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Study on the Impact of Air Pollution on Agricultural Export Trade

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Abstract: With the gradual intensification of the global environmental pollution trend, air pollution has a vital impact role in agricultural export trade. This manuscript uses balanced panel data from 30 Chinese provinces and districts from 2005–2019 in China to empirically verify the mechanism of the impact of air pollution on agricultural exports. The following results were achieved using the fixed effect and moderating effect model. The results show that air pollution significantly inhibits the growth of agricultural export trade. In particular, the presence of environmental regulations will weaken this adverse effect. Regionally, the negative impact of air pollution on China's agricultural export trade in large agricultural provinces is significantly greater than that in non-agricultural areas. To ensure the sustainable development of China's agricultural export trade, we should strengthen the ability to cope with air pollution, actively expand diversified international markets, and strive to improve the technological content and green level of exported agricultural products in order to achieve innovative green development of agricultural export trade.

Keywords: air pollution; agricultural export; environmental regulations; green development

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1. Introduction

Since China's accession to the World Trade Organization (WTO) in 2001, agricultural trade has entered deeply into the global economic wave, and China has gradually become a world agricultural trade power. According to the United Nations Commodity Trade Statistics Database of 2020: China's total agricultural trade grew from US$27.9 billion in 2001 to US$230.07 billion in 2019, a net increase of 8.2 times at constant prices. Of this, agricultural export trade was US$16.07 billion and reached US$79.10 billion in 2019, with an average annual growth rate of 8.5%. The export share of agricultural products rose from 2.19% in 2001 to 4.33% in 2019, with overall steady growth in the export scale [1,2]. In terms of the types of agricultural exports, China's agricultural exports to foreign countries have become increasingly diversified, with 679 types of Chinese agricultural exports in 2001 and up to 814 types in 2019.

The stable development of agricultural products export trade can only be achieved with an excellent agrarian environment. In recent years, while the competitiveness of agricultural exports has rapidly improved, the problem of environmental pollution has become more and more serious. Among various types of pollution, air pollution is the most prevalent and visible environmental problem that China is currently facing; it has harmed agricultural economic development and cannot be ignored [3,4]. Extreme pollution from air pollution has a direct impact on the world's ecological ecosystem and climate change, affecting the efficiency of agricultural production and increasing the cost of agricultural export trade, including agricultural trade barriers, trade transfer, and so on. Thus, air pollution will indirectly affect the trade of farm products [5,6]. According to Aragon and Rud [7], depending on the crop and the type of pollutant, air pollution may cause a 30–60% decrease in agricultural productivity. Agricultural production activities strictly require a suitable climate and calm environment. Therefore, to effectively deal with a series of negative effects brought about by environmental pollution, several countries hope to take an environment-friendly green sustainable development path. Furthermore, national governments have started the introduction of a series of environmental protection policies to curtail the environmental pollution problem. For example, in the United States, the New Agricultural Act Agricultural Environmental Protection Policy was introduced in 2014 to improve the agricultural production environment and the rule of law for agricultural ecological compensation [8]. The Fifth Plenary Session of the 19th Communist Party of China also re-emphasized the need to firmly adhere to the concept that "lucid waters and lush mountains are invaluable assets." In this context, strengthening environmental regulation is gradually becoming one of the primary measures to deal with environmental pollution problems and develop a sustainable economy [9].

However, green trade barriers have started to emerge in some countries on the grounds of protecting the ecological environment, imposing a series of restrictive measures on agricultural products from importing countries. According to UNEP (United Nations Environment Programme) of 2020, among more than 250 multilateral environmental agreements worldwide, more than 20 agreements contain trade clauses. China's agricultural exports are facing increasingly severe risks and challenges. Therefore, it is essential to study the environmental pollution caused by air pollution for agricultural export trade. Based on this, how China should maintain and enhance the international competitiveness of agricultural products by properly handling the relationship between the environment and agricultural products deserves attention and research. At the same time, an in-depth investigation of the impact of environmental pollution, especially air pollution, on China's agricultural export trade has essential reference value for scientific guidance of China's agricultural export trade. There, assessing how air pollution affects trade export in China is an essential topic for policymaking decisions.

Generally speaking, there exist many studies on the foreign trade of agricultural products, especially the discussion on the import and export of agricultural products by the environment. However, combining the existing research directions and findings [10,11], there are still some things that could be improved. There needs to be a more systematic empirical analysis based on the impact of air pollution on China's agricultural product export trade. Existing research on the trade of environmental pollution around agricultural products primarily focuses on relatively extensive qualitative and simple quantitative analysis [12,13], lacking specific quantification and systematic quantitative research on environmental pollution. Therefore, we have adopted an approach widely used in the previous literature, an econometric model based on panel data, to empirically analyze the impact of environmental pollution, especially air pollution, to explore the effect of air factors on China's agricultural export trade. In addition, statistics were selected from 30 provinces in the mainland of China from the year 2005–2019, and fixed-effects and moderating-effects models were applied to validate the problem and empirically examine the role of the relationship between air pollution and agricultural exports in China.

Drawing on some advanced studies that are beneficial to this paper [14], and considering the effects of environmental pollution, especially air pollution, on the export trade of agricultural products, this research makes two contributions. First, in terms of the research object, by quantifying the degree of air pollution, the impact of air factors in the environmental pollution on the export of agricultural products is analyzed in detail so as to reflect the current situation of the effects of air pollution on China's agricultural product trade, as well as the severity of the present air pollution. Second, in terms of research methods, this paper adopts the fixed effect model and moderating effect model, and in the case of considering endogenous problems, uses the instrumental variable estimation method to systematically study the impact of air pollution on China's agricultural export trade and identifies the process mechanism of influence.

2. The Literature Review

In recent years, under the guidance of green development, research on economic growth has gradually expanded to ecological resources and environmental pollution. Many studies at home and abroad have shown the existence of the environmental Kuznets curve (EKC). This theory believes that the economic growth of many countries will lead to different degrees of environmental pollution while promoting rapid economic and social development at the expense of the environment. There will be a trend of deterioration first and then improvement in environmental quality [15–17]. Some scholars have explored the relationship between environmental pollution and agriculture. Most of the research focuses on the different impacts of agricultural development on the environment. According to the research conclusions, they can be roughly divided into three categories: First, agricultural trade harms a country's agricultural environment. Many foreign studies have shown that the liberalization of international agricultural trade will exacerbate the depletion of natural resources such as forests and arable land in a country and the deterioration of the environment [18–20]. Domestic scholar Wen Chen [21] focused on exploring the impact of agricultural product export trade on the farming environment through cointegration analysis and other methods. The empirical results showed that there was a significant positive correlation between the two. Based on the analysis of agricultural policies and forecasting models, Jikun Huang et al. [22] found that trade is not conducive to the environment, but the impact is relatively small. Second, the environmental effect of agricultural export trade is positive. Khan [23] pointed out that trade liberalization can promote the rational allocation of resources among economic sectors such as agriculture and manufacturing, effectively improve resource utilization and agricultural competitiveness, and be conducive to developing export-oriented agriculture. Scholars such as Zhang Lingyun [24] explored the time-series data from 1986 to 2003 and used the EKC model to prove that the export of China's planting products will ease the per capita use of chemical fertilizers and reduce environmental pollution. Third, the impact of agricultural trade on a country's environment is uncertain [25,26].

Some scholars have studied the impact of environmental pollution on agricultural development. For example, based on the background of global climate warming, Fang Su et al. [27] concluded that the two major climate change factors of accumulation and precipitation have an inhibitory effect on food security, and natural disasters caused by climate change have increased the uncertainty of food security. Pengju Liu and others [28] believe that pesticide residues not only endanger the health of residents but also cause serious pollution to soil, water quality, and air, and at the same time, cause considerable losses to the export trade of agricultural products in developing countries. According to the analysis of Meemken and Qaim [29], organic agriculture is more sustainable than traditional agriculture. During the production of agricultural products, more attention should be paid to protecting the environment rather than "recovery after pollution." Combining organic and conventional models contributes to the green sustainability of global agriculture. Therefore, environmental improvement is conducive to the development of China's agricultural trade [30]. To this end, a series of environmental regulation measures have emerged. Shi Shuai et al. [31] found that market-incentivized environmental regulation can alleviate the contradiction between agricultural carbon emission reduction and industrial development, and regulate the contradiction between low-carbon agricultural development and environmental protection, which helps to form a green and healthy agricultural development. While Kemao Peng et al. [32] through empirical analysis, believed that the degree of environmental pollution interacts with the competitiveness of agricultural products in international trade, and increasing the tolerance of environmental pollution can improve the global competitiveness of China's agricultural products. However, some countries establish trade barriers to protect the environment, leading to low efficiency, low economic benefits, and poor bilateral trade relations of China's agricultural products export, which will significantly inhibit China's agricultural products export [33]. Countries should vigorously develop green trade in farm products, which is beneficial to the stable development of agricultural product trade, reduces the pressure on agricultural and environmental resources, and maintains the steady growth of the social economy.

3. Theories and Hypotheses

According to the above analysis, the impact of air pollution on the export trade of agricultural products is mainly reflected in the production and trade effects. Among them, the three paths of production effect are as follows: First, air pollution will inhibit the average growth of crops. The respiration and photosynthesis of crops will be weakened due to increased suspended particulate matter in the atmosphere, such as PM2.5 and other toxic substances [34]. In addition, the gradual scarcity of ecological resources affects the average growth of vegetables, fruits, rice, and other crops, leading to a decline in the quality and production of crops, thus, affecting the supply of agricultural products for export trade. Second, because air pollution can damage human health and affect work emotions, it can reduce work efficiency and labor supply in the agricultural sector, resulting in increased agricultural production costs and low efficiency and exerting certain pressure on agricultural product exports. Existing studies have shown that for every 1% increase in suspended particulate matter (content) in the air, labor input (days) will decrease by 0.4% [35,36]. Third, air pollution adversely affects the agricultural production sector. When air pollution intensifies, it affects the input of agricultural production materials such as fertilizers and pesticides and increases agricultural production costs. Excessive use of chemical fertilizers and pesticides further aggravates air pollution and causes the agrarian production sector to bear more environmental taxes.

The trade effect have mainly manifested in two aspects: green barriers and trade diversion. Among them, countries began to build green trade barriers to protect the environment. China's agricultural product exports face more stringent testing, technical standards, and inspection items. Moreover, it raises the entry threshold for agricultural products, promotes the increase in the cost of agricultural product export trade, and reduces the green competitiveness of agricultural product export trade [35]. At the same time, due to the environmental pollution, the importing countries of agricultural products seek environmentally friendly countries to import green agricultural products, hence, reducing the export volume of China's agricultural products and affecting the trade volume. Therefore, it will cause massive pressure on the export of farm products under air pollution in China.

To reduce the adverse effects of air pollution, countries have begun to introduce a series of environmental regulation measures to improve environmental quality and gain a competitive advantage in export trade. The implementation of environmental regulations can reduce the level of air pollution and ease the pressure on agricultural export trade. First, environmental regulation will trigger the "innovation compensation" effect. Porter [37] pointed out that appropriate environmental regulation stimulates the innovation behavior of enterprises, and adopting more efficient production equipment and technology not only helps reduce pollution but also increases corporate profits. When a country is faced with environmental regulation restrictions, exporters try their best to seek to maximize utilization, break through the problems of rising factor prices and high costs, vigorously develop technological innovation, update production technology and innovate trade models, and improve productivity and trade efficiency [38–40]. As a result, it can reduce the cost of environmental taxes collected by the government, improve the quality of agricultural products and the price competitiveness in international trade, and promote the expansion of the export scale of agricultural products. Second, the green effect brought about by environmental regulation can enhance the ecological competitiveness of foreign trade of agricultural products. Environmental regulation includes not only direct rule but also a series of invisible principles such as the public's behavior and awareness of environmental protection, which makes the public demand whether there are green factors in the non-price factors of agricultural products, that is, quality, appearance, and cultural connotation. Due to the green market brought by consumers' green demand [41], producers are encouraged to consider improving the environmental competitiveness of agricultural products. In other words, the ecological friendliness of agrarian products in production, sales, and use can increase the added value of products, breakthrough trade barriers, and promote the export of agricultural products. Finally, environmental regulations bring image effects to agricultural product export enterprises. If enterprises make excellent and positive behaviors in environmental management, in that case, it helps establish a green image of agricultural product export trade, cultivate long-term export competitiveness of agricultural products, and eliminate the negative reputation of a "pollution paradise." Building a green image of China will increase the demand for trade cooperation for agriculture, expand market share and scale, improve product quality and sales, break through the green trade barriers of importing countries, and enhance the competitiveness and profits of Chinese agricultural products. The primary path of the impact of air pollution on the export trade of agricultural products is shown in Figure 1.

Given the above analysis, hypotheses H1 and H2 are put forward in this paper.

Hypothesis H1. *Air pollution has a negative effect on China's agricultural export trade.*

Hypothesis H2. *Environmental regulation plays a regulating role in the process of air pollution's impact on China's agricultural product export trade.*

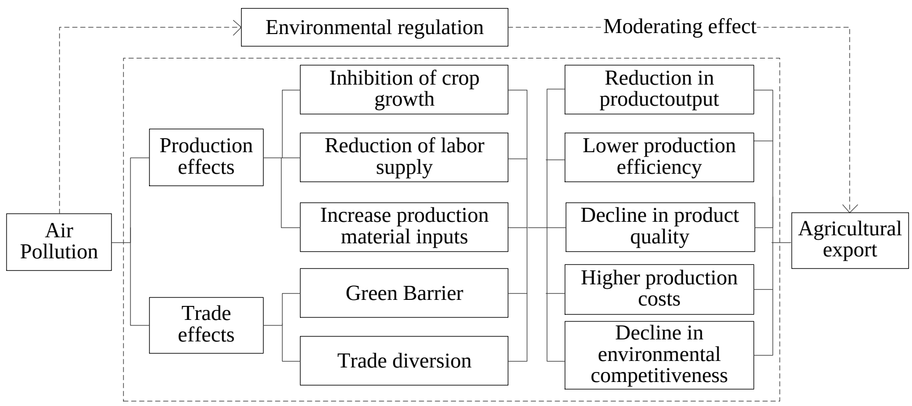

Figure 1. The basic path of the effect of air pollution on the agricultural export trade.

4. Design of Research

4.1. Sample Selection and Data Sources

This paper selects 30 provinces that cover the main areas for the agricultural industry (municipalities, autonomous regions) in mainland China from 2005 to 2019 as the research object. Due to the apparent lack of data in the Tibet Autonomous Region in China for many years, it was deliberately eliminated, and a total of 450 samples were sorted out. Among them, Beijing, Tianjin, Shanghai, and Chongqing are four special samples, that is, municipalities directly under the Central Government. This manuscript ranks China based on its annual gross agricultural product, dividing the country's 30 provinces into non-agricultural and agricultural provinces where the top ten regions are, respectively: Henan, Shandong, Sichuan, Jiangsu, Hebei, Hunan, Heilongjiang, Guangdong, Hubei, and Guangxi, and the remaining twenty provinces are non-agricultural provinces. Part of the data comes from the year of 2020 "China Statistical Yearbook", "China Environmental Statistical Yearbook", "China Urban Statistical Yearbook", "China Rural Statistical Yearbook", and the "Statistical Yearbook" of various provinces. The air pollution index comes from Columbia University Economic Data and Application Center Satellite monitoring data. Due to the lack of data on individual indicators in a few provinces and individual years, interpolation methods are used to complete them. As the data related to the economy have a certain degree of time trend and there is a slight time trend in the data selected for this paper, the interpolation method used is able to simulate the economic movements and does not change or affect the conclusions of the empirical results. To make the sample data complete, the interpolation method is used in this manuscript to fill in individual missing values.

4.2. Variable Selection

The core variables include explained variables and explanatory variables, among which the explained variable is agricultural product export trade (export), and the explanatory variables are air pollution index (air_pollution) and environmental regulation (environmental_regulation).

4.2.1. Explained Variable

The core variable to be explained in this paper is the export trade of agricultural products. The indicators used in existing studies to measure the agricultural product export trade are mainly divided into two categories: one is to use the absolute index of agricultural product export volume directly; the other is to compare the export volume of agricultural products with other indicators to build relative metrics. This manuscript uses the export value of agricultural products to measure the explained variable, and the period is the "China Statistical Yearbook" from 2005 to 2019.

4.2.2. Explanatory Variable

The air pollution index is the core explanatory variable, where the degree of air pollution is usually measured based on the concentration of pollutants in the air. There exist many types of air pollutants, such as haze, soot, SO_2, nitrogen oxides, carbon dioxide, and other substances. However, on the contrary, in China, the leading cause of air pollution is haze. For a long time, haze has had a substantial impact on China's economic development and social life, and the main component of haze is PM2.5. Therefore, this manuscript calculates the air pollution index value according to the formal "Ambient Air Quality Index (AQI) Regulations (Trial)" method given by the national environmental protection department and uses the annual average concentration of PM2.5, the primary pollutant that forms smog, to measure. For data resources, since China only began to report PM2.5 concentration data in major cities in 2013, and the data were seriously missing from 2005 to 2012, to ensure the continuity of the data, we used the research method of Shiyi Chen et al. [42] for reference. We adopted the annual average value of PM2.5 concentrations worldwide as measured by satellites released by the Center for Socioeconomic Data and Applications of Columbia University in the United States. The ArcGIS software is used to analyze the PM2.5 data of China's provinces. The comparison reveals that the PM2.5 concentration values obtained by this algorithm for 2013–2019 are slightly lower than those in the China Environmental Statistics Yearbook for each location, though the difference is not significant.

4.2.3. Moderator Variable

The moderator variable in this paper is the environmental regulation index. The existing measurement methods of environmental regulation can be roughly divided into two types: construction of scoring indicators based on surveys and measurement-based, including the number of local environmental protection administrative penalties, wastewater and gas emissions, and corporate pollutant emissions and constructing surveys, etc. The level of environmental regulation will vary with the degree of influence of each province on environmental pollution, and the rapid development of the industry will inevitably affect the cost of environmental pollution control. As a result, to ensure the accuracy, representativeness, and availability of the data, this manuscript measures the level of environmental regulation by the ratio of pollution discharge treatment fees to industrial-added value in various provinces and cities. In order to prevent the impact of dimensions on the regression results, the data are centrally processed.

4.2.4. Control Variables

Considering the comprehensive impact of air pollution on the export trade of agricultural products by various factors, we select the following control variables: domestic waste disposal (waste_disposal), grain production structure (per_grain), irrigation structure (irrigation), agricultural machinery power (agrimachine), agricultural fertilizer application (fertilizer), crop sown area (crop_area), and consumer price (price_index). Among them, domestic waste disposal (waste_disposal) is characterized by the harmless disposal rate of household waste; grain production structure (per_grain) is measured by the grain output per unit area of planting land; irrigation structure (irrigation) is represented by effective irrigated area; agricultural mechanical power (agrimachine) is measured by the total capacity of agricultural machinery; agricultural chemical fertilizer application (fertilizer) is represented by the scalar amount of agrarian chemical fertilizer application; crop sown area (crop_area) is characterized by the total crop planted area; consumer price (price_index) is indicated by the consumer price index. To alleviate the interference of data fluctuations on the results, all control variables were logarithmized.

The descriptive statistics of the variables in this paper are shown in Table 1.

Table 1. Descriptive statistics.

Variable	Symbol	Obs	Mean	Std.Dev.	Min	Max
export trade of agricultural products	export	450	13.58	1.444	8.731	16.649
air pollution	air_pollution	450	3.667	0.384	2.308	4.451
domestic waste disposal	waste_disposal	450	4.346	0.351	2.573	4.605
grain production structure	per_grain	450	−1.112	0.255	−1.768	−0.382
irrigation structure	irrigation	450	7.243	1.015	4.694	8.729
agricultural machinery power	agrimachine	450	7.585	1.086	4.543	9.499
agricultural fertilizer application	fertilizer	450	4.802	1.099	1.82	6.574
crop sown area	crop_area	450	8.173	1.112	4.484	9.609
consumer price	price_index	450	4.631	0.017	4.582	4.701

4.3. Model Settings

4.3.1. Fixed Effect Model

With reference to related studies [27], to investigate the impact of air pollution on the export trade of agricultural products, based on 30 provincial panel data, according to theoretical analysis and data characteristics, this paper constructs a panel fixed effect model as follows:

$$\text{export}_{it} = \propto_0 + \propto_1 \text{air\_pollution}_{it} + \lambda Z_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

where export_{it} is the core explained variable, representing the export trade volume of agricultural products. $\text{air\_pollution}_{it}$ is the core explanatory variable, denoting the local air pollution index. Z_{it} shows the control variable, and the subscripts i and t represent various provinces and years, respectively. $\propto_1$ is the estimated parameter, and it is the focusing coefficient of this paper. If $\propto_1$ is significantly negative, air pollution will reduce the export value of China's agricultural trade. The control variable group Z_{it} indicates a series of control variables at the provincial level in the region. μ_i represents the individual fixed effect. ν_t shows the fixed effect of year, and ε_{it} means the random error term.

4.3.2. Moderating Effect Model

According to the previous analysis on the mechanism of the regulatory effect of environmental regulation, to further test the regulatory impact of environmental regulation on the relationship between air pollution and agricultural product export trade volume, that is, the intensity of environmental regulation will affect the effect of air pollution on agricultural product export, so the regulatory effect model is constructed as follows:

$$\begin{aligned} \text{export}_{it} = \alpha_0 + \quad & \alpha_1 \text{air\_pollution}_{it} + \alpha_2 \text{environmental\_regulation}_{it} \\ & + \beta_1 (\text{aqi}_{it} \times \text{environmental\_regulation}_{it}) + \lambda Z_{it} + \mu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{2}$$

where environmental_regulation$_{it}$ indicates the intensity of environmental regulation, and the interaction term (aqi$_{it}$ × environmental_regulation$_{it}$) of the air pollution index and the primary item of environmental regulation is used to measure the moderating effect of environmental regulation between the two. $\alpha_1 + \beta_1$environmental_regulation$_{it}$ represents the impact of air pollution on the export trade of agricultural products under the regulation of environmental regulations.

4.3.3. Quantile Regression Model

In order to distinguish the effects of air pollution on the agricultural export trade of provinces with different levels of agrarian export trade and to facilitate the treatment of sample heterogeneity across regions and diverse groups of agricultural export trade, this research uses a quantile regression model whose essence is mainly an extension on mean regression [43]. Compared to least squares regression, it can estimate parameter regression at any quantile point, and this result does not rely on the assumptions of the error term distribution. Consequently, the quantile regression estimates are more robust and will be much less affected by outliers than the ordinary least squares estimates. In this study, referring to Koenker [44], we construct a quantile panel econometric model by using a quantile regression model to estimate fixed effects on panel data and combine the approach of Shuyan Zhang and Yongan Dai [45] to estimate the standard errors of coefficients by using a self-sampling method on panel data.

The parameter estimate of the conditional distribution function is:

$$\hat{\beta}(\tau) = \arg\min_{\beta \in R^p} \sum_{i=1}^{n} \rho_\tau \left(\text{export}_i - x_i^T \beta \right) \tag{3}$$

where the conditional quantile of the panel fixed effects is expressed as:

$$Q_{yi}(\tau \big| x_{it}, \alpha_i) = x_{it}^T \beta(\tau_k) + \alpha_i \tag{4}$$

According to the quantile panel model proposed by Alexander et al. [46], the parameters are estimated as follows:

$$\hat{\beta} = \text{argmin} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{i=1}^{N} \omega_k \rho_{\tau k} \left(\text{export}_{it} - \alpha_i - x_{it}^T \beta(\tau_k) \right) + \lambda \sum_{i=1}^{N} |\alpha_i| \tag{5}$$

Among them: argmin$(\cdot)$ denotes the value taken when the function obtains the minimum value.

To verify the effect of air pollution on the level of agricultural export trade, the conditional quantile function is constructed in this paper as follows.

$$Q_{yi}(\tau | \alpha_i, \xi_t, x_{it}) = \alpha_i + \sum \beta_n \text{air\_pollution}_{it} + \sum \beta_k Z_{it} + \xi_t \tag{6}$$

5. Results

5.1. Benchmark Regression Results

Table 2 reports the results of the impact of air pollution on the export trade of agricultural products. For model selection, the fixed effect model is selected for estimation after the Hausman test results. Models (1) to (4) are the regression results of fixed effects without control variables, mixed least quadratic regression, fixed effects with control variables added, and random effects regression, respectively. From the results in columns (1) to (4), it can be seen that the regression coefficients of air pollution air_pollution are all significantly negative, indicating that the regression results of this paper are robust and reliable. In columns (1) and (3), the absolute value of the regression coefficient of the fixed effect air_pollution without the control variable is 1.267, which is significantly greater than the absolute value of the fixed effect regression coefficient of 0.907 after the control variable is added, and both pass the 1% significant level test. The result shows that air pollution has a particularly negative effect on the export trade of agricultural products, and it will reduce the export value of agricultural products. The control variables added are more reasonable, effectively controlling the endogenous problems of regression, which preliminarily proves hypothesis H1 that the export of agricultural products from China is negatively impacted by air pollution. The intensification of air pollution in China will lead to the deterioration of the agricultural products' production environment and reduce farmers' income and health. Then, it will increase the production cost of agricultural products, reduce production efficiency, and inhibit the export trade of agricultural products.

Table 2. Benchmark regression results of the impact of air pollution on agricultural export trade.

Variable	(1)	(2)	(3)	(4)
air_pollution	−1.267 ***	−0.253 *	−0.907 ***	−0.754 ***
	(−7.85)	(−1.81)	(−5.89)	(−5.14)
waste_disposal		0.603 ***	0.323 ***	0.334 ***
		(4.16)	(3.71)	(4.01)
per_grain		1.322 ***	0.299	0.399 **
		(7.10)	(1.47)	(1.98)
irrigation		0.982 ***	0.221	0.291
		(6.04)	(1.06)	(1.51)
agrimachine		−0.497 ***	0.572 ***	0.519 ***
		(−3.04)	(4.74)	(4.33)
fertilizer		2.052 ***	1.006 ***	1.136 ***
		(14.90)	(4.52)	(5.47)
crop_area		−2.059 ***	−0.989 ***	−1.305 ***
		(−12.24)	(−4.52)	(−6.41)
price_index		−2.206	1.447	1.098
		(−0.85)	(1.48)	(1.10)
_cons	18.23 ***	27.21 **	6.444	9.423 **
	(30.78)	(2.26)	(1.37)	(2.01)
N	450	450	450	450
R^2	0.128	0.569	0.493	

*** means significant at the 1% level, ** means significant at the 5% level, * means significant at the 10% level. The errors in the brackets are robust labels. Same below. The column (1) to (4) are the regression results of fixed effects without control variables, mixed least quadratic regression, fixed effects with control variables added, and random effects regression, respectively.

In addition, as far as the control variables are concerned, the regression coefficients of domestic waste disposal, agricultural machinery power, and the scalar amount of agrarian chemical fertilizers are 0.323, 0.572, and 1.006, respectively, all of which are significantly positive at the 1% level. It shows that for the samples in this paper, with the increase in these control variables, the production efficiency and product quality of agricultural products will be improved, and the export competitiveness of agricultural products will be enhanced. Hence, agricultural product export trade volume growth is supposed to be promoted.

5.2. Robustness Test

5.2.1. Eliminate Samples

Because there are significant differences between centrally administered municipalities and ordinary provinces in terms of air pollution, agricultural environment, and agricultural product export trade, this paper excludes the municipalities samples of Beijing, Tianjin, Shanghai, and Chongqing, which are urban districts with corporate status and selfgovernment powers. It retains the examples of ordinary provinces to perform the regression again. Column (2) in Table 3 reports the regression results after removing the samples, and for the convenience of comparison, column (1) lists the original fixed effect results. It can be seen that the regression coefficient of air pollution is still significantly negative at the 1% level, and the absolute value of this coefficient is 1.043, which is greater than the regression coefficient before excluding centrally administered municipalities (0.907). This indicates that air pollution significantly impacts agricultural export trade in provinces without centrally administered municipalities. The strong negative impact laterally supports hypothesis H1 and further strengthens the core conclusion of this paper.

Table 3. Robustness Test 1.

Variable	(1)	(2)	(3)	(4)
air_pollution	−0.907 ***	−1.043 ***	−0.907 ***	−0.833 ***
	(−5.89)	(−6.06)	(−5.25)	(−5.89)
waste_disposal	0.323 ***	0.276 ***	0.323 ***	0.284 ***
	(3.71)	(2.85)	(3.70)	(3.55)
per_grain	0.299	0.0475	0.299	0.345 *
	(1.47)	(0.20)	(1.24)	(1.84)
Irrigation	0.221	0.368	0.221	0.187
	(1.06)	(1.61)	(0.91)	(0.98)
Agrimachine	0.572 ***	0.540 ***	0.572 ***	0.591 ***
	(4.74)	(4.05)	(4.33)	(5.33)
Fertilizer	1.006 ***	1.298 ***	1.006 ***	0.839 ***
	(4.52)	(4.92)	(4.03)	(4.11)
crop_area	−0.989 ***	−1.313 ***	−0.989 ***	−0.928 ***
	(−4.52)	(−3.90)	(−4.87)	(−4.63)
price_index	1.447	1.429	1.447	1.529 *
	(1.48)	(1.33)	(1.41)	(1.71)
_cons	6.444	7.134	6.444	6.462
	(1.37)	(1.27)	(1.31)	(1.50)
N	450	390	450	450
R^2	0.493	0.511	0.493	0.499

Note: *** means significant at the 1% level, * means significant at the 10% level. The model (1) represents the initial baseline regression result. The model (2) is the estimated outcome after excluding the sample of municipalities. The model (3) indicates the regression analysis after random sampling. The model (4) shows the statistical result after 5% bilateral tailing.

5.2.2. Random Sampling

Based on the benchmark analysis, this manuscript randomly drew samples to test the regression results' robustness further. The sampling results are shown in column (3) of Table 3. According to the regression results, the regression coefficients and significance levels of air pollution and each control variable are consistent, showing that the selected sample data is fully representative and the baseline regression results are credible. Therefore, this provides more evidence in favor of the paper's hypothesis H1 and the intensification of air pollution will inhibit China's agricultural export trade.

5.2.3. Winsorization

In order to eliminate the interference of the outliers in the sample data on the regression results, all variables were subjected to a bilateral winsorization of 5% up and down. The regression results after shrinking are shown in column (4) of Table 3. It can be seen that the regression coefficient of air pollution is significantly negative at the 1% level, which is the same as the baseline regression results. The above results show that the harsh agricultural environment caused by air pollution significantly reduces the export value of farm products, thus, further validating the hypothesis H1 of the manuscript, that is, the inhibitory effect of air pollution on agricultural export trade, and strengthening the robustness of the core findings.

5.2.4. Quantile Regression

In the above regression, the main concern is the regression of the mean, which cannot better reflect the overall situation of the conditional distribution. To further enhance the robustness of the results, this paper considers quantile regression for analysis. Referring to the quantile regression method of Koenker and Bassett [36], this manuscript compared the first and last parts of the explanatory variables to avoid the influence of extreme values and fully reflect the data situation. In this paper, by comparing three quantile points (0.30, 0.60, 0.90), China's 30 provinces, autonomous regions, and municipalities are divided into three agricultural product export trade areas: low, medium, and high. The regression results are shown in Table 4 (2)~(4) column. For the convenience of comparing the errors and differences between benchmark regression and quantile regression, column (1) presents the benchmark regression results. It can be seen from Table 4 that the regression coefficients of air pollution at the three quantile points are all significantly negative at the 1% level, and the absolute values of the regression coefficients at the higher quantile points are all greater than that of the based one. It manifests that the intensification of air pollution will negatively impact provinces with higher agricultural export trade. This finding successfully evaluates the H1 hypothesis. It is obvious that the results are still robust, which proves the general applicability of the core conclusions obtained in this paper.

Table 4. Robustness Test 2.

Variable	(1)	(2)	(3)	(4)
air_pollution	−0.907 ***	−0.681 ***	−1.047 ***	−1.324 ***
	(−5.89)	(−2.69)	(−3.29)	(−2.67)
waste_disposal	0.323 ***	0.307 **	0.333 **	0.354
	(3.71)	(2.54)	(2.18)	(1.48)
per_grain	0.299	0.434	0.215	0.0488
	(1.47)	(1.37)	(0.54)	(0.08)
Irrigation	0.221	0.207	0.229	0.247
	(1.06)	(0.58)	(0.51)	(0.35)
agricultural_machinery	0.572 ***	0.641 ***	0.530 **	0.446
	(4.74)	(3.30)	(2.16)	(1.16)
Fertilizer	1.006 ***	1.160 ***	0.909 *	0.719
	(4.52)	(3.07)	(1.90)	(0.96)
crop_area	−0.989 ***	−1.248 ***	−0.827 **	−0.510
	(−4.52)	(−4.35)	(−2.30)	(−0.91)
price_index	1.447	0.874	1.804	2.507
	(1.48)	(0.58)	(0.95)	(0.85)
_cons	6.444			
	(1.37)			
N	450	450	450	450
R^2	0.493			

Note: *** means significant at the 1% level, ** means significant at the 5% level, * means significant at the 10% level. The column (1) displays the original fixed effects results. Columns (2) to (4) show the quantile regression results at three quantile points 0.30, 0.60, and 0.90, respectively.

5.3. Endogeneity Test

To avoid endogenous problems caused by measurement errors, omitted variables, and unobservable factors, this paper uses the instrumental variable method to solve the endogenous issues in the model and the two-stage least squares method to estimate the model. According to the requirements of the correlation and exogenous instrumental variables, the index of forest coverage rate is selected as the instrumental variable of air pollution. Since the size of the forest coverage rate is highly related to the degree of air pollution and has an exogenous nature with the export trade volume of agricultural products, therefore, it is reasonable to choose the indicator of forest coverage.

Table 5 reports the regression estimation results of the instrumental variables. Among them, column (1) is the first-stage estimation, which uses the endogenous explanatory variable air pollution of the original fixed-effects model to perform least squares (OLS) estimation on the instrumental variable forest cover and obtain the fitted values of the explanatory variables, and this stage validates the results of the effect of the instrumental variable forest cover on the endogenous variable air pollution. The results show that choosing forest coverage rate as an instrumental variable has better explanatory power for endogenous variables, and the regression coefficient is negative at the 10% significance level. Gradually improving the air quality and living environment in China will have a better effect on improving the air pollution level. Column (2) is listed as the second-stage estimation, which applies the fitted values of the explanatory variables obtained in the first stage to OLS estimation of the original model to obtain the estimated values of the model to eliminate the effect of endogeneity. This stage estimates the statistical results of the impact of the fitted values obtained using the instrumental variables on the explanatory variable agricultural export trade. It can be seen that after considering endogenous issues, air pollution still harms the agricultural products export trade and passes the significance test. The absolute value of the coefficient 11.26 is significantly greater than the coefficient of the baseline regression (0.907). It indicates that the air pollution index can better explain the changes in agricultural export trade, which again supports the baseline regression's core conclusion and the H1 hypothesis.

Table 5. Instrumental variable regression.

Variable	**(1)**	**(2)**
	The First Stage	**The Second Stage**
IV	−0.0653 *	
	(−1.79)	
air_pollution		−11.26 *
		(−1.91)
control variables	Yes	Yes
_cons	−3.578 **	
	(−2.31)	
N	450	450
R^2	0.356	−5.063

Note: ** means significant at the 5% level, * means significant at the 10% level. The first stage uses the endogenous explanatory variable air pollution of the original fixed-effects model to perform least squares (OLS) estimation on the instrumental variable forest cover and obtain the fitted values of the explanatory variables. The second stage applies the fitted values of the explanatory variables obtained in the first stage to OLS estimation of the original model to obtain the estimated values of the model.

5.4. Heterogeneity Analysis

The above studies have shown that air pollution can significantly inhibit agricultural export trade. On this basis, the research area is subdivided to discuss further the differences in the impact of air pollution on agricultural production provinces. Due to specific differences in the export trade of agricultural products in various regions in China, some provinces have a higher degree of agricultural mechanization and modernization, higher product quality and benefits, and a larger scale of agricultural product exports, which may be more sensitive to the impact of air pollution. Therefore, this paper divides the 30 provinces in the country into non-agricultural and agricultural provinces according to the ranking of the total value of agricultural production (the top ten provinces: Henan, Shandong, Sichuan, Jiangsu, Hebei, Hunan, Heilongjiang, Guangdong, Hubei, Guangxi). The direct effects of air pollution on the export trade of agricultural products in these two regions are shown in Table 6. Models (1)~(2) are the regression results of fixed and random effects of non-agricultural provinces, and the remainder are the results of large agricultural provinces. Overall, the regression coefficients of air pollution are all significantly negative, and the absolute values of the regression coefficients in large agricultural provinces are considerably more extensive than those in non-agricultural provinces. Based on the practical validation of hypothesis H1, this estimation finding further suggests that air pollution has the most considerable negative impact on agricultural export trade in large agrarian provinces.

Table 6. Regional heterogeneity.

Variable	(1)	(2)	(3)	(4)
air_pollution	−0.765 ***	−0.576 ***	−0.924 ***	−0.869 ***
	(−3.82)	(−3.03)	(−4.01)	(−3.75)
waste_disposal	0.247 ***	0.298 ***	0.600 ***	0.499 ***
	(2.60)	(3.22)	(3.01)	(2.68)
per_grain	0.541 **	0.600 ***	−0.0794	0.140
	(2.35)	(2.62)	(−0.20)	(0.34)
irrigation	0.885 ***	0.801 ***	−1.802 ***	−1.337 ***
	(3.48)	(3.43)	(−4.56)	(−3.39)
agricultural_machinery	0.391 ***	0.340 **	1.241 ***	1.247 ***
	(2.74)	(2.38)	(5.66)	(5.61)
fertilizer	0.873 ***	0.952 ***	1.648 ***	1.544 ***
	(3.37)	(3.84)	(3.65)	(3.65)
crop_area	−1.033 ***	−1.317 ***	−0.327	−1.232 **
	(−4.38)	(−5.84)	(−0.40)	(−2.25)
price_index	1.323	0.928	1.385	1.097
	(1.11)	(0.76)	(0.92)	(0.69)
_cons	4.764	8.561	6.203	12.98
	(0.85)	(1.52)	(0.63)	(1.52)
N	300	300	150	150
R^2	0.485		0.654	

Note: *** means significant at the 1% level, ** means significant at the 5% level. The columns (1) and (2) are the regression results of fixed effects and random effects for large non-agricultural provinces, while the (3) and (4) columns are for large agricultural provinces.

On the one hand, since the export trade of agricultural products in non-agricultural provinces is not a pillar industry, the production scale and mechanization degree are relatively low, the product quality and scale are not high, and the export scale of agricultural products is small, so they are less affected by environmental factors caused by domestic air pollution. On the other hand, for a large agricultural province, its agricultural products have higher production efficiency, larger scale, and more strict standards. They pay more attention to product quality and green factors. At the same time, the higher level of mechanization development and modernization is more conducive to the use of high-tech agricultural products. Thereby, it can provide higher-quality agricultural product exports. As a result, major agricultural provinces are more sensitive to international influences, and their export trade is more vulnerable to air pollution. When air pollutants increase, and air pollution intensifies, it will result in a poor agricultural environment, which is more likely to affect the production of agricultural products in large agricultural provinces, thereby, hindering the development of export trade.

5.5. Analysis of the Moderating Effect of Air Pollution on the Export Trade of Agricultural Products

According to the previous analysis, air pollution significantly inhibits the export trade of agricultural products. To further explore the transmission mechanism of this effect, that is, whether environmental regulation has a moderating effect on the relationship between air pollution and agricultural product exports, this manuscript selects environmental regulation indicators to investigate the mechanism of environmental regulation.

Table 7 shows the test results of the moderating effect of environmental regulation. In model (1), the leading effect coefficient of air pollution on agricultural product export is negative, presenting that air pollution has an inhibitory effect on agrarian product export. Model (2) results from the moderating effect of environmental regulation. Among them, the regression coefficient of environmental regulation is 1.077, which is significantly positive at the 1% level and indicates that environmental regulation can effectively reduce the inhibitory effect of air pollution on agricultural export trade. This is mainly due to the improvement of environmental regulations in various provinces and cities, which will increase the cost of pollution control and the improvement of the agricultural environment. In addition, it will improve the production efficiency and quality of agricultural products to promote the competitiveness of agricultural product exporters and the export of agricultural products development. This result proves that environmental regulation plays an essential regulating role in the transmission mechanism of the influence of air pollution on agricultural product export trade. Moreover, it effectively verifies Hypothesis H2 that environmental regulation contributes to reducing the impact of air pollution on China's agricultural export trade and the deepening of air pollution will affect the level of environmental regulation, thus, affecting the export trade of agricultural products.

Table 7. Regulatory regression results.

Variable	(1)	(2)
air_pollution	−0.907 ***	−0.824 ***
	(−5.89)	(−5.28)
control variable	yes	yes
environmental_regulation		1.077 ***
		(2.67)
_cons	6.444	6.563
	(1.37)	(1.41)
N	450	450
R^2	0.493	0.501

*** means significant at the 1% level. The model (1) displays the original fixed effects results, while the model (2) is the result from the moderating effect of environmental regulation.

6. Conclusions and Implications

6.1. Conclusions

Under environmental pollution, resource depletion, and trade protectionism, it is significant to break through the green barriers and find a sustainable development path that is friendly to the environment and economically developed. To this end, this paper profoundly explores the mechanism of the impact of air pollution on the export trade of agricultural products. It uses the panel data of 30 provinces in China from 2005 to 2019 to establish a fixed effect model, and a moderating effect model empirically examines the relationship between the two and systematically analyzes the moderating role of environmental regulation in this process. The main conclusions are as follows: ① Air pollution can significantly inhibit the export trade of agricultural products, and this conclusion still holds after considering endogenous issues and a series of robustness tests such as eliminating samples, random sampling, winsorization, and quantile regression. ② Environmental regulation plays a regulating role in the process of air pollution inhibiting agricultural product export trade, and it reduces the negative impact of air pollution on agricultural product export. ③ Air pollution has diverse effects on the export trade of agricultural products in different regions. The export of agricultural products in large agricultural provinces is more sensitive to international influences and more vulnerable to the adverse effects of air pollution.

In terms of theoretical contributions, this paper systematically sorts out the mechanism of environmental pollution, especially air pollution, on China's agricultural export trade, mainly by elaborating this influence mechanism through two aspects: production effect and trade effect, and enriching the regulatory impact of this process. The manuscript complements and expands the traditional research by studying the influence mechanism of air pollution levels on agricultural export trade in a multidimensional manner. It provides a reference value for effectively promoting the competitiveness and trade growth of China's agricultural exports and lays a theoretical foundation for realizing environmental regulation to guide China's agricultural export trade better scientifically.

6.2. Implications

The above findings have important policy implications for coping with environmental pollution and ensuring sustainable agricultural export trade development.

1. Using excessive chemical fertilizer products in modern agriculture makes agricultural surface sources and ecological environment pollution more serious. Concerning the inhibiting effect of air pollution on the export trade of agricultural products, on the one hand, the government should strengthen the ability to cope with air pollution, improve the construction of air pollution prevention and control systems, enhance the forecasting ability of air pollution disasters, and improve the growth environment of agricultural products. It will help to mitigate the negative impact of air pollution on labor production supply, improve agricultural production efficiency, reduce agricultural production costs, and expand the scale of agricultural production. On the other hand, we should continue to increase the publicity of the concept of green development and strengthen the policy guidance of the idea that "lucid waters and lush mountains are invaluable assets." We should encourage producers to use green pesticides, green fertilizers, and clean energy to reverse the resource and environmental deficit and achieve a "win-win" situation for both the environment and the economy. We should also continuously promote the standardization and greening of agricultural production, optimize the allocation of production factors, and improve the efficiency of arable land use. The concept of green trade will be deeply implemented into agricultural development, and the road of sustainable agricultural trade development will follow.
2. As air pollution leads to the export trade of agricultural products facing green barriers and trade diversion, vigorously developing green agricultural business has become the main direction of China at present. Protecting the environment and green development has become a global consensus, and green agricultural trade has become the mainstream of the world's agricultural business. The green, circular, and low-carbon development of farm products is supposed to be promoted intensely. China's agricultural export trade should seize the opportunity to promote green production, improve the technical content of agricultural exports, reduce environmental pollution, and achieve the coordinated development of agricultural work, ecological resources, and the environment. At the same time, we should improve the mechanism of the agricultural trade system, establish open cooperation and fair competition in trade cooperation, play the leading role of the market in determining price formation, and promote the global competitiveness of China's agricultural products. In addition, the implementation of green trade requires the introduction of high-end talents who are familiar with the laws and regulations of agricultural trade in various countries and the latest environmental protection trends to face the increasingly stringent and complex agricultural export testing process and break through the green trade barrier fetters, which is conducive to expanding the scale of China's agricultural export trade.
3. We must strictly implement various environmental regulation measures and increase environmental regulation efforts. Government departments in all provinces and cities should increase the input of environmental regulation, urge the agricultural production sector to reduce the emission of various environmental pollutants, and promote the internalization of agricultural, environmental costs. On the one hand, we should transfer agricultural, environmental costs to polluters, such as levying environmental taxes or fines, to achieve the adjustment of agricultural production factor inputs to reduce the negative impact of environmental pollution on agricultural products. On the other hand, We should reduce positive incentives for agricultural decay, decline or eliminate subsidies for pesticides, and shift to increasing subsidies for green production factor inputs. We should establish and improve green ecology-oriented agricultural subsidies systems and quality testing systems, promote the quality and standards of agricultural exports, and enhance the competitiveness of China's international trade.

4. We should develop agricultural export trade planning and environmental management standards in accordance with the local conditions of each province. Provinces with different scales of agriculture should combine their regional environment and agricultural development level from different focus directions to ensure the safety of agricultural export trade. As most of China's large agricultural provinces are located in the main grain-producing areas, their production scale is larger, and their export standards are higher, so they are more vulnerable to the impact of environmental pollution, and their strategic position is related to the overall food and agricultural export security of the country. We should strengthen the policy tilt and financial investment in large agricultural provinces, encourage the development of advanced agricultural technology, and develop trade programs and incentives suitable for local agricultural economic development. Moreover, environmental regulation is supposed to be enhanced appropriately, and standards of agricultural products should be tested in large agricultural provinces to promote the innovative development of agricultural export trade.

The study has some limitations as well. First, we focus on one environmental factor, air pollution, for our analysis. However, some other factors, such as climate change, can impact the export trade; therefore, future studies can consider the role of climate change in export trade development. Finally, we generalized the export trade of agricultural products in this study; however, we believe having a heterogenous analysis based on major exports will help design improved policies for the nation. Therefore, future researcher should consider the study of such an idea.

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References

1. Qiang, W.; Niu, S.; Wang, X.; Zhang, C.; Liu, A.; Cheng, S. Evolution of the global agricultural trade network and policy implications for China. *Sustainability* **2019**, *12*, 192. [CrossRef]
2. UNCTAD. *Data Center of the United Nations Conference on Trade and Development Database*; United Nations: Geneva, Switzerland, 2020.
3. Wei, J.; Guo, X.; Marinova, D.; Fan, J. Industrial SO2 pollution and agricultural losses in China: Evidence from heavy air polluters. *J. Clean. Prod.* **2014**, *64*, 404–413. [CrossRef]
4. Li, H.; Tang, M.; Cao, A.; Guo, L. Assessing the relationship between air pollution, agricultural insurance, and agricultural green total factor productivity: Evidence from China. *Environ. Sci. Pollut. Res.* **2022**, *29*, 78381–78395. [CrossRef] [PubMed]
5. Wei, Y.; Huang, C.; Li, J.; Xie, L.L. An evaluation model for urban carrying capacity: A case study of China's mega-cities. *Habitat Int.* **2016**, *53*, 87–96. [CrossRef]
6. Qiu, Q.; Wang, Y.; Qiao, S.; Liu, R.; Bian, Z.; Yao, T.; Nguyen, T.S. Does air pollution affect consumer online purchasing behavior? The effect of environmental psychology and evidence from China. *J. Clean. Prod.* **2020**, *260*, 120795. [CrossRef]
7. Aragón, F.M.; Rud, J.P. Modern industries, pollution and agricultural productivity: Evidence from Ghana. *Int. Growth Cent. Work. Pap.* **2013**.

8. Wang, S.Q. Analysis of Agricultural Environmental Protection Policies in the New U.S. Farm Bill 2014. *World Agric.* **2015**, *8*, 88–91.
9. Li, J.; Ji, J.; Zhang, Y. Non-linear effects of environmental regulations on economic outcomes. *Manag. Environ. Qual.* **2019**, *30*, 368–382. [CrossRef]
10. Pandya, S.; Gadekallu, T.R.; Maddikunta, P.K.R.; Sharma, R. A Study of the Impacts of Air Pollution on the Agricultural Community and Yield Crops (Indian Context). *Sustainability* **2022**, *14*, 13098. [CrossRef]
11. Liu, W.; Yang, H.; Liu, Y.; Kummu, M.; Hoekstra, A.Y.; Liu, J.; Schulin, R. Water resources conservation and nitrogen pollution reduction under global food trade and agricultural intensification. *Sci. Total Environ.* **2018**, *633*, 1591–1601. [CrossRef]
12. Ghimire, A.; Lin, F.; Zhuang, P. The Impacts of Agricultural Trade on Economic Growth and Environmental Pollution: Evidence from Bangladesh Using ARDL in the Presence of Structural Breaks. *Sustainability* **2021**, *13*, 8336. [CrossRef]
13. Ahmed, N.; Hamid, Z.; Mahboob, F.; Rehman, K.U.; Ali, M.S.E.; Senkus, P.; Wysokińska-Senkus, A.; Siemiński, P.; Skrzypek, A. Causal Linkage among Agricultural Insurance, Air Pollution, and Agricultural Green Total Factor Productivity in United States: Pairwise Granger Causality Approach. *Agriculture* **2022**, *12*, 1320. [CrossRef]
14. Hua, J.; Zhu, D.; Jia, Y. Research on the Policy Effect and Mechanism of Carbon Emission Trading on the Total Factor Productivity of Agricultural Enterprises. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7581. [CrossRef] [PubMed]
15. Shahbaz, M.; Ozturk, I.; Afza, T.; Ali, A. Revisiting the environmental Kuznets curve in a global economy. *Renew. Sustain. Energy Rev.* **2013**, *25*, 494–502. [CrossRef]
16. Destek, M.A.; Ulucak, R.; Dogan, E. Analyzing the environmental Kuznets curve for the EU countries: The role of ecological footprint. *Environ. Sci. Pollut. Res.* **2018**, *25*, 29387–29396. [CrossRef] [PubMed]
17. Lian, Y. Economic Hierarchy and Environmental Pollution: An Environmental Kuznets Curve Study Based on Carbon Emission. *Stat. Decis.* **2021**, *37*, 146–150.
18. López, R. Environmental externalities in traditional agriculture and the impact of trade liberalization: The case of Ghana. *J. Dev. Econ.* **1997**, *53*, 17–39. [CrossRef]
19. Bandara, J.S.; Coxhead, I. Can trade liberalization have environmental benefits in developing country agriculture: A SriLankan case study. *J. Policy Model.* **1999**, *21*, 349–374. [CrossRef]
20. Barbier, E.B. Links between economic liberalization and rural resource degradation in the development regions. *Agric. Econ.* **2000**, *23*, 299–310. [CrossRef]
21. Chen, W. An empirical study on the relationship between agricultural export trade and environmental pollution in China. *J. Fujian Agric. Forestry Univ. Philos. Soc. Sci.* **2012**, *15*, 31–35.
22. Huang, J.K.; Xu, Z.G.; Li, N.H.; Luo, S.G. A New Round of Trade Liberalization and China's Agriculture, Poverty and Environment. *Bull. National Nat. Sci. Found. China* **2005**, *3*, 142–146.
23. Khan, M.S. Macroeconomic adjustment in developing countries: A policy perspective. *World Bank Res. Obs.* **1987**, *2*, 23–42. [CrossRef]
24. Zhang, L.Y.; Mao, X.Q.; Tu, Y.Y.; Hu, T. An econometric analysis of the environmental impact of trade liberalization of Chinese plantation products. *China Popul. Res. Environ.* **2005**, *6*, 46–49.
25. Lu, W.C.; Guo, X.C. The impact of agricultural trade liberalization on our environment and countermeasures. *Chin. Rural Econ.* **2002**, 46–51.
26. Johansson, R.C.; Cooper, J.; Peters, M. An agri-environmental assessment of trade liberalization. *Ecol. Econ.* **2006**, *58*, 37–48. [CrossRef]
27. Su, F.; Liu, J.; Wang, S.G.; Shang, H.Y. Impacts of climate change on food security in different grain producing areas of China. *China Popul. Res. Environ.* **2022**, *32*, 140–152.
28. Liu, P.J.; Ma, Y.Q.; Guo, Y.Z. Current status of pesticide residues in Chinese agricultural products and its impact on export trade. *J. Agric. Sci. Technol.* **2017**, *19*, 8–14.
29. Meemken, E.M.; Qaim, M. Organic Agriculture, Food Security, and the Environment. *Annu. Rev. Res. Econ.* **2018**, *10*, 39–63. [CrossRef]
30. Gao, X.; Li, G.C.; Wei, S.J. Agricultural Trade Openness, Agricultural Growth and the Agricultural Environment. *J. Huazhong Agric. Univ. Soc. Sci. Ed.* **2018**, *4*, 54–60.
31. Shi, S.; Jing, Y.; Zhai, T. The Role of Market Incentive-based Environmental Regulation on Low Carbon Agriculture Development and the Implementation Path. *Adm. Forum* **2021**, *28*, 139–144.
32. Peng, K.M.; Yang, M.C.; Xi, L.Q. Co-integration Relationship between Environmental Pollution and International Competitiveness of Agricultural Products in China and Implications. *East China Econ. Manag.* **2013**, *27*, 51–54.
33. Li, L.; Zhu, H. Analysis on Trade Effect of Green Barriers and on Agricultural Product Export and Maritime Transport in China. *J. Coast. Res.* **2020**, *115*, 477–480. [CrossRef]
34. Wu, C.Y.; Wang, X.F. Advances in research on the effects of foliar dust on plant reflectance spectra and physiological ecology. *Chin. J. Appl. Environ. Biol.* **2014**, *20*, 1132–1138.
35. Ostro, B.D. The Effects of Air Pollution on Work Loss and Morbidity. *J. Environ. Econ. Manag.* **1983**, *10*, 371–382. [CrossRef]
36. Hanna, R.; Van, B.G.; Kolker, E. The Effect of Pollution on Labor Supply: Evidence From a Natural Experiment in Mexico City. *J. Public Econ.* **2015**, *122*, 68–79. [CrossRef]
37. Porter, M.E. America's green strategy. *Sci. Am.* **1991**, *264*, 168. [CrossRef]

38. Lanoie, P.; Patry, M.; Lajeunesse, R. Environmental regulation and productivity: New findings on the Porter hypothesis. *J. Product. Anal.* **2001**, *30*, 121–128. [CrossRef]
39. Alpay, E.; Buccola, S.; Kerkvliet, J. Productivity growth and environmental regulation in mexican and U. *S. Food Manuf. Am. J. Agric. Econ.* **2002**, *84*, 887–901. [CrossRef]
40. Hamamoto, M. Environmental regulation and the productivity of Japanese manufacturing industries. *Res. Energy Econ.* **2006**, *28*, 299–312. [CrossRef]
41. Tang, L.J.; Yuan, Y. On the Impact of Environmental Regulation on Agribusiness Competitiveness and the Transmission Mechanism. *Rural Econ.* **2014**, *2*, 31–34.
42. Chen, S.; Chen, D. Haze Pollution, Government Governance and High Quality Economic Development. *Econ. Res. J.* **2018**, *53*, 20–34.
43. Roger, K.; Gilbert Bassett, J. Regression Quantiles. *Econometrica* **1978**, *46*, 33–50.
44. Koenker, R. Quantile regression for longitudinal data. *J. Multivar. Anal.* **2004**, *91*, 74–89. [CrossRef]
45. Zhang, S.X.; Dai, Y.A. Heterogeneity, Fiscal Decentralization, and Urban Economic Growth—A Study Based on a Panel Quantile Regression Model. *J. Financial Res.* **2012**, *1*, 103–115.
46. Alexander, M.; Harding, M.; Lamarche, C. Quantile regression for time-series-cross-section data. *Int. J. Stat. Manag. Syst.* **2011**, *6*, 47–72.