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Research on the Impact of Agricultural Financial Support on Agricultural Carbon Compensation Rate

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Abstract: Based on the consideration of the dual attributes of agricultural carbon emission and carbon sink, this study measures the agricultural carbon compensation rate (ACCR) of 31 provinces in China from 2006 to 2019, the impact of agricultural financial support on ACCR and its transmission mechanism are empirically analyzed using a spatial econometric model and intermediary effect model. The results show that: (1) a significant spatial correlation between agricultural financial support and ACCR; (2) increased agricultural financial support is conducive to the improvement of ACCR; (3) agricultural financial support has the most significant effect on the ACCR in the eastern region; (4) the effect of agricultural financial support on ACCR has a spatial spillover effect but is not significant; (5) agricultural technological progress is the intermediary variable that agricultural financial support affecting ACCR. Therefore, it is suggested to promote agricultural emission reduction through collaboration, innovative financial support mechanisms, implementation of differentiated financial support strategies, exerting the radiation effect of financial support to agriculture, and pushing up the level of agricultural mechanization.

Keywords: agricultural financial support; agricultural carbon compensation rate; spatial Durbin model; low-carbon agriculture

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1. Introduction

Since the industrial revolution, a large amount of carbon dioxide emitted by human production and living has been one of the main causes of global climate change. In response to the adverse effects of climate change, nearly 200 parties worldwide signed the Paris Agreement [1,2]. As a major greenhouse gases emitter, China has proposed a "national independent contribution" under the framework of the Paris Agreement, promising that carbon dioxide emissions will peak around 2030 and the carbon dioxide emissions per unit of GDP will decrease by 60–65% by 2030 compared with 2005 [3,4]. The Third National Information Circular of the People's Republic of China on Climate Change, issued in 2019, shows the greenhouse gas emissions from agricultural activities in 2014 were about 830 million tons equivalent to carbon equivalent, and carbon sink from land use, land-use change and forestry was about 1.12 billion tons. Agriculture is the basis of national economic development, and compared with the secondary and tertiary industries, agriculture has dual attributes of carbon emission and carbon sink. Under the premise of ensuring food security, increasing the ACCR is of great significance to promoting the "carbon peaking and carbon neutrality goals" [5]. In February 2022, the Opinions of the State Council of the Central Committee of the Communist Party of China on Promoting Rural Revitalization in 2022 was released, which is the 19th central document focusing on agriculture, rural areas, and farmers since the 21st century, which focuses on the "Problems about Agriculture, Rural areas and Peasantry". Agriculture is basic, weak, multifunctional, and public goods in nature and requires financial support and protection from the government to guarantee sustainable agricultural development [6]. In recent years, China's financial support for agriculture has been continuously enhanced. Agricultural financial support has increased from CNY 43.022 billion in 1995 to CNY 2242.211 billion in 2019 [7], with an average annual growth of 17.9%. The continuous enhancement of financial support for agriculture has improved agricultural infrastructure and science and technology to a certain extent and improved the development level and international competitiveness of China's agriculture [8]. Agricultural financial support promotes agricultural development through direct inputs, financial subsidies, tax incentives, and other ways. Will China's agricultural financial support have an impact on the ACCR while promoting agricultural development? Clarifying the impact mechanism of agricultural financial support on ACCR will help expand the way of agricultural carbon sink increase and reduction and accelerate the green transformation and upgrading of agriculture.

There have been studies on agricultural carbon emissions, mainly focusing on the following three aspects. Firstly, studies related to agricultural carbon emissions. The existing studies mainly measure agricultural carbon emissions from agrarian material inputs, CH_4 emissions in rice production, livestock breeding, and abnormal waste disposal [9]. On this basis, the spatial characteristics of agrarian carbon emissions [10,11], the relationship between agricultural economic growth and agricultural carbon emissions [12,13], the efficiency of agricultural carbon emissions [14], and the path of agrarian carbon emission reduction [15] were discussed. Many studies have focused on the correlation between industrial structure [16], agricultural technological progress [17], and rural human capital [18]. Secondly, studies related to the carbon effect of agriculture. Due to the dual nature of agricultural carbon emissions, studies have involved the net carbon sink of agriculture [19] as well as the situations and potential of unilateral agricultural carbon sink [20]. In view of the huge carbon sink potential of agriculture, the paths and suggestions for developing carbon sink agriculture are put forward [21], mainly including promoting circular agriculture, promoting organic agriculture, and changing farming methods, etc. [22,23]. Thirdly, studies related to carbon emission reduction in agriculture. It has been confirmed that technological progress in agriculture is the main driver of carbon reduction in agriculture [24,25]. Advances in agricultural technology can promote the deep integration of agrarian production resources and production methods, which helps to form an efficient and low-energy consumption agricultural development model and release the potential for agricultural carbon emission reduction [26].

As for the impact of agricultural financial support on agriculture, scholars have conducted in-depth studies, mainly including the following three aspects. Firstly, the impact of agricultural financial support on agricultural economic development, which is mainly verified by most scholars based on the production function model. The results show that agricultural financial support is conducive to promoting agricultural economic growth, and optimizing the structure of financial support for agriculture is crucial to agricultural economic development [27,28]. Secondly, the impact of agricultural financial support on the income gap between urban and rural residents. As an important element for the government to guide rural development, financial support for agriculture can promote farmers' income and narrow the income gap between urban and rural residents [29]. However, some scholars believe that there will be urban bias in government financial expenditure allocation and unreasonable structure of financial support to agriculture will increase the income gap between urban and rural areas [30]. Thirdly, with regard to the impact of agricultural financial support on the environment, some studies believe that agricultural financial support will distort market mechanisms, leading to excessive use of chemical-like elements and significantly increasing agricultural surface source pollution emissions [31]. However, financial support for agriculture promotes technological progress and resource endowments, thus contributing to agricultural carbon emissions reduction.

Existing studies focus on the impact of agricultural financial support on carbon emissions; most of them are from the perspective of carbon emission without considering the dual attributes of agricultural carbon emission and carbon sink and without an in-depth analysis of the impact mechanism of agricultural financial support. In order to make up for the deficiency of existing studies, this paper uses a spatial econometric model to explore the impact of agricultural financial support on ACCR under the premise of fully considering the spatial correlation of ACCR. This study uses the mediating effect model to verify the influencing mechanism. It is expected to provide a theoretical basis for comprehensively evaluating the policy effect of agricultural financial support and promoting agricultural emission reduction.

2. Policy Background and Mechanism Analysis

2.1. Policy Background

In China, agriculture is a basic industry but also a weak industry, which is vulnerable to both natural disasters and market risks. China has been managing the various risks facing agriculture through various agricultural financial support policies. Since 2004, China's No.1 Central Document has focused on the "Problems about Agriculture, Rural areas and Peasantry" for 18 consecutive years. China has implemented a series of policies to support, benefit and strengthen agriculture, and has increased investment in agriculture and gradually improved agricultural production conditions. In 2018, the Ministry of Agriculture and Rural Affairs and the Ministry of Finance released the Financial Key Policies for Strengthening Agriculture and Benefiting Farmers, which covers direct subsidies for farmers, agricultural restructuring, and the promotion of green technologies in agriculture. In 2019, the agricultural financial support policy focused on a green and ecological-oriented agricultural subsidy system, clarifying the new direction of future agricultural subsidy reform. The financial support policy for agriculture emphasizes the conservation and utilization of agricultural resources and lays the foundation for transforming the agricultural development mode and achieving the transformation and upgrading of the agricultural structure. At present, China is in a critical period of building a new economic development pattern and promoting common prosperity and needs to better play the role of government financial support. Compared to urban areas, rural financial resources are insufficient, and agricultural production infrastructure is backward. The government can improve the overall efficiency of financial resources utilization through financial support policies and gradually form a long-term mechanism to promote farmers' income and agricultural environment improvement.

2.2. Mechanism Analysis

In recent years, China's agricultural financial support has given strong support to agricultural infrastructure construction, agricultural technology investment, and subsidy of agricultural support. According to the classification of the Organization for Economic Cooperation and Development (OECD), agricultural subsidies are divided into agricultural producer support and general service support. Agricultural producer support includes price support and direct subsidies. The price support includes the lowest price purchase policy and temporary purchase and storage of grain. Agricultural subsidies include input use subsidies, linkage subsidies, and decoupling subsidies. General service support includes science and technology promotion, farmer training, investment in resource and environmental protection, and infrastructure construction. At present, China's agricultural financial support has entered the stage of in-depth development, focusing on supporting green agriculture, rural revitalization, and agricultural science and technology innovation, and promoting the transformation of traditional agriculture to modern agriculture.

2.2.1. Impact of Agricultural Financial Support on ACCR

Agricultural financial support plays an important role in enhancing the ACCR and affects both agricultural carbon emissions and agricultural carbon sink (see Figure 1).

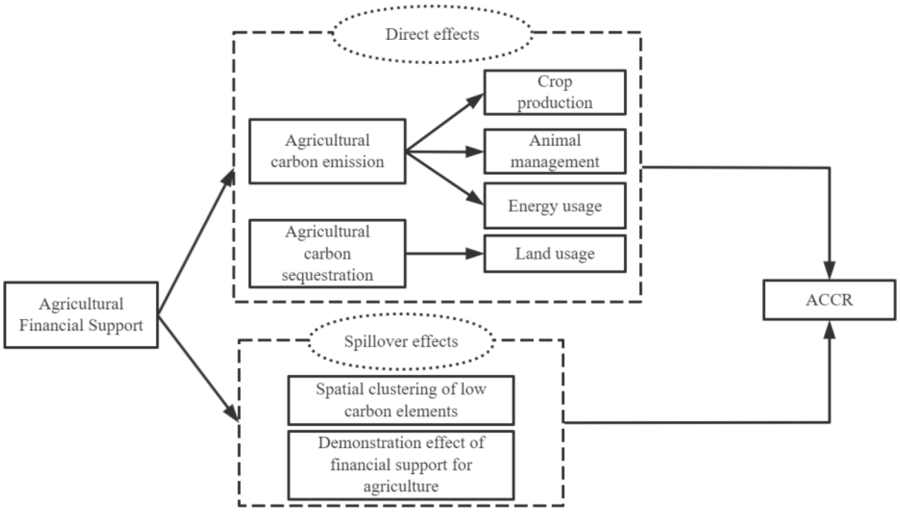

Figure 1. Impact of agricultural financial support on ACCR.

The impact of agricultural financial support on agricultural carbon emission is mainly reflected in three aspects: crop production, animal management, and energy use [32]. First, the carbon emission reduction of agricultural crop production includes the reduction of rice cultivation and crop residue management. Technology subsidies in agricultural financial support can promote the development of low-carbon rice crop technology, realize linked precision irrigation and drainage of rice production, and reduce methane emissions and energy consumption during rice production. At the same time, subsidies for farmland protection and quality improvement in agricultural financial support will improve the utilization rate of straw resources and the efficiency of crop residue management. Second, carbon emission reduction of animal management includes enteric fermentation emission reduction and fecal management. Agricultural financial support promotes feed processing enterprises to optimize feed ratios and improve feed processing, and reduce carbon emissions from animal intestinal fermentation. At the same time, agricultural financial support can promote large-scale and intensive livestock production, thus helping realize the recycling and harmless utilization of animal manure and reducing carbon emissions generated in the process of manure management. Third, in terms of energy use, financial funds strongly support the construction of clean energy systems for agriculture, covering solar, wind, biomass, and other clean energy sources, while encouraging agricultural enterprises and farmers to use clean energy to reduce agricultural carbon emissions.

The impact of agricultural financial support on agricultural carbon absorption is reflected in agricultural land use [33]. Subsidies for returning farmland to forest and grass and subsidies for peatland restoration in agricultural financial support have improved the coverage of forest and grass in China and rebuilt forest and grass ecology. Returning farmland to forest and pasture to grass has made remarkable achievements in reducing soil erosion and improving vegetation cover. At the same time, the increase in forest land area helps to increase the forest carbon sink, and its sustainable carbon sink benefits are significant. Agricultural financial support measures such as building high-standard farmland and expanding the implementation area of conservation tillage in agricultural financial support will improve the carbon sink function of farmland, thus increasing the agricultural carbon sink.

In addition, agricultural financial support not only increases the local ACCR but also has a spillover effect on the surrounding areas. Agricultural financial support will promote the spatial clustering of low-carbon factors. For example, the emission reduction and sink increase in agricultural financial support have a demonstration effect on neighboring areas, thus speeding up the transformation of low-carbon operation mode and low-carbon efficiency in neighboring areas, cultivating compound green and low-carbon cycle agriculture with efficient use of resources, and realizing the low-carbon transformation of agricultural development.

Hypothesis 1. *Agricultural financial support can effectively increase the ACCR, and this effect has spatial spillover effects.*

2.2.2. Mediating Effects of Technological Progress in Agriculture

Economist Schultz pointed out in his book *Transforming Traditional Agriculture* that government investment in agricultural research will accelerate the transformation of agricultural technology [34]. Cohen et al. (1994) confirmed the correctness of this view that the government would promote agricultural technology progress by formulating inductive incentive policies [35]. The three costs of science and technology in agricultural financial support (referring to the trial production of new products, intermediate tests, and subsidies for scientific research in agricultural research departments) promote the agricultural technology progress and production technology innovation, accelerate the promotion and application of agricultural scientific and technological achievements, and enhance agricultural technology service capability. The expenditure on supporting agriculture through science and technology will optimize the scale and structure of agricultural production and strengthen the promotion and application of agricultural science and technology. The agricultural output will be increased under the premise that the number of factors input remains unchanged, and agriculture will be guided to develop in the direction of intensification and scale. Agricultural technological progress mainly affects agricultural carbon emissions through three aspects. Firstly, it improves the utilization efficiency of production factors. Agricultural technological progress can improve the quality and efficiency of chemical inputs such as fertilizers, pesticides, and agricultural film [36]. Under the condition of constant factor input, it can increase agricultural output per unit of land area, thereby reducing agricultural carbon emissions. Secondly, agricultural technological progress can improve farmers' professional and technical literacy through the learning effect and technology spillover effect, thereby improving agricultural production efficiency. Thirdly, agricultural technological progress improves the utilization efficiency of labor by influencing or creating new means of labor. For example, the updating of agricultural machinery technology eliminates backward agricultural machinery and equipment, reduces agricultural diesel consumption, and thus significantly reduces agricultural carbon emissions. Given this, we put forward:

Hypothesis 2. *Agricultural technical progress is the mediating variable of agricultural financial support affecting ACCR.*

3. Model and Data

3.1. Variable Selection and Data Sources

3.1.1. Variable Selection

1. Explained variable

Agricultural carbon compensation rate (CR). The agricultural carbon compensation rate is the ratio of agricultural carbon sink to carbon emission. When the ratio equals 1, it indicates that agricultural carbon sink is equal to carbon emission. When the ratio is greater than 1, it indicates that the agricultural carbon sink is greater than carbon emission. When the ratio is less than 1, it indicates that the agricultural carbon sink is less than agricultural carbon emission. The higher the ACCR, the stronger the agricultural carbon absorption capacity in this area. The formula for ACCR is as follows.

$$CR = CT/CE \tag{1}$$

where CR is the agricultural carbon compensation rate, CT is the total carbon absorption in agriculture, and CE is the total carbon emission in agriculture.

Due to the great differences in agricultural resource endowments among provinces, agricultural carbon sink, and carbon emissions vary greatly among regions. The calculation of agricultural carbon emissions includes four aspects. Firstly, the carbon emissions generated by the input of agricultural materials mainly include the carbon emissions generated by chemical fertilizers, pesticides, agricultural film, diesel, and irrigation power consumption [37]. Secondly, the carbon emissions generated during the rice growth cycle. Thirdly, livestock farming produces carbon emissions, mainly including the carbon emissions from the intestinal fermentation of ruminant feeding and manure management. Fourthly, carbon emissions from agricultural waste disposal, mainly from agricultural straw incineration. Agricultural carbon emissions are the sum of the four types of emission sources. The formula for agricultural carbon emissions is as follows.

$$CE = \sum C_{ni} = \sum T_{ni} \cdot \delta_n \tag{2}$$

where CE is the total carbon emissions of province i. C_{ni} is the carbon emissions of province i and carbon emission sources n. T_{ni} denotes the different carbon emission sources, and δ_n denotes the carbon emission factor. The specific carbon emission factors refer to Liu et al., Cui et al., and Tian et al. [38,39].

Agricultural carbon sink mainly considers the carbon sink during the whole life cycle of crop growth, without considering forest land and grassland. There are two reasons for this: Firstly, there is no unified standard for measuring carbon sinks in woodlands and grasslands, and the coefficient values provided by different institutions vary greatly. Secondly, compared with crop cultivation, woodland and grassland are less affected by human activities. Agricultural carbon sink calculation mainly includes specific crop species such as rice, wheat, corn, potatoes, cotton, rape, beans, sugar beets, peanuts, sugar cane, melons, and tobacco. The formula for agricultural carbon sinks is as follows.

$$CT = \sum C_{mi} = \sum c_m \cdot Y_m \cdot (1 - r)/HI_m \tag{3}$$

where CT is the total carbon uptake; C_{mi} is the amount of carbon absorbed by province i, crop m; c_m is the amount of carbon absorbed per unit of organic matter synthesized by crop m through photosynthesis; Y_m is the economic yield of crop m; r is the water content of the economic product fraction of the crop; HI_m is the economic coefficient of crop m.

2. Core explanatory variable

Financial Support for Agriculture (*FS*). Financial support policy for agriculture is an effective means for the country to solve the "Problems about Agriculture, Rural areas and Peasantry" Financial support for agriculture is the sum of all financial resources directly or indirectly used by the government to develop agricultural production, improve the rural environment and improve the living standards of farmers. *China Statistical Yearbook* no longer subdivides the financial support for agriculture after 2006, and the statistics of agriculture, forestry, and fishery expenditures are calculated in agriculture, forestry, and water affairs. Therefore, to ensure the consistency of the data scale structure within the research interval, this paper uses the agriculture, forestry, and water affairs expenditures after 2006 for the analysis in the empirical process.

3. Mediator variable

Technological progress in agriculture (*TL*). Drawing on existing research, this study adopts the agricultural mechanization level to measure agricultural technology's progress. There are two main reasons for this: firstly, China's current agricultural machinery-based technology has evolved into a leading technology, and the improvement of the agricultural mechanization level will optimize the combination of agricultural input factors, thereby improving agricultural productivity. Secondly, agricultural financial support will improve the level of agricultural mechanization through agricultural machinery purchase subsidies and agricultural science and technology investment. Considering the variability of agricultural production scale in each province, this paper uses the ratio of total agricultural machinery power to the agricultural sown area to measure the level of agricultural mechanization.

4. Control variables

Agricultural chemical inputs (*CI*). Agricultural chemical inputs generally include pesticides, fertilizers, agricultural films, etc. When measuring carbon emissions from agriculture, carbon emissions from fertilizers account for a larger proportion of the total emissions of agricultural chemical inputs. Therefore, the ratio of discounted fertilizer to crop sown area is used to express agricultural chemical inputs. The scale of grain planting (*GF*). In the process of grain planting, the tillage operation, material input, waste disposal, etc., will produce carbon emissions. In general, the larger the scale of grain planting, the more carbon emissions will generate. In this paper, we use grain sown area to measure the scale of grain planting. Level of agricultural economic development (*AE*). The ratio of the total output value of agriculture, forestry, animal husbandry, and fishery to the rural population is used to express the level of agricultural economic development, which will affect the market maturity of agricultural products and agricultural production factors and can influence the structure of agricultural production and agricultural production factor inputs, thus affects ACCR. Agricultural fixed assets investment (*FA*). The increase in investment in agricultural fixed assets helps to improve agricultural infrastructure and reduce factor inputs per unit of output, which may affect ACCR. The income level of rural residents (*IN*) is measured by the net income of rural residents. Sectoral proportional optimization index (*ST*) is expressed by the ratio of non-planting output value to the total output value of agriculture, forestry, and fishery output.

3.1.2. Data Sources

This paper selects panel data from 31 provinces in mainland China (excluding Hong Kong, Macao, and Taiwan due to missing data) from 2006–2019. ACCR data were obtained from our calculations. Data on agricultural financial support, agricultural mechanization level, and other control variables were obtained from the *China Statistical Yearbook* and *China Rural Statistical Yearbook*. Descriptive statistics of the variables are shown in Table 1.

Table 1. Descriptive statistics of variables.

Variables	Number of Samples	Mean	Standard Deviation	Min	Max
ln*CR*	434	0.1364	0.4745	−1.2267	1.0729
ln*FS*	434	−2.4092	0.6836	−5.2360	−1.5925
ln*TL*	434	0.1224	1.9720	−7.7981	1.8595
ln*CI*	434	−0.5686	1.9528	−2.1891	6.9767
ln*GF*	434	−0.4461	0.2125	−1.1142	0.1335
ln*AE*	434	9.2856	0.5494	7.6475	10.5740
ln*FA*	434	5.5199	1.4407	0	8.6600
ln*IN*	434	8.9698	0.5926	7.5931	10.4101
ln*ST*	434	−0.8316	0.2436	−1.6678	−0.2520

3.2. Model Setting

3.2.1. Spatial Durbin Model

To accurately reflect the impact of agricultural financial support on the ACCR, this study constructs a spatial panel regression model based on the adjacent spatial weight matrix and the geographic distance spatial weight matrix. LM (lag), LM (error), Robust LM (lag), and Robust LM (error) tests were all significant at the 1% level of significance. Both LR and Wald tests reject the original hypothesis at the 1% level, i.e., the spatial Durbin model cannot degenerate into a spatial lag model and a spatial error model. After the above tests, this paper selects the spatial Durbin model with two-way fixed effects for empirical analysis. In order to make the data stable, all explanatory variables are logarithmic. The model is set as follows.

$$\ln CR = \rho W \ln CR + \alpha_0 + \tau \ln FS + \gamma Control + \varphi W \ln FS + \theta W Control + \mu_{it} \quad (4)$$

where ρ, φ, and θ represent the agricultural carbon emissions of neighboring cities, agricultural financial support, and the intensity of influence of control variables on local agricultural carbon emission, respectively. *Control* is the control variable. α_0 is a constant term. W is the spatial weight matrix. In this paper, we use the neighboring matrix and the inverse geographic distance matrix as the spatial weight matrix. The main diagonal elements of the spatial weight matrix are all 0. The non-primary diagonal elements of the neighboring matrix take the value of 1 when the two provinces are adjacent and 0 when they are not. The non-principal diagonal element of the inverse geographic distance matrix is $1/d_{ij}$, and d_{ij} represents the geographic distance between the two provincial capitals. μ_{it} is the random error term.

3.2.2. Mediating Effect Model

From the theoretical analysis section, it is clear that agricultural financial support may affect the ACCR through agricultural technological progress. Based on the intermediary effect test steps, the intermediary effect of technological progress in agriculture is identified [40]. The model is set as follows.

$$\ln CR = \rho W \ln CR + \alpha_0 + \tau_1 \ln FS + \gamma Control + \varphi W \ln FS + \gamma W Control + \mu_{it} \quad (5)$$

$$\ln TL = \rho W \ln TL + \alpha_0 + \theta \ln FS + \gamma Control + \varphi W \ln FS + \gamma W Control + \mu_{it} \quad (6)$$

$$\ln CR = \rho W \ln CR + \alpha_0 + \tau_2 \ln FS + \delta \ln ML + \gamma Control + \varphi W \ln FS + \lambda W \ln ML + \gamma W Control + \mu_{it} \quad (7)$$

where M is the mediating variable, and the other explanatory variables are the same as in model (4). The steps of the mediating effect test are as follows. Firstly, the intensity of agricultural financial support is regressed on the ACCR to test the significance of the coefficient τ_1. Secondly, the intensity of agricultural financial support was regressed on the agricultural technological progress variable to test the significance of the coefficient θ. Finally, the intensity of agricultural financial support and agricultural technological progress variables are regressed on the ACCR simultaneously. When both θ and δ are significant, if τ_2 is significant, it indicates that agricultural technological progress has a partial mediating effect, and if τ_2 is not significant, it means that agricultural technological progress has a complete mediating effect.

4. Empirical Results and Analysis

4.1. Result of ACCR Measurement

4.1.1. Spatial Distribution Characteristics of ACCR

To show more intuitively the spatial differences of China's ACCR, this study divided the examination period into two periods: 2006–2012 and 2012–2019. The results were plotted as shown in Figure 2. In general, the provinces with low ACCR remained stable during the study period, and the regions with higher rates showed an expansion trend, indicating that China's ACCR was on the rise in general. Specifically, the provinces with high ACCR in 2006 were mainly distributed in Xinjiang, Jilin, Shanxi, Henan, Guangxi, etc. The area of provinces with high ACCR in 2019 was expanded, mainly distributed in Xinjiang, Inner Mongolia, Jilin, Heilongjiang, Liaoning, Shanxi, Henan, Shandong, and Guangxi.

Thirteen provinces of Liaoning, Hebei, Shandong, Jilin, Inner Mongolia, Jiangxi, Hunan, Sichuan, Henan, Hubei, Jiangsu, Anhui, and Heilongjiang are classified as major grain-producing areas, while other provinces are classified as non-major grain-producing areas concerning the regulations of the State Food Bureau of China. From the comparison results of grain-producing regions, the ACCR in 2006–2019 was significantly higher in grain-planting regions than in non-grain-planting regions. It is worth noting that Jiangxi and Hunan, which are major grain-producing regions, have lower ACCR, which may be due to the fact that both provinces are large rice-growing provinces. Compared with other food crops, rice emits more CO_2 during its growth cycle.

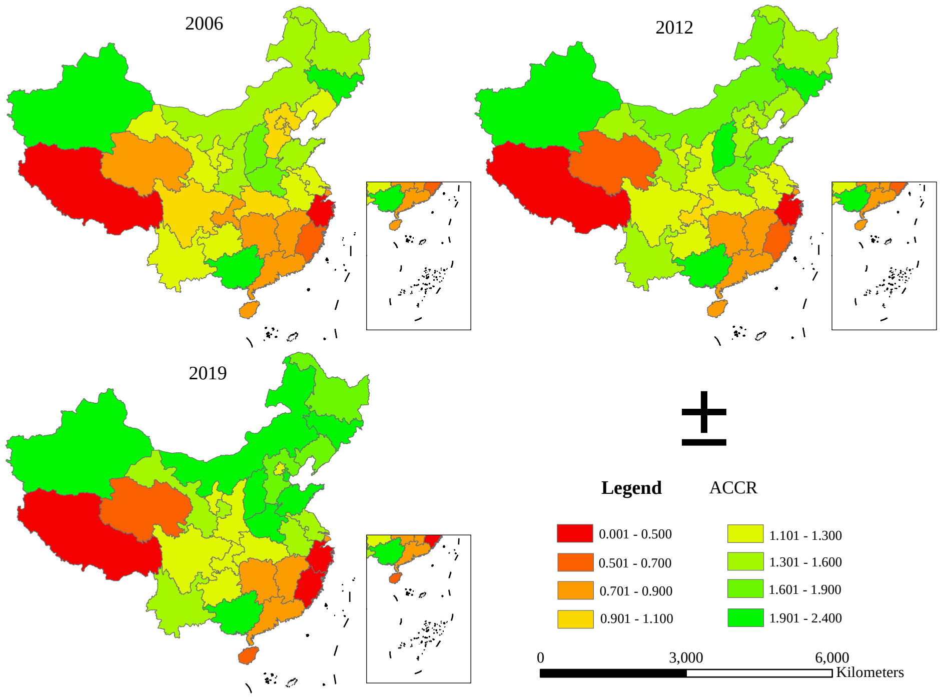

Figure 2. Spatial distribution of ACCR.

4.1.2. Spatial Correlation of ACCR

This paper analyzes the correlation of ACCR in each province from the perspective of spatial correlation. Global spatial autocorrelation is used to describe the overall distribution of a certain attribute among geospatial units so as to judge whether the attribute value is relevant to the overall spatial unit. Local spatial autocorrelation is used to describe the distribution location of the clustering of geospatial units with similar attributes, and the specific formula is omitted [41].

The spatial econometric model is applied on the premise that the value of an attribute on a spatial unit is correlated with the same attribute on an adjacent spatial unit. Therefore, before analyzing the impact of agricultural financial support on the ACCR, this study needs to verify whether the two variables are spatially correlated. The overall spatial correlation results of ACCR and agricultural financial support from 2006 to 2019 are shown in Table 2. The global spatial correlation test shows that ACCR and agricultural financial support show a significant positive spatial correlation for all years under the inverse geographic distance spatial weight matrix, indicating that the spillover effects of ACCR and agricultural financial support are significant in terms of geographic distance. From the time dimension, the spatial correlation of ACCR shows a fluctuating upward trend. It indicates that the spatial correlation of ACCR is gradually increasing while the spatial correlation of agricultural financial support is gradually decreasing.

Table 2. Spatial correlation between ACCR and agriculture financial support.

Year	ln*CR*	ln*FS*		ln*CR*	ln*FS*		ln*CR*	ln*FS*
2006	0.030 * (1.889)	0.147 *** (5.770)	2011	0.053 *** (2.597)	0.110 *** (4.831)	2016	0.043 ** (2.280)	0.113 *** (4.721)
2007	0.034 ** (2.029)	0.140 *** (5.477)	2012	0.040 ** (2.228)	0.103 *** (4.539)	2017	0.081 *** (3.386)	0.170 *** (6.697)
2008	0.045 ** (2.339)	0.116 *** (4.787)	2013	0.045 ** (2.354)	0.146 *** (5.989)	2018	0.044 ** (2.293)	0.108 *** (4.526)
2009	0.030 * (1.919)	0.105 *** (4.518)	2014	0.030 * (1.907)	0.177 *** (7.282)	2019	0.059 *** (2.748)	0.106 *** (4.639)
2010	0.043 ** (2.297)	0.129 *** (5.241)	2015	0.034 ** (2.036)	0.100 *** (4.194)			

Note: *, **, and *** denote significant at the 10%, 5%, and 1% levels, respectively, with Z values in parentheses.

4.2. Analysis of the Impact of Financial Support to Agriculture on ACCR

The spatial correlation test of the ACCR above fully proves that the ACCR has a significant spatial correlation. If this is not considered in the model construction, the model estimation results may be greatly biased. Therefore, this paper introduces a spatial econometric model, and after the Hausman test, this study chooses a two-way fixed-effects spatial Durbin model.

To investigate the effect of financial support to agriculture on the ACCR, this paper uses a spatial Durbin model to regress agricultural financial support and other explanatory variables based on the adjacency weight matrix and geographic distance matrix. Due to the introduction of the spatial weight matrix, the model is no longer endogenous and overcomes the shortcomings of biased or invalid OLS estimation results of traditional econometric models, as shown in Table 3.

Table 3. Spatial econometric regression results of the effect of agricultural financial support on ACCR.

Variables	Countrywide	Countrywide	Eastern	Central	Western
	(1)	(2)	(3)	(4)	(5)
ln*FS*	0.0201 **	0.0281 **	0.0535 **	−0.0069	0.0107
	(0.0101)	(0.0114)	(0.0190)	(0.0142)	(0.0175)
ln*CI*	−0.0138	−0.0049	−0.0785	0.1443 ***	0.0325
	(0.0296)	(0.0337)	(0.0742)	(0.0517)	(0.0392)
ln*GF*	0.4381 ***	0.3818 ***	0.3830 ***	0.4137 ***	−0.0553
	(0.0308)	(0.0337)	(0.0573)	(0.0790)	(0.0933)
ln*AE*	0.0048	−0.0343	−0.0598	−0.0509	0.0523
	(0.0238)	(0.0288)	(0.0447)	(0.0474)	(0.0483)
ln*FA*	0.0008	0.0076	−0.0013	0.0371	0.0207 *
	(0.0071)	(0.0083)	(0.0150)	(0.0232)	(0.0114)
ln*IN*	−0.6367 ***	−0.3993 ***	−0.4098 **	−0.0903	−0.5480 **
	(0.1057)	(0.1157)	(0.1893)	(0.1663)	(0.2505)
ln*ST*	−0.1242 **	−0.1784 ***	−0.0194	−0.0211	−0.0719
	(0.0515)	(0.0595)	(0.1625)	(0.0723)	(0.0722)
Time fixed	YES	YES	YES	YES	YES
Province fixed	YES	YES	YES	YES	YES
ρ	0.6024	0.5761 ***	0.4489 ***	0.3779 ***	−0.6250 ***
	(0.4249)	(0.0892)	(0.1058)	(0.1234)	(0.2151)
N	434	434	154	140	140
R^2	0.4945	0.5456	0.6101	0.7423	0.6907

Note: *, **, and *** denote significant at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are robust standard errors.

Columns (1) and (2) show the results of the model estimation under the adjacency weight matrix and the geographic distance weight matrix, respectively. It can be seen that the coefficients of agricultural financial support are all significantly positive at the 5% significance level, which proves the robustness of the study findings. Due to the space limitation, this study uses the geographic distance weight matrix for analysis. At the national level, the effect of agricultural financial support on the ACCR in column (2) is positive and significant at the 5% level. This suggests that agricultural financial support significantly increases the ACCR; for every 1% increase in agricultural financial support intensity, the ACCR will increase by 0.0281%. Hypothesis one is verified. At the regional level, the effect of agricultural financial support on ACCR has significant variability. It shows a significant positive effect in the eastern region and a non-significant effect in the central and western regions. The main reasons are as follows. Firstly, the efficiency of the use of agricultural financial support funds is higher in the eastern regions than in the central and western regions. The fragmentation of agricultural support funds will increase administrative costs and make it difficult to form a synergistic effect to support agricultural development. It has a greater negative impact on the central and western regions with insufficient funds, reducing the scale efficiency of capital use in the central and western regions. Secondly, the investment of agricultural financial support funds is unbalanced. The scale of agricultural financial support investment in the eastern region is large, while the scale of input in the central and western regions is small, and there is a large gap in agricultural financial support funds. Coupled with the unreasonable structure of administrative expenditure and productive expenditure, it is difficult to have an impact on the rate of agricultural carbon compensation.

4.3. Direct, Indirect, and Total Effects

According to Lesage and Elhorst [42,43], the regression coefficients of the spatial Durbin model can not fully reflect the effect of the explanatory variables on the explained variables, and their total, direct, and indirect effects need to be calculated. Direct effects reflect the effects of changes in explanatory variables on the explained variables of the local spatial unit. Indirect effects reflect the effects of changes in explanatory variables on the explanatory variables of adjacent spatial units. The specific results are shown in Table 4. In terms of the direct effect, agricultural financial support has a positive effect on the ACCR, and it is significant at the 1% level of significance, indicating that the increase in local agricultural financial support helps to enhance the local ACCR. In terms of indirect effects, although the effect of agricultural financial support on ACCR is positive, it is not significant, indicating that the "demonstration effect" of local agricultural financial support intensity on neighboring provinces is not obvious. In terms of the overall effect, the effect of agricultural financial support on the ACCR is positive at the 10% significance level; that is, overall, the increase in the intensity of agricultural financial support has a significant positive effect on the ACCR.

Table 4. Regression results for total, direct, and indirect effects.

Variables	Total Effects	Direct Effects	Indirect Effects
ln*FS*	0.4956 *	0.0397 ***	0.4559
	(0.2997)	(0.0149)	(0.2898)
ln*CI*	0.0396 ***	−0.0025	0.0421
	(0.0067)	(0.0324)	(0.0329)
ln*GF*	−1.1776 **	0.3460 ***	−1.5237 ***
	(0.5605)	(0.0385)	(0.5416)
ln*AE*	−0.0282	−0.0354	0.0072
	(0.0883)	(0.0273)	(0.0902)
ln*FA*	−0.0449	0.0066	−0.0516 *
	(0.0298)	(0.0078)	(0.0294)
ln*IN*	0.0068	−0.3897 ***	0.3966 ***
	(0.0706)	(0.1096)	(0.1249)
ln*ST*	0.9707 *	−0.1456 **	1.1163 **
	(0.5642)	(0.0582)	(0.5499)

Note: *, **, and *** denote significant at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are robust standard errors.

4.4. Testing the Mediating Effects of Technological Progress in Agriculture

From the results of the mediating effect test in Table 5, it is clear that agricultural technology progress plays a mediating role in the process in the process of agricultural financial support affecting ACCR. From the regression results, firstly, without considering the effect of mediating variables, the effect of agricultural financial support on the ACCR is significantly positive. Secondly, the core explanatory variable ln*FS* has a significant positive effect on the mediating variable, indicating that agricultural financial support has a positive contribution to agricultural technological progress. Thirdly, after including the mediating variables, the effect of agricultural technology progress on the ACCR is significantly positive, which indicates that agricultural technology progress may reduce agricultural carbon emission by changing the factor structure and improving agricultural production efficiency and may also increase agricultural carbon absorption by increasing the planting area of food crops, thereby promoting the improvement of ACCR. The effect of the core explanatory variable ln*FS* on the ACCR is positive, and the absolute value and significance of the coefficient have decreased. It indicates that the positive effect of agricultural technological progress on ACCR has a partial mediating effect. Hypothesis 2 was tested.

Table 5. Results of the mediating effect test.

Variables	ln*CR*	ln*TL*	ln*CR*
ln*FS*	0.0281 **	0.5337 ***	0.0205
	(0.0114)	(0.0677)	(0.0125)
ln*TL*			0.7210 ***
			(0.0735)
Control variables	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes
N	434	434	434
R^2	0.5456	0.9703	0.5073

Note: **, and *** denote significant at the 5%, and 1% levels, respectively. Numbers in parentheses are robust standard errors.

5. Discussion

The agricultural ecosystem has dual effects of carbon emission and carbon sink. Much of the literature focus on agricultural carbon emission, but less attention has been paid to the carbon sink effect of agriculture. In addition to affecting agricultural output, agricultural financial support can also regulate agricultural carbon emissions and carbon sink by influencing the production decision behavior of farmers. There are few studies linking agricultural financial support and the agricultural dual carbon effect. Based on clarifying the impact of agricultural financial support on agriculture's dual carbon effect, this study brings agricultural financial support, agricultural technological progress, and ACCR into the same framework. The spatial Durbin model is used to examine the influence paths of agricultural financial support on ACCR and explain the mediating effect played by agricultural technological progress in it.

Agricultural financial support is of great significance to the development of low-carbon agriculture. The government should not only focus on the short-term impact of agricultural financial support on carbon emission reduction but also pay attention to the transformation path of low-carbon operation mode of micro-farmers under the incentive of agricultural financial support so as to give full play to its long-term impact. At the same time, it is necessary to explore multiple realization mechanisms of agricultural low-carbon development, such as market-oriented mechanisms of low-carbon development, to stimulate the vitality and efficiency of the market and promote agricultural carbon emission reduction at a low cost.

This study has several limitations. First, the agricultural financial support is expressed in terms of agricultural, forestry, and water affairs expenditure rather than purely agricultural expenditure, which can only be an approximate proxy for the scale of fiscal agricultural expenditure. Second, when studying the impact of agricultural financial support on agricultural carbon offset rate, there is a lack of agricultural financial support data at the farm household level, but the purpose of this paper is to explain and illustrate the scientific aspects of the study. The empirical results of this paper can lead to revealing conclusions. In the future, agricultural financial support data at the household level can be further used to study the impact of agricultural financial support on ACCR and then verify the robustness of the conclusion of this study. Third, in terms of the selection of the spatial weight matrix, the spatial spillover effect of agricultural financial support on ACCR is not obvious under the inverse geographic distance spatial weight matrix, and it fails to reflect the temporal change of the impact of agricultural financial support on ACCR at the same time, which can be further analyzed by introducing spatio-temporal weight matrix in the future.

Despite these limitations, the findings of this paper have certain reference significance for the development of low-carbon agriculture. Our findings highlight the importance of financial support for agriculture. To achieve the goal of carbon neutrality in agriculture, it is important to consider the implementation of effective agricultural financial support policies in China and to consider the balance of localities. It should be noted, however, that those different countries have different fiscal structures and agricultural development strategies; therefore, the findings of this paper may not apply to other countries and regions.

6. Conclusions

Based on panel data for 31 provinces in China from 2006 to 2019, this paper investigates the effects of agricultural financial support on ACCR and the mediating effects of agricultural technological progress. The study shows that: (1) ACCR has a significant spatial correlation under the spatial weight matrix of geographical distance, and the ACCR has an overall increasing trend; (2) agricultural financial support has a significant positive effect on the ACCR, but this effect has obvious heterogeneity in the eastern, central, and western regions, with the most significant effect of agricultural financial support on the ACCR in the eastern region; (3) agricultural financial support has a spatial spillover effect on the ACCR, but it is insignificant; (4) agricultural technology progress plays a significant mediating role in the process of agricultural financial support affecting ACCR.

Based on the above conclusions, the following countermeasures are proposed.

First, coordinate inter-regional emission reduction and sink enhancement policies and promote the formation of a synergistic linkage mechanism between emission reduction and sink enhancement policies in the region. When formulating agricultural emission reduction and sink policies, the spatial correlation of agricultural carbon compensation rates among regions should be fully considered. For example, according to the spatial correlation characteristics of carbon emission reduction, the "lead-follow" type of synergistic emission reduction strategy should be implemented, and the leading region should actively explore agricultural technologies to promote emission reduction and sink increase, fully explore favorable factors that promote regional emission reduction and sink increase, explore diversified paths of emission reduction and sink increase, and at the same time promote agricultural carbon emission reduction in the follow region through technology transfer and financial investment, etc., so as to promote a long-term mechanism for collaborative emission reduction.

Second, innovate financial support for agriculture, and strengthen the green cycle orientation of financial support to agriculture. Firstly, innovate the allocation mechanism of financial support for agriculture, increase the tilt to green cycle agriculture in the use of financial support for agriculture, give full play to the guiding and supporting role of financial support for agriculture, and improve the ecological benefits of the use of financial support for agriculture. Secondly, improve the long-term incentive mechanism of financial support for agriculture, improve the green recycling agriculture production subsidy system, give full play to the environmental protection effect of agricultural subsidies, and promote low-carbon agricultural development by supporting the comprehensive utilization of agricultural waste, promoting the reduction of agricultural chemicals and increasing efficiency, and implementing green breeding and recycling agriculture pilot measures. Thirdly, explore the withdrawal mechanism of financial support for agriculture, adapt to the needs of the market economy operation, gradually weaken the direct support for agricultural production and operation, and instead increase the financial support for agricultural ecological protection, agricultural science and technology projects, green breeding and recycling agricultural pilot construction, agricultural infrastructure construction, etc.

Third, a differentiated agricultural financial support strategy is implemented to achieve a balanced regional development of low-carbon agriculture. From this study, agricultural financial support has a significant positive effect on the ACCR in the eastern region, while the western and central regions are not significant. Therefore, the eastern region can increase environmental protection expenditures to further expand the emission reduction and sink effect. The central and western regions need to highlight the guidance of financial support on agricultural technology innovation, set up special funds for agricultural technology promotion, and increase subsidies for agricultural production and operation entities to apply new technologies and promote low-carbon agricultural production.

Fourth, the policy radiation effect of financial support to agriculture is brought into play to strengthen the linkage and coordination of the impact of financial support policies on the dual carbon effect of agriculture. The research results show that the current spillover effect of fiscal support for agriculture on the agricultural carbon compensation rate is not significant. Therefore, provinces should fully realize that the effect of encouraging fiscal support policies for agriculture may be offset by the spatial spillover effect in the surrounding areas, pay attention to the synchronization of agricultural support policies, and promote the areas with high efficiency of the fiscal support policy for agriculture to radiate to low-lying areas, so as to effectively promote the regional ACCR.

Fifth, promote the level of environment-friendly agricultural mechanization and increases the economic and ecological benefits of agricultural production. The empirical results show that agricultural financial support plays a significant role in promoting the ACCR through technological progress, which is mainly manifested in the improvement of the agricultural machinery level. Improving the level of agricultural mechanization helps to achieve accurate control of agricultural input factors, improve agricultural efficiency, reduce resource consumption, and promote agricultural large-scale and intensive production. First, we should improve the agricultural machinery purchase subsidy policy, focus on the low-carbon transformation of agriculture, and strengthen the application of resource-saving agricultural machinery technology. Second, we should strengthen the construction of agricultural mechanization infrastructures, such as the construction of machine roads and agricultural machinery storage sheds, etc., improve the operating conditions of agricultural machinery, and enhance the scale of agricultural machinery cultivation.

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