up as follows:

$$y_{it} = \alpha_0 + \alpha_1 P_i + \alpha_2 T_t + \alpha_3 P_i T_{it} + \alpha_4 X_{it} + u_{it} \tag{18}$$

In the above formula, y_{it} represents the area or proportion of grain cultivation, P_i is the group dummy variable; when Pi takes value of 1, the sample belongs to the treatment group (eastern provinces), and 0 indicates that it belongs to the control group (western provinces); T_t is a time dummy variable, before the implementation of the policy, the value of T_t is 0 (before 2005), 0 otherwise. X_{it} are other control variables, including local economic development level (proportion of secondary and tertiary industries), agricultural mechanization degree and other characteristic variables.

5. Results and Discussion

We first apply the DID method to examine the overall impact of agricultural subsidy policies on grain planting area and its proportion, and then gradually add the control factors using a specific measurement model (18) to analyze the impact of agricultural subsidy policies on grain planting structure. In order to ensure that the impact of the policy can be effectively identified, this paper will test the robustness of model estimation results from macro and micro perspectives, and compare the impact of agricultural subsidy policies on grain acreage and its proportion.

5.1 Macroscopic Perspective

Table 8. Results of DID of Agricultural Subsidy Policy on Grain Planting Area

	Control Group	Treatment Group	Difference	Standard Error	T-value
Before 2005	7.093	7.589	0.497***	0.176	2.83
After 2005	7.025	7.571	0.545***	0.134	4.06

*Note: ***, ** and * mean significant at 1%, 5% and 10% statistical levels respectively.*

The results of DID method show that after the implementation of the agricultural subsidy policy, the grain planting area of the treatment group is 0.545 thousand hectares higher than that of the control group (see Table 8). It can be obtained that agricultural subsidies have increased the area by 0.048 thousand hectares. Before 2005, the total difference of grain planting areas between the eastern and western provinces was 0.497 thousand hectares, but it was 0.545 thousand hectares after the implementation of the policy. The implementation of the agricultural subsidy policy indeed increased the gap between the two.

Table 9. Results of DID of Agricultural Subsidy Policy on Grain Planting Area Proportion

	Control Group	Treatment Group	Difference	Standard Error	T-value
Before 2005	0.443	0.530	0.087***	0.015	6.00
After 2005	0.395	0.555	0.160***	0.011	14.48

*Note: ***, ** and * mean significant at 1%, 5% and 10% statistical levels respectively.*

Table 9 shows the DID analysis results of the agricultural subsidy policy on the proportion of grain planting area. Similarly, the proportion of grain planting area in the treatment group is 0.160 higher than that in the control group after the implementation of the agricultural subsidy policy. Thus, the proportion of grain planting area increases by 0.073. Before 2005, the total difference in the proportion of grain planting areas between the eastern and western provinces was 0.087, while, it was 0.16 after the implementation of the policy. The implementation of the agricultural subsidy policy also increased the gap between the two. Therefore, the implementation of the agricultural subsidy policy will promote farmers to increase the area of grain cultivation and its proportion. This conclusion is also consistent with the previous hypothesis.

Table 10. Effect of Agricultural Subsidy Policy on Grain Planting Structure

	Proportion of Grain Acreage			Grain Acreage		
	(1)	(2)	(3)	(4)	(5)	(6)
PT	0.132***	0.078***	0.078***	0.103**	0.101***	0.101***
	(0.012)	(0.010)	(0.010)	(0.048)	(0.026)	(0.026)
Policy	-0.305***	-0.217*	-0.134***	-2.225***	-0.139	-0.325***
	(0.082)	(0.125)	(0.018)	(0.459)	(0.362)	(0.048)
Mechanization degree	0.030***	0.078***	0.078***	0.300***	0.451***	0.451***
	(0.007)	(0.017)	(0.015)	(0.035)	(0.058)	(0.042)
Agricultural acreage	0.019**	0.001	0.001	0.478***	0.014	0.014
	(0.008)	(0.005)	(0.007)	(0.048)	(0.014)	(0.018)
Agricultural labors	0.004	0.051	0.051	0.566***	-0.028	-0.028
	(0.009)	(0.046)	(0.047)	(0.041)	(0.143)	(0.129)
Proportion of female	-0.266	0.050	0.050	-1.379	0.227	0.227
	(0.182)	(0.115)	(0.146)	(1.002)	(0.344)	(0.397)
Proportion of elderly workforce	0.217**	-0.068	-0.068	0.365	-0.030	-0.030
	(0.109)	(0.046)	(0.065)	(0.421)	(0.145)	(0.176)
Local economic development level	0.280***	-0.399**	-0.399***	-1.700***	-1.807***	-1.807***
	(0.070)	(0.192)	(0.116)	(0.256)	(0.455)	(0.315)
Time Fixed Effects	yes	yes	yes	yes	yes	yes
Spatial Fixed Effect		yes			yes	
FE			yes			yes
N	434	434	434	434	434	434
R2_a	0.388	0.882	0.346	0.99	0.346	0.99
AIC	-1608.3	-1548.3	-599.971	-539.971	-599.971	-539.971

*Note: ***, ** and * mean significant at 1%, 5% and 10% statistical levels respectively.*

A more general DID model (18) was further selected to analyze the impact of agricultural subsidy policies on grain planting structure here. As shown in Table 10, models (1), (2), and (3) are regression models of agricultural subsidy policies for the proportion of grain planting area, followed by control time effects, control time and province effects, and FE effect. Models (4), (5), and (6) are regression models of agricultural subsidy policies for grain acreage, followed by control time effects, control time and province effects, and FE effect. At this time, the coefficient of the dummy variable PT is a double difference estimator.

The coefficients of PT from model (1) to model (3) are all significantly positive, indicating that the regression results are robust, that is, the proportion of grain planting area in the eastern provinces has increased in the positive direction significantly after the implementation of the policy. The estimation results from model (4) to model (6) show that the coefficients of PT are significantly positive, whether it is time control alone, simultaneously control time and province effect, or control time and fixed effect, indicating that the regression result is robust. The grain acreage in the eastern provinces has also undergone a significant positive increase since the implementation of the policy, which is consistent with the assumptions in this paper.

5.2 Microscopic Perspective

We then verify the hypothesis from a micro perspective and compare the impact of agricultural subsidy policies on the area of grain cultivation and its proportion to enhance the cogency. Since Jiangsu is a major agricultural province in China, the state has strongly supported its agricultural development, so the subsidy policy can play a better role. Moreover, Jiangsu province has vast population and limited farmland, and there is a prominent contradiction between its land resources and agricultural development. Under the above premise, choosing Jiangsu region, where the contradiction between people and land is more prominent, as the research sample can better reflects the impact of subsidy policies on the grain planting structure and enthusiasm of farmers, and is helpful to analyze the impact mechanism of agricultural subsidy policies. Therefore, this paper selects the survey data of farmers in Jiangsu province located in the eastern region for the empirical test at the micro level. The sample data comes from the author's random questionnaire surveys of 196 sample farmers in Jiangsu Province in 2018, including surveys of farmers' production activities, household characteristic variables and the planting area of food crops.

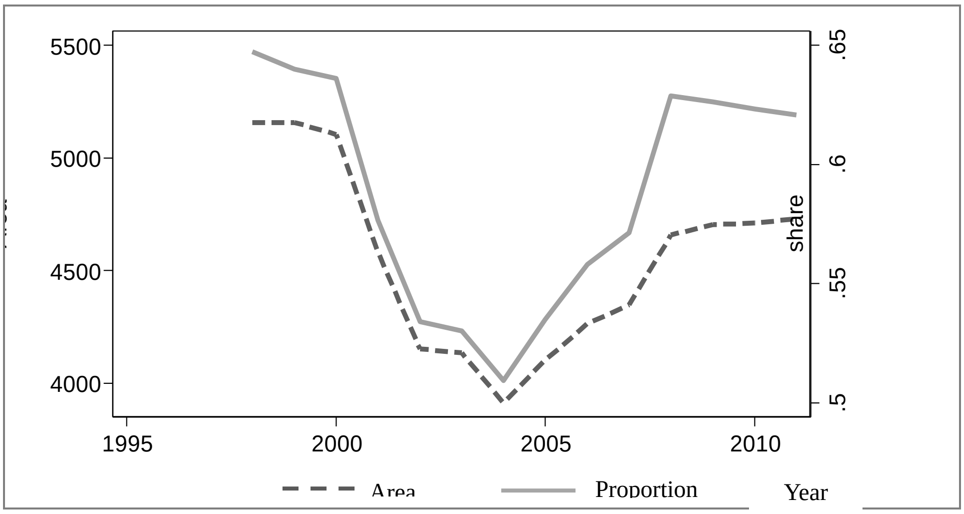

Figure 5. Trend in Grain Planting Structure in Jiangsu Province

Source: The authors collated the data based on 196 sample farmers in Jiangsu Province.

Both the grain acreage and its proportion in Jiangsu Province showed a downward trend before the implementation of the agricultural subsidy policy in 2004, while after the implementation of the agricultural subsidy policy in 2004, the area and proportion began to increase year by year with the same change trend overall, showing a V-shape (Fig. 5). It is also consistent with the tendency of the entire eastern region, indicating that Jiangsu province is indeed representative to some extent.

Based on the above analysis, the specific regression model is set up as follows:

$$y_{it} = \alpha_0 + \alpha_1 Subsidy_{it} + \alpha_2 X_{it} + \varepsilon_{it} \quad (19)$$

y_{it} represents the area or proportion of grain planting, Subsidyit is the policy dummy variable, $Subsidy_{it}$ is 1 means farmers who are subsidized, 0 represents farmers without agricultural subsidies; X_{it} stands for other control variables, including age and gender of head of the household, nature of production activities, education level, cultivated land area, fixed asset investment and other production of farmers Characteristic variables, also, the farmland area, fixed asset investment, and labor force are all processed in logarithm.

Table 11. Effect of Agricultural Subsidy Policy on Grain Planting Structure in Jiangsu Province

	Proportion of Grain Acreage	Grain Acreage
	(1)	(2)
Subsidy Policy	0.081***	0.097***
	(0.011)	(0.025)
Age	0.003**	0.001
	(0.001)	(0.003)

Education Level	0.013***	0.043***
	(0.004)	(0.010)
Gender	0.010	0.006
	(0.024)	(0.056)
Nature of Activities	-0.011	0.007
	(0.012)	(0.027)
Cultivated Land Area	0.003	0.304***
	(0.017)	(0.041)
Num of labor force	-0.024	0.041
	(0.016)	(0.037)
Fixed Asset Investment	0.004	0.027***
	(0.004)	(0.009)
Time Fixed Effects	yes	yes
FE	yes	yes
N	196	196
R2_a	-0.227	-0.230
AIC	-4236.227	-163.560

*Note: ***, ** and * mean significant at 1%, 5% and 10% statistical levels respectively.*

As shown in Table 11, similar to the macro level analysis, model (1) is a regression model of agricultural subsidy policy on the proportion of grain planting area after controlling time and individual effects. Model (2) is a regression model of agricultural subsidy policy on grain acreage after controlling time and individual effects. At this time, the coefficient of the dummy variable Subsidyit is the difference estimator.

The estimation results of model (1) and model (2) show that the coefficients of the dummy variable Subsidyit are both significantly positive, that is, the grain planting area and proportion of farmers in Jiangsu Province have changed significantly in a positive direction after the implementation of the policy, which verifies the correctness of the hypothesis in this paper again.

6. Conclusions

6.1 Research Conclusions

It has been 14 years since the implementation of the grain subsidy policy in 2004. Judging from the effect of the implementation of the policy, the agricultural subsidy policy has a positive effect on the grain planting structure of farmers. With relevant data of factors affecting farmers' grain planting structure, This paper adopts DID model, and multiple linear regression model to conduct empirical research. It explores the effect of agricultural "four subsidies" policy from the micro and macro perspectives. The analysis concluded:

The implementation of the subsidy policy has indeed changed the farmers' food production input behavior, significantly stimulating the farmers to increase the land input for food production, that is, the area and proportion of grain cultivation have increased. The "four subsidies" policy of agriculture has played a positive role in promoting China's grain production mainly through two ways: On the one hand, it has affected the farmers' production function by promoting technological progress. Subsidies for improved varieties of crops, purchase of agricultural machinery and comprehensive direct subsidies for agricultural materials are all subsidy policies for agricultural inputs. These subsidies can increase the quantity and improve the quality of agricultural capital inputs, thus expanding the possibility frontier of grain production technology. On the other hand, the cost function is modified by reducing the cost, thus affecting the grain planting structure. The direct subsidy of grain will greatly reduce farmers' agricultural production costs and increase their income, thereby increasing the area of grain. The research results of this paper provide a theoretical basis for the implementation of agricultural subsidy policy in China.

6.2 Policy Implications

Through analyzing and reflecting the current agricultural subsidy system in China, I draw the following policy implications from the empirical results:

(1) The government should continue to implement the grain subsidy policy, and increase the intensity of the "four subsidies" in agriculture, so that agricultural subsidies can promote grain production with certain sustainability. The state should attach more importance to food security and focus on increasing output when designing agricultural subsidy policies. The subsidy structure can be optimized through flexible exertion of various agricultural subsidy policy tools so as to highlight subsidy priorities. For example, the so-called "efficiency-type" financial subsidy project, represented by subsidies for purchasing agricultural machinery and other equipment, which can improve agricultural production conditions and farmers' production efficiency, can improve the comprehensive production capacity of national food and enhance the international competitiveness of China's agriculture.

(2) Increase the subsidies for farmers with large-scale grain production. The current form of subsidies in China is directly linked to the actual grain planting area, and the scale efficiency of subsidies shows an increasing trend. The increase of subsidies for large scale grain producers can mobilize the enthusiasm of farmers to grow grain, encourage farmers to expand the scale of grain planting, thus promoting farmers to carry out large-scale grain production and improving the scale efficiency of grain production.

(3) We can appropriately raise the relative price of grain and improve the grain market system. Increasing the relative price of grain can arouse the enthusiasm of farmers in grain production. A well-established grain market system and a sound grain purchasing system can protect the interests of farmers from losses, improve the efficiency of funds, and enable farmers to truly benefit from it.

References

Ahearn, M. C., El-Osta, H., & Dewbre, J. (2006). “The Impact of Coupled and Decoupled Government Subsidies on Off-farm Labor Participation of US Farm Operators”. *American Journal of Agricultural Economics*, *88*(2), 393-408. https://doi.org/10.1111/j.1467-8276.2006.00866.x

Anthony, D., Becker, R., & Judge, P. (2014). “Evidence of Distortionary Effects of Decoupled Payments in U.S. Indica Rice Production”. *Atlantic Economic Journal*, *42*(3), 65-275. https://doi.org/10.1007/s11293-014-9421-7

Cao, G., Zhou, L., Yi, Z., Zhang, Z., & Han, X. (2010). “The Impact of Agricultural Machinery Purchase Subsidy on Farmers’ Purchase Behavior: An Empirical Analysis Based on Rice Planting in Jiangsu Province”. *Chinese Rural Economy*, (6), 38-48.

Chen, F., Fan, Q., & Gao, T. (2010). “Agricultural Policy, Grain Output and Grain Production Adjustment Capacity”. *Economic Research Journal*, (11), 101-114.

Chen, H., Wu, L., & Wang, Y. (2010). “The Impact of Subsidy Policy on China’s Grain Production: An Empirical Study Based on Provincial Data from 2004 to 2007”. *Journal of Agrotechnical Economics*, (4), 100-106.

Chung-Hui, L., Shih-Wen, H., Vey, W., & Chi-Chur, C. (2017). “Agricultural R&D, policies, (in)determinacy, and growth”. *International Review of Economics & Finance*, *51*(9), 328-341. https://doi.org/10.1016/j.iref.2017.06.005

Fang, S., & Wang, W. (2009). “Research on Agricultural Subsidy Policy under the Background of Rapid Cost Rising”. *Management World*, (9), 9-108.

Gao, M., Song, H., & Michael, C. (2017). “Does subsidy reduce the loss of grain production efficiency? - Analysis Based on Dynamic Asset Poverty Theory”. *Management World*, (9), 85-100.

Huang, J., Wang, X., Zhi, H., & Huang, Z. (2011). “The Impact of Direct Grain Subsidy and Comprehensive Agricultural Subsidy on Agricultural Production”. *Journal of Agrotechnical Economics*, (1), 4-12.

Ivana, K. V., & Rastislav, K. (2016). “Quantification of the Effect of Subsidies on the Production Performance of the Slovak Agriculture”. *Procedia Economics and Finance*, *39*, 298-304. https://doi.org/10.1016/S2212-5671(16)30327-6

Jean, J. M., & Kristof, D. W. (2017). “The influence of public subsidies on farm technical efficiency: A robust conditional nonparametric approach”. *European Journal of Operational Research*, *259*, 1112-1120. https://doi.org/10.1016/j.ejor.2016.11.014

Key, N., & Roberts, M. J. (2009). “Nonpecuniary Benefits to Farming: Implications for Supply Response to Decoupled Payments”. American Journal of Agricultural Economics, *91*(1), 1-18. https://doi.org/10.1111/j.1467-8276.2008.01180.x

Koo, W. W., & Kennedy, P. L. (2006). The impact of agricultural subsidies on global welfare. *American Journal of Agricultural Economics*, *88*, 1219-1226. https://doi.org/10.1111/j.1467-8276.2006.00936.x

Laure, L., & Yann, D. (2016). “Common Agricultural Policy support, technical efficiency and productivity change in French agriculture”. *Review of Agricultural, Food and Environmental Studies*, (97), 15-28. https://doi.org/10.1007/s41130-016-0007-4

Li, J. (2016). “Evaluation of Agricultural Subsidy Policy Effect: Incentive Effect and Wealth Effect”. *Chinese Rural Economy*, (12), 17-32.

Lin, W., & Ru, Y. (2014). “A Preliminary Analysis of China’s Farmers’ Direct Subsidy Policy System and Investment since 2001”. *Chinese Rural Economy*, (12), 4-12.

Liu, K. (2010). “Analysis on the Influence and Mechanism of Grain Production Subsidy Policy on Farmers’ Decision - making Behavior on Grain Planting—A Case Study of Jiangxi Province”. *Chinese Rural Economy*, (2), 12-21.

Long, L., Wang, Y., Bradley, G., Ridoutt, et al. (2019). “Agricultural subsidies assessment of cropping system from environmental and economic perspectives in North China based on LCA”. *Ecological Indicators*, *96*, 351-360. https://doi.org/10.1016/j.ecolind.2018.09.017

Luo, D., Li, W., & Chen, J. (2013). “Grain Benefits: Differentiation Characteristics and Policy Implications—Based on the Survey of 3400 Grain Farmers”. *Management World*, (7), 59-70.

Ma, Y., & Yang, Y. (2005). “The Impact of Grain Direct Subsidy Policy on Farmers’ Willingness to Grow Grain, Farmers’ Income and Production Input—An Empirical Study Based on Hebei Case”. *Journal of Agrotechnical Economics*, (2), 7-13.

Meimei, L., & Huang, Q. (2019). “Exploring the relationship between agricultural intensification and changes in cropland areas in the US Agriculture”. *Ecosystems & Environment*, *274*, 33-40. https://doi.org/10.1016/j.agee.2018.12.019

Mu, Y., & Xiao, C. (2009). “SCGE Model Construction and Simulation Analysis of China’s Agricultural Subsidy Policy”. *The Journal of Quantitative & Technical Economics*, (1), 3-15.

Sunil, K. (2006). “Relative profitability, supply shifters and dynamic output response, in a developing economy”. *Journal of Policy Modeling, Elsevier*, *28*(1), 67-88. https://doi.org/10.1016/j.jpolmod.2005.06.014

Thomas, S., Jayne, N. M. M., William, J. B., & Joshua, A. (2018). “Review: Taking stock of Africa’s second-generation agricultural input subsidy programs”. *Food Policy*, *75*, 1-14. https://doi.org/10.1016/j.foodpol.2018.01.003

Wang, O., & Yang, J. (2014). “The Impact of Agricultural Subsidy on Chinese Farmers’ Grain Production”. *Chinese Rural Economy*, (5), 20-28.

Xu, Q., Yin, R., & Zhang, H. (2011). “Scale Economy, Scale Reward and Moderate Scale Management of Agriculture—An Empirical Study Based on China’s Grain Production”. *Economic Research Journal*, (3), 59-71.

Ying, W., Richard, E. B., Qi, Z., Li, J., & Song, C. (2019). “Effects of payment for ecosystem services and agricultural subsidy programs on rural household land use decisions in China: Synergy or trade-off?”, *Land Use Policy*, *81*(2), 785-801. https://doi.org/10.1016/j.landusepol.2018.10.057

Zhan, S. (2017). "Riding on self-sufficiency: Grain policy and the rise of agrarian capital in China". *Journal of Rural Studies*, *54*, 151-161. https://doi.org/10.1016/j.jrurstud.2017.06.012

Zhong, C., Chen, S., & Xu, C. (2013). "Structural Changes, Relative Prices of Factors and Farmers' Behavior: Theoretical Model and Micro-empirical Evidence of Agricultural Subsidy". *Journal of Financial Researc*h, (5), 167-180.

Zhong, F., Gu, H., & Ji, Y. (2008). "The Role Differentiation of Farmers and the Income Distribution Effect of Agricultural Subsidy Policy: An Empirical Study on the Income Distribution Effect of Agricultural Tax Relief and Grain Direct Subsidy in Jiangsu Province". *Management World*, (5), 65-70.

Zhu, M., Li, X., & Cheng, G. (2015). "Analysis of the Impact of Comprehensive Income Subsidy on China's Total Factor Productivity of Maize—DEA-Tobit Two-stage Method Based on Provincial Panel Data". *Chinese Rural Economy*, (11), 4-14.

Note

Note 1. From 2004-2013. Due to the unavailability of some data, the four agricultural subsidies in each province were only obtained from 2004 - 2013.