sustainability

Article

The Impact of Rural Industrial Integration on Agricultural Carbon Emissions Evidence from China Provinces Data

Yu Zhang [1,]* and Yikang Liu [2]

[1] School of Economics and Management, Southwest University of Science and Technology, Mianyang 621010, China
[2] School of Life Science and Engineering, Southwest University of Science and Technology, Mianyang 621010, China; lyk613@sina.com
* Correspondence: yuzhang@swust.edu.cn

Abstract: Based on the data from China's provincial panel from 2008 to 2019, this paper explores the impact of rural industrial integration (RII) on agriculture carbon emissions (ACE). It is found that RII has significantly inhibited ACE. The 1% increase in RII led to a 2.133% reduction in ACE; the RII can realize the goal of green agriculture by accelerating urbanization, thus inhibiting ACE. The labor structure has a significant positive moderating effect on agricultural carbon emission reduction in the process of RII. In the threshold analysis, it is found that the rural labor structure has a single threshold nonlinear effect, and the effect of RII on inhibited ACE is more pronounced when the level of labor structure is more than the threshold of 0.829. This conclusion not only contributes to understanding the relationship between the RII, urbanization, labor structure, and carbon emissions, but also provides substantial support for further promoting the implementation of the rural revitalization strategy and achieving the dual-carbon goal.

Keywords: rural industrial integration; rural revitalization; carbon emissions

Citation: Zhang, Y.; Liu, Y. The Impact of Rural Industrial Integration on Agricultural Carbon Emissions Evidence from China Provinces Data. *Sustainability* **2024**, *16*, 680. https://doi.org/10.3390/su16020680

Academic Editors: Mojtaba Aghajani Delavar and Junye Wang

Received: 4 December 2023
Revised: 3 January 2024
Accepted: 10 January 2024
Published: 12 January 2024

1. Introduction

The continuous increase in greenhouse gases, primarily carbon dioxide, has resulted in the frequent occurrence of extreme phenomena such as drought and flood polarization. In the face of the growing global climate problem, carbon abatement action has garnered consensus across various industries [1–3]. China has made active exploration in global climate governance, and, in 2020, China committed to the world to achieve the strategic goal of carbon peak by 2030 and carbon neutrality by 2060, commonly known as the "dual carbon" goal. This commitment has raised the pressure for the reduction of carbon emissions in China to an unprecedented level. ACEs in China count approximately 17% of the whole carbon emissions. Consequently, reducing carbon emissions in agriculture plays a crucial role in achieving the "dual carbon" goal in China [4,5].

The concept of RII in China was first introduced in China's "Several Opinions on Intensifying Reform and Innovation and Accelerating Agricultural Modernization" Document in 2015 [6]. It is defined as "expanding the agricultural industry chain, enhancing the added value of agriculture, vigorously developing characteristic planting and breeding industries, agricultural product processing industries, rural service industries, supporting the development of one village, one product, one township (county) and one industry, strengthening the county economy, actively developing multiple agricultural functions, tapping into the value of rural ecological leisure, tourism and sightseeing, culture and education, increasing investment in rural tourism and leisure infrastructure construction, activating rural factor resources, and increasing farmers' income". RII is a significant approach to comprehensively promote rural revitalization, especially in terms of industrial prosperity.

Since 2015, primary, secondary, and tertiary industries have been tried to integrated in rural areas, and such attempts referred to as RII has become a key component of the China's government's policies on agriculture over the years [7]. RII occurs through the infusion of advanced and emerging technologies into the agricultural sector. The interconnection and extension of the three industries, along with the active development of leisure agriculture, rural e-commerce, and other green industries, centralize the resources of the three industries, effectively reducing production costs and further enhancing the relationships of urban and rural areas [8]. Consequently, during the process of integrating three rural industries, green agriculture can be promoted, leading to the improvement of the traditional extensive agricultural production model, the improvement of agricultural productivity and the reduction of ACE. Furthermore, under the guidance of constructing AII demonstration zones and implementing policies for urban–rural integration development at the county level, secondary and tertiary industries play a pivotal role in population concentration and urbanization. This results in the establishment of small towns and large-scale industrial parks with agricultural products and leisure tourism as defining characteristics, thus promoting the local urbanization process for rural residents. The gradual formation of rural urbanization acts as a deterrent to local carbon emissions

Currently, research on RII focuses mainly on three main directions. First, there is an interpretation of the connotation of RII. This direction investigates the modes and approaches of integrating the three industries. For example, RII was an advanced form and upgraded version of agricultural industrialization, with more active business innovation, more blurred industrial boundaries, and closer interest connection [9]. The essence of RII lies in the internalization of the division of labor among industries, particularly the social production division of labor between sub-industries of the primary industry and the sub-industries of the secondary and tertiary industries [10]. Second, some research focuses on evaluating the development level of RII. Currently, when constructing relevant evaluation index systems, scholars primarily aim to incorporate as many specific business forms involved in the RII as possible to improve the comprehensiveness of their connotation [11,12]. Thirdly, studies examine the economic benefits of RII. Primary research in this area focuses on increasing farmers' income and narrow the income gap [7,13]. The RII in the rural region can directly or indirectly promote the consumption level of residents [14].

Although empirical analyses on RII abound, most of them primarily focus on the economic benefits without exploring its impact on the ecological environment. The RII through the penetration of high and new technology into the agricultural industry, and the linkage and extension between the three industries concentrates resources, effectively reduces production costs, improves agricultural productivity and thus reduces local ACE. This paper aims to make up for the shortage of existing literature by constructing the impact of the RII in various provinces on ACE in China. Specifically, it analyzes whether RII can indirectly mitigate ACE through promoting urbanization. The innovation of this paper lies in three aspects. Firstly, this paper analyzes the relevant mechanism of the impact of RII on ACE, enriches the existing research system of RII, and studies and analyzes the issue of low-carbon agriculture. Second, based on reality, this article tests whether RII can indirectly reduce ACE through the mechanism of promoting urbanization. Third, it examines the impact mechanism of the RII on ACE under the influence of labor structure, thus considering both economic and green sustainable development.

2. Theoretical Mechanism

2.1. Direct Effect of RII on ACE

RII and ACE

The RII is based on the primary industry. By cross-integrating among industries, new business forms are created to extend the agricultural industrial chain, ultimately leading to the formation of agricultural industrial complexes and consortiums, thus achieving agricultural modernization [15]. In the integrated development process, RII, aided by new technologies and models, optimizes the industrial structure and improves production efficiency. This, in turn, facilitates the formation of agricultural industrial complexes and links through industrial agglomeration. Optimization of the industrial structure, improved agricultural production, and establishment of industrial agglomeration effectively reduce local carbon emissions [16–20]. Furthermore, the active development of the third green industry, such as rural tourism and rural healthcare, can contribute to the betterment of the ecological environment in rural areas [21–24].

Based on the above analysis, Hypothesis 1 is proposed as the following:

Hypothesis 1: *RII has a direct inhibitory effect on ACE.*

2.2. Indirect Effect of RII on ACE

2.2.1. Urbanization, RII, and ACE

Urbanization is a key factor affecting the level of carbon emissions and, RII plays a vital role in the integration of urban and rural [25,26]. The mediating effect of urbanization is evident in the fact that the integration of the rural three industries can curb ACE by promoting the urbanization process. The ultimate development of urbanization can limit the growth of carbon emissions, while the advancement of RII can accelerate the urbanization process.

RII emphasizes the need for secondary and tertiary industries, which rely on agricultural and rural resources, to remain in rural areas as much as possible. It advocates vigorous agritourism and other services while fostering urban–rural mobility, which promoting rural urbanization and urban horticulture and finally urban–rural integration is promoted. Specifically, through the establishment of demonstration zones of three-industry integration in rural areas and the policy guide for urban–rural integration at the county level, secondary and tertiary industries can play a driving role in population concentration and urbanization. They can contribute to the creation of small towns and large industrial parks characterized by the full industrial chain of agricultural products and leisure tourism, facilitating the local urbanization process for rural residents. The gradual formation of rural urbanization will effectively curb the increase in local carbon emissions. Then, Hypothesis 2 is proposed as the following:

Hypothesis 2: *RII inhibits ACE by accelerating the urbanization process.*

2.2.2. Labor Structure, RII, and ACE

The increasing of pro non-agricultural employment level in rural areas represents the diversification and rationalization of the local industrial structure and can effectively promote local high-quality development. The influence mechanism of rural labor force structure on agricultural carbon emission is mainly manifested as the agricultural "de-internalization effect" and "redistribution effect" [27–29]. With the development of RII, the organic integration of the three industries will promote the extension of the industrial chain, further expand the production scale and generate more employment opportunities for the secondary and tertiary industries in the local area, thus effectively absorb the redundant rural labor force and alleviate the pressure of local resources and environment; while, with the decrease in the rural labor force and the development of the RII, the three industries are organically integrated into rural areas with the help of new technologies, new models, and other forms, thus optimizing the industrial structure, improving the production efficiency of the RII, and finally forming the agricultural industrial complex and linkage body under the form of industrial agglomeration, making the local industrial structure more diversified and rationalized. As a result, the rationalization of the labor structure can accelerate the development, and in the process of gradual rationalization of the labor structure, it accelerates the transformation of local agricultural production mode under extensive situations to efficient and reasonable modern agricultural production and operation mode, thus forming an impact on energy conservation and emission reduction of local ACE after improving production efficiency and rational development of industrial structure. In the final industrial integration in the form of the formation of an agricultural industry complex process, the local three industries with the aid of new technology and the new mode of organic integration make the structure of the industry three gradually rationalized, so may in the process of local labor structure development of RII and ACEs is not only a pure linear influence. Then, Hypotheses 3 and 4 are introduced as the following:

Hypothesis 3: *The labor structure has a significant positive moderating effect on ACE reduction in the process of RII.*

Hypothesis 4: *Labor structure is a threshold variable for the impact of RII on ACE.*

3. Model Setting, Variable Selection, and Data Description

3.1. Model Setting

(1) Restraining the effect of RII on ACE. Based on the theoretical analysis presented earlier, this article constructs a panel regression model to analyze the impact of RII on ACE. To address the fluctuation in different variable data, this paper applies the logarithm transformation to some variables to mitigate potential estimation biases caused by heteroskedasticity. The model is set as follows.

$$\mathrm{LnCe}_{it} = c + \alpha_1 \mathrm{int}_{it} + \beta_1 X_{it} + \varepsilon_{it} \tag{1}$$

In Equation (1), i denotes the province and t denotes the year. LnCe_{it} represents the dependent variable, that is, the carbon dioxide emissions of the i province in year t. int_{it} is the core explanatory variable, representing RII level. X_{it} is a set of control variables. ε_{it} represents the random disturbance.

(2) The mediating effect test. Based on the previous analysis, RII is expected to impact carbon emissions by influencing the urbanization process. To verify these inferences, this article adopts a mediation model, drawing on the approach of Wen and Ye [30], and utilizes the distribution regression method.

First, a regression estimate is conducted to analyze the impact of RII on ACE.

$$\mathrm{LnCe}_{it} = c + \alpha_1 \mathrm{int}_{it} + \beta_1 X_{it} + \varepsilon_{it} \tag{2}$$

Next, a regression estimation is performed with urbanization as the dependent variable and RII as the core explanatory variable.

$$\mathrm{LnCity}_{it} = c + \alpha_2 \mathrm{int}_{it} + \beta_2 X_{it} + \varepsilon_{it} \tag{3}$$

Finally, a regression estimate is performed with carbon emissions as a dependent variable, RII as the core explanatory variable, and urbanization as the mediating variable. These variables are included in the same model.

$$\mathrm{LnCe}_{it} = c + \alpha_3 \mathrm{int}_{it} + \gamma_1 \mathrm{LnCity}_{it} + \beta_3 X_{it} + \varepsilon_{it} \tag{4}$$

The variables represented by the letters in the equations align with the previous descriptions. X_{it} represents the control variables, which remain consistent with the previous model. ε_{it} denotes the random disturbance term.

The mediating effect is assessed through the following testing procedure: In the first step, the coefficient α_1 in Equation (2) is tested. The second step involves testing whether the coefficient α_2 in Equation (3) and the coefficient $\gamma 1$ in Equation (4) pass the significance test. The third step involves testing the coefficient α_3. If the coefficient passes the significance test, it indicates a significant direct effect, implying that the mediating variable plays a role in the mediation effect.

(3) The moderating effect test. Considering that the development of labor structure has a moderating effect on agricultural carbon emission reduction in the process of RII, the following moderating model is constructed to test its moderating effect:

$$\mathrm{LnCe_{it}} = \mathrm{c} + \alpha_4\mathrm{int_{it}} + \gamma_2\mathrm{labor_{it}} + \delta_1\mathrm{int}_{it} \times \mathrm{labor}_{it} + \beta_4\mathrm{X_{it}} + \varepsilon_{\mathrm{it}} \quad (5)$$

The coefficient δ_1's significance reflect the labor structure can moderate RII on ACE. Meanwhile, due to the interaction of the labor structure and RII level, regression mistakes can be caused by the collinearity. As a result, the interaction items are centralized according to the research conducted by Balli and Srensen [31]. In Model (5), except for the variable of newly added labor structure and the interaction term of RII, the other variables are consistent with those in Model (1).

(4) The threshold effect test. Considering labor structure has a nonlinear impact on ACE reduction in the process of RII. To detect the threshold effect, the following single-threshold regression model is constructed based on Model (5):

$$\mathrm{LnCe_{it}} = \mathrm{c} + \alpha_5\mathrm{int_{it}} \times \mathrm{F}(\mathrm{labor_{it}} \le \mathrm{q}) + \alpha_6\mathrm{int_{it}} \times \mathrm{F}(\mathrm{labor_{it}} \ge \mathrm{q}) + \beta_5\mathrm{X_{it}} + \varepsilon_{\mathrm{it}} \quad (6)$$

In model (6), F (*) represents the index function, q is the threshold value, and the rest of the variables are the same as models (5).

3.2. Variable Selection

3.2.1. Explained Variable

The explained variable is the total carbon emissions (CO_2) of the agricultural industry. The data for this variable are obtained from the China Carbon Accounting Database (CEAD) provided by the National Physical Earth Data Center (NGDC) DMSP/OLS, and the NPP/VIIRS night light data inversion. These data offer the advantages of consistent statistical calibration and strong continuity, following the detailed approach of Wang Shaojian [32–37].

3.2.2. Explanatory Variables

The core explanatory variable is the level of RII (int). Currently, there is no authoritative index system in the academic domain. To construct an evaluation system for the level of RII, this article refers to the work of Zhang and Zhou [38]. The evaluation system includes three dimensions: the extension of the agricultural industry chain, the utilization of agricultural multifunctionality, and the comprehensive integrated development of agricultural technology. The specific evaluation system detail is presented in Table 1.

(1) Extension of the agricultural industry chain: This dimension is measured by two indicators: agricultural product processing industry level and agricultural machinery level. Extension of the agricultural industry chain involves the organic combination of agricultural production with processing and sales, thus extending the industrial chain to enhance the added value of agricultural products. The agricultural-product-processing industry level is indicated by the ratio of the main business income of the agricultural product processing industry to the total output value of the primary industry. The agricultural machinery level is indicated by the ratio of the total power of the primary processing machinery for agricultural products to the sown area of the crops.

(2) Utilization of agricultural multifunctionality: This dimension is measured by two indicators: leisure agriculture level and primary industry services level. The utilization of agricultural multifunctionality refers to the deep integration of agriculture with tourism, culture, health, and pension industries, and gives full play to the ecological function of agriculture. This paper utilizes the ratio of the annual operating income of leisure agriculture to the total primary industry value to represent it. The primary industry service level is indicated by the ratio of the total output value of the primary industry services to the total output value of the primary industry.

(3) Comprehensive development of agricultural technology: This dimension is measured using two indicators: interest linkage mechanisms level and new forms of agricultural business level. The development of RII can encourage farmers to increase their income, which depends on the participation degree of industrial integration subjects and their driving degree to farmers. Therefore, this document selects the number of farmer-specialized cooperatives per 10,000 people in rural areas to represent this dimension. New forms of agricultural business refer to the transformation of traditional agriculture through new ideas, technologies, and models. Facility agriculture is currently one of the new key forms of agriculture in China, playing a significant role in production and services. Therefore, the ratio of the total area of agricultural facility to the area of cultivated land is chosen to represent this aspect.

Table 1. Integration level assessment system of three industries in rural areas.

Primary Indicator	Secondary Indicator	Indicator Composition	Data Source
The extension of the agricultural industry chain	Agricultural product processing industry level	Main income of the agricultural product processing industry (bia)/the total output value of the primary industry (tvp) (%)	bia: statistical yearbooks of each province from 2008 to 2019 tvp: National Bureau of Statistics of China, https://www.stats.gov.cn (accessed on 15 September 2022)
	Agricultural machinery level	Total power of the primary processing machinery for agricultural products (ppm)/the sown area of the crops (sac)	ppm: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022) sac: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022)
The utilization of agricultural multi-functionality	Leisure farming level	Annual operating income of leisure agriculture (ila)/Value added of the primary industry (api) (%)	ila: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022) api: National Bureau of Statistics of China, https://www.stats.gov.cn (accessed on 15 September 2022)
	Primary industry service level	Total output value of the primary industry service (vps)/Value added of the primary industry (api) (%)	vps: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022) api: National Bureau of Statistics of China, https://www.stats.gov.cn (accessed on15 September 2022)
The comprehensive development of agricultural technology	Interest linkage mechanism level	The number of farmer-specialized cooperatives per 10,000 people in rural areas (fac) (amount)	fac: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022)
	New forms of agricultural business level	The total area of facility agriculture (taf)/area of cultivated land (acl) (%)	taf: China Greenhouse Data System, http://data.sheshiyuanyi.com/AreaData (accessed on 15 September 2022) acl: Ministry of Agriculture and Rural Affairs of China, http://zdscxx.moa.gov.cn (accessed on 15 September 2022)

After determining the index system, and following the method of Li and Zhichun [39], this paper applies the entropy method to calculate the proportion of each index and uses the linear weighting method to obtain the development level of RII in China, and the procedure is calculated by Stata16 software. Due to the space limitation, the calculation steps of entropy method are not explained in detail. The entropy method provides objective weights for each index considering the information content of the data themselves, offering better objectivity compared to the analytic hierarchy process.

3.2.3. Mediating Variable

The mediating variable is urbanization (lncity), which is measured by the proportion of the nonagricultural population in the total population, and a logarithmic transformation is applied to minimize the influence of heteroscedasticity.

3.2.4. Moderating Variable and Threshold Variable

Labor structure (Labor) is represented by the ratio of the non-farm employment to the regional labor force, which means that the higher proportion of non-agricultural employment in the region can be regarded as the labor structure optimization in the current economic environment according to the research by Geng Peng [40]. In this paper, labor structure is the moderating variable and threshold variable. With the development of RII, the labor structure optimization will be accelerated, and finally through the rationalization of labor structure, RII will have a greater impact on ACE.

3.2.5. Control Variables

This paper selects several control variables based on relevant research, including studies by Li et al. [7], Ge et al. [14], and Miao et al. [41]. The following variables are included:

(1) Land transfer rate (ara): This variable is represented by the ratio of the total cultivated land area contracted by the household to the total area of cultivated land contracted by the household for operation. Land transfer promotes the diversification of local land use, affecting both the local economy and ecology [42,43].
(2) Degree of rural mechanization (mer): This variable is expressed as the ratio of the total power of rural machinery to the cultivated land area. The degree of rural mechanization impacts diesel consumption in local rural areas, thereby affecting the ecological environment.
(3) Proportion of financial support to agriculture (fis): This variable represents the ratio of financial support to agriculture to total financial expenditure. Financial support to agriculture provides crucial financial assistance for the development of local rural enterprises, exerting an important influence on local economic and ecological development.
(4) Rural education level (edu): This variable is indicated by the average years of education of rural residents. Higher levels of rural education are conducive to local development and the dissemination of low-carbon environmental awareness.
(5) Rural economic level (pgdp): This variable is expressed as the ratio of total rural GDP to the total rural population at the end of the year [44].
(6) Urban–rural income gap (gap): This variable is expressed as urban residents' per capita disposable income and rural per capita disposable income [45].

3.3. Description of Data

This paper utilizes panel data from 30 provinces (autonomous regions and municipalities) in mainland China, covering the period from 2008 to 2019 (due to the serious lack of some data in Hong Kong, Macao, Taiwan, and Tibet, they are not included in the research sample). The main business income data of the agricultural product processing industry are obtained from the statistical yearbooks of each province from 2012 to 2019. The business income data for leisure agriculture and rural tourism are sourced from the Chinese Leisure Agriculture Yearbook. The output value data for agriculture, forestry, animal husbandry, and fishery majors and auxiliary activities are derived from the China Tertiary Industry Statistical Yearbook. Data on the facility's agriculture area are obtained from the National Greenhouse Data System. The remaining variables are sourced from China's statistical yearbooks and the statistical yearbooks of various provinces over the years, without individual explanations provided. The websites of the above variable data are listed in Table 1. In case of missing values, this paper employs the linear interpolation method for data processing. The descriptive statistics of the main variables are presented in Table 2.

Table 2. Descriptive statistical results of the variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
$lnCO_2$	360	5.693	0.916	3.265	7.066
int	360	0.163	0.107	0.012	0.563
lncity	360	3.997	0.224	3.486	4.492
labor	360	0.607	0.108	0.316	0.957
ara	360	26.702	16.681	2.326	74.800
mer	360	0.790	0.358	0.325	1.701
fis	360	0.112	0.031	0.041	0.181
edu	360	7.664	0.601	6.004	9.304
pgdp	360	1.047	0.544	0.301	2.988
gap	360	2.761	0.500	1.85	4.200

4. Empirical Results

4.1. The Direct Effect of RII on ACE

To detect the relationship of RII and ACE, this article establishes a baseline regression model with ACE as the explained variable and RII as the core explanatory variable. The results of baseline support Hypothesis 1 and the regression results are presented in Table 3. Column (1) shows of the results of RII on ACE, while column (2) illustrates the impact of RII on ACE after the addition of control variables. According to column (1), the regression coefficient of industrial integration on ACE is −1.911, significant at the 1% level. According to column (2), after the addition of control variables, the inhibitory effect of RII on ACE is not weakened, but gradually enhanced. Therefore, the results confirm that RII significantly inhibits ACE. Thus, the research Hypothesis 1 is proven.

Table 3. Baseline regression results.

	(1) **$lnCO_2$**	**(2)** **$lnCO_2$**
int	−1.911 ***	−2.133 ***
	(−5.263)	(−5.931)
ara		0.011 ***
		(3.767)
mer		0.336 ***
		(3.049)
fis		3.590 ***
		(4.325)
edu		−0.018
		(−0.2150)
pgdp		0.058
		(0.577)
gap		−0.2850 ***
		(−2.869)
_cons	5.719 ***	6.018 ***
	(106.494)	(8.716)
Observations	360	360

Note: t values are presented in parentheses; *** present at 1% significance levels.

Regarding other main control variables, the coefficient of the land transfer rate is positive and significant at the 1% level, indicating that a 1% increase in the land transfer rate will promote a 0.011% increase in ACE. The positive effect may result from the increased diversity of local land uses, including the allocation of land for high-carbon industries. The coefficient of the degree of rural mechanization is positive and significant at the 1% level, suggesting that a 1% increase in the degree of rural mechanization will promote a 0.336% increase in ACE, in alignment with reality. The coefficient of the degree of financial support to agriculture is positive and significant at the 1% level, indicating that a 1% increase in financial support to agriculture will lead to a 3.59% increase in ACE. This may be attributed to the excessive investment in rural secondary industry projects by local governments, which emphasizes the development of the rural economy, and which subsequently results in increased greenhouse gas emissions. The coefficient of the rural education level is negative, indicating that a higher rural education level corresponds to better low-carbon awareness among rural residents. However, this result does not pass the significance test, which suggesting the effect is not significant. The coefficient of the rural economic level is positive while this result does not pass the significance test, suggesting that the effect is not significant. The regression coefficient of the urban–rural income gap regression is negative and significant at the 1% level, suggesting that a 1% increase in the degree of the urban–rural income gap will reduce a 0.285% increase in ACE.

4.2. The Mediating Role of Urbanization in RII and ACE

To provide a detailed understanding of the mediating effect of RII and urbanization on ACE, this paper constructs a multiple regression model. ACE serve as the explained variable, RII as the core explanatory variable, and urbanization as the mediating variable. The regression results are presented in Table 4, where column (3) demonstrates the impact of RII on ACE, column (4) illustrates the impact of RII on urbanization, and column (5) reveals the impact of RII on ACE mediated by urbanization. The coefficient of RII on urbanization is positive at 0.457, significant at the 1% level, which means RII plays an important role in promoting urbanization, aligning with reality. Column (5) shows the specific impact of RII on ACE under the mediating effect of urbanization. The coefficient of RII on ACE is negative at 1.683, significant at the 5% level, while the coefficient of urbanization is significant at the 1% level. These results indicate that urbanization acts as a partial intermediary in the relationship between RII and ACE. Therefore, RII inhibits ACE by promoting urbanization.

Table 4. Results of mediation effect.

	(3) **lnCO_2**	**(4)** **lncity**	**(5)** **lnCO_2**
int	−2.133 ***	0.457 ***	−1.683 **
	(−5.931)	(5.502)	(−2.514)
lncity			−2.795 ***
			(−6.690)
ara	0.011 ***	0.001	0.0240 ***
	(3.767)	(1.648)	(5.162)
mer	0.336 ***	−0.1340 ***	0.109
	(3.049)	(−7.811)	(0.756)
fis	3.590 ***	−1.141 ***	−2.917
	(4.325)	(−4.600)	(−1.478)
edu	−0.018	0.066 ***	0.428 ***
	(−0.215)	(5.377)	(4.343)
pgdp	0.058	0.134 ***	−0.547 **
	(0.577)	(4.869)	(−2.483)
gap	−0.285 ***	−0.145 ***	-0.894 ***
	(−2.869)	(−8.358)	(−6.073)
_cons	6.018 ***	3.916 ***	16.369 ***
	(8.716)	(30.269)	(8.540)
Observations	360	360	360

Note: t values are presented in parentheses; **, *** present at 5% and 1% significance levels, respectively.

Currently, there are different explanations for the mediating effect in the academic field. Wen et al. pointed out that if the explanatory variable coefficients of both column (3) and column (4) are significant and if the mediating variable and the explanatory variable are both significant in column (5), the mediating effect is partially significant. If the explanatory variable is insignificant and the mediating variable is significant, it indicates a complete mediating effect [26]. Otherwise, the mediating effect is not valid. Based on the regression results in Table 4, it can be observed that the explanatory variable of RII is significant in column (3), column (4) and column (5). On the other hand, the mediating variable of urbanization is significant. This outcome confirms a significant partially mediating effect, indicating that RII has a further inhibitory effect on ACE through the mediating effect of urbanization. Therefore, research Hypothesis 2 is proven.

4.3. The Moderating Role of Labor Structure in RII and ACE

Table 5 shows the labor structure has a moderating influence on RII and agricultural carbon emission. According to column (6), The coefficient of the interaction term of RII and labor structure is significantly negative, indicating that labor structure has a significant positive moderating effect on ACE reduction in the process of RII. After adding control variables to column (7), the regression coefficient of the interaction term is significantly negative, it was further verified that the development of labor structure significantly positive moderating effect on ACE reduction in the process of RII. Therefore, research Hypothesis 3 is proven.

Table 5. Results of moderating effect.

	(6) **lnCO_2**	**(7)** **lnCO_2**
int	−1.201 ***	−1.649 ***
	(−3.047)	(−4.182)
labor	−2.219 ***	−2.230 ***
	(−3.280)	(−3.249)
Int * labor	−7.763 ***	−7.352 ***
	(−4.155)	(−3.298)
ara		0.011 ***
		(3.77)
mer		0.330 ***
		(3.065)
fis		2.232 ***
		(2.616)
edu		0.080
		(0.952)
pgdp		0.245 **
		(2.292)
gap		−0.166
		(−1.647)
_cons	6.989 ***	6.273 ***
	(17.589)	(8.525)
Observations	360	360

Note: t values are presented in parentheses; **, *** present at 5% and 1% significance levels, respectively.

4.4. The Threshold Effect

Table 6 reports the single threshold test result of labor structure on the impact of RII and ACE. Moreover, the threshold model denies the null hypothesis that there is no threshold effect, regardless of whether the control variable is added to the corresponding threshold model, indicating that labor structure is a threshold variable for RII to ACE.

Table 6. Threshold effect test.

Threshold	**RSS**	**MSE**	**Fstat**	**Prob**	**Crit10**	**Crit5**	**Crit1**
Single	15.625	0.045	48.540	0.023	35.748	39.924	54.190
Double	14.806	0.043	19.240	0.207	41.290	64.067	92.141

Table 7 shows that the single threshold impact of labor structure is 0.829 and Table 8 reports the findings of the threshold regression. The coefficient of RII on ACE is −2.095

when labor structure is below the threshold value of 0.829, significant at the statistical level of 10%, and increases to −3.979 when the labor structure develops over the threshold value of 0.829, and significant at the statistical level of 1%. The results show that RII has a nonlinear effect on agricultural carbon emission reduction due to the development of labor structure, With the increasing degree of labor structure development, there is a significant inhibiting effect. In the early stage of RII, because there is no large-scale industrial park integrating with the secondary and tertiary industries, there are no more non-agricultural positions. At this time, RII is still in the stage of relying on the primary industry, and at this time, the inhibitory effect on ACE just has been active; with the development of RII, there are more job selection opportunities in the local area, which leads to the continuous development of the local labor structure, and ultimately promotes RII to more significantly restrain ACE. Therefore, Hypothesis 4 is proven.

Table 7. Estimation of the single threshold value.

Model	**Threshold**	**Lower**	**Upper**
Th-1	0.829	0.786	0.854

Table 8. Regression results of the threshold effect.

	(1) **lnCO_2**
ara	0.011 **
	(2.696)
mer	0.285 *
	(1.927)
fis	2.981 ***
	(3.351)
edu	0.031
	(0.357)
pgdp	0.098
	(0.992)
intit × F (laborit ≤ 0.829)	−2.095 *
	(−2.012)
intit × F (laborit ≥ 0.829)	−3.979 ***
	(−3.873)
_cons	4.875 ***
	(8.889)
Observations	360

Note: t values are presented in parentheses; *, **, *** present at 10%, 5%, and 1% significance levels, respectively.

4.5. Heterogeneity Analysis

Considering vast territory, uneven economic development, and variations in resource endowments between regions caused by geographical and historical factors, it is necessary to examine heterogeneity between the eastern, central, and western provinces of China. The regression results are presented in Table 9, with column (9) for the eastern region, column (10) for the central region, and column (11) for the western region.

According to Table 9, the coefficient of column (9) for RII on ACE in eastern China is positive at 0.924 but not significant, which suggests that RII has no obvious effect on ACE in eastern China. In column (10), the coefficient of RII on ACE in central China is negative at 2.135 and significant at the level of 10%, which indicates that RII has a significant inhibitory effect on ACE in central China. In column (11), the regression coefficient of RII on ACE in western China is negative at 4.168 and significant at the 1% level. The results demonstrate that industrial integration has a significant inhibitory effect on ACE in the western region of China.

Table 9. Benchmark regression heterogeneity test results.

	(9) Eastern $lnCO_2$	(10) Central $lnCO_2$	(11) Western $lnCO_2$
int	0.924	−2.135 *	−4.168 ***
	(1.153)	(−2.287)	(−6.667)
ara	0.002	0.014 **	0.011
	(0.372)	(2.963)	(1.480)
mer	0.355	0.231 **	0.713
	(1.545)	(3.010)	(1.502)
fis	2.301	3.874 **	2.501 *
	(1.019)	(2.432)	(2.036)
edu	0.101	−0.073	−0.007
	(0.600)	(−0.827)	(−0.038)
pgdp	−0.369	0.159 **	0.215
	(−1.742)	(2.426)	(0.905)
gap	−0.578	0.136	−0.211
	(−1.404)	(0.881)	(−0.782)
_cons	5.965 ***	5.467 ***	5.519 ***
	(3.915)	(6.578)	(3.240)
Observations	132	96	132

Note: t values are presented in parentheses; *, **, *** present at 10%, 5%, and 1% significance levels, respectively.

In summary, the coefficient of RII in column (11) exhibits the strongest impact. Therefore, compared to the central region, RII has a more prominent inhibitory effect on ACE in the western region, while RII has no obvious effect on ACE in the eastern region.

5. Robustness Test

5.1. Endogeneity Test

To overcome the endogenous problem, this paper intends to choose the primary lag term of RII as the instrumental variable. These replacements are incorporated into the baseline regression model to obtain column (12) and column (13), respectively, as shown in Table 10.

Table 10. Robustness test-RII lagging behind one period.

	(12) $lnCO_2$	(13) $lnCO_2$
L.int	−1.943 ***	−2.094 ***
	(−5.105)	(−5.648)
ara		0.014 ***
		(4.219)
mer		0.333 ***
		(2.956)
fis		2.883 ***
		(3.327)
edu		0.063
		(0.721)
pgdp		0.015
		(0.141)
gap		−0.271 ***
		(−2.645)
_cons	5.753 ***	5.356 ***
	(106.971)	(7.312)
Observations	330	330

Note: t values are presented in parentheses; *** present at 1% significance levels.

The results of the robustness test column (12) and column (13) reveal that the coefficient of lagged RII on ACE is negative and significant at the 1% level, which indicates that the endogeneity problem does not have a significant effect on the research conclusion in this paper, so the baseline regression results in this paper have good robustness.

5.2. Replacing Dependent Variables

To further examine the influence of RII on ACE, this paper uses the method of replacing dependent variables to address the issue of mutual causality. Specifically, the explained variable *ACE* is replaced by rural per capita carbon emissions (CCEs). These replacements are incorporated into the baseline regression model to obtain column (14) and column (15), respectively, as shown in Table 11.

Table 11. Robustness test—replacement by the explained variable.

	(14) **aco_2**	**(15)** **aco_2**
int	−0.406 *** (−3.794)	−0.429 *** (−3.976)
ara		0.003 *** (2.849)
mer		0.092 *** (2.764)
fis		0.957 *** (3.838)
edu		−0.030 (−1.197)
pgdp		−0.024 (−0.791)
gap		0.020 (0.678)
_cons	0.230 *** (14.494)	0.218 (1.051)
Observations	360	360

Note: t values are presented in parentheses; *** present at 1% significance levels.

The results of the robustness test, column (14) and column (15), reveal that the coefficient of RII on CCEs is negative and significant at the 1% level. This indicates that even after replacing the dependent variable, RII still has a significant inhibitory effect on ACE.

In conclusion, the robustness analysis aligns with the previous findings. This robustness analysis confirms the inhibitory effect of RII on ACE.

6. Discussion

RII has a direct inhibitory effect on ACE, according to the regression results of Table 3 column (1), and a 1% increase in RII will reduce a 2.133% increase in ACE. In the RII development process, aided by new technologies and models, the industrial structure is optimized and production efficiency is improved. This, in turn, facilitates the formation of agricultural industrial complexes and links through industrial agglomeration [46]. Optimization of the industrial structure, improved agricultural production, and establishment of industrial agglomeration effectively reduce local carbon emissions [16–24,47].

The RII inhibits ACE by accelerating the urbanization process, according to the results of Table 4. The RII advocates the vigorous development of agritourism and other services while fostering urban–rural mobility. The development of RII can contribute to the creation of small towns and large industrial parks characterized by the complete industrial chain of agricultural products and leisure tourism, facilitating the local urbanization process for rural residents [48]. The gradual formation of rural urbanization will effectively curb the increase in local carbon emissions [25,26].

The labor structure has a significant positive moderating effect on ACE reduction in the process of RII, according to the regression results of Table 5, column (7). With the development of RII, the three industries are organically integrated into rural areas by new technologies, new models, and other forms, thus optimizing the industrial structure, promoting RII more effectively, and finally forming the agricultural industrial complex and linkage body under the form of industrial agglomeration, making the local industrial structure more diversified and rationalized [49–51]. In the process of gradual rationalization of the labor structure, RII has an effect on resource saving and emission reduction of local ACE after improving production efficiency [50]. The research shows that the labor structure plays a moderating role in ACE reduction in the process of RII, indicating the labor structure has a sustainable and beneficial role in the development of green agriculture in China [27–29].

The labor structure is a threshold variable for the relationship of RII between ACE, according to the regression results of Table 8. With the development of RII, there are more job selection opportunities in the local area, which leads to the continuous development of the local labor structure, when the labor force structure is rationalized, the association between the local three industries will be closer, and the production scale will be further increased, so that the impact of inhibiting ACE will be more significant [27,52].

7. Conclusions and Policy Suggestions

7.1. Conclusions

Based on data from the China provincial panel from 2008 to 2019, this paper constructs an evaluation index system for the development level of RII and examines the relationship between industrial integration, ACE, urbanization, and labor structure. This study reveals the following findings.

First, RII significantly inhibits the increase in carbon emissions in agricultural areas, contributing to the goals of green and low-carbon agriculture. A 1% increase in RII led to a 2.133% reduction in ACE. RII promotes the process of urbanization, facilitating urban–rural integration and integrated development. Urbanization acts as an intermediary mechanism, inhibiting the increase in ACE resulting from industrial integration.

Second, the local labor structure significantly promoted the inhibition effect of RII on ACE, and had a positive moderating effect. With the continuous development of labor structure, there is a nonlinear relationship between the inhibition effect of RII on ACE. When the level of labor structure is below 0.829, the inhibition effect of RII on ACE is -2.095; when the level of labor structure is above 0.829, the inhibition effect of RII on ACE is increased to -3.397.

Finally, the effect of RII on ACE varies between regions. In the eastern region, there is no obvious effect relationship between RII and ACE, while in the central and western regions, RII has a negative relationship with ACE.

7.2. Policy Suggestions

Based on the results above, this paper proposes the following policy suggestions. These policy suggestions, based on the research findings, aim to promote sustainable agricultural practices, promote rural development, and mitigate carbon emissions in the agricultural sector.

First, RII should be continuously promoted in rural areas. RII not only contributes to increasing farmers' income and rural revitalization but also promotes low-carbon agriculture. This, in turn, leads to faster and better rural development and rural modernization.

Second, new technologies and business models should be paid more attention to and introduced in RII. Local governments should guide the integration of new technologies, new business forms, and new business models into the agricultural industry chain. This includes expanding from the primary industry to the secondary and tertiary industries, establishing agricultural industrial complexes and associations, and realizing agricultural modernization. These efforts will drive urban–rural integration, increase farmers' income, and promote the development of low-carbon agriculture.

Third, regional heterogeneity should be considered in the process of RII: Given the regional disparities in China, policymakers should consider the diverse levels of RII development in different regions. Tailored policies and strategies should be implemented to maximize the inhibitory effect of RII on ACE. In particular, attention should be paid to promoting industrial integration in the western region, where it has a more prominent inhibitory effect on ACE.

Fourth, more attention should be paid to urbanization. Urbanization plays a vital role in mediating the impact of RII on ACE. Policies should aim to promote urbanization and its integration into rural areas. The development of small towns and large-scale industrial parks with local characteristics can accelerate the urbanization process for rural residents, further facilitating the integrated development of urban and rural areas.

Fifth, strengthen the role of the development of local labor structure: The development of labor structure can effectively promote the sustainable development of the local economy and green and can speed up the process of agricultural modernization.

Author Contributions: Y.Z.: conceptualization, methodology, software, writing—reviewing and editing, visualization; Y.L.: data curation, writing—original draft preparation. 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 on request from the corresponding author.

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

References

1. Hansen, J.; Sato, M.; Ruedy, R.; Lacis, A.; Oinas, V. Global warming in the twenty-first century: An alternative scenario. *Proc. Natl. Acad. Sci. USA* **2000**, *97*, 9875–9880. [CrossRef] [PubMed]
2. Ramanathan, V.; Feng, Y. Air Pollution, Greenhouse Gases and Climate Change: Global and Regional Perspectives. *Atmos. Environ.* **2009**, *43*, 37–50. [CrossRef]
3. Wang, R.R.; Zhang, Y.; Zou, C.M. How does agricultural specialization affect carbon emissions in China? *J. Clean. Prod.* **2022**, *370*, 133463. [CrossRef]
4. Du, Y.Y.; Liu, H.B.; Huang, H.; Li, X.H. The carbon emission reduction effect of agricultural policy——Evidence from China. *J. Clean. Prod.* **2023**, *406*, 137005. [CrossRef]
5. Xu, B.; Lin, B. Factors affecting CO_2 emissions in China's agriculture sector: Evidence from geographically weighted regression model. *Energy Policy* **2017**, *104*, 404–414. [CrossRef]
6. China State Council, Several Opinions on Intensifying Reform and Innovation and Speeding Up Agricultural Modernization. Available online: https://www.gov.cn/zhengce/2015-02/01/content_2813034.htm (accessed on 15 September 2022).
7. Li, X.L.; Ran, G.H. How does the integration of rural industries affect the income gap between urban and rural areas Based on the dual perspectives of rural economic growth and urbanization. *Agric. Technol. Econ.* **2019**, *8*, 17–28. [CrossRef]
8. Zhao, X.; Han, Y.J.; Jiang, N. The integration of rural three industries: Connotation definition, practical significance and driving factors analysis. *Rural. Manag.* **2016**, *157*, 28–29.
9. Ma, X.H. Some thoughts on promoting the integration and development of rural primary, secondary and tertiary industries. *Rural. Manag.* **2016**, *157*, 28–29.
10. Su, Y.Q.; You, Y.T.; Wang, Z.G. The integrated development of primary, secondary and tertiary industries in rural areas: Theoretical discussion, current situation analysis and countermeasures. *China Soft Sci.* **2016**, *308*, 17–28.
11. Yu, T. Evaluation and analysis of the integrated development of rural primary, secondary and tertiary industries. *Macroecon. Res.* **2020**, *11*, 76–85. [CrossRef]
12. Chen, X. *Evaluation of Rural Three-Industry Integration Development*; Jilin University: Jilin, China, 2021. [CrossRef]
13. Li, Y.X.; Dai, Z.Y.; Ding, S.J. Research on the effect of rural primary, secondary and tertiary industry integration on farmers 'income increase—Based on PSM analysis of 345 farmers' surveys. *J. Huazhong Agric. Univ. (Soc. Sci. Ed.)* **2017**, *130*, 37–44. [CrossRef]
14. Ge, J.H.; Wang, M.; Tang, Y.M. The integration of rural three industries, urban and rural residents 'consumption and income gap efficiency and fairness be combined? *China's Rural. Econ.* **2022**, *3*, 50–66.
15. Zheng, F.T.; Cui, H.X.; Cheng, Y. Industrial integration needs to break through the traditional way. *Agric. Eng. Technol.* **2015**, 39. [CrossRef]
16. Yang, J.; Cai, W.; Ma, M.; Li, L.; Liu, C.; Ma, X.; Chen, X. Driving forces of China's CO_2 emissions from energy consumption based on Kaya-LMDI methods. *Sci. Total Environ.* **2019**, *711*, 134569. [CrossRef] [PubMed]

17. Wu, L.; Sun, L.; Qi, P.; Ren, X.; Sun, X. Energy endowment, industrial structure upgrading, and CO_2 emissions in China: Revisiting resource curse in the context of carbon emissions. *Resour. Policy* **2021**, *74*, 102329. [CrossRef]
18. Raihan, A.; Ibrahim, S.; Muhtasim, D.A. Dynamic impacts of economic growth, energy use, tourism, and agricultural productivity on carbon dioxide emissions in Egypt. *World Dev. Sustain.* **2023**, *2*, 100059. [CrossRef]
19. Li, H.; Liu, B.F. The effect of industrial agglomeration on China's carbon intensity: Evidence from a dynamic panel model and a mediation effect model. *Energy Rep.* **2022**, *8*, 96–103. [CrossRef]
20. Han, F.; Xie, R.; Fang, J.; Liu, Y. The effects of urban agglomeration economies on carbon emissions: Evidence from Chinese cities. *J. Clean. Prod.* **2018**, *172*, 1096–1110. [CrossRef]
21. Akadiri, S.S.; Akadiri, A.C.; Alola, U.V. Is there growth impact of tourism? Evidence from selected small island states. *Curr. Issues Tour.* **2019**, *22*, 1480–1498. [CrossRef]
22. Dogan, E.; Aslan, A. Exploring the relationship among CO_2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence. *Renew. Sustain. Energy Rev.* **2017**, *77*, 239–245. [CrossRef]
23. Lee, J.W.; Brahmasrene, T. Investigating the influence of tourism on economic growth and carbon emissions: Evidence from panel analysis of the European Union. *Tour. Manag.* **2013**, *38*, 69–76. [CrossRef]
24. Yue, X.G.; Liao, Y.; Zheng, S.; Shao, X.; Gao, J. The role of green innovation and tourism towards carbon neutrality in Thailand: Evidence from bootstrap ADRL approach. *J. Environ. Manag.* **2021**, *292*, 112778. [CrossRef]
25. Xu, J.J.; Wang, J.C.; Li, R.; Yang, X.J. Spatio-temporal effects of urbanization on CO_2 emissions: Evidences from 268 Chinese cities. *Energy Policy* **2023**, *177*, 113569. [CrossRef]
26. Chen, M.X. Actively explore the long-term mechanism of urban-rural integration development. *Reg. Econ. Rev.* **2018**, *33*, 119–121.
27. Chen, Y.B.; Wang, S. Rural labor outflow, agricultural scale operation and agricultural carbon emissions. *Econ. Manag.* **2022**, *36*, 43–49.
28. Hao, Y.; Zhang, Z.Y.; Yang, C.; Wu, H. Does structural labor change affect CO_2 emissions? Theoretical and empirical evidence from China. *Technol. Forecast. Soc. Chang.* **2021**, *171*, 120936. [CrossRef]
29. Shao, S.; Li, B.; Fan, M.; Yang, L. How does labor transfer affect environmental pollution in rural China? Evidence from a survey. *Energy Econ.* **2021**, *102*, 105515. [CrossRef]
30. Wen, Z.L.; Ye, B.J. Mediating Effect Analysis: Methods and Model Development. *Adv. Psychol. Sci.* **2014**, *22*, 731–745. [CrossRef]
31. Balli, H.O.; Srensen, B. Interaction effects in econometrics. *Empir. Econ.* **2013**, *45*, 583–603. [CrossRef]
32. Wang, S.J.; Xie, Z.H.; Wang, Z.H. Spatial-temporal evolution and influencing factors of county-level carbon emissions in China. *Geogr. J.* **2021**, *76*, 3103–3118.
33. Shan, Y.; Guan, D.; Zheng, H.; Ou, J.; Li, Y.; Meng, J.; Mi, Z.; Liu, Z. China CO_2 emission accounts 1997–2015. *Sci. Data* **2018**, *5*, 170201. [CrossRef]
34. Shan, Y.; Huang, Q.; Guan, D.; Hubacek, K. China CO_2 emission accounts 2016–2017. *Sci. Data* **2020**, *7*, 54. [CrossRef]
35. Guan, Y.; Shan, Y.; Huang, Q.; Chen, H.; Wang, D.; Hubacek, K. Assessment to China's Recent Emission Pattern Shifts. *Earth's Future* **2021**, *99*, e2021EF002241. [CrossRef]
36. Guan, Y.; Shan, Y.; Huang, Q.; Chen, H.; Wang, D.; Hubacek, K. New provincial CO_2 emission inventories in China based on apparent energy consumption data and updated emission factors. *Appl. Energy* **2021**, *184*, 742–750.
37. Carbon Emission Accounts and Datasets. Available online: https://www.ceads.net/data/province/ (accessed on 24 September 2023).
38. Zhang, Y.; Zhou, Y.H. Digital inclusive finance, traditional financial competition and rural industrial integration. *Agric. Technol. Econ.* **2021**, *317*, 68–82.
39. Yang, L.; Sun, Z.C. Evaluation of the development level of new urbanization in western China based on entropy method. *Econ. Issues* **2015**, *3*, 115–119.
40. Geng, P. The impact of labor structure and innovation ability on regional economic growth. *Bus. Econ. Res.* **2021**, *9*, 158–160.
41. Miao, L.J.; Chen, J.; Fan, T.Z.; Lv, Y.Q. impact of digital economy development on carbon emissions-based on panel data analysis of 278 prefecture-level cities. *South. Financ.* **2022**, *2*, 45–57.
42. Ma, G.; Lv, D.; Jiang, T.; Luo, Y. Can Land Transfer Promote Agricultural Green Transformation? The Empirical Evidence from China. *Sustainability* **2023**, *15*, 13570. [CrossRef]
43. Liao, X.; Qin, S.; Wang, Y.; Zhu, H.; Qi, X. Effects of Land Transfer on Agricultural Carbon Productivity and Its Regional Differentiation in China. *Land* **2023**, *12*, 1358. [CrossRef]
44. Shao, S.; Zhang, K.; Dou, J.M. The effect of economic agglomeration on energy saving and emission reduction: Theory and Chinese experience. *Manag. World* **2019**, *35*, 36–60+226.
45. Wojewodzki, M.; Wei, Y.; Cheong, T.S.; Shi, X. Urbanization, agriculture and convergence of carbon emissions nexus: Global distribution dynamics analysis. *J. Clean. Prod.* **2023**, *385*, 135697. [CrossRef]
46. Yang, X.; Jia, Z.; Yang, Z.; Yuan, X. The effects of technological factors on carbon emissions from various sectors in China—A spatial perspective. *J. Clean. Prod.* **2021**, *301*, 126949. [CrossRef]
47. Kang, Z.Y.; Ke, L.; Qu, J. The path of technological progress for China's low-carbon development: Evidence from three urban agglomerations. *J. Clean. Prod.* **2018**, *178*, 644–654. [CrossRef]
48. Dong, F.; Li, Y.; Qin, C.; Sun, J. How industrial convergence affects regional green development efficiency: A spatial conditional process analysis. *J. Environ. Manag.* **2021**, *300*, 113738. [CrossRef]

49. Huang, J.; Chen, X.; Yu, K.; Cai, X. Effect of technological progress on carbon emissions: New evidence from a decomposition and spatiotemporal perspective in China. *J. Environ. Manag.* **2020**, *274*, 110953. [CrossRef]
50. Zhao, P.; Wan, J. Land use and travel burden of residents in urban fringe and rural areas: An evaluation of urban-rural integration initiatives in Beijing. *Land Use Policy* **2021**, *103*, 105309. [CrossRef]
51. Wang, S.H.; Wang, X.Q.; Chen, S.S. Global value chains and carbon emission reduction in developing countries: Does industrial upgrading matter? *Environ. Impact Assess. Rev.* **2022**, *97*, 106895. [CrossRef]
52. Wang, J.; Hu, M.M.; Tukker Arnold Rodrigues João, F.D. The impact of regional convergence in energy-intensive industries on China's CO_2 emissions and emission goals. *Energy Econ.* **2018**, *80*, 512–523. [CrossRef]