Frontiers in Economics and Management Volume 6 Issue 1, 2025
ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

Impact of Green Finance Development on Agricultural Carbon Emissions

-- Based on Provincial Panel Data During 2006-2019

Zhiyu Chen

The University of Melbourne, Melbourne, Australia

Abstract

Global climate warming has become a problem that cannot be ignored. Agricultural carbon emissions, as the main source of carbon emissions in China, is an indispensable step to achieve the "double carbon" goal. In 2015, green development joined the Chinese development concept, advocating for an environmental value-oriented approach, and striving to promote the green and low-carbon production and lifestyle. Green Finance, as an important component of the green development concept, is of great significance to agricultural carbon reduction. This paper utilizes the panel data of 25 provinces in China during 2006-2019 to study the impact of the level of green finance development on agricultural carbon emissions by using the fixed effects model. The results suggest that green credit, green insurance, and green securities can all inhibit agricultural carbon emissions, and the research results remain valid after the robustness test. Based on the research results, this paper puts forward relevant policy recommendations from the perspective of assisting the development of green finance and improving the current situation of agricultural carbon emissions.

Keywords

Green Finance; Agricultural Carbon Emission Intensity; Fixed Effects Model.

1. Introduction

1.1. Research Background

With global greenhouse gas (GHG) concentrations rising at an unprecedented rate, people are facing increasingly severe natural disasters. Therefore, global warming has become an international problem that should not be overlooked. In 2015, 178 countries signed The Paris Agreement. Next year, China joined The Paris Agreement and collaborated with nearly 200 countries to develop new climate change response plans. In 2020, Xi, the President of the People's Republic of China, stated at the 75th Session of The United Nations General Assembly "China will increase its national contributions and adopt more effective policies and measures, striving to peak its carbon dioxide emissions before 2030, and to achieve carbon neutrality before 2060." "Double carbon" goal is of great significance and a tough task. However, agricultural carbon emissions, as the main source of carbon emissions, are an indispensable step towards the "double carbon" goal. Data from the Food and Agriculture Organization of the United Nations shows that carbon dioxide emissions from agriculture and food production account for 31% of total carbon emissions which means agriculture has already become the world's second largest carbon emissions contributor (Liu et al., 2022). China, as a great agricultural country, although carbon emissions and carbon intensity per capita are at a low level, the absolute amount of agricultural carbon emissions is high. Therefore, the research about agricultural carbon emissions and relevant policies and measures will have an important impact on worldwide climate change.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

In 2015, the Fifth Plenary Session of the 18th Central Committee of the Communist Party of China (CPC) adopted the "Recommendations of the Central Committee of the Communist Party of China on the Formulation of the Thirteenth Five-Year Plan for National Economic and Social Development", which clarifies the main objectives of the " 13th Five-Year Plan" period and adds green development to China's development concepts, which, along with innovation, coordination, openness, and sharing, constitutes the five development concepts. The five development concepts advocate environmentally-friendly, low-carbon production and lifestyle. Green finance, as an important part of green development concept, can not only guide the flow of capital, optimize the allocation of resources and promote the structural reform of the green industry at the micro level, but also alleviate the contradiction between environmental protection and economic development, and promote the sustainable development of the society, economy and environment at the macro level.

Based on current agricultural carbon emissions issues and the importance and necessity of development of green finance, this paper combines green finance and agricultural carbon emissions and uses the panel data of 25 provinces in China during 2006-2019, and applies the fixed effects model to study the impact of green finance development on agricultural carbon emissions.

1.2. Research Purpose

With the proposal of "double carbon" goals, China's green finance development rises to a new level, which is of great significance in the process of promoting the development of agricultural carbon reduction. This study aims to summarize and analyze the current state of China's green finance development and its impact on agricultural carbon emissions by collecting and organizing data related to green finance and agricultural carbon emissions in 25 provinces in China during 2006-2019, and put forward reasonable suggestions based on the analysis results.

1.3. Theoretical Implications

At present, research on agricultural carbon emissions mainly focuses on the spatial and temporal evolution of agricultural carbon emissions and the impact of agricultural economic growth and agricultural technological progress on carbon emissions, while green finance research focuses on the theoretical analysis of regional development paths or research on the relationship between green finance and high-quality economic development. There is limited evidence to consider the impact of green finance development on agricultural carbon emissions and its mechanism as a whole. Most of the research stays in the theoretical foundation and qualitative analysis, lacking relevant empirical analysis. Therefore, this paper will further provide empirical evidence for the development of relevant theories and provide new ideas for development on the basis of existing studies.

1.4. Practical Implications

Despite the rapid development of green finance, China's total agricultural carbon emissions remain high due to its large population base. Coupled with different national conditions, China can not completely learn from foreign development theories and there are still some practical problems to be solved. To help achieve agricultural carbon reduction and rural revitalization strategies, it is necessary to improve the green financial policy system, optimize the allocation of financial resources to drive the optimization of the allocation of other resource factors, so that the role of green finance is fully played. Therefore, it is of practical significance to study the impact of green finance development on agricultural carbon emissions.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

2. Literature Review

2.1. Green Finance

At present, countries around the world have not yet reached a consensus on the concept and connotation of green finance. Numerous scholars have made different definitions from different perspectives. Domestically, Gao (1998) defines green finance as a financial operation strategy, i.e., starting from the basic national policy of environmental protection, utilizing financial department management to promote balanced development between environmental resource and economy. Xiong (2004) explains the general understanding of green finance in academia, i.e., financial institutions should pay attention to environmental protection and governance and the efficient use of resources, and promote the sustainable development of economy and ecology, and thus promote the sustainable development of mankind. In 2016, the top-level framework of China's green finance system was established for the first time. The People's Bank of China (PBC), along with six other ministries, has defined green finance as economic activities that support environmental improvement, address climate change, and use resources efficiently. In short, it refers to diversified financial services provided to sectors such as environmental protection, energy conservation, and clean energy.

On the foreign side, the concept of green finance originates from environmental finance. Salazar is the first foreign scholar to study green finance and he believes that environmental finance is a kind of financial innovation brought about by the demand for environmental protection, and a bridge between finance and environmental industry. Subsequently, the American Heritage Dictionary published in 2000 defined green finance as environmental finance with sustainability, i.e., utilizing diversified financial instruments to invest heavily in environmental protection, exclusively for the protection of ecological environment and species diversity. In essence, there is no significant difference between foreign environmental finance and domestic green finance.

Compared to foreign countries, China’s green finance started relatively late and it’s difficult to learn from foreign development experience. Therefore, the development of green financial products, the formulation of relevant laws and policies, and the establishment of a green financial framework system in line with China's national conditions need to find out for themselves. In 2015, the Integrated Reform Plan for Promoting Ecological Progress put forward the requirement of construction of a green finance system for the first time, and established the general direction of China's green finance development. The following year, the release of Guidelines for Establishing the Green Financial System indicates that China has become the first economy to establish a relatively complete green finance policy system in the world. In 2021, the 14th Five-Year Plan and 2035 Vision Outline explicitly pointed out that it was necessary to accelerate the green transformation of the development model and vigorously develop green finance.

At present, green credit and green bonds are located in the base of the green finance pyramid, with the largest amount of investment in the market and the most significant and stable effect, accounting for 97% of China's total green finance, while other green financial products account for only 3% (Liang, 2022). According to the statistics of the People's Bank of China, the balance of domestic and foreign currency green credit reached ¥19.55 trillion by the end of June 2022, with a year-on-year growth rate of 40.4%. The scale of China's green credit consistently ranks first in the world. By the end of June of the same year, the scale of China's green bonds stock stood at ¥1.33 trillion, ranking second in the world, indicating that the influence of China's green finance market has continued to increase in the world (Zhang, 2023).

In addition, other green finance instruments such as green insurance, China Carbon Emissions Trading Exchange (CCETE) and green funds are also developing steadily. In recent years, the development of green insurance has been faster, mainly in green agricultural insurance,

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

catastrophe index insurance and environmental pollution liability insurance. As of 2019, environmental pollution liability insurance has been piloted in 31 provinces, involving more than 20 fields (Xiao, 2023). Carbon market is one of the core policy tools to achieve the "double carbon" goals. In 2010, China put forward the requirements to establish a CCETE gradually, and formulated a phased plan for the construction of the carbon market from the beginning to the pilot and ultimately the gradual improvement of the carbon market. In 2021, the national unified carbon market started online trading. As the world's largest carbon emitter, China's carbon market has enormous potential for development.

Many scholars have analyzed the current problems of green finance and this paper summarizes them into four parts.

First, the development of green finance is not comprehensive and imperfect. The financial support of China's agricultural carbon reduction field mainly relies on green credit. The product system lacks diversification and risks are difficult to diversify. Thus, it is difficult to obtain the trust of financial institutions to carry out related financial activities. Green finance is a cross-sector emerging industry, which has not been developed for a long time in China. So the rules and regulations for existing green finance instruments have not yet been perfected, supervision is insufficient and the completeness and adequacy of information disclosure need to be improved. At present, the system of green credit and green bonds is relatively perfect, whereas other green finance products still have some problems. For example, the definition of green funds is not clear, and the Funds for Investment in Securities does not have a special definition of private equity funds and other types of investment funds with a lack of specific legal documents (Wang, 2023).

Second, the development of green finance is uneven across the country. At present, China's green finance is developing more rapidly in coastal cities and some provincial capitals, whereas the development process of the third and fourth tier cities is slow. And green finance is mainly concentrated in the large nation-owned commercial banks, while the local corporate financial institutions account for a relatively small proportion of the total (Liang, 2022). Liu et al. (2022) also pointed out that the green finance market is mainly aimed at the industrial field, with a relative lack of practice in the agricultural field. In reality, the implementation of green finance requires the government to consider factors such as the level of local development and formulate targeted policies. Green finance policies in different regions may not be applicable to each other due to the local protectionism mindset in some areas, so that the policy cannot be fully implemented, and the regional differentiated development of green finance is hindered.

Third, the popularization and service efficiency of green finance is low. The popularization and service efficiency of green finance refers to whether it is convenient for enterprises to carry out business and use products related to green finance, or whether enterprises are willing to carry out green finance business (Yu, 2023). In the past, the process of financial activities was complicated and cumbersome, participants usually needed to be handled offline, and the overall efficiency was low. Nowadays, the emergence of the internet has greatly enhanced the convenience of people's lives. However, green finance has not yet been fully integrated with internet technology, and the handling of green finance business remains traditional, which has hindered the popularization and development of green finance in the regions with advanced internet infrastructure to a certain extent.

Fourth, enterprises and consumers lack environmental awareness. On the one hand, enterprises do not pay attention to environmental protection and there is unethical false propaganda. Some enterprises will pack and sell products that do not meet the standards as green products to be able to get a lower threshold of green financial services. On the other hand, customers ' environmental awareness is weak, and they continue to purchase high-pollution products. According to the supply and demand relationship, as the market demand for green

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

products decreases, the supply also decreases accordingly, and green finance loses some space for development.

2.2. Agricultural Carbon Emissions

Carbon emissions generally refer to GHG emissions, and carbon dioxide is a main component of GHGs, hence the term carbon is used as a proxy. In May 2019, The Intergovernmental Panel on Climate Change (IPCC) clearly stated that the main GHGs in the agricultural sector are Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). All GHGs emitted in agricultural production are called agricultural carbon emissions (Liu et al., 2022).

At present, the relevant statistical departments lack a unified collection of agricultural carbon emissions data. The carbon emission coefficients used by most scholars are from the IPCC, Oak Ridge National Laboratory (ORNL), the College of Biological Sciences, and Institute of Agricultural Resources and Ecology (IREEA) at Nanjing Agricultural University, etc. Moreover, compared with industrial carbon sources, agricultural carbon sources are diverse and come in various forms. There is no unified standard in academia for this and the selection of carbon sources varies slightly among different scholars. Drawing on existing studies, this paper will broadly classify agricultural carbon sources into four categories. The first category is agricultural materials, i.e., GHG emissions from fertilizers, pesticides, agricultural films, and directly consumed fossil fuels. The second category is livestock and poultry farming. According to the IPCC assessment report and related studies, carbon emissions from livestock and poultry farming mainly come from CH_4 generated by intestinal fermentation of ruminants, such as cattle and sheep, and CH_4, N_2O generated by animal manure management. The third category is agricultural land use. The cultivation process of rice, winter wheat, soybeans, maize, cotton and vegetables all generate CO_2 and CH_4, and the main source of which is rice cultivation, especially under traditional irrigation methods as it is easy to form an anaerobic environment and thus emit methane gas. The fourth category is crop combustion, i.e., the carbon released from the burning of straw.

2.3. Impact of Green Finance on Agricultural Carbon Emissions

With the continuous rise of global carbon concentration, nine climate tipping points have been or are currently being breached, and the climate crisis faced by all mankind is imminent. To deal with climate change and reduce GHG emissions, scholars at home and abroad have carried out a large number of studies on carbon emission reduction. Based on data from different countries and different empirical methods, some scholars believe that financial development can cause an inhibition of agricultural carbon emissions (Tamazian et al., 2019; Gu & He, 2012). Shahbaze et al. (2013) stated that financial development can reduce carbon emissions through promoting corporate innovation and strengthening environmental awareness. Other scholars hold the opposite view, arguing that financial development can promote carbon emissions by accelerating economic growth and increasing energy consumption, and that there is an inverted U-shaped relationship between them (Salahuddin et al., 2015; Dogan et al., 2016; Hu & Wang, 2018).

As China lacks the direct data collection of agricultural carbon emissions, there's little literature that studies agricultural carbon emissions and most of the studies focus on the impact of economic growth on agricultural carbon emissions. Qin and Li (2013) adopted a spatial econometric model to study the impact of agricultural economic growth on the intensity of agricultural carbon emissions and the spatial spillover effect based on the panel data of 31 provinces in China during 2007-2020. The study finds that the spatial aggregation pattern of economic growth, represented by agricultural carbon emission intensity and per capita agricultural GDP, is mainly characterized by H-H and L-L clusters and economic growth and technological advance help to decrease local agricultural carbon emission intensity. Qiu and Lu (2019) constructed a VAR model based on agricultural development and energy consumption

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

data in China during 2001-2017, and found that agricultural economic development was an important cause of the increase in agricultural carbon emissions by using impulse response function and ANOVA. Kuang and Xie (2023) constructed fixed effects model based on the panel data of 27 provinces in China during 2000-2020, analyzed the impact of multiple drivers on agricultural carbon emissions and found that economic development level, agricultural production structure and fertilizer technology play a dominant role in increasing agricultural carbon emissions, whereas agricultural plantation structure and pesticide technology are the two drivers that inhibit agricultural carbon emissions.

Green finance is not only a significant factor to achieve the "double carbon" goal and reduce agricultural carbon emissions, but also a crucial role in promoting rural revitalization and achieving high-quality sustainable development of the economy. Yin et al. (2019) used a fixed effects model to study the inhibitory effect and conduction path of green credit on carbon emissions based on the panel data of 23 provinces, municipalities and autonomous regions in China during the period of 2006-2015. And it is shown that green credit can significantly reduce carbon emissions through the path of investing in green environmental industries and developing advanced technologies. Jiang et al. (2020) established a dynamic panel data model based on the data from 23 provinces during the period of 2006-2016 and analyzed the impact of green credit and green venture capital on carbon emissions from the perspective of investment and financing. The results showed that green credit and green venture capital both have adverse effects on carbon emissions. Wang (2021) adopted the DID model to conduct empirical study based on the panel data of 29 provinces during 2011-2018 and found that the green finance "experimental field" policy can effectively promote regional carbon emissions reduction through the optimization and upgrading of industrial structure. He et al. (2019) used the VAR model to measure the impact of green credit, green securities, green insurance and green investment on CO_2 emissions per unit of GDP during 2002-2016. It is shown that green finance can effectively inhibit carbon emissions, and the inhibition effect is gradually increasing with time. Li et al. (2020) found that green credit, green investment, green insurance and green securities all contribute to reducing agricultural carbon emissions using the VAR model.

2.4. Literature Summary

At present, domestic research on green finance mainly focuses on products that account for a large proportion and have mature development levels, such as green credit and green securities due to limited development of green finance products and the difficulty of measuring agricultural carbon emissions in China. The research on agricultural carbon emissions is limited by the lack of unified data collection. In summary, there's little literature that combines green finance development and agricultural carbon emissions, and even fewer literature that comprehensively examine the impact of green finance on agricultural carbon emissions. The marginal contribution of this paper lies in two aspects. First, this paper will examine the relationship between green finance development and agricultural carbon emissions in a targeted manner and enrich the relevant research results. Second, this paper will provide theoretical references for the realization of the "double carbon" goal and the promotion of the green and low-carbon transformation of the agricultural economy in China on the basis of the top-level design.

3. Mechanism Analysis

3.1. Signalling Effect

Since the notion of green finance has been widely spread, a large number of scholars started to study the mechanism of action of how green finance development supports carbon emission reduction to improve the quality of green finance services. Among them, the signaling effect is

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

a widely accepted view among scholars. It refers to the financial policies and measures that emphasize the concept of green environmental protection and sustainable development, guide finance tilt to the agricultural and low-carbon industries, and deliver green signals to the market. Specifically, low-pollution and low-energy-consumption enterprises that have received the signal can make better investment decisions to attract other enterprises to involve in green industries, and innovate agricultural low-carbon technologies, such as changing the traditional flooding irrigation mode and adopting low-carbon rice planting mode to obtain financial support from the government. Meanwhile, the high-pollution and high-energy-consumption enterprises that have been punished by high-interest-rate loans will warn other "two-high" enterprises to take action in advance to optimize and upgrade their technology and industrial structure (Xu,

3.2. Resources Optimization Effect

In China, the economy of rural regions is in trouble and is facing resource shortage issues. Government guides the capital flows to rural areas through fiscal policies, such as lowering the financing threshold and adjusting lending rate properly, not only to reduce the agricultural carbon emissions, but also to achieve rural revitalization and solve issues relating to agriculture, rural areas and farmers. The main measures to optimize the allocation of green financial resources include innovating green v products and carrying out pledge services related to agricultural carbon reduction (Lei et al., 2021).

In 2021, PBC has launched support tools for carbon emission reduction and the special re-lending to support the clean and efficient use of coal and offers low-threshold loans to eligible financial institutions. Then, financial institutions provide preferential interest rates for carbon emission reduction projects, enabling the carbon emission reduction effect in the fields of clean energy, energy conservation, carbon sequestration technology, to be fully realized. Theoretically, by directing capital flows to rural green industries, the government can not only alleviate the financial pressure on agricultural business entities, making it easier for them to obtain financing and purchase more modern equipment, but also push corporations to implement technical improvement by reducing funding to high-pollution and high-energy-consumption enterprises.

3.3. Risk Sharing Effect

Agricultural carbon reduction is a high-tech, high-input, high-risk project, which is highly dependent on agricultural technological innovation, and requires a large amount of capital to support its operation whether it is in technology development process or production stage (Lei et al., 2021). Thus, many small and medium-sized local financial institutions are reluctant to promote the implementation of agricultural carbon reduction. However, green finance, such as the issuance of bonds, stocks and other financial products and some financial derivatives, can reduce this kind of risk (Liu & Liu, 2022). Moreover, the establishment of a green credit guarantee fund can also help to perfect the green guarantee mechanism. To be specific, some rural farming households contribute funds to establish cooperatives, with a portion of these funds designated as a green credit guarantee fund. Local banks then provide low-interest loans to the farming households based on their contribution ratios and farming scale. The loans are exclusively used for agricultural technology upgrades and purchasing modern equipment, thereby promoting agricultural carbon emissions reduction.

4. Data and Model Construction

4.1. Sources of Data

Since the development of green credit in Gansu, Qinghai, Ningxia, Guizhou, Tibet and Shanxi is imperfect, and Hong Kong, Macau, and Taiwan are at different stages of green development

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

compared to China's mainland, they are not considered as empirical objects. Original marketization index is only updated to 2019, and the data for 2020-2023 is extrapolated through the literature. Considering the impact of the COVID-19, the extrapolation results may deviate from the actual ones. Therefore, this paper uses 25 provinces in China during the period of 2006- 2019 as the object of study.

Data on green credit, green investment, green securities and green insurance come from China Industry Statistical Yearbook, China Statistical Yearbook, WIND database and Yearbook of China's Insurance, respectively. Data on agricultural carbon emissions come from China Rural Statistical Yearbook, China Energy Statistical Yearbook, ORNL, IPCC and IREEA. Data on agricultural industry structure, urbanization level, and rural income level in China are from China Statistical Yearbook. Data on marketization level is from China Marketization Index.

4.2. Main Variables

4.2.1. Core Explanatory Variables

Table 1. Definition of Variables.

	Variable name	Measure	Notation
Dependent variable	Agricultural carbon emission intensity	Agricultural carbon emissions/Total agricultural output	In(C/AGDP)
Explanatory variable	Green credit	interest expenditure of the top six energy-consuming industries/Total industrial interest expenditure of each province	InGC
	Green investment	Pollution control investment/GDP	lnGIV
Control variable	Green insurance	Agricultural insurance expenditure/total insurance expenditure	lnGIS
	Green securities	Market value of environmental protection enterprises/A-share market value	lnGS
	Marketization level	Regional marketization development level	MAR
	Agricultural industry structure	Agricultural production output/total output of agriculture, forestry, animal husbandry and fishery	AIS
	Urbanization level	Regional urban population/regional total population	UR
	Rural income level	Per capita disposable income of rural residents	PCDI

Core explanatory variables are green finance development. Jun Ma (2016), chairman of Green Finance Committee, China Society for Finance & Banking (GFC), put forward the top ten green finance development areas during the " 13th Five-Year Plan" period. He et al. (2019) divided it into four levels: green credit, green securities, green insurance and green investment. Previous studies have mostly used green credit level to represent the level of green finance development, which fails to fully reflect the meaning of green finance. Therefore, considering the accessibility as well as representativeness of green finance, this paper uses green credit (lnGC), green securities (lnGS), green insurance (lnGIS) and green investment (lnGIV) to measure the level of green finance development, and to study the impact of green finance development on agricultural carbon emissions.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

There are four main measures of green credit in the academic world, namely, the proportion of green credit, the proportion of energy conservation and environmental protection project loans, the "bank loan" in industrial pollution management investment and the proportion of interest expenditure of the top six energy-consuming industries (Xie & Liu, 2019). This paper uses the proportion of interest expenditure of the top six energy-consuming industries as a reverse indicator of green credit, following Xie and Liu (2019). The measurement methods of green investment, green insurance and green securities will draw on the evaluation system of green finance development level proposed by Zeng et al. (2014). The specific definition of each variable is shown in Table 1.

4.2.2. Dependent Variable

The dependent variable is agricultural carbon emission intensity (ln (C/AGDP)), that is, the agricultural carbon emission corresponding to each unit of agricultural economic output, and then it is logarithmized. Due to the lack of data on agricultural carbon emissions in China, this paper will draw on the existing research results and adopt the carbon emission coefficient method by IPCC. Regarding the calculation of carbon emissions, the first step is to determine the source of emissions. The above has roughly categorized agricultural carbon sources into four types: agricultural materials, livestock and poultry farming, agricultural land use, crop combustion. Considering the availability of data and the difficulty of measurement, this paper uses the first three categories, the carbon emission coefficients as shown in Table 2 and Table 3. The second step is to determine the carbon emission factor, the carbon emission factor refers to the CO_2 emission coefficient during a specific energy consumption process, such as the power generation process. For example, the amount of CO_2 emitted from energy consumption to generate one kilowatt-hour of electricity is the CO_2 emission coefficient of the power generation process. The final step is to multiply the amount of carbon emission source by its carbon emission factor to get the carbon emissions. The formula can be expressed as $C=\sum Ci =\sum Ti \times \delta i$, where C is the total agricultural carbon emissions, Ci is the carbon emissions of each source, Ti is the activity level of each source, and δi is the carbon emission factor of each source.

Table 2. Carbon emission coefficients of agricultural materials and agricultural land use.

Category	Carbon source	Carbon emission coefficient	Unit	Data source
Agricultural materials	Fertilizer	0.896	kgC/kg	ORNL
	Pesticide	4.934	kgC/kg	ORNL
	Agricultural film	5.180	kgC/kg	IREEA
	diesel	0.593	kgC/kg	IPCC
Agricultural land use	Irrigation	266.48	kgC/hm^2	Duan et al., 2011

Table 3. Carbon emission coefficients of livestock and poultry farming.

Category	Carbon source	Intestinal fermentation $Kg(CH_4)\cdot(head\cdot a)^{-1}$	Animal manure management $Kg(CH_4)\cdot(head\cdot a)^{-1}$	Animal manure management $Kg(N_2O)\cdot(head\cdot a)^{-1}$
Livestock and poultry farming	Cattle	47.00	1.00	1.39
	Sheep	5.00	0.16	0.86
	Pig	1.00	4.00	0.53

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

4.3. Descriptive Statistical Analysis

Table 4 shows the observations, mean, median, standard deviation, minimum and maximum of each variable. For core explanatory variables, green credit and green insurance, which have the highest market volume, are better developed, with mean values of 0.509 and 0.806, respectively. There is a large development gap between provinces for green insurance, with the minimum value of 0.001 and the maximum value of 7.972. The development of green investment is the most lagging, with the maximum value of 0.006. For the dependent variable, the mean value of agricultural carbon emission intensity is 0.252 and the extremum value differs greatly, indicating that significant differences in agricultural carbon emissions may exist among provinces due to varying levels of economic development.

Table 4. Descriptive statistics.

Variable	Observation	Mean	Median	Std. Dev.	Minimum	Maximum
GC	350	0.509	0.514	0.123	0.192	0.829
GS	350	0.189	0.154	0.148	0.00100	0.631
GIV	350	0.00100	0.00100	0.00100	0	0.00600
GIS	350	0.806	0.499	1.047	0.00100	7.972
C/AGDP	350	0.252	0.238	0.0900	0.0900	0.540
MAR	350	7.995	8.123	1.629	3.359	11.490
AIS	350	0.510	0.501	0.0770	0.339	0.740
UR	350	56.89	54.95	13.87	30.50	89.60
PCDI	350	10269	9446	5561	2392	33195

4.4. Correlation Analysis

This paper conducts the significance test of correlation between all variables. As shown in Table 5, there is correlation between the independent variables and the dependent variable.

Table 5. Correlation matrix.

	lncagdp	lngc	lngs	lngiv	lngis	mar	ais	ur	lnpcdi
lncagdp	1								
lngc	0.276***	1							
lngs	0.291***	0.245***	1						
lngiv	0.559***	0.295***	0.290***	1					
lngis	-0.435***	-0.130**	-0.0510	-0.349***	1				
mar	-0.399***	-0.651***	-0.296***	-0.317***	0.101*	1			
ais	-0.0520	0.143***	-0.157***	0.183***	0.0210	-0.366***	1		
ur	-0.372***	-0.454***	-0.401***	-0.371***	0.441***	0.673***	-0.272***	1	
lnpcdi	-0.714***	-0.544***	-0.220***	-0.469***	0.613***	0.644***	-0.138***	0.733***	1

*** p<0.01, ** p<0.05, * p<0.1

4.5. Multicollinearity Test

To ensure the accuracy of research results, this paper conducts a multicollinearity test. As shown in Table 6, variance inflation factor (VIF)=2.900, VIF is a way to measure the collinearity

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

in the multiple linear regression model. In general, there's no multicollinearity when VIF<10 and the model is well constructed.

Table 6. Multicollinearity Test.

VARIABLES	VIF	1/VIF
lnpcdi	6.460	0.155
ur	3.670	0.272
mar	3.030	0.330
lncagdp	3.010	0.333
lngis	2.260	0.443
lngiv	1.680	0.595
lngs	1.620	0.618
ais	1.480	0.677
Mean	VIF	2.900

4.6. Estimation Model

To determine the measure model, this paper conducts an F-test first to examine the existence of individual effects (ui). P=0.0000 indicates that null hypothesis is rejected and there's an individual effect. Then, this paper conducts a Hausman test to examine if ui is correlated with core explanatory variables. P<0.05 indicates that null hypothesis is rejected. Therefore, an individual fixed effects model is adopted and the test results are shown in Table 7.

Table 7. Hausman test.

(1)	
VARIABLES lngc	FE
lngs lngiv lngis	0.101***
mar	(0.0341)
	-0.0397**
ais	(0.0161)
	0.0194**
ur	(0.00860)
	-0.0219***
lnpcdi	(0.00551)
	0.00925
Constant	(0.0100)
	-2.039***
Observations Number of id	(0. 195)
R-squared Hausman p-value	-0.00891***
	(0.00257)
	-0.455***
	(0.0343)
	4.273***
	(0. 190)
	350
	25
	0.935
	58.59
	8.81e-10

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 The baseline model is set as follows:

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

$$\ln(C/AGDP)it = \alpha0+\alpha1\ln GCit+\alpha2\ln GIVit+\alpha_3\ln GISit+\alpha_4\ln GSit+\alpha5\ln PCDIit+\alpha6AISit +\alpha7MARit+\alpha8URit+\varepsilon it \quad (1)$$

i denotes provinces, t denotes time, C/AGDP represents the intensity of agricultural carbon emissions, GC represents the level of green credit development, GIV represents the level of green investment development, GIS represents the level of green insurance development, and GS represents the level of green securities development. Control variables are other factors that may affect agricultural carbon emissions, including the agricultural industry structure (AIS), the marketization level (MAR), the urbanization level (UR), rural income level (PCDI), and εit is a random disturbance term.

5. Empirical Results

5.1. Regression Results

As shown in Table 8, column (1) suggests that green credit has a significantly positive impact (at the 1% level) on agricultural carbon emissions, indicating that as the interest expense ratio of the top six energy-consuming industries decreases, agricultural carbon emissions also decrease. As the interest expense ratio of high energy-consuming industries is a reverse indicator, the lower the ratio, the better the level of green credit development. Therefore, green credit can encourage farming households to use low-carbon agricultural technologies and advanced equipment and facilities through the green credit guarantee fund or other low-interest-rate and low-threshold loans to promote the development of green agriculture and reduce agricultural carbon emissions. Columns (2), (3) and (4) suggest that the results are significant after adding green securities, green investment and green insurance.

This paper uses column (8) as the baseline regression results. It is found that all variables except green investment as well as agricultural industry structure pass the significance test, indicating that green credit, green insurance, and green securities all cause inhibition of agricultural carbon emissions. To be specific, the coefficients of green insurance and green securities are negative, indicating that the intensity of agricultural carbon emissions decreases with the increase of agricultural insurance expenditure and the market value of environmental protection enterprises.

For green insurance, it may be due to the fact that with the economic development of rural areas, the support of government funds, the change of traditional conservatism and the high-quality guarantees provided by insurance companies, more and more agricultural business entities choose to purchase agricultural insurance, actively use carbon sequestration technologies, and engage in modern agricultural production activities, which leads to a reduction of agricultural carbon emissions.

For green securities, the rise in the market value of environmental protection enterprises indicates that environmental protection enterprises are gaining momentum and are able to invest more funds in environmental management, pollution control and energy saving projects, and thus reduce agricultural carbon emissions. The reason why the coefficient of green investment is insignificant may be that the environmental pollution investment mainly concentrates in the industrial field, and the agricultural field is relatively lacking.

For control variables, the rural income level passes significance test at the 1% level, and coefficient is negative, indicating that the higher the rural income level, the more funds will be invested in low-carbon agricultural technologies and equipment, which will significantly reduce the agricultural carbon emissions and improve the efficiency of agricultural production. The marketization level has a significantly negative impact on the agricultural carbon emissions. Marketization level reflects the economic development level of each region and the efficiency

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

of market resources allocation to a certain extent. The higher the marketization level of a region, the better the environment for the development of enterprises, and the stronger the ability of independent innovation, which can develop more efficient agricultural low-carbon technologies and reduce the agricultural carbon emissions generated by the traditional cultivation methods.

Table 8. Regression analysis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	lncgdp	lncgdp	lncgdp	lncgdp	lncgdp	lncgdp	lncgdp	lncgdp
lngc	0.339***	0.329***	0.322***	0.318***	0.300***	0.328***	0.315***	0.210***
	(6.43)	(6.28)	(6.20)	(6.15)	(5.92)	(6.30)	(5.93)	(4.57)
lngs		-0.072***	-0.065***	-0.061**	0.084***	-0.097***	-0.102***	-0.051**
		(-2.81)	(-2.54)	(-2.40)	(-3.31)	(-3.73)	(-3.87)	(-2.26)
lngiv			0.035** (2.27)	0.034** (2.18)	0.031** (2.07)	0.030** (2.02)	0.031** (2.05)	0.020 (1.61)
lngis				-0.027**	0.019	-0.018	-0.020*	-0.034***
				(-2.21)	(-1.56)	(-1.52)	(-1.67)	(-3.37)
mar					0.068*** (-4.11)	-0.064*** (-3.90)	-0.066*** (-3.99)	-0.044*** (-3.12)
ais						0.087** (2.13)	0.127** (2.46)	-0.017 (-0.37)
ur							0.006 (1.26)	0.022*** (5.13)
lnpcdi								-0.725*** (-11.09)
Constant	-3.137***	-3.269***	-3.037***	-3.159***	-2.694***	-2.804***	-3.148***	3.022***
	(-72.86)	(-51.56)	(-25.26)	(-23.99)	(-15.73)	(-15.76)	(-9.66)	(4.87)
Observations	350	350	350	350	350	350	350	350
R-squared	0.918	0.921	0.922	0.923	0.927	0.928	0.928	0.949
Number of id	25	25	25	25	25	25	25	25
company FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5.2. Robustness Test

In general, green finance instruments have a time lag from the introduction of the policy to its role. Therefore, this paper uses a distributed lag model to do regression analysis. As shown in Table 9, all explanatory variables are significant, indicating that green finance policies are effective and ensuring the robustness of research results.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

Table 9. Robustness analysis.

	(1)		(2)		(3)
VARIABLES	lncagdp	VARIABLES	lncagdp	VARIABLES	lncagdp
L.lngc	0.116*** -0.0406	L2.lngc	0.151*** -0.0401	L3.lngc	0.0778* -0.0444
L.lngs	-0.0440*** -0.0167	L2.lngs	-0.0413** -0.0164	L3.lngs	-0.0380** -0.0187
L.lngiv	0.0405*** -0.00888	L2.lngiv	0.0597*** -0.00902	L3.lngiv	0.0455*** -0.0102
L.lngis	-0.00992* -0.00524	L2.lngis	0.00423 -0.00507	L3.lngis	-0.0113** -0.0056
mar	0.00339 -0.0106	mar	0.0108 -0.0108	mar	0.00736 -0.0124
ais	-1.926*** -0.198	ais	-2.173*** -0.201	ais	-2.308*** -0.225
ur	-0.00743*** -0.00278	ur	-0.00909*** -0.00284	ur	-0.00864*** -0.00325
lnpcdi	-0.458*** -0.0381	lnpcdi	-0.448*** -0.0399	lnpcdi	-0.437*** -0.049
Constant	4.351*** -0.212	Constant	4.592*** -0.233	Constant	4.395*** -0.295
Observations	325	Observations	300	Observations	275
Number of id	25	Number of id	25	Number of id	25
R-squared	0.929	R-squared	0.925	R-squared	0.903

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

6. Results and Suggestions

6.1. Research Conclusion

This paper utilizes the panel data of 25 provinces in China during 2006-2019 to study the impact of the level of green finance development on agricultural carbon emissions by using the fixed effects model. The results suggest that green credit, green insurance, and green securities can all inhibit agricultural carbon emissions, and the research results remain valid after the robustness test.

6.2. Policy Suggestions

Based on the research conclusions above, this paper puts forward the following suggestions from the perspective of boosting green finance development and improving the current situation of agricultural carbon emissions.

First, improve the rules and regulations of green finance and enrich the green finance product system. The pathway to achieving agricultural carbon reduction through green finance requires legal protection and support. Therefore, the government should perfect the regional differentiation regulations of green finance as soon as possible, meanwhile, improve information disclosure quality, establish the information sharing mechanism between provinces and solve information asymmetry. Furthermore, the diversification of the green finance product system is of great significance to the development of financial institutions to carry out related financial activities and realize agricultural carbon reduction. At present, the most common ones in the green finance market are green credit and green bonds, while other green financial tools, such as CCETE, have more development opportunities. Therefore, the government should intensify its popularization to enlarge the scope of carbon market coverage.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

Second, increase investment in agricultural technology research and play the guarantee function of green finance. Agricultural carbon reduction plays a crucial role in the realization of the "double carbon" goal and agricultural low-carbon technology innovation is of great importance to promote agricultural carbon reduction. The popularization and service efficiency of agricultural low-carbon technologies and financing issues of rural areas are closely related to each other. One of the reasons for financing issues in rural areas is the chronic lack of resources. In this case, the government should actively take measures to help guide the flow of funds to the countryside, continue to optimize the allocation of rural resources and promote rural revitalization. Another reason is the conservatism mentality of the agricultural business entities. In this case, green finance should give full play to its role as a guarantee and establish a green guarantee fund to reduce the risk of agricultural business entities. Meanwhile, a green financial incentive and constraint mechanism can be established to guide financial institutions to further strengthen green assets allocation and environmental risk management through performance evaluation of green finance, interest rate subsidies, etc.

Third, strengthen green awareness of farming households and cultivate low-carbon agricultural professionals. Whether it is to realize the high-quality development of green finance, or to realize the green low-carbon transformation of the agricultural economy, in addition to the strong financial support of the government, financial institutions and enterprises, it is more necessary for everyone to pay attention to the concept of environmental protection. Due to the backwardness of regional development and the traditional farming methods, the environmental awareness of farmers is generally weak and it is difficult to implement the green low-carbon policies in rural areas. Thus, the local government should provide special education, training, and guidance to farmers to learn to use modern agricultural equipment and low-carbon technologies. In addition, China should vigorously train professionals in the field of agricultural low-carbon, not only to learn foreign carbon sequestration technologies, but also to contribute to agricultural carbon reduction while combining with national conditions of China.

References

[1] Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews, 60, 1074–1085.

[2] Duan, H.P., Zhang, Y., Zhao, J.B., Bian, X.M. (2011). Carbon Footprint Analysis of Farmland Ecosystem in China. Institute ofSoil and Water Conservation. 5, 203.

[3] Gao, J.L. (1998). "Green finance" and sustainable financial development. Finance Theory and Teaching. 4, 20–22.

[4] Gu, H.M., & He, B. (2012). Study on Chinese Financial Development and Carbon Emission. China Population Resources and Environment. 22(08), 22–27.

[5] He, W.J., Chen, H.H., & Wang, Z. (2019). An Empirical Study on the Dynamic Relationship between Green Financial Development and Carbon Emissions--Testing based on VAR model. Journal ofGuizhou Normal University (Social Sciences). 01, 99–108.

[6] Hu, J.Y., & Wang, M.Q. (2018). An empirical analysis on effect of financial development on carbon emissions in China--Based on provincial panel data of recent 20 years. Shandong Social Sciences. 04, 118–124.

[7] Hu, X.D., & Wang, J.M. (2010). Estimation of livestock greenhouse gases discharge in China. Transactions ofthe Chinese Society ofAgricultural Engineering. 26(10), 247–252.

[8] Jiang, H.L., Wang, W.D., Wang, L., & Wu, J.H. (2020). The Effects of the Carbon Emission Reduction of China's Green Finance--An Analysis Based on Green Credit and Green Venture Investment. Finance Forum. 11, 39–48.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0023

[9] Kuang, A.P., & Xie, C.K. (2023). The Influencing Factors and Regional Differences of Our Country's Agricultural Carbon Emissions Under the Background of "Double Reduction"--Based on LDMI Decomposition and Panel Regression Analysis. Journal of Zaozhuang University. 40(02), 87–102.

[10] Lei, Y., Xiang, Y.B., Zheng, W., & Yang, Z.Y. (2021). Financial Strategies to Address Agricultural Carbon Emission Issues. Financial Perspectives Journal. 01, 18–23.

[11] Li, P.Z., Chen, S., & Sun, J.F. (2020). The dynamic relationship between green finance and agricultural carbon emissions was analyzed. Journal ofShanxi Radio & TV University. 02, 101–106.

[12] Liang, Y. (2022). Reflections on How Finance Can Facilitate Green and Low-Carbon Development. Times Finance. 02, 78–79.

[13] Liu, R.M., & Liu, M.X. (2022). The impact of green finance development on agricultural carbon emissions--based on the perspective of agricultural technology innovation. Agriculture And Technology. 42(15), 160–163.

[14] Liu, S.Q., Qin, L.G., & Hou, Y. (2022). Study on agricultural carbon emission reduction effect of green credit--An empirical analysis based on panel data from 30 provinces. Agricultural Economy. 10, 103–106.

[15] Ma, J. (2016). The Ten Key Areas of Green Finance Development During the 13th Five-Year Plan Period. China Banking. 01, 22–24.

[16] Qin, Y.X., & Li, S.C. (2023). An empirical study on the spatial spillover effects of agricultural economic growth and agricultural carbon emission intensity. Hubei Agricultural Sciences. 62(4), 232–238.

[17] Qiu, W., & Lu, D.N. (2019). Analysis of factors affecting agricultural carbon emission based on VAR model and its dynamic response mechanism. Hubei Agricultural Sciences, 58(24), 271-276.

[18] Salahuddin, M., Gow, J., & Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust? Renewable and Sustainable Energy Reviews, 51, 317–326.

[19] Shahbaz, M., Solarin, S. A., Mahmood, H., & Arouri, M. (2013). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. Economic Modelling, 35, 145–152.

[20] Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. Energy Policy, 37(1), 246–253.

[21] Wang, T.T. (2021). The Impact of Green Finance Pilot Policies on Regional Net-Zero Carbon Targets. Finance and Economy. 12, 52–62.

[22] Wang, X.R. (2023). A Comparative Study of Green Finance: Domestic and International Perspectives. Management & Technology ofSME. 2, 192–194.

[23] Xiao, Z.X. (2023). Key Reflections on the Development of Green Finance. Money China. 03, 63–65.

[24] Xie, T.T., & Liu, J.H. (2019). How does green credit affect China's green economy growth? China Population, Resources and Environment. 9, 83–90.

[25] Xiong, X.P. (2004). Reflections on the Transition from Traditional Finance to Green Finance. Ecological Economy. 11, 60–62.

[26] Xu, S., Zhao, X.X., Yao, S. (2018). Analysis on the Effect of Green Credit on the Upgrading of Industrial Structure. Journal ofShanghai University ofFinance and Economics, 20(2), 59– 72.

[27] Yin, H., Wang, L., & Liu, N.N. (2019). Green Credit and Carbon Emissions: Emission Reduction Effects and Conduction Paths. Environmental Science and Management. 44(11), 9–14.

[28] Yu, Z.H. (2023). Pathways for Green Finance to Drive High-Quality Economic Development. Business & Economy. 05, 174–176.

[29] Zhang, M.Q. (2023). Research on Green Finance Boosting China's Sustainable Economic Development. China Journal ofCommerce. 06, 098–101.

[30] Zeng, X.W., Liu, Y.Q., Man, M.J., & Shen, Q.L. (2014). Measurement Analysis of the Development Level of China's Green Finance. Journal of China Executive Leadership Academy Yan'an. 7(6), 112–121.