

Article

The Impact of Green Finance on Agricultural Pollution and Carbon Reduction: The Case of China

Li Cao  and Jiaqi Gao *

College of Economics & Management, Shanghai Ocean University, Shanghai 201306, China; l-ca@shou.edu.cn

* Correspondence: m210701213@st.shou.edu.cn

Abstract: Based on the double-carbon target, the agricultural sector has implemented the concept of being green and synergistically promoted pollution and carbon reduction. Positioned as a novel financial paradigm, green finance places greater emphasis on environmental stewardship compared to its traditional counterparts. This focus enhances resource allocation efficiency, thereby achieving the goal of reducing pollution and carbon emissions. To research the influence of green finance on agricultural pollution and carbon reduction, this study leverages panel data spanning 2011 to 2021 from 31 provinces, autonomous regions, and municipalities across China. It employs the fixed-effect model and mediating-effect model. The findings reveal that: (1) Green finance exerts a notable influence on reducing both pollution and carbon emissions in agriculture, with the latter showing a more pronounced effect. (2) Regional disparities exist in green finance, affecting agricultural pollution and carbon reduction. (3) By fostering technological innovation and optimizing industrial frameworks, green finance emerges as a catalyst for curbing surface pollution and carbon dioxide emissions in agriculture. On this basis, relevant suggestions are put forward to provide policy insights for improving the green financial system, which will help further promote carbon and pollution reduction.

Keywords: green finance; agricultural pollution reduction and carbon reduction; intermediary effect



Citation: Cao, L.; Gao, J. The Impact of Green Finance on Agricultural Pollution and Carbon Reduction: The Case of China. *Sustainability* **2024**, *16*, 5832. <https://doi.org/10.3390/su16145832>

Received: 15 May 2024

Revised: 5 July 2024

Accepted: 8 July 2024

Published: 9 July 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Since the reform and opening up, China's economic development has been quite rapid, and while the economy is developing at a high speed, the problems of excessive resource consumption and greenhouse gas emissions are becoming more prominent, seriously affecting people's daily lives. Therefore, focusing on environmental protection in the economic development has become an important trend in China's economic development.

Since the dual-carbon target was put forward, the agricultural sector has implemented the concept of being a green and low-carbon industry and the overall carbon emissions have shown a downward trend but with inter-annual fluctuations [1]. Meanwhile, strides have been made in curtailing non-point source pollution, witnessing a decline in chemical pesticide and fertilizer application alongside enhanced resource efficiency, but the problem is still prominent [2,3]. Related planning is a clarion call to bolster prevention and management efforts against non-point source pollution in agriculture and encourage green development in agriculture. June 2022 witnessed the collaborative issuance of the “*pollution reduction and carbon reduction synergistic implementation plan*”, underscoring the pivotal juncture where simultaneous strides in pollution and carbon mitigation have emerged as imperative in China's new stage [4], where it is necessary to promote synergistic increase in efficiency in the field of agriculture, to promote the agricultural green production methods, and to implement in-depth fertilizer and pesticide reduction and increase efficiency actions [5].

The traditional financial industry is only concerned about high economic returns, ignoring the environmental damage of its economic activities, which is contrary to China's

economic and social sustainable development. Therefore, green finance has emerged. Green finance, as a new type of financial model, pays more attention to environmental protection than traditional finance [6]. The development of green finance can effectively dovetail with green development and economic optimization and inject strong kinetic energy into sustainable development. In the context of the development of the new normal economy, green finance, as an important strategic fulcrum of economic and financial development, is of great practical significance for China's agricultural pollution reduction and carbon reduction.

Considering all the context presented above, this article studies the impact of green finance on agricultural carbon emissions and non-point source pollution; this can provide a reference for promoting high-quality agricultural development through the development of green finance. The article selects panel data spanning from 2011 to 2021 from 31 Chinese provinces. Employing fixed-effects regression and mediated-effects models, it conducts research. This article substantiates the positive influence of green finance on pollution and carbon reduction within agriculture, and there is regional heterogeneity. Simultaneously, it elucidates the intermediary function of technological advancement and industrial structure optimization. The innovation lies in: (1) The research perspective: At present, there are more industrial carbon emission reduction theories exploring green finance, while scant attention has been paid to its impact on the agricultural sector. Green finance serves as the principal catalyst for China's environmental endeavors. Agricultural activities constitute a substantial portion of the nation's carbon emissions, with non-point source pollution posing a considerable challenge. This extends the understanding of green finance's influence on agroecological studies. (2) Research content: This paper introduces the industrial structure optimization and technological progress and analyzes the impact mechanism. It explores the different impacts in the different regions and provides a theoretical basis for developing green finance tailored to the local conditions in various regions.

2. Literature Review

In the 1990s, Jose Salazar (1998) [7] first put forward the concept of environmental finance, which is to provide capital financing for the environmental protection industry. Green finance mainly solves the financing problem of the green economy [8]. Green finance emerged from traditional finance in response to the demands of the modern economy. It prioritizes the preservation of the natural environment [9,10]. With the development of green finance, many countries and organizations are exploring incorporating carbon emissions disclosure into corporate social responsibility evaluations [11]. Many companies have made active attempts and found that green investing is cheaper and better, as is shown in Matallín-Sáez's research results [12]. China's green finance has gradually formed a green financial system, which is mainly consisted of green credit, green insurance, and other products.

Many scholars have studied green finance's function [13]. It has multiple roles. First, green finance can increase the financial sector's economic efficiency and is an inevitable path for them to realize sustainable development [14]. Secondly, green finance can transform the mode of economic growth. Mainly including the "filter" function of filtering "two high and one leftover" projects through the standard of loan restriction, the "incubator" function of supporting the new energy and clean technology, and the "diffuser" function of expanding green finance to personal finance [15]. Thirdly, green finance improves the country's ecological balance and economic growth and enhances ecological efficiency [16–18]. From this, it can be seen that green finance plays a very important role and has significance in the process of economic and social development.

Currently, more and more scholars around the world are paying attention to the impact of green finance on climate [19]. The global agricultural pollution problem is a major challenge [20]. China's proposal of dual-carbon goals has attracted widespread attention from various countries. Under the dual-carbon goal, the problem of agricultural environmental issues has attracted extensive attention from scholars [21]. Many scholars have studied

them. In recent years, China's agricultural pollution and carbon emissions have improved significantly, but the problem still exists [22]. Putting the market and the government into beneficial actions is particularly important to steadily drive pollution and carbon reduction. Green finance, as a significant market tool, can help increase the resource allocation effect, promoting the formation of a green and low-carbon long-term mechanism and realizing a greater emission reduction effect [23–26]. Tamazian et al. pointed out that financial instruments can achieve carbon reduction by increasing investment in technological research and development, promoting technological innovation, and improving resource utilization efficiency [27]. From the viewpoint of the sub-dimension of green finance, various financial instruments are all conducive to reducing agricultural pollution emissions [28–30]. Based on the 2010–2016 Beijing–Tianjin–Hebei data in China, Li et al. (2019) studied carbon emissions [31] and Guo et al. [32] (2022) contended that green finance can help carbon reduction from agriculture and confirmed the unidirectional causal relationship between them. There are several approaches to realize the benefit of green financing. By easing financial restrictions, encouraging industrial structure modernization, and encouraging technical innovation, green finance reduces agricultural carbon emissions. Nevertheless, there are problems in the role of green finance [33]. Therefore, it still has great potential in agricultural pollution and carbon reduction.

In conclusion, with the development of green finance, more scholars have become interested in green finance and formed some results, which are of some significance to the article. However, certain limitations exist in the literature. Firstly, the existing literature mainly concentrates on the connotation, measurement, and role of green finance itself. Secondly, about how green finance affects the environment, the literature mostly studies the impact on the overall environment or on a specific branch of the environment and pays less attention to the impact on the environmental problems in the field of agriculture. Therefore, this paper studies how green finance reduces agricultural pollution and carbon through theoretical and empirical analyses. It also examines how green finance transmits these reductions through technological advancement and industrial structure optimization in order to provide a new path to develop green finance in agriculture in China and to enhance the capacity for sustainable development.

3. Theoretical Analysis and Hypothesis

3.1. *The Impact of Green Finance on Agricultural Pollution Reduction and Carbon Reduction*

Carbon dioxide and pollutants have the same root and origin, so there is a potential for synergistic control [34,35]. Green finance, as a product of environmental issues in the economic and social importance of the previously highlighted points, played an important effect of decrease of carbon emissions and pollution. Firstly, resource allocation is impacted by green finance [27]. Green finance provides financial support for farmers' business activities, guiding the flow of production factors towards green industries, broadens the financing channels for farmers, eases the pressure on farmers' financing, and provides incentives for farmers to carry out green production; in addition to financing thresholds, quotas, and other conditions, financial institutions will give more interest rate concessions to green enterprises and further reduce the financial pressure on enterprises [36]. Accordingly, there will be a reduction in the subsidies available to energy-intensive and highly polluting businesses, which will have an impact on them. Green finance attracts social capital through banks and other financial institutions, provides farmers with capital, promotes green agricultural production, improves agricultural production efficiency, and thus reduces agricultural pollution and carbon. Furthermore, it has a policy guidance effect. Green finance is a crucial act to implement the national green development concept and realize the "double carbon" strategy. Green finance releases market signals, restricts the development of "two high" enterprises, helps guide agriculture towards green and low-carbon development, upgrades production technology, transforms production equipment, improves environmental protection facilities, optimizes factor inputs, controls

high-polluting agricultural enterprises, and increases the reduction of agricultural pollution and carbon.

Hypothesis 1 (H1). *Green finance promotes agricultural pollution reduction and carbon reduction.*

3.2. Regional Heterogeneity Mechanism Analysis

Different regions have large differences in factor endowments, social conditions, economic levels, and other aspects, resulting in a certain difference in agricultural development, while there is also a gap in green finance [31,37]. First, the east has a solid economic foundation whose financial system is more perfect in terms of policy and other factors. Meanwhile, the economy in the central and western area is more backward, along with talent movement to developed regions, the lack of capital and talent to support innovation and green finance lags behind. Secondly, the agricultural production efficiency in eastern regions is higher, coupled with a high degree of environmental awareness, encouragement of low-carbon green development as well as green financing has created an effective interactive promotion. In contrast, pollution emissions are higher and agricultural science and technology is used less frequent in the central and western regions. Therefore, the role of green financing in agricultural surface source pollution and carbon in different regions may differ.

Hypothesis 2 (H2). *There is regional heterogeneity in the pollution reduction and carbon reduction effect of green finance on agriculture.*

3.3. The Mediating Effect of Technological Innovation and Industrial Structure Optimization

(1) Green finance will promote technological progress [38,39]

Firstly, it offers financial support and risk diversification for enterprise technological innovation. Agricultural technological innovation requires enterprises to make larger capital investments, has longer time costs, and there is some uncertainty, so green finance can provide support [40,41]. Green financing may help businesses innovate technologically and optimize production equipment while providing financial support. It can improve green, clean energy research and technology development investment [42]. And green finance has a supervisory role, forcing enterprises to innovate. For enterprises that are actively engaged in innovation to provide better financial services, it incentivizes enterprises to implement the new development concept: technological innovation [43]. Therefore, green finance can promote technological innovation.

In turn, technological progress promotes the reduction of agricultural pollution and carbon. Firstly, technological progress reduces factor consumption by optimizing resource allocation, thereby reducing carbon dioxide and pollutant emissions [44,45]. Technological progress reforms agricultural production methods, promotes the conversion of agricultural technological conditions, changes the production function, and optimizes factor coordination; farmers, with digital technology and large databases, optimize the production process and monitor, collect, and analyze factor inputs, climate change, and price fluctuations in real time during the entire process of agriculture, improving resource allocation efficiency [46]. Therefore, technological progress can transform technological benefits into economic benefits, enabling farmers to reduce pollution emissions while ensuring output. Efficient and green technological innovation can help achieve reductions in pollution and carbon emissions.

Hypothesis 3 (H3). *Technological progress is a mechanism via which green finance contributes to reducing agricultural pollution and carbon pollution.*

(2) Green finance promotes industrial structure optimization [47].

Green finance influences how capital is allocated and helps to solve the issue of their not being enough money for development. Green credit and other means prompt capital to flow to green projects [48,49], put idle funds into the hands of farmers through leverage,

increase the level of expertise and scale in agriculture, and encourage the agricultural industrial structure's transition to a capital-intensive one; agricultural insurance helps farmers to disperse and transfer the uncertainty and risk in production and operation, protects the economic benefits of farmers, and promotes the enthusiasm of farmers to optimize the industrial structure. The movement of factors toward green manufacturing is guided by the market signal issued by green financing [50,51]. It makes factor allocation more reasonable, promotes farmers to take the initiative to carry out intelligent, digital, and modernized construction, encouraging modernization and transforming agriculture.

The agricultural industrial structure's progressive decarbonization and greening is crucial for sustainable development [52,53].

Hypothesis 4 (H4). *The optimization of the industrial structure is a mechanism via which green finance contributes to reducing agricultural pollution and carbon pollution.*

4. Materials and Methods

4.1. Model Setting

This model is designed to conduct the research:

$$\text{CO}_{2,it} = \alpha_0 + \beta_0 \text{GF}_{it} + \sum \eta_j X_{itj} + u_i + v_t + \varepsilon_{it} \quad (1)$$

$$\text{MYWR}_{it} = \alpha_1 + \beta_1 \text{GF}_{it} + \sum \eta_j X_{itj} + u_i + v_t + \varepsilon_{it} \quad (2)$$

$\text{CO}_{2,it}$ and MYWR_{it} represent the dependent variables of agricultural carbon emissions and non-point source pollution, GF_{it} represents the core explanatory variable of green finance, X_{it} represents control variables, u_i and v_t represent provincial and time-fixed effects, respectively, and ε_{it} symbolizes a random perturbation term.

For further research of the transmission mechanism of green finance on agricultural pollution reduction and carbon reduction, a mediation-effect model was developed based on the studies of Wen Zhonglin (2006) [54]. The specific model is as follows:

$$M = \alpha_2 + \beta_2 \text{GF}_{it} + \sum \eta_j X_{itj} + u_i + v_t + \varepsilon_{it} \quad (3)$$

$$\text{CO}_{2,it} = \alpha_3 + \beta_3 \text{GF}_{it} + \gamma_1 M_{it} + \sum \eta_j X_{itj} + u_i + v_t + \varepsilon_{it} \quad (4)$$

$$\text{MYWR}_{it} = \alpha_4 + \beta_4 \text{GF}_{it} + \gamma_2 M_{it} + \sum \eta_j X_{itj} + u_i + v_t + \varepsilon_{it} \quad (5)$$

where M represents intermediary variables, including technological progress and industrial structure optimization, $\text{CO}_{2,it}$ and MYWR_{it} are consistent with the above, GF_{it} represents the core explanatory variable of green finance, X_{it} represents control variables, u_i and v_t represent provincial and time-fixed effects, respectively, and ε_{it} symbolizes a random perturbation term.

Sobel's test was used to test for the presence of a mediating effect, and when the p -value was below 0.1, the effect was considered statistically significant. The mediating effect was analyzed by observing how green finance influenced the dependent variable before and after introducing the mediator variable, which was reflected by multiplying the coefficient of green finance on mediator variable (β_2) by the coefficient of the latter on the dependent variable (γ) ($\beta_2 \times \gamma$) [54].

4.2. Variables and Data

- (1) Explained variables are as follows. The explanatory variables include agricultural non-point source pollution (MYWR) and carbon emissions (CO_2).

MYWR: The amount of fertilizer pollution, ground film residue, and pesticide pollution will be combined into the agricultural surface source pollution index through the entropy value method, and the following are the precise calculating formulae: the amount of fertilizer pollution = the amount of fertilizer applied $\times$ (1 – fertilizer utilization) = the amount of fertilizer applied $\times$ 65%; the amount of pesticide pollution = the amount of

pesticide used $\times 50\%$; and the amount of ground film residue = the amount of ground film used $\times 10.3\%$.

The computation used in this research, which focuses on the agricultural carbon emissions of 31 provinces between 2011 and 2021, is as follows:

$$tpf = \sum E_i = \sum T_i \times \rho_i \quad (6)$$

where tpf denotes carbon emissions originating from agricultural activities, E_i signifies the emissions from individual carbon sources, T_i indicates the quantity of each carbon source, and ρ_i represents the corresponding carbon emission coefficients that are seen in Table 1.

Table 1. Carbon emission coefficient.

Carbon Source	Carbon Emission Coefficient	Reference Source
Diesel oil	0.59 kg/kg	IPCC2012
Chemical fertilizer	0.89 kg/kg	Oak Ridge National Laboratory
Pesticide	4.93 kg/kg	Oak Ridge National Laboratory
Agricultural film	5.18 kg/kg	IREEA
Irrigation	266.48 kg/kg	Duan H. et al. (2011) [55]
Tillage	312.60 kg/kg	School of Biology and Technology, China Agricultural University

Notes: IPCC represents Intergovernmental Panel on Climate Change. IREEA represents The Institute of Resource, Ecosystem and Environment of Agriculture of Nanjing Agricultural University.

- (2) Explaining variables are as follows. Green finance (GF). This study uses the entropy value approach to develop a green finance index and selects green credit, green investment, green insurance, the green bond, the green fund, and green equity as the primary indicators. The ratio of the credit for environmental protection projects to total credit is known as green credit, and the proportion of the amount invested in pollution control to the GDP for the environment is represented as green investment; green insurance is indicated by the ratio of the amount of green insurance to premium income; the ratio of total green bond issuance to the total and the ratio of market capitalization of green funds to the total are selected as an indicator of the green bond and green fund, respectively; green equity is indicated by the proportion of carbon and emissions trading to the total equity market trading.
- (3) Mediating variables are as follows. The mediating variables are industrial structure optimization (IS) and technological progress (TP). The variables are measured, respectively, by the proportion of the secondary's output value to the tertiary industry's and by the internal spending on research and development financing to GDP.
- (4) Control variables are as follows. Urbanization (UL): The ratio of urban population to total. There is a driving effect of urbanization on agriculture [56]. Economic level (GDP): Using GDP, with 2011 as the base period for deflation. Human capital (HC): Measured using average years of education, it is the driver of technological innovation [57,58]. Opening up level (OPEN): Measured using the total import and export of agricultural products as a share of GDP, it is an important path for agricultural revitalization. Level of transportation infrastructure (TRANS): Measured by the logarithm of highway mileage, the level of transportation accessibility has a strong link with the development of agriculture [59].

The variables are given in Table 2. The region—year is the unit of observation.

Table 2. Variable definition.

Variable Type	Indicators
Explained variable	carbon dioxide emissions agricultural non-point source pollution
Explanatory variable	green finance
Mediating variables	technological progress industrial structure optimization
Control variable	agricultural financial expenditure human capital transportation convenience level of opening up to the outside world urbanization level

4.3. Data Sources

The paper selected 31 provinces, municipalities, and autonomous areas as research objects, selecting relevant data from 2011 to 2021. The data are from the China Statistical Yearbook (2012–2022), China Energy Statistical Yearbook, China Environmental Statistical Yearbook, and EPS database, and the interpolation approach is used to augment a tiny quantity of missing data. The data were hand-collected from the yearbooks.

Table 3 displays the descriptive statistics. As can be seen from Table 3, the observations of the article include 341 units. The standard deviations of all variables are small, indicating minimal fluctuation. The standard deviations of green finance, agricultural carbon emissions, and surface pollution are smaller than the mean, indicating more stable data. There is a large gap between the maximum and minimum values for agricultural carbon emissions and surface source pollution, indicating that there is a large gap in pollution emissions in different regions.

Table 3. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Carbon emissions	341	5.373	1.124	2.664	6.903
Agricultural non-point source pollution	341	0.243	0.171	0.002	0.724
Green finance	341	0.757	0.071	0.620	0.899
Industrial structure optimization	341	1.351	0.722	0.527	5.244
Technical progress	341	0.017	0.012	0.002	0.065
Urbanization level	341	0.586	0.131	0.228	0.896
Economic level	341	9.311	0.462	8.542	10.781
Human capital	341	0.020	0.006	0.008	0.042
Level of opening up	341	0.260	0.288	0.008	1.548
Transportation infrastructure level	341	11.681	0.840	9.400	12.896

Bivariate correlations were also calculated but are not reported. They show that CO₂ and MYWR are both negatively correlated with GF, preliminarily indicating that green finance supports pollution reduction. GDP is positively correlated with HC, which indicates that a more educated population augurs well for a more productive economy. GDP is positively correlated with OPEN, which indicates that economic interactions with foreign countries enhance the level of output in the People's Republic of China.

5. Results and Discussion

5.1. Analysis of Benchmark Regression Results

In Table 4, columns (1)–(6) are the results of OLS, random effect and fixed effect, respectively. Columns (1)–(3) are the effects of green finance on carbon emissions, and the results show that green finance has a negative effect on agricultural carbon emissions and that the results are significant at a 1% significance level. Columns (4)–(6) are the effects of

green finance on agricultural non-point source pollution, and the results show that green finance also has a significant negative effect on agricultural non-point source pollution. The results show that green finance also has a significant negative effect on agricultural non-point source pollution. The absolute values of the coefficient of green finance on carbon emissions and surface source pollution are 0.939 and 0.193, respectively. The results indicate that green finance can effectively inhibit agricultural surface source pollution and carbon dioxide emissions, with obvious pollution reduction and carbon reduction effects, i.e., H1 is verified. The impact of secondary indicators of green finance is researched. The findings reveal that most indicators have positive influence on mitigating agricultural pollution and carbon emissions (due to space limitations, the results will not be presented here).

Table 4. Regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	CO ₂	CO ₂	CO ₂	MYWR	MYWR	MYWR
GF	−4.266 *** (0.576)	−1.003 *** (0.163)	−0.939 *** (0.154)	−0.394 *** (0.105)	−0.215 *** (0.056)	−0.193 *** (0.056)
UL	2.566 *** (0.690)	0.956 *** (0.274)	1.419 *** (0.274)	−0.283 ** (0.125)	−0.056 (0.088)	−0.049 (0.100)
GDP	0.118 (0.184)	−0.195 *** (0.058)	−0.132 ** (0.057)	0.161 *** (0.033)	−0.045 ** (0.019)	−0.057 *** (0.021)
HC	27.68 *** (8.321)	−12.51 *** (3.383)	−14.14 *** (3.208)	4.146 *** (1.510)	−1.996 * (1.152)	−1.993 * (1.176)
OPEN	−0.494 ** (0.229)	0.283 *** (0.066)	0.311 *** (0.063)	−0.025 (0.042)	−0.035 (0.023)	−0.043 * (0.023)
TRANS	1.293 *** (0.050)	0.348 *** (0.068)	0.100 (0.076)	0.182 *** (0.009)	0.085 *** (0.0180)	0.059 ** (0.028)
Constant	−9.539 *** (1.828)	3.500 *** (0.887)	5.525 *** (0.886)	−2.994 *** (0.332)	−0.087 (0.276)	0.313 (0.325)
Observations	341	341	341	341	341	341
R-squared	0.714	0.578	0.398	0.590	0.394	0.326
Number of ids	31	31	31	31	31	31

Notes: The values in parentheses are standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Among the control variables, for agricultural carbon emissions, the urbanization level is significantly positive at the 1% significance level, the economic development level is significantly negative at the 5% significance level, the human capital level is significantly negative at the 1% significance level, the degree of openness to the outside world is significantly positive at the 1% significance level, and the level of transportation infrastructure has a positive effect but the result is not significant. For agricultural non-point source pollution, the level of urbanization has a negative effect but the result is not significant, the level of economic development is significantly negative at the 1% significance level, the level of human capital is significantly negative at the 10% significance level, the degree of openness to the outside world is significantly negative at the 10% significance level, and the level of transportation infrastructure is significantly negative at the 5% significance level. The coefficient of GDP is mostly negative ($p < 0.05$), which indicates that economic activity in the People's Republic of China is generally conducted in an environmentally friendly manner. The coefficients of HC are mostly negative ($p < 0.10$), which may be because an educated population can better appreciate the importance of environmental responsibility. The level of opening up to the outside world affects the level of trade, which in turn affects agricultural production and consequently impacts pollution and carbon emissions. The coefficient of transportation infrastructure may reflect China's shift towards electric vehicles. Urbanization affects agricultural pollution and carbon reduction through factors such as land interest rates and population migration, but this impact may have a turning point.

5.2. Heterogeneity Analysis

Considering the size and diversity of China's resources, climate, and economic landscape, it is reasonable to assume that the impact of green finance will differ among different regions. Table 5 showcases the findings of this study, employing the conventional categorization into three regions: East, Central, and West. These results indicate that green finance's contribution varies by location, proving H2.

Table 5. Heterogeneity Analysis.

Variables	Eastern		Middle		Western	
	CO ₂	MYWR	CO ₂	MYWR	CO ₂	MYWR
GF	−2.844 *** (0.452)	−0.293 ** (0.145)	−0.031 (0.197)	−0.0007 (0.203)	−5.702 *** (1.218)	−0.223 * (0.187)
UL	2.248 *** (0.744)	−0.582 ** (0.239)	0.539 (0.372)	−1.268 (0.207)	1.298 (1.139)	−0.139 (0.175)
GDP	−0.673 *** (0.138)	0.076 * (0.076)	−0.305 *** (0.050)	−0.131 * (0.068)	1.277 *** (0.397)	0.289 *** (0.061)
HC	−21.745 *** (7.059)	5.716 ** (2.271)	−10.717 *** (3.927)	6.243 * (3.269)	56.830 *** (16.819)	−2.739 (2.585)
OPEN	−0.539 *** (0.154)	0.037 (0.050)	−0.552 * (0.243)	−0.169 (0.256)	−1.656 (1.009)	−0.162 (0.155)
TRANS	0.979 *** (0.032)	0.148 *** (0.011)	−0.162 * (0.085)	0.273 *** (0.030)	1.399 *** (0.122)	0.203 *** (0.019)
Constant	2.123 * (1.277)	−1.709 *** (0.411)	10.777 *** (1.007)	−1.178 * (0.675)	−20.216 *** (4.022)	−4.514 *** (0.618)
Observations	132	132	99	99	110	110
R-squared	0.957	0.788	0.466	0.715	0.674	0.563
Number of id	12	12	9	9	10	10

Notes: The values in parentheses are standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In the eastern region, green finance's influence on agricultural carbon emissions and pollution is negative, with these effects passing the significance test. The respective coefficients' absolute values are 2.844 and 0.293. The eastern region boasts greater economic, institutional, and locational advantages, among others, with a more comprehensive green financial system. The regions of Beijing–Tianjin–Hebei and the Yangtze River Delta lead the country's green finance development. The eastern region has made great contributions by using diversified green financial tools. Despite not being significant, green finance in the central area exhibits a negative impact. Leveraging the green finance era, the western region has steadily accelerated its development, laying the groundwork for agriculture's pollution and carbon reduction. Green finance is also significantly negative. The absolute values of the coefficients are 0.223 and 5.702. The eastern region has the greatest impact on non-point source pollution, while the western region has the greatest impact on agricultural carbon emissions.

5.3. Mechanism Analysis

Through an analysis of theoretical mechanisms, this paper delves into the integration of technological innovation and optimization of industrial structures, aiming to elucidate the path by which green finance impacts on mitigating pollution and reducing carbon emissions. The specific process is as follows: First, entail estimation of the baseline model. The second stage verified how green finance affects mediating variables. Finally, the article estimates the mediating effect with mediating variables as another independent variable. Using fixed-effects regression, it compares the coefficients of the green finance in baseline models with their counterparts in the augmented model.

Table 6 shows the results. Without adding intermediary variables, the findings from columns (1) and (2) means that each unit increase in green finance translates into a 0.939 and 0.193 unit decrease in agricultural carbon emissions and surface source pollution. Green

finance exerts a dual effect, reducing pollution and carbon emissions. The second phase's results are showed in column (3). As indicated in column (3), green finance shows a notable influence of 0.018 at the 1% significance level, implying its contribution to technological progress. After adjusting for technological progress, the findings reveal coefficients of -0.701 and -0.101 for green finance's impact, both significant at the 1% level, indicating its continued negative influence. The coefficients of technological progress are -12.98 and -4.978 , respectively. The absolute value of green finance's coefficient is smaller than the absolute value in the baseline regression results, which proves that a partial mediating effect exists. For the models using CO_2 as the measure of pollution, the intermediation effect $= 0.018 \times (-12.980) = -0.234$; for the models using non-point source pollution as the measure of pollution, the intermediation effect $= 0.018 \times (-4.978) = -0.090$. The t-statistic of Sobel's test reveals that this effect is significant ($p < 0.05$). This indicates that green finance contributes to propel agricultural pollution and carbon reduction by promoting technological progress, thus, technological advancement serves as a pivotal pathway. Hypothesis 3 is verified.

Table 6. Mediation effect results of technological progress.

Variables	(1)	(2)	(3)	(4)	(5)
	CO_2	MYWR	TP	CO_2	MYWR
TP				-12.980^{***} (2.625)	-4.978^{***} (0.958)
GF	-0.939^{***} (0.154)	-0.193^{***} (0.056)	0.018^{***} (0.003)	-0.701^{***} (0.156)	-0.101^* (0.057)
UL	1.419^{***} (0.274)	-0.049 (0.100)	0.006 (0.006)	1.498^{***} (0.264)	-0.019 (0.096)
GDP	-0.132^{**} (0.057)	-0.057^{***} (0.021)	0.0001 (0.001)	-0.131^{**} (0.054)	-0.056^{***} (0.020)
HC	-14.14^{***} (3.208)	-1.993^* (1.176)	0.176^{***} (0.068)	-11.86^{***} (3.126)	-1.116 (1.141)
OPEN	0.311^{***} (0.063)	-0.043^* (0.023)	-0.003^{**} (0.001)	0.273^{***} (0.061)	-0.058^{***} (0.022)
TRANS	0.0997 (0.076)	0.059^{**} (0.028)	-0.003^* (0.0016)	0.059 (0.074)	0.043 (0.027)
Constant	5.525^{***} (0.886)	0.313 (0.325)	0.0316^* (0.019)	5.936^{***} (0.858)	0.471 (0.313)
Sobel Test				$p = 0.042$	$p = 0.098$
Observations	341	341	341	341	341
R-squared	0.398	0.268	0.588	0.443	0.327
Number of ids	31	31	31	31	31

Notes: The values in parentheses are standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The number of green patents in China continues to increase. According to relevant data, the global green and low-carbon patents authorized in 2016–2022 totaled 558,000 and the disclosure volume totaled 1,047,000, of which China's share is as high as 37%. In the agricultural sector, the scale of research and development investment by Chinese agriculture-related enterprises has been increasing. Agricultural technology innovation cannot be separated from the financial support; green finance is crucial in this regard.

The specific areas of technology in the agricultural field that are mainly reflected in the provinces will be the IoT, computer vision and artificial intelligence, and other technologies deployed in agriculture. Specifically, real-time field data are collected by IoT devices powered by sensor technology, enabling farmers to make decisions. High-resolution and location-specific views are provided by photography from drones and satellites in conjunction with the GPS. These technological innovations are producing disruptive and sustainable changes in agricultural practices.

The results in columns (1) and (2) in Table 7 agree with the earlier findings. The second stage of analysis reveals that there is a positive influence of green finance on

optimizing industrial structure, as indicated by column (3). When the intermediary variable is introduced in the third phase, it becomes apparent that green finance maintains a substantial negative influence on both carbon emissions (with a coefficient of -0.633) and non-point source pollution (with a coefficient of -0.096). The absolute values of the coefficients are lower than the corresponding coefficients of the benchmark regression, which indicates that there is a part of the intermediary effect. For the models using CO_2 as the measure of pollution, the intermediation effect = $1.873 \times (-0.164) = -0.307$; for the models using non-point source pollution as the measure of pollution, the intermediation effect = $1.873 \times (-0.164) = -0.097$. The results passed the Sobel test. This suggests that, via encouraging industrial structure upgrading, green finance may reduce agricultural pollution and carbon. Hypothesis 4 is verified.

Table 7. Mediation effect results of industrial structure upgrading.

Variables	(1)	(2)	(3)	(4)	(5)
	CO_2	MYWR	IS	CO_2	MYWR
IS				-0.164^{***} (0.026)	-0.052^{***} (0.010)
GF	-0.939^{***} (0.154)	-0.193^{***} (0.0563)	1.873^{***} (0.317)	-0.633^{***} (0.153)	-0.096^* (0.057)
UL	1.419^{***} (0.274)	-0.0490 (0.100)	0.230 (0.565)	1.456^{***} (0.258)	-0.0371 (0.096)
GDP	-0.132^{**} (0.057)	-0.0570^{***} (0.021)	-0.471^{***} (0.117)	-0.210^{***} (0.055)	-0.0815^{***} (0.020)
HC	-14.14^{***} (3.208)	-1.993^* (1.176)	-2.616 (6.626)	-14.57^{***} (3.025)	-2.129^* (1.127)
OPEN	0.311^{***} (0.063)	-0.0433^* (0.023)	-0.943^{***} (0.129)	0.157^{**} (0.064)	-0.092^{***} (0.024)
TRANS	0.100 (0.076)	0.059^{**} (0.028)	0.309^{**} (0.157)	0.150^{**} (0.072)	0.0748^{***} (0.027)
Constant	5.525^{***} (0.886)	0.313 (0.325)	0.871 (1.831)	5.668^{***} (0.836)	0.358 (0.311)
Sobel Test				$p = 0.000$	$p = 0.033$
Observations	341	341	341	341	341
R-squared	0.398	0.268	0.648	0.467	0.330
Number of ids	31	31	31	31	31

Notes: The values in parentheses are standard errors. $*** p < 0.01$, $** p < 0.05$, $* p < 0.1$.

5.4. Robustness Test and Endogeneity Test

In light of potential biases in the measurement of the green finance index, this research performs a robustness test by substituting indicators for the primary explanatory factors. We selected micro enterprise data and re-evaluated indicators such as green credit and green securities using relevant data from A-share listed companies. Green credit is measured by the proportion of newly added bank loans from listed environmental protection enterprises to listed enterprise loans. Green securities are measured by the proportion of the market value of listed environmental protection companies to the market value of listed companies. On this basis, we performed regression estimation again. The results show that the sign of the main indicator coefficients is generally consistent and significant. Thus, the regression results above are reliable. For space reasons, they are not reported here.

This article may face endogeneity problems. First, there may be a two-way causality problem; the urgency of the need for green finance tends to be stronger in regions with higher levels of pollution and carbon emissions. The second problem is omitted variables. Although the model controls for a range of possible factors, there may still be bias due to omitted variables or measurement errors in green finance. After the article lags green finance by one period, the results are still significant; further lagging all control variables by one period, the results are still significant. Therefore, the above results are shown to be robust. For space reasons, they are not reported here.

6. Conclusions

The dual-carbon target is important, in which agricultural pollution reduction and carbon reduction occupies a crucial position. Green finance, as an important means of environmental protection, has flourished in the new era and exerted a big influence on agricultural carbon pollution reduction. This paper uses panel regression and mediation-effect models to empirically study how green finance affects pollution reduction and carbon reduction in agriculture. It selects provincial panel data collected between 2011 and 2021 from 31 provinces in mainland China.

The conclusions show that: First, there are considerable benefits to both surface source pollution and carbon reduction from agricultural sources when green finance is used. Second, the availability of green finance for reducing agricultural pollution and carbon emissions varies by location. Third, technological advancement and industrial structure optimization are two key paths, and green finance can reduce agricultural pollution and carbon emissions by promoting these two factors.

Scholars from many countries have studied and proven the impact of green finance on the environment and climate. This study also confirms that green finance has a positive impact on the environment and further proves that green finance has enormous potential in reducing pollution and carbon emissions in agriculture. Therefore, this article proposes the following suggestions:

First, insist on improving and optimizing green finance. Strengthen the green direction guidance of small- and medium-sized banks. Encourage joint-stock banks, city (agricultural) commercial banks, and village banks to actively respond to strengthen and expand green financial business, optimize internal institutions and staffing, and take the initiative to make up for their own shortcomings in science and technology, talent, and other aspects. Accelerate green financial product innovation; green financial product innovation can be empowered by cloud computing, big data, and other modern financial technologies, provide diversified, multi-level financial services for green business entities, and continuously enrich the grounded and effective green financial products.

Second, enhance the green financial system to promote the synergy of agricultural pollution and carbon reduction. The government can introduce policies to incentivize farmers to use low-carbon agricultural production methods, such as the introduction of a greenhouse gas emissions tax on high-polluting agricultural production and the use of financial subsidies to farmers to use clean energy. A national agricultural carbon emissions trading platform could be established to guide agricultural production in a low-carbon direction through the trading and pricing of carbon emission rights. In addition, establishing a green agricultural credit rating system is also a very important step. Finally, since green financial development varies greatly among different regions, provinces and cities should strengthen communication, fully explore their own resource advantages, and develop regional green finance.

Third, promote industrial structure and technical advancement. In order to fully realize the goal, we must, on the one hand remove financial barriers to agricultural technological innovation, support it financially, and consistently enhance the effectiveness of the translation of scientific research findings and, on the other hand, we must fully utilize green finance to curb and modify high-pollution agriculture's antiquated production practices, compelling it to alter and improve environmental efficiency.

The shortcomings of this article are: Firstly, the calculation of agricultural non-point source pollution and carbon emissions in the article draws on previous research, but currently the academic community has not formed a unified standard for its calculation, which may lead to errors between the empirical results and actual values. Secondly, although this article has conducted a detailed study on the mechanism between green finance and agricultural pollution reduction and carbon reduction, further research is needed to enhance the theoretical and profound nature of this article. Future studies can be carried out from the following angles: Firstly, future research can more accurately calculate agricultural carbon emissions and non-point source pollution. Second, future research can

analyze the subject using more aspects and disciplines to broaden the theoretical analysis framework. Research can also be conducted from a spatial perspective.

Author Contributions: Conceptualization, J.G.; methodology, L.C.; software, J.G.; validation, L.C. and J.G.; formal analysis, L.C.; data curation, J.G.; writing—original draft preparation, J.G.; writing—review and editing, L.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Su, L.; Wang, Y.; Yu, F. Analysis of regional differences and spatial spillover effects of agricultural carbon emissions in China. *Heliyon* **2023**, *9*, e16752. [[CrossRef](#)] [[PubMed](#)]
2. Wang, H.; Liu, C.; Xiong, L.; Wang, F. The spatial spillover effect and impact paths of agricultural industry agglomeration on agricultural non-point source pollution: A case study in Yangtze River Delta, China. *J. Clean. Prod.* **2023**, *401*, 136600. [[CrossRef](#)]
3. Ji, Y.; Gao, D.; Liu, Q.; Su, J.; Liu, Y.; Zhao, J.; Yang, Y.; Fu, Y.; Huang, G. An integrated framework for agricultural non-point source pollution control technology evaluation: Application of an improved multiple attribute decision making method. *Expert Syst. Appl.* **2023**, *229*, 120319. [[CrossRef](#)]
4. Xian, B.; Xu, Y.; Chen, W.; Wang, Y.; Qiu, L. Co-benefits of policies to reduce air pollution and carbon emissions in China. *Environ. Impact Assess. Rev.* **2024**, *104*, 107301. [[CrossRef](#)]
5. Chen, S.; Tan, Z.; Wang, J.; Zhang, L.; He, X.; Mu, S. Spatial and temporal evolution of synergizing the reduction of pollution and carbon emissions and examination on comprehensive pilot effects—evidence from the national eco-industrial demonstration parks in China. *Environ. Impact Assess. Rev.* **2023**, *101*, 107147. [[CrossRef](#)]
6. Yu, H.; Wei, W.; Li, J.; Li, Y. The impact of green digital finance on energy resources and climate change mitigation in carbon neutrality: Case of 60 economies. *Resour. Policy* **2022**, *79*, 103116. [[CrossRef](#)]
7. Salazar, J. Environmental Finance: Linking Two World. In Proceedings of the a Workshop on Financial Innovations for Biodiversity, Bratislava, Slovakia, 1–3 May 1998; Volume 1, pp. 2–18.
8. Cowan, E. *Topical Issues in Environmental Finance*; EEPSEA Special and Technical Paper from Economy and Environment Program for Southeast Asia (EEPSEA); IDRC: Ottawa, ON, Canada, 1998.
9. Abdul Gafoor, C.P.; Perumbalath, S.; Daimari, P.; Naheem, K.T. Trends and patterns in green finance research: A bibliometric study. *Innov. Green Dev.* **2024**, *3*, 100119. [[CrossRef](#)]
10. Wang, Y.; Zhi, Q. The Role of Green Finance in Environmental Protection: Two Aspects of Market Mechanism and Policies. *Energy Procedia* **2016**, *104*, 311–316. [[CrossRef](#)]
11. Albitar, K.; Hussainey, K. Sustainability, Environmental Responsibility and Innovation. *Green Financ.* **2023**, *5*, 85–88. [[CrossRef](#)]
12. Matallín Sáez, J.C.; Soler-Domínguez, A. Cost and performance of carbon risk in socially responsible mutual funds. *Quant. Financ. Econ.* **2023**, *7*, 50–73. [[CrossRef](#)]
13. Zhang, T.; Zhao, F. A study on the relationships among green finance, environmental pollution and economic development. *Energy Strategy Rev.* **2024**, *51*, 101290. [[CrossRef](#)]
14. Ambec, S.; Lanoie, P. Innovation at the service of the environment and business performance. *INRAE Sci. Soc.* **2008**, *2007*, 1–5.
15. Volz, U. Fostering Green Finance for Sustainable Development in Asia. In *Routledge Handbook of Banking and Finance in Asia*; Routledge: London, UK, 2018; pp. 488–504.
16. Wang, C.; Liu, P.; Ibrahim, H.; Yuan, R. The temporal and spatial evolution of green finance and carbon emissions in the Pearl River Delta region: An analysis of impact pathways. *J. Clean. Prod.* **2024**, *446*, 141428. [[CrossRef](#)]
17. Prasad, S.; Ansari, S. *Green Financing: Role of Public Sector Banks*; Social Science Electronic Publishing: New York, NY, USA, 2015.
18. Lan, J.; Wei, Y.; Guo, J.; Li, Q.; Liu, Z. The Effect of Green Finance on Industrial Pollution Emissions: Evidence from China. *Resour. Policy* **2023**, *80*, 103156. [[CrossRef](#)]
19. Zhang, D.; Zhang, Z.; Managi, S. A bibliometric analysis on green finance: Current status, development, and future directions. *Financ. Res. Lett.* **2019**, *29*, 425–430. [[CrossRef](#)]
20. Paustian, K.; Lehmann, J.; Ogle, S.; Reay, D.; Robertson, G.P.; Smith, P. Climate-smart soils. *Nature* **2016**, *523*, 49–57. [[CrossRef](#)] [[PubMed](#)]
21. Wang, L.; Yang, X.; Cai, Q. Influence mechanism of green finance on regional emission reduction. *Heliyon* **2024**, *10*, e23861. [[CrossRef](#)]
22. Van Veelen, B. Cash cows? Assembling low-carbon agriculture through green finance. *Geoforum* **2021**, *118*, 130–139. [[CrossRef](#)]

23. Zhang, G.; Guo, B.; Lin, J. The impact of green finance on enterprise investment and financing. *Financ. Res. Lett.* **2023**, *58*, 104578. [\[CrossRef\]](#)
24. Zhao, L.-T.; Li, F.-R.; Wang, D.-S. How to achieve the common developments of green finance and clean energy in China? Evidence from coupling coordination evaluation. *Ecol. Indic.* **2023**, *155*, 111011. [\[CrossRef\]](#)
25. Ran, C.; Zhang, Y. The driving force of carbon emissions reduction in China: Does green finance work. *J. Clean. Prod.* **2023**, *421*, 138502. [\[CrossRef\]](#)
26. He, L.; Gan, S.D.; Zhong, T.Y. The impact of green credit policy on firms' green strategy choices: Green innovation or green-washing? *Environ. Sci. Pollut. Res.* **2022**, *29*, 73307–73325. [\[CrossRef\]](#) [\[PubMed\]](#)
27. Tamazian, A.; Chousa, J.P.; Vadlamannati, K. Does Higher Economic and Financial Development Lead to Environmental Degradation: Evidence from BRIC Countries. *Energy Policy* **2009**, *37*, 246–253. [\[CrossRef\]](#)
28. Gianfrate, G.; Peri, M. The Green Advantage: Exploring the Convenience of Issuing Green Bonds. *J. Clean. Prod.* **2019**, *219*, 127–135. [\[CrossRef\]](#)
29. Zhang, W.; Ke, J.; Ding, Y.; Chen, S. Greening through finance: Green finance policies and firms' green investment. *Energy Econ.* **2024**, *131*, 107401. [\[CrossRef\]](#)
30. Fang, L.; Hu, R.; Mao, H.; Chen, S. How crop insurance influences agricultural green total factor productivity: Evidence from Chinese farmers. *J. Clean. Prod.* **2021**, *321*, 128977. [\[CrossRef\]](#)
31. Li, L.; Liu, D.; Hou, J.; Xu, D.; Chao, W. The Study of the Impact of Carbon Finance Effect on Carbon Emissions in Beijing-Tianjin-Hebei Region—Based on Logarithmic Mean Divisia Index Decomposition Analysis. *Sustainability* **2019**, *11*, 1465. [\[CrossRef\]](#)
32. Guo, L.; Zhao, S.; Song, Y.; Tang, M.; Li, H. Green Finance, Chemical Fertilizer Use and Carbon Emissions from Agricultural Production. *Agriculture* **2022**, *12*, 313. [\[CrossRef\]](#)
33. Han, X.; Wang, Y.; Yu, W.; Xia, X. Coupling and coordination between green finance and agricultural green development: Evidence from China. *Financ. Res. Lett.* **2023**, *58*, 104221. [\[CrossRef\]](#)
34. Dong, F.; Yu, B.; Pan, Y. Examining the Synergistic Effect of CO₂ Emissions on PM_{2.5} Emissions Reduction: Evidence from China. *J. Clean. Prod.* **2019**, *223*, 759–771. [\[CrossRef\]](#)
35. Cheng, J.; Tong, D.; Zhang, Q.; Liu, Y.; Lei, Y.; Yan, G.; Yan, L.; Yu, S.; Cui, R.Y.; Clarke, L.; et al. Pathways of China's PM_{2.5} Air Quality 2015–2060 in the Context of Carbon Neutrality. *Natl. Sci. Rev.* **2021**, *8*, nwab078. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Taghizadeh-Hesary, F.; Yoshino, N. The way to induce private participation in green finance and investment. *Financ. Res. Lett.* **2019**, *31*, 98–103. [\[CrossRef\]](#)
37. Yue, H.; Zhou, Z.; Liu, H. How does green finance influence industrial green total factor productivity? Empirical research from China. *Energy Rep.* **2024**, *11*, 914–924. [\[CrossRef\]](#)
38. Zhang, L.; Sun, H.; Pu, T.; Sun, H.; Chen, Z. Do green finance and hi-tech innovation facilitate sustainable development? Evidence from the Yangtze River Economic Belt. *Econ. Anal. Policy* **2024**, *81*, 1430–1442. [\[CrossRef\]](#)
39. Bai, R.; Lin, B. Nexus between green finance development and green technological innovation: A potential way to achieve the renewable energy transition. *Renew. Energy* **2023**, *218*, 119295. [\[CrossRef\]](#)
40. Chen, Z.; Zhang, Y.; Wang, H.; Ouyang, X.; Xie, Y. Can green credit policy promote low-carbon technology innovation? *J. Clean. Prod.* **2022**, *359*, 132061. [\[CrossRef\]](#)
41. Irfan, M.; Razzaq, A.; Sharif, A.; Yang, X. Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China. *Technol. Forecast. Soc. Change* **2022**, *182*, 121882. [\[CrossRef\]](#)
42. Jia, J.; He, X.; Zhu, T.; Zhang, E. Does green finance reform promote corporate green innovation? Evidence from China. *Pac.-Basin Financ. J.* **2023**, *82*, 102165. [\[CrossRef\]](#)
43. Huang, Y.; Chen, C.; Lei, L.; Zhang, Y. Impacts of green finance on green innovation: A spatial and nonlinear perspective. *J. Clean. Prod.* **2022**, *365*, 132548. [\[CrossRef\]](#)
44. Zhang, Y.; Lan, M.; Zhao, Y.; Su, Z.; Hao, Y.; Du, H. Regional carbon emission pressure and corporate green innovation. *Appl. Energy* **2024**, *360*, 122625. [\[CrossRef\]](#)
45. Zhang, L.; Cai, C.; Singh, K.; Zhong, K. Green technology innovation, trade deficit and carbon emission transfer in agriculture under the new “dual circulation” development pattern of China. *Ecol. Indic.* **2024**, *159*, 111757. [\[CrossRef\]](#)
46. Zhang, X.; Davidson, E.A.; Mauzerall, D.L.; Searchinger, T.D.; Dumas, P.; Shen, Y. Managing nitrogen for sustainable development. *Nature* **2015**, *528*, 51–59. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Zhang, G. The heterogeneous role of green finance on industrial structure upgrading—Based on spatial spillover perspective. *Financ. Res. Lett.* **2023**, *58*, 104596. [\[CrossRef\]](#)
48. Zhang, K.; Li, Y.; Qi, Y.; Shao, S. Can Green Credit Policy Improve Environmental Quality? Evidence from China. *J. Environ. Manag.* **2021**, *298*, 113445. [\[CrossRef\]](#)
49. Ge, T.; Cai, X.; Song, X. How does renewable energy technology innovation affect the upgrading of industrial structure? The moderating effect of green finance. *Renew. Energy* **2022**, *197*, 1106–1114. [\[CrossRef\]](#)
50. Mngumi, F.; Shaorong, S.; Shair, F.; Waqas, M. Does Green Finance Mitigate the Effects of Climate Variability: Role of Renewable Energy Investment and Infrastructure. *Environ. Sci. Pollut. Res.* **2022**, *29*, 59287–59299. [\[CrossRef\]](#)
51. Yumei, H.; Iqbal, W.; Irfan, M.; Fatima, A. The Dynamics of Public Spending on Sustainable Green Economy: Role of Technological Innovation and Industrial Structure Effects. *Environ. Sci. Pollut. Res.* **2022**, *29*, 22970–22988. [\[CrossRef\]](#) [\[PubMed\]](#)

52. Zheng, Y.; Tang, J.; Huang, F. The impact of industrial structure adjustment on the spatial industrial linkage of carbon emission: From the perspective of climate change mitigation. *J. Environ. Manag.* **2023**, *345*, 118620. [[CrossRef](#)]
53. Liu, L.; Zhang, L.; Li, B.; Wang, Y.; Wang, M. Can financial agglomeration curb carbon emissions reduction from agricultural sector in China? Analyzing the role of industrial structure and digital finance. *J. Clean. Prod.* **2024**, *440*, 140862. [[CrossRef](#)]
54. Wen, Z.; Zhang, L.; Hou, J. Mediated moderator and moderated mediator. *Acta Psychol. Sin.* **2006**, *38*, 448–452.
55. Duan, H.; Zhang, Y.; Zhao, J.; Bian, X. Carbon Footprint Analysis of Farmland Ecosystem in China. *J. Soil Water Conserv.* **2011**, *25*, 203–208.
56. Jiang, S.; Zhou, J.; Qiu, S. Digital Agriculture and Urbanization: Mechanism and Empirical Research. *Technol. Forecast. Soc.* **2022**, *180*, 121724. [[CrossRef](#)]
57. Lio, M.; Liu, M.C. ICT and Agricultural Productivity: Evidence from Cross-Country Data. *Agric. Econ.* **2006**, *34*, 221–228. [[CrossRef](#)]
58. Chan, M. Mobile phones and the good life: Examining the relationships among mobile use, social capital and subjective well-being. *New Media Soc.* **2015**, *17*, 96–113. [[CrossRef](#)]
59. Lu, H.; Zhao, P.; Hu, H.; Zeng, L.; Wu, K.S.; Lv, D. Transport infrastructure and urban-rural income disparity: A municipal-level analysis in China. *J. Transp. Geogr.* **2022**, *99*, 103292. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.