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The Mechanism of the Impact of Export Trade on Environmental Pollution: A Study from a Heterogeneous Perspective on Environmental Regulation from China

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Abstract: The majority of the literature currently in existence on trade and pollution has concentrated on the analysis of both factors' combined effects, and only a few studies have used heterogeneous environmental regulation as a starting point to investigate the underlying mechanisms of the impact of export trade on environmental pollution at the indirect level. We construct a mediating and moderating effect model using panel data from 30 provinces in China from 2002 to 2019 to investigate the mechanism of the effect of export trade on environmental pollution. Export trade produces large indirect inhibitory effects on environmental pollution only through market incentive-based restrictions, whereas the mediation impacts of government administrative and public monitoring laws are not significant. By interacting with elements such as technical innovation and energy structure, export trade can also negatively regulate its bad consequences on environmental degradation. According to the heterogeneity analysis's findings, processing trade indirectly reduces pollution emissions by changing administrative rules and cutting emission costs, but general trade indirectly increases environmental pollution by favorably impacting market-based incentives regulations. The moderating effects of improving energy structures, industrial structure optimization, and R&D competition effects diminish the positive aggravating effect of general trade on pollution emissions, while processing trade has the opposite effect. The only means of controlling the harmful impact of processing trade on environmental degradation is through interaction with technical progress.

Keywords: export trade; environmental pollution; environmental regulation; influence mechanism; intermediary effect

Citation: Luo, H.; Qu, X.; Hu, Y. The Mechanism of the Impact of Export Trade on Environmental Pollution: A Study from a Heterogeneous Perspective on Environmental Regulation from China. *Sustainability* **2022**, *14*, 6330. https://doi.org/10.3390/su142416330

Academic Editors: Byung Il Park, Taewoo Roh, Jootae Kim and Jinsup Jung

Received: 18 October 2022
Accepted: 3 December 2022
Published: 7 December 2022

1. Introduction

International trade is a significant means and channel for international economic cooperation and interchange between nations, as well as the foundation and beginning point of China's opening-up to the world. Over the last four decades of reform and opening up, the Chinese people have opened roads and bridged every gap, from overcoming the hurdles of localized manufacturing to joining the globalized economy that first fueled the "China Miracle." However, the burgeoning rise of international trade and the entry of foreign money have brought capital and technology to China, while the environmental concerns such as resource depletion and ecological degradation left behind by China's long-term pursuit of extensive growth are not favorable to sustained and high-quality economic development. The ecological and environmental issues have become a global problem that all countries are facing across the world. As a result, these countries are proactively facing the challenges caused by the deterioration of the environment, because the climate changes have done great impact for the global ecological system as well as the human health and social development. At the same time, The present growth of protectionism in the global economy, the advent of counter-globalization, "economic friction between major countries," and "the breakdown of multilateral trade norms and accords" will inevitably

exacerbate global environmental threats. In the face of the current world and national conditions of increasingly urgent resource and environmental constraints, the Sixth Plenary Session of the 19th CPC Central Committee clearly pointed out that the construction of ecological civilization is a fundamental plan for the sustainable development of the Chinese nation, protecting the ecological environment is to protect the productive forces, improving the ecological environment is to develop the productive forces, and never sacrifice the environment in exchange for momentary economic growth. Also in the report of the 20th Congress of the CPC, it further stressed the need to further promote the prevention and control of environmental pollution, adhere to the precise treatment of pollution, scientific treatment of pollution, and continue to fight a good blue sky, blue water, clean soil defense. However, As the world's second-biggest economy and the world's largest developing nation, China's principal objective at this time is still economic growth, and coordinating the relationship between economic development and emission reduction has become a conundrum for large developing nations [1]. It follows that the reduction pollution and emissions to enhance development efficiency is not only a necessary requirement for China to promote the optimization and upgrading of trade in goods and achieve a high level of openness to the outside world, but also a necessary road to promote the harmonious coexistence of human beings and nature in the new era, as well as well as a promise from China to the international society that it has to keep. In the face of the dual pressures of anti globalization and environmental degradation, at the key node of China's efforts to promote the building of a trade power and a "beautiful China", there is great theoretical and policy relevance in investigating the effects of China's export trade on environmental pollution and the mechanisms behind these effects. This is true not only because it involves the reversal of China's international trade policy, but also because it concerns the country's pursuit of long-term, high-quality economic growth, and social stability.

Therefore, based on the provincial panel data of China, this paper attempts to deeply explore the mechanism of the impact of export trade on China's environmental pollution from the two dimensions of mediating effect and moderating effect by establishing a multiple mediation effect model. On the one hand, government administrative regulation, market incentive regulation and public supervision regulation are regarded as intermediary variables to test the intermediary transmission mechanism of environmental pollution caused by export trade. On the other hand, technological innovation, energy structure, industrial structure and R&D competition are regarded as moderating variables to test the moderating effect of export trade on environmental pollution. In addition, this paper also divides export trade into general trade and processing trade, so as to verify whether there are differences in the impact mechanism of heterogeneous trade modes on environmental pollution.

Copeland and Taylor incorporated a country's environmental policy into international trade and first presented the Pollution Haven Hypothesis (PHH), which asserts that the effect of free trade under varying environmental regulations in each country is that pollution increases. This theory proposes that given the differing environmental regulations of various nations, the effect of free trade is the transfer of pollution from developed to developing countries, which in turn produces environmental contamination in emerging countries [2]. Since then, several academic research has been conducted to evaluate the validity of this theory, and the majority of these articles have verified the PHH impact in terms of foreign investment [3,4]. The "pollution halo theory" reaches a conflicting result by asserting that foreign investment is advantageous to the environmental quality of the host nation [5,6]. Further research on the relationship between trade and environmental pollution indicates that trade-induced productivity gains are a significant factor in the decline of environmental pollution and that the reduction in pollution caused by trade-induced institutional change can offset the increase in pollution caused by growth and structural changes resulting from trade accessibility [7]. Furthermore, it has been suggested that trade flows do not result in a "pollution paradise effect" since the high costs of trade owing to environmental rules would be countered by cost savings due to enhanced eco-

efficiency [8]. Contrarily, Levinsen contends that international trade has a limited capacity to lower emissions of pollutants brought on by manufacturing [9], that technological advancement is the primary driver of pollution reduction, that the transfer of pollutants via trade does not diminish overall world emissions of pollutants, and that the impacts of trade on poor nations' emission reduction goals [10]. The research by Ren et al. demonstrates that China's expanding trade surplus is a major contributor to the fast growth in CO_2 emissions, and that FDI flows worsen China's CO_2 emissions [11]. It is evident that foreign experts have not reached a unified opinion about the link between international trade and environmental damage.

As China's trade expands and environmental issues deepen, an increasing number of domestic researchers are focusing on the national level and deriving the relationship between trade and environmental pollution from various study angles. Ye et al. found that trade exacerbates environmental pollution because the development of export volume exacerbates the level of environmental pollution in China owing to the comparatively high number of pollution-intensive businesses among Chinese industrial trade exporters [12,13]. A similar conclusion was reached by Hu Yi et al. in their study: exports considerably increased air pollution [14]. In contrast, Haiqing Ni and Bojie Wang et al. stated in their research that the indirect technical benefits of China's export trade might boost technology level upgrading and hence reduce environmental pollution, albeit with a twofold threshold [15,16]. Chen Dengke concluded, based on firm-level statistics, that the elimination of trade barriers in China resulted in a substantial reduction in enterprises' pollution emissions [17]. Ren Li determined the comparative advantage of environmental restrictions on trade using a gravity model, resulting in a strong negative link between environmental regulations and export trade in China [18]. Kang Zhiyong, on the other hand, argues that environmental regulation impacts China's export trade through cost effect and innovation compensation effect and that a modest carbon reduction strategy may accomplish a win-win scenario of enhancing environmental quality and export development [19].

Based on a review of the relevant literature, it is possible to deduce a few key points. First, most current studies on the link between trade and pollution concentrate on the international investment viewpoint; second, most studies on export trade and environmental pollution concentrate on the net impact of export trade on pollution; and third, few studies examine the potential beneficial indirect effects of the two. To investigate the direct impacts of export trade on environmental contamination, the majority of the available literature uses conventional panel models and threshold models. Furthermore, from the standpoint of research methods, the body of knowledge has employed traditional panel models and threshold models to examine the direct effects of export trade on environmental pollution, whereas few studies have considered heterogeneous environmental regulations as mediating variables and employed mediating effect models to examine the indirect effects of both. In light of this, the innovation of this paper in the following ways: Initially, the research content is innovative, the research focuses on the indirect impact mechanism of export trade on environmental pollution and studies the mediating effect of export on environmental pollution from three perspectives: government administrative regulation, market incentive regulation, and public supervision regulation are measured, in addition to the regulatory mechanism of export on environmental pollution in terms of technological spillover, structural optimization, and forced innovation. Moreover, in terms of research methodology, we consider heterogeneous environmental regulations as mediating variables and develop a multiple mediating effects model to test the possible mediating transmission mechanisms between variables and the moderating effects between control variables and independent variables. And finally, according to the various trade modes, the export trade is subdivided into general trade and processing trade in order to determine the effect mechanism of different trade modes on environmental pollution and its variability.

2. The Mechanism of the Role of Export Trade on Environmental Pollution

2.1. The Mechanism of Mediating Effect

2.1.1. The Intermediary Role Mechanism of Government Administrative-Type Regulation

Coase's theory states that government regulation is the primary factor in resolving environmental issues because it has the power to interfere in the emission behavior of companies via administrative orders and controls, and the intensity of government regulation is affected by the emission behavior of firms [20]. This illustrates that, from the standpoint of the game between government and firms, trade export is favorable if international trade enterprises tend to cut emissions and innovate in the manufacturing process, and unfavorable if the opposite occurs. The effect of companies' production behavior on administrative-type government regulation is partly random, and the local government's present actions about environment-related laws and regulations will be affected to some degree by the enterprises' pre-emission activity. Strict environmental rules may reduce pollution organically, but they can also reduce exports since the high cost of regulations can directly damage the international competitiveness of companies. The "Porter hypothesis" posits that adequate environmental legislation will have an incentive impact on innovation and that foreign trade businesses would spontaneously create green manufacturing technology within an acceptable cost range, hence reducing pollution emissions at their source. Accordingly, the production choices of foreign trade companies may have some influence on the behavior of the government regulatory agencies, which in turn may affect the production decisions of the firms in the future, and have an indirect effect on environmental pollution.

2.1.2. The Intermediary Mechanism of Market Incentive-Based Regulation

Through market-based regulatory instruments such as emission charges, environmental protection taxes, the issuance of tradable emission permits, and subsidies, the government incentivizes emissions companies to conduct research and development (R&D) and innovation in pollution reduction, thereby halting the underlying causes of continuous environmental degradation. In [21] the long-term use of this cutting-edge technology in the area where the businesses are situated would lower pollution emissions across the whole region, resulting in a reduction in the amount of emission fees. Similarly, in the face of intense competition on the international market, businesses may take the initiative to reduce emissions, thereby reducing the payment of emission fees. This may have a competitive imitation effect on other local businesses and a significant effect on the total amount of regional pollution emissions. Thus, export trade is expected to result in tighter market-motivated environmental regulating measures. When market incentives and environmental regulations are strengthened, it may encourage competent international export companies to further upgrade their production methods and product quality. This will support the optimization and modernization of the foreign export structure, which will ultimately contribute to a reduction in the pollution emissions of foreign trade companies. In conclusion, export trade may have a major indirect impact on environmental degradation by affecting the stringency of market-motivated environmental rules.

2.1.3. Intermediary Mechanism of Public Monitoring-Type Regulation

Trade expansion will inevitably have a stimulating influence on the economy of the home nation, and with economic growth and the enhancement of people's quality of life, it may inspire public support for environmental protection. Therefore, the expansion of trade could have a beneficial effect on regulations with public supervision. However, there is a lag period associated with this effect, and the uncertainty inherent in the emission reduction choices made by foreign trade firms affects the indirect effect of public supervised legislation on pollution. After being reported by public oversight, businesses may be motivated to alter their production practices or decrease their emissions. However, the production cost of foreign trade companies and the technical level of the firms themselves place further constraints on this incentive, and only within the cost range authorized by enterprises and the feasible technical conditions can the production choices of foreign

trade enterprises be modified properly. Therefore, it may be deduced that trade exports may have some impact on the intensity of public monitoring-type regulation, but it remains experimentally unverified whether this influence has a substantial indirect effect on environmental pollution.

2.2. Moderating Effect Mechanism of Action

Unlike intermediary variables, regulatory variables affect the direction (positive or negative) or strength of the existing relationship between independent variables and dependent variables. That is, the purpose of regulatory effects is to study how the original causal chain of independent variables and dependent variables changes under the influence of regulatory variables. Through the moderating impacts of technical innovation compensation, energy structure transformation, industrial structure optimization, and R&D competition, export trade interacts with moderating factors to worsen or mitigate environmental pollution to some degree. The action mechanism is shown in Figure 1.

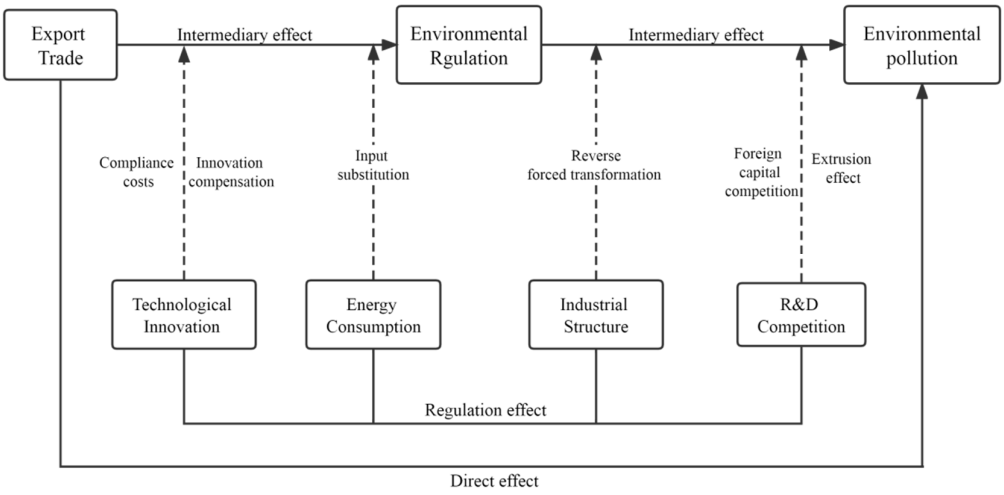

Figure 1. Flow chart of action mechanism.

2.2.1. Regulation Effect of Technological Innovation

The majority of a country's technical advancement derives from beyond its borders, and one of the primary lines of impact is the technology spillover delivered by international trade [22]. Free trade, on the one hand, intensifies worldwide competition, compelling businesses to aggressively pursue technical innovation. Moreover, by interacting with sophisticated multinational corporations in the course of international trade, businesses may become more attuned to new inventive ideas and technological levels, therefore enhancing their green technology innovation skills. However, the Porter hypothesis argues that even mild environmental regulation may benefit export businesses by encouraging them to innovate and making them more competitive in the global market via technological advancements, offsetting some of the high cost of compliance. This will mitigate a portion of the high cost of compliance, provide a compensating impact of innovation, and indirectly enhance environmental quality.

2.2.2. Effect of Energy Structure Modification

In general, the energy consumption of foreign trade companies and their pollution emissions are strongly connected; particularly for high-energy-consuming trade firms, the relationship between energy consumption and export trade will raise pollution emissions. However, businesses engaging in international trade will certainly face a slew of foreign competitors, which will have a positive impact on the efficiency with which they use their production resources, leading to increased productivity thanks in part to the contribution of inputs such as energy and other elements. Similarly, the high cost of environmental

restrictions may compel firms in energy-intensive, highly polluting sectors to actively lower their demand for fossil energy inputs [23] and seek other clean alternative inputs. Trade may also have an effect on the market-driven reform of energy consumption pricing, which compels businesses to boost their demand for clean energy and lower their use of fossil fuels.

2.2.3. Industrial Structure Adjustment Impact

Free trade promotes the movement of manufacturing materials from less productive sectors to more productive sectors, hence optimizing resource allocation and increasing firm productivity [24]. Meanwhile, the overseas income obtained by international trade businesses in the course of trade export delivers more plentiful R&D funds for companies, which allows the enterprise structure to approach new industries, thus leading to the optimization and upgrading of company industrial structure [25], all of which may have a beneficial effect on environmental pollution. It is evident that the relationship between industrial structure and export trade may have a suppressive impact on environmental pollution due to the industrial structure's regulatory influence. However, the structural optimization impact of heavily polluting businesses cannot be accomplished quickly, and if the cost burden imposed by the "cost compliance theory" is excessive, it will not result in the structural transformation of businesses.

2.2.4. Effect of R&D Competition Regulation

Foreign trade firms engage in trade exports concurrently with a substantial influx of foreign capital into the nation. Especially the arrival of vertically oriented foreign firms will also take part in the local market resources, which might boost the market competitiveness of comparable local export enterprises to some level, driving enterprises to raise investment in research and development of new industries. This may, to some degree, boost the market competitiveness of comparable local export businesses and compel them to spend more on R&D for new sectors. On the other hand, the economies of scale effect provided by free trade are beneficial to boosting the return on R&D capital of businesses, leading to an increase in revenue [26] and encouraging businesses to raise their R&D expenditure. It is apparent that businesses will raise their investment in R&D capital for their own growth and worldwide competitiveness, as well as their R&D investment in green developing sectors. However, the admission of foreign firms may also render domestic firms unduly reliant on FDI firms for technology, stifling their own desire for technological innovation and resulting in an increase in pollution rather than a reduction. Thus, it can be concluded that the interplay between FDI and export trade will result in increased pollution under the crowding-out impact of innovation, but will lessen environmental pollution under the competitive effect of R&D.

3. Variables and Models

3.1. Variable Descriptions and Data Sources

- Explained variables (*ep*). To assess the amount of pollution emissions, industrial sulfur dioxide, industrial wastewater, industrial smoke and dust emissions, and industrial solid waste production were chosen since different units of different pollutants could not be added. After standardizing the emission data of different contaminants, the entropy value approach was used to compute the comprehensive index of environmental pollution.
- Explanatory variables. Total trade (*exp)*, measured using the share of total exports of goods trade (by destination and origin) in GDP of each province; general trade (*gen)*, measured by the share of total general trade in exports of each province in total export trade; processing trade (*pro*), measured by the share of total exports of incoming processing trade in total export trade of each province.
- Mediating variables (*er*). The mediating variables in this paper are three types of environmental regulations, which are classified into three categories: government

administrative regulations (*cer)*, market incentive regulations (*mer)*, and voluntary public regulations (*ver),* drawing on the research results of Cai, Wu-Cheng et al. [27]. (i) government administrative regulation (*cer)* is measured *by* the cumulative environmental laws and regulations enacted by each province; (ii) market incentive regulation (*mer)* is measured by the annual amount of emission fees paid by each province; and (iii) public monitoring regulation *(ver) is* characterized by the annual number of environmental petitions filed by each province.

- Control variables (*CV*). (i) technology level (*tec),* inscribed by the total number of patent applications granted per million people per year in each province; (ii) energy consumption (*ener*), measured by the share of coal consumption in total energy consumption in each province; (iii) industrial structure (*is*), measured by the share of tertiary industry output in secondary industry output in each province; (iv) foreign direct investment (*fdi)*, taking into account the cumulative effect of FDI, calculated by the perpetual inventory method (v) human capital (*h), measured* by the proportion of full-time equivalent of R&D personnel to employment; (vi) economic development level (*pgdp), measured* by the real GDP per capita of each province; (vii) R&D intensity (*rd*), measured by the proportion of annual internal expenditure on R&D to the GDP of each province; (viii) environmental regulation at the national level (*penl*), measured by the number of environmental administrative penalties imposed by each province in that year. The number of environmental administrative penalties imposed in each province is used to measure the national level environmental regulation.

Taking into account the availability of data for each indicator, this study chooses panel data for 30 provinces (autonomous regions and municipalities directly under the central government) in China from 2002 to 2019, except Tibet and Hong Kong, Macao, and Taiwan. Descriptive statistics of variables are shown in Figure 1. The information shown above comes from a number of different sources, including the China Statistical Yearbook, the China Environment Yearbook, regional statistical yearbooks, the National Research Network, and the WIND database. Using 2002 as the base year, the study deflates the data of monetary variables measured in terms of money. To eliminate the influence of heteroskedasticity, all indicators excluding the ratio variables are logarithmized and expressed as ln (Table 1).

Table 1. Descriptive statistics of variables.

	Variables	Symbol	Mean Value	Standard Deviation	Minimum Value	Maximum Value
Explained variable	Pollution intensity	*ep*	3.188	2.043	0.062	9.012
Explanatory variables	Total trade	*exp*	15.347	18.489	0.550	99.29
	General trade	*gen*	62.412	21.795	1.760	99.91
	Processing trade	*pro*	28.282	19.959	0.200	130.5
	Government administrative regulations	*cer*	109.79	80.784	1.100	321.00
	Market incentive regulations	*mer*	54,523	49,960	866.0	359,000
	Voluntary public regulations	*ver*	1988	1905	2.000	20,620
Intermediary variables	Technology level	*tec*	1158.6	1708.6	23.01	10,499
	Energy consumption	*ener*	1.602	1.054	0.291	7.650
	industrial structure	*is*	10.25	5.606	4.944	51.692
	Foreign direct investment	*fdi*	45,545	82,377	157.28	647,000
	Human capital	*h*	3.701	4.193	0.240	24.670
	Economic development level	*pgdp*	27,060	20,566	3086	135,000
	R&D intensity	*rd*	1.440	1.128	0.140	7.410
	Environmental regulation at the national level	*penl*	3759.8	5482.3	1.23	45,140

3.2. Model Construction

In order to examine the baseline association between export trade and environmental contamination, the following regression model has been developed.

$$\ln ep_{it} = \alpha_0 + \beta_1 \exp_{it} + \sum_{j=1}^{n} \gamma_i CV_{ijt} + \nu_i + \delta_t + \mu_{it} \quad (1)$$

In Equation (1), i is the province, t is the year, and j is the number of control variables. α_0, β_1, and γ_i are the constant terms, explanatory variables *exp*, and coefficients to be estimated for the control variables CV. ν_i denotes individual fixed effects, δ_t indicates time fixed effects, and μ_{it} represents a random disturbance term.

To examine the presence of mediating effects of export trade on environmental pollution, where diverse environmental legislations serve as mediating factors, as well as the particular impacts of export trade on environmental pollution. Based on the findings of Freedman et al. [28], the following model of mediating impact is created.

$$\ln ep_{it} = \alpha_0 + c \exp_{it} + \sum_{j=1}^{n} \gamma_i CV_{ijt} + \nu_i + \delta_t + \varepsilon_{1it} \quad (2)$$

$$\ln ER_{ijt} = \alpha_0 + a_i \exp_{it} + \sum_{j=1}^{n} \gamma_i CV_{ijt} + \nu_i + \delta_t + \varepsilon_{2it} \quad (3)$$

$$\ln ep_{it} = \alpha_0 + c' \exp_{it} + b_i ER_{ijt} + \sum_{j=1}^{n} \gamma_i CV_{ijt} + \nu_i + \delta_t + \varepsilon_{3it} \quad (4)$$

In Equations (2)–(4), c is the parameter to be estimated for the core explanatory variable *exp*, which characterizes the total effect of export trade on environmental pollution; ln*ER is the* three mediating variables of government administrative-type regulation (ln*cer*), market incentive-type regulation (ln*mer*) and public monitoring-type regulation (ln*ver*), respectively; b_i is the estimated coefficient of the explanatory variable on the mediating variable c' is the estimated coefficient of the direct effect of the explanatory variables on the explained variables; γ_i is the coefficient to be estimated for the control variable CV, and ε_{1it}–ε_{3it} are the random disturbance terms. In the above model, the mediating effect (i.e., indirect effect) is the product of coefficients a and b, and its relationship with the total and direct effects is expressed by the following equation:

$$c = c' + ab \quad (5)$$

The moderation effect of export trade on environmental pollution is modeled as described in the following equation.

$$\begin{aligned} \ln ep_{it} = {} & \lambda_0 + \lambda_1 \exp_{it} + \lambda_2 \exp_{it} \times \ln tec_{it} + \lambda_3 \exp_{it} \times \ln ener_{it} + \lambda_4 \exp_{it} \times is_{it} + \\ & \lambda_5 \exp_{it} \times \ln fdi_{it} + \lambda_6 \exp_{it} \times rd_{it} + \sum_{i=1}^{n} \gamma_i \ln CV_{ijt} + \mu_i + \eta_t + \varepsilon_{4it} \end{aligned} \quad (6)$$

In Equation (6) γ_2–γ_5 represents the interaction term regression coefficients of export trade and the moderating variables technology level, energy consumption structure, industrial structure, FDI, and R&D investment, while λ_i is the estimated coefficient for each control variable. The remaining terms have the same meaning as in Equation (2).

Sobel test and Bootstrap test are commonly used to test the mediation effect, but the premise of using Sobel test is to assume that the estimated coefficients of the model obey the normal distribution. Usually, even if the coefficients in the above model are normally distributed, the product of the coefficients is no longer normal distribution, resulting in the calculation of its standard error can only be approximate. This increases the probability that the test results will make the first type of error [29]. The research of Preacher et al. shows

that the confidence interval obtained by the nonparametric percentile Bootstrap method with deviation correction is more accurate and more powerful than that obtained by Sobel method, so this paper uses Bootstrap method to test the intermediary effect [30].

Bootstrap method is a non parametric repeated sampling method, which has no requirements for the distribution of intermediary effects, and can effectively avoid the problem of non normal distribution of samples. In the sampling with put back, after repeatedly obtaining Bootstrap samples similar to the original samples, by calculating the product of the coefficients and the estimated value of the total effect after each sampling, the nonparametric approximate sampling distribution of the mediation effect is obtained. In this process, the intermediate effect confidence interval with 95% confidence was constructed between the 2.5th percentile and the 97.5th percentile. In order to avoid the possible deviation of the confidence interval obtained by the nonparametric percentile Bootstrap, this paper uses the nonparametric percentile Bootstrap method of deviation correction to test the intermediate effect, and adjusts the percentile of the confidence interval to correct the deviation of the estimated value of the intermediate effect.

4. Empirical Results

4.1. Baseline Regression

As a starting point for the sub-empirical analysis, considering the benchmark relationship between export trade and environmental pollution, regression analysis of Equation (1) using the variables in Table 1, Three columns of regression results indicate the use of mixed OLS regression, individual fixed effects regression, and individual and time bi-directional fixed effects regression, respectively, to analyze the benchmark model of this paper. The *p*-value of the Hausman test in the regression results is 0.000, indicating that using fixed effects to regress the model is appropriate. All three columns of regression results indicate that export trade is significantly and negatively related to environmental pollution, indicating that the growth of export trade suppresses environmental pollution and that each unit of growth in export trade can reduce the level of environmental pollution by 0.068%, which is consistent with the conclusion reached by Wang Bojie [16] et al. (Table 2).

Table 2. Baseline Test Results.

	Model 1	**Model 2**	**Model 3**
Variables	Pool OLS	FE	FE
exp	−0.107 ***	−0.070 ***	−0.068 ***
	(−3.673)	(−3.262)	(−3.068)
Constant term	0.760	−3.219 ***	−1.954
	(0.491)	(−3.420)	(−1.115)
Control variables	Yes	Yes	Yes
Individual effects	No	Yes	Yes
Time Effect	No	No	Yes
Hausman test		0.000	0.000
Adj-R^2	0.764	0.302	0.402
Sample size	540	540	540

Note: t-values in parentheses, *** $p < 0.01$.

4.2. Mediating Effect Test

The findings of the test for numerous mediating effects using the Bootstrap technique of bias reduction are shown in Table 3. Export trade lessens the intensity of government administrative-type regulation through the transmission mechanism that mediates government administrative-type regulation. But the effect of government administrative-type regulation on pollution is not significant, and as such the product of their regression coefficients is also not significant, i.e., government administrative-type regulation as a mediating variable has no significant effect on the explanatory variable, indicating that exports have no indirect effect on environmental pollution by influencing government administrative-type

regulation instruments. This outcome is due to the fact that the government's environmental statutes and regulations in the present time are impacted by the choice of foreign trade firms to cut emissions in the previous period. When international trade firms tend to cut emissions and innovate in the previous time, the government's goal in the present period is to relax regulation, thus export trade has a propensity to weaken the government's administrative regulation. Moreover, in the present era of lax government regulation, the motivation of foreign trade companies to cut emissions is waning, thus it cannot have a big impact on environmental pollution. There is no major indirect influence of export trade on government administrative regulation. Consistent with the findings of the benchmark regression, the coefficients of the direct impact and total effect regressions are negative and significant, demonstrating that China's environmental pollution is steadily decreasing with the trade of its exports.

Table 3. Results of Bootstrap test for the Mediation Effect.

Government Administrative Type Regulation					
Paths	**Coefficient/Effect**	**Estimated Value**	**S.E.**	95% **Confidence Interval**	
				Lower Limit	**Upper Limit**
ln*cer-exp*	*Coefficient a*	−0.156 ***	0.025	−0.205	−0.107
ln*ep*-ln*cer*	*Coefficient b*	0.041	0.030	−0.019	0.100
ln*ep*-ln*cer-exp*	Indirect	−0.006	0.006	−0.021	0.006
ln*ep*-ln*cer-exp*	Direct	−0.101 ***	0.025	−0.152	−0.053
ln*ep-exp*	Total	−0.106 ***	0.024	−0.158	−0.063
Market Incentive Based Regulation					
Paths	Coefficient/Effect	Estimated Value	S.E.	95% Confidence Interval	
				Lower limit	Upper limit
ln*mer-exp*	*Coefficient a*	−0.153 ***	0.020	−0.192	−0.114
ln*ep*-ln*mer*	*Coefficient b*	0.418 ***	0.033	0.354	0.483
ln*ep*-ln*mer-exp*	Indirect	−0.064 ***	0.013	−0.094	−0.041
ln*ep*-ln*me-exp*	Direct	−0.043 ***	0.021	−0.085	−0.010
ln*ep-exp*	Total	−0.107 ***	0.023	−0.154	−0.065
Public scrutiny type regulation					
Paths	Coefficient/Effect	Estimated Value	S.E.	95% Confidence Interval	
				Lower limit	Upper limit
ln*ver-exp*	*Coefficient a*	−0.016	0.032	−0.079	0.046
ln*ep*-ln*ver*	*Coefficient b*	0.127 ***	0.023	0.082	0.172
ln*ep*-ln*ver-exp*	Indirect	−0.002	0.006	−0.014	0.010
ln*ep*-ln*ver-exp*	Direct	−0.105 ***	0.023	−0.148	−0.057
ln*ep-exp*	Total	−0.107 ***	0.024	−0.149	−0.056

Note: t-values in parentheses,*** $p < 0.01$

The product of the two regression coefficients is negative, indicating that exports have a major negative indirect influence on pollution via changing market-incentive regulation. Exports can greatly reduce the amount of sewage charges from the standpoint of the intermediary transmission mechanism of market-incentive regulation, and the increase of sewage charges favorably affects environmental pollution. This is due to the fact that the variable defining the market-incentive regulation is the total amount of emission fees paid by businesses, and the lower the total amount of emission fees paid by businesses, the fewer pollutants the businesses emit, which is more conducive to the improvement

of environmental quality. On the other hand, foreign export enterprises may take the initiative to reduce emissions in response to fierce competition on the international market, thereby reducing the payment of emission fees. This will have a competitive imitation effect on other local enterprises, which will have a significant indirect suppressive effect on the total regional pollution emissions. The estimated coefficient of the direct effect is also significantly negative (−0.043), and the absolute value of the total effect coefficient increases under the influence of the negative indirect effect compared to the coefficient of the direct effect, which further verifies the indirect effect mechanism of export trade inhibiting the increase of pollution emissions by reducing the amount of emission fees paid by enterprises.

Regarding the regulatory framework that mediates public scrutiny, the export strategy of businesses has no substantial effect on public scrutiny regulation. Although public scrutiny regulation has a significant and positive influence on environmental pollution, the product of the two regression coefficients is not statistically significant, indicating that exports have no mediation effect on environmental pollution by influencing public scrutiny regulation. The above regression results indicate that, firstly, the production behavior of foreign exporters has no significant effect on public scrutiny regulation, despite the fact that an increasing number of people may participate in environmental monitoring as economic development and quality of life improve. The public's engagement in environmental monitoring is influenced by the enthusiasm for public monitoring and the type of emission enterprises in various regions; nevertheless, the export trade did not have a substantial impact on public scrutiny regulation during the national sample period. Secondly, public scrutiny has an aggravating effect on environmental pollution because businesses may alter their production tactics in response to scrutiny reports and may be pushed to minimize emissions and innovate. In addition, there is a lag in the impact of public monitoring and reporting behavior on the emission production tactics of businesses, therefore public monitoring conduct tends to increase environmental pollution.

4.3. Results of the Test for Moderating Effects

Models 1–3 are the estimation results of the regression using mixed OLS, individual fixed effects, and individual and time two-way fixed effects, respectively; the Hausman test p-value is 0.000, indicating that it is reasonable to select fixed effects for the model's regression, as model 3 fits better in the fixed effects regression. Model 3 is therefore chosen as the final explanatory model.

At the 1% significance level, the regression coefficient of the interaction term between export trade and technology level is significantly negative, indicating that foreign trade enterprises can negatively regulate the impact of trade on environmental pollution through technological innovation in the export process, thereby bringing positive environmental effects. Due to the consideration of competitiveness enhancement, foreign trade businesses may take the initiative to promote technological innovation motivation to seek a more advanced technology level in order to increase their competitiveness in the worldwide market. Moreover, the growth in export revenues of businesses will have a stimulating effect on their technical innovation capabilities. The regression coefficient of the interaction term between export trade and the energy consumption is significantly negative, indicating that export trade can positively influence the transformation and upgrading of energy consumption structure and bring about a negative regulatory effect on pollution when both variables interact. Due to the intense competition in the international market, foreign trade enterprises will be motivated to transform and upgrade their energy structure. Environmental regulations can also have a pull effect on energy structure transformation and upgrading, thereby preventing the growth of pollution emissions at the source. The coefficient of the interaction term between export trade and industrial structure is negative but insignificant, indicating that the interaction between export trade and industrial structure has no detrimental influence on pollution regulation through its optimal transformation. This is due to the fact that, even though the structural transformation of foreign

trade enterprises (primarily some heavy pollution enterprises) is subject to an increase in input costs, environmental regulation pressure does not serve the purpose of compelling enterprises to transform and upgrade in order to reduce pollution emissions. As part of the transformation and upgrading of Chinese trade companies, the transition from processing trade to general trade constitutes a substantial portion of the trade's primary transformation method, Changing how exports are handled is likewise an example of structural upgrading, but this is a double-edged sword because it means that trade export mode transformation is itself an example of structural upgrading. Despite the fact that the transformation of trade export mode is also a kind of structural transformation and upgrading, the majority of Chinese processing trade companies have remained in the mode of primary production for a long time, with fewer high-end production links. Even though these businesses have accomplished the initial transformation and upgrading, there is still a significant gap between their technical level and that of mature general trade businesses; consequently, they are unable to achieve the effects of emission reduction and innovation in the near future (Table 4). The regression coefficient of the regression coefficient of the Interaction term between export trade and FDI is positive, but insignificant, indicating that the interaction between FDI and export trade does not have a significant effect on environmental pollution, i.e., the current entry of foreign capital does not have a significant competitive incentive effect on Chinese trade exporters, and therefore cannot have a positive indirect effect on the emission reduction behavior of firms. The significant positive regression coefficient of the interaction between export trade and R&D level indicates that export trade does not negatively regulate pollution emissions by compelling enterprises to increase R&D investment, indicating that China's export trade may be displacing R&D investment. However, foreign trade enterprises may be motivated to increase green R&D investment due to international competitiveness considerations, but this motivation is insufficient. Although international competitiveness may inspire foreign trade companies to expand green R&D expenditure, this motivation is undermined by the "crowding out effect," which increases rather than decreases the detrimental impact of their involvement in environmental pollution (Table 4).

Table 4. Test Results for the Adjustment Effect.

Variables	Model 1 Pool OLS	Model 2 FE	Model 3 FE
$exp \times \ln tec$	0.048	−0.079 ***	−0.074 ***
	(0.729)	(−3.596)	(−3.567)
$exp \times \ln ener$	0.134	−0.114 *	−0.112 *
	(0.878)	(−1.844)	(−1.919)
$exp \times is$	−0.335 *	−0.003	−0.008
	(−1.776)	(−0.068)	(−0.227)
$exp \times \ln fdi$	0.081 **	0.024	0.035
	(2.175)	(0.851)	(1.343)
$exp \times rd$	0.150 *	0.181 ***	0.153 ***
	(1.972)	(7.807)	(6.817)
Constant Term	1.079	−0.682	−1.727
	(1.043)	(−0.695)	(−1.055)
Other Variables	Yes	Yes	Yes
Individual Effects	No	Yes	Yes
Time Effect	No	No	Yes
Hausman Test		0.000	0.000
Adj-R^2	0.654	0.479	0.569
Sample Size	540	540	540

Note: t-values in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Heterogeneity Analysis

Due to the fact that China's foreign trade consists primarily of processing trade and general trade, and that the production mode and production efficiency of general trade enterprises differ from those of processing trade enterprises, the aforementioned analysis

mechanism may exhibit heterogeneity due to the different export trade structures. In order to investigate the influence mechanism of different trade modes on environmental pollution and their differences, the Chinese export trade is subdivided further into general trade and processing trade for regression analysis.

5.1. Heterogeneity Analysis of Mediating Effects

In terms of direct and total effects, The regression coefficient of the general trade is significantly and positively related to environmental pollution, because all production stages of general trade are conducted domestically, and the demand for energy and resources and other factor inputs is greater than that of processing trade, resulting in higher emission needs than processing trade, so the expansion of general trade is positively related to environmental pollution. When market incentive-based regulation is the mediating variable, only then is the mediating effect of general trade on environmental pollution substantial, but general trade increases the total amount of emission charges, which is the variable defining market incentive-based regulation. Environmental pollution is positively associated with market incentive-based regulation, hence the product of the two coefficients is positive, indicating that general trade indirectly increases environmental pollution by influencing market incentive-based regulation, and revealing that international trade indirectly contributes to environmental degradation by influencing market incentive regulation (Table 5).

This is attributable to the reality that general trade has a greater demand for pollutant discharge than processing trade. Moreover, the transition from processing to general trade in China has been gaining momentum as the country's trade structure has been modernized and expanded. Although the transformation of processing trade into general trade indicates the improvement of trade firms' scale, technology, and expertise [31], it also raises the demand for energy resources and other factor inputs, leading to an increase in pollutant emissions. The general trade regression coefficients on government administrative regulation and public supervision regulation are not significant. Although both government strong administrative control and public oversight regulation have positive and statistically significant effects on pollution levels in the environment, the product coefficients describing their mediating effects are no longer statistically significant.

The regression coefficients of both direct and total effects are significantly negative, indicating that processing trade is significantly and negatively related to environmental pollution. This is due to the fact that the production method corresponding to processing trade is labor-intensive, rarely requiring energy resources such as coal, and therefore not leading to an increase in pollution. According to the results of the test of the mediating effect, processing trade has a considerable negative indirect influence on environmental pollution by considerably influencing government administrative regulations and market incentive regulations. First, processing trade has a negative influence on government administrative regulation, and government administrative regulation increases pollution; therefore, the product of the two coefficients is strongly negative, and the mediating effect is negative. Second, processing trade tends to reduce the emission fee, which is the variable defining market incentive regulation, and market incentive regulation is positively associated with environmental pollution, so the product of the two coefficients is negative, i.e., the mediating effect of processing trade on environmental pollution under market incentive regulation is negative. This implies that processing trade indirectly reduces environmental pollution through market-incentive regulation, as the production method of processing trade is cleaner than that of general trade. Consequently, the total amount of emission fees of foreign trade enterprises tends to decrease as processing trade exports increase. Although the coefficient of the direct influence of the explanatory variable on the explanatory variable is significant, the product of the two is no longer significant; therefore, neither is its mediating effect (Table 5).

Table 5. Heterogeneity test Results for the Intermediation Effect.

General Trade						
	Paths	**Coefficient/ Effect**	**Estimated Value**	**S.E.**	**95% Confidence Interval**	
					Lower Limit	**Upper Limit**
Government Administration Type	ln*cer-gen*	*Coefficient a*	0.014	0.017	−0.019	0.046
	ln*ep*-ln*cer*	*Coefficient b*	0.184 ***	0.036	0.113	0.255
	ln*ep*-ln*cer-exp*	Indirect	0.003	0.004	−0.006	0.011
	ln*ep*-ln*cer-exp*	Direct	0.060 ***	0.019	0.023	0.095
	ln*ep-exp*	Total	0.063 ***	0.020	0.025	0.100
Market Incentive Type	ln*mer-exp*	*Coefficient a*	0.042 ***	0.016	0.010	0.073
	ln*ep*-ln*mer*	*Coefficient b*	0.607 ***	0.028	0.551	0.662
	ln*ep*-ln*mer-exp*	Indirect	0.025 ***	0.013	0.002	0.051
	ln*ep*-ln*me-exp*	Direct	0.038 ***	0.014	0.011	0.064
	ln*ep-exp*	Total	0.063 ***	0.019	0.025	0.098
Public Monitoring type	ln*ver-exp*	*Coefficient a*	−0.007	0.22	−0.052	0.037
	ln*ep*-ln*ver*	*Coefficient b*	0.282 ***	0.024	0.235	0.330
	ln*ep*-ln*ver-exp*	Indirect	−0.002	0.009	−0.018	0.017
	ln*ep*-ln*ver-exp*	Direct	0.065 ***	0.017	0.032	0.098
	ln*ep-exp*	Total	0063 ***	0.019	0.026	0.101
Processing Trade						
	Paths	Coefficient/ Effect	Estimated value	S.E.	95% confidence interval	
					Lower limit	Upper limit
Government Administration Type	ln*cer-exp*	*Coefficient a*	−0.074 ***	0.019	−0.001	−0.037
	ln*ep*-ln*cer*	*Coefficient b*	0.138 ***	0.035	0.070	0.206
	ln*ep*-ln*cer-exp*	Indirect	−0.010 ***	0.005	−0.025	−0.003
	ln*ep*-ln*cer-exp*	Direct	−0.135 ***	0.020	−0.175	−0.096
	ln*ep-exp*	Total	−0.145 ***	0.020	−0.184	−0.107
Market Incentive Type	ln*mer-exp*	*Coefficient a*	−0.132 ***	0.017	−0.167	0.098
	ln*ep*-ln*mer*	*Coefficient b*	0.566 ***	0.029	0.509	0.623
	ln*ep*-ln*mer-exp*	Indirect	−0.075 ***	0.015	−0.104	−0.048
	ln*ep*-ln*me-exp*	Direct	−0.070 ***	0.017	−0.103	−0.037
	lnep-exp	Total	−0.145 ***	0.021	−0.186	−0.106
Public Monitoring type	ln*ver-exp*	*Coefficient a*	0.038	0.044	−0.048	0.125
	ln*ep*-ln*ver*	*Coefficient b*	0.283 ***	0.025	0.234	0.332
	ln*ep*-ln*ver-exp*	Indirect	0.011	0.016	−0.189	0.044
	ln*ep*-ln*ver-exp*	Direct	−0.066 ***	0.034	−0.133	−0.002
	ln*ep-exp*	Total	−0.055 ***	0.038	−0.127	−0.022

Note: t-values in parentheses, *** $p < 0.01$.

5.2. Heterogeneity Analysis of the Moderating Effect

Models 1 to 6 are regression estimates of the moderating effects of general trade and processing trade, where the results of the Hausman test indicate that a fixed-effects model is appropriate for regression analysis. Models 3 and 6 are selected as the final explanatory models because the estimation findings of the two-way fixed-effects model fit better when accounted for.

The regression coefficient of the interaction term between general trade and technology level has a significantly positive regression coefficient, indicating that the relationship between general trade exports and technological innovation worsens environmental pollution. The coefficients of the interaction term between general trade and energy consumption, industrial structure, FDI, and R&D investment are all significantly negative, indicating that exports of general trade can negatively regulate the original negative environmental impact of general trade by adjusting energy consumption structure, optimizing industrial structure, and promoting R&D competition, etc. Possible causes for the aforementioned outcomes are: First, general trade enterprises have a higher initial requirement for energy

inputs than manufacturing businesses. However, as a result of increased competition in the global market, general trade enterprises may have a superiority effect on the allocation of production resources, resulting in the transfer of energy and other input factors to enterprises with higher productivity, thereby optimizing the energy structure. Secondly, the long-term accumulated R&D achievements and production technology of general trade enterprises provide a solid support for their transformation and upgrading. Furthermore, the overseas earnings obtained in trade exports also assist the enterprise structure to new industries, thereby achieving the goal of pollution reduction and emission reduction by optimizing the industrial structure. Finally, the entry of FDI will generate competition to local general trade export enterprises (Table 6).

Finally, a country's general trade exporters may benefit from the competitive pressures wrought by the arrival of FDI, compelling enterprises to increase investment in research and development funds; the increase in investment in research and development will inevitably have a positive impact on enterprise green technology innovation, thereby facilitating the achievement of pollution reduction and emission reduction.

The regression coefficient of the interaction term between processing trade and technology level is strongly negative, indicating that the interaction between processing trade and technological innovation can, in fact, play an indirect role in preventing the growth of pollution. The fact that the interaction coefficients of processing trade with energy consumption, foreign direct investment, and R&D expenditure are all strongly positive indicates that processing trade greatly exacerbates environmental pollution through interaction with the factors listed above. The explanations for these outcomes are: First, processing trade does not involve the consumption and use of local energy resources, and it may only interact with energy consumption through the process of general trade transformation. The relationship between processing trade and energy consumption tends to degrade the environment as a result of the shift in the production mode of commercial companies, which necessitates more energy resources and increases their pollution emissions. Second, since the production method of processing trade companies is very simple and rarely includes high-end production, it has no competitive incentive effect on FDI firms joining the local market. Finally, processing trade firms are not directly involved in the research and development of new technologies in the production process; as a result, they are unable to connect with the R&D investment to reduce pollution (Table 6).

Table 6. The Heterogeneity test Results for the Moderating Effects.

General Trade				Processing Trade			
Variables	**Model 1**	**Model 2**	**Model 3**	**Variables**	**Model 4**	**Model 5**	**Model 6**
	Pool OLS	**FE**	**FE**		**Pool OLS**	**FE**	**FE**
gen×ln*tec*	−0.087 ***	0.041 ***	0.041 ***	*pro*×ln*tec*	0.054	−0.037 ***	−0.027 ***
	(−2.798)	(4.074)	(4.344)		(1.210)	(−3.519)	(−2.722)
gen×ln*ener*	−0.154 *	−0.104 ***	−0.100 ***	*pro*×ln*ener*	0.105	0.098 ***	0.107 ***
	(−1.978)	(−4.847)	(−4.970)		(0.990)	(4.610)	(5.492)
gen×*is*	−0.047	−0.041 ***	−0.049 ***	*pro*×*is*	0.011	0.030 **	0.022
	(−1.077)	(−3.377)	(−4.363)		(0.142)	(1.979)	(1.580)
gen×ln*fdi*	0.023	−0.053 ***	−0.052 ***	*pro*×ln*fdi*	−0.015	0.035 ***	0.036 ***
	(1.065)	(−4.909)	(−4.983)		(−0.799)	(3.847)	(4.230)
gen×*rd*	−0.001	−0.050 ***	−0.051 ***	*pro*×*rd*	0.003	0.078 ***	0.077 ***
	(−0.044)	(−5.336)	(−5.904)		(0.057)	(7.037)	(7.532)
Constant term	−3.074	−6.784 ***	−7.841 ***	Constant term	1.820	−0.799	−0.972
	(−1.184)	(−5.992)	(−4.416)		(1.062)	(−0.908)	(−0.617)
Other Variables	Y	Y	Y	Other Variables	Y	Y	Y
Individual effects	N	Y	Y	Individual effects	N	Y	Y
Time Effect	N	N	Y	Time Effect	N	N	Y
Hausma test		0.000	0.000	Hausman test		0.000	0.000
Adj−R^2	0.783	0.442	0.549	Adj−R^2	0.775	0.458	0.568
Sample size	540	540	540	Sample size	540	540	540

Note: t-values in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6. Conclusions and Policy Recommendations

Using the inter-provincial panel data of China from 2002 to 2019, we empirically examine the mechanism of the effect of export trade on environmental pollution by creating a multiple mediating effect model and a moderating effect model. We further classify export trade into general trade and processing trade to determine whether there is any heterogeneity in the aforementioned mechanism of effect depending on the trade mode. The following are the conclusions: (i) export trade has a substantial direct inhibitory effect on environmental pollution; therefore, the expansion of trade is favorable to China's environmental position. (ii) Whether export trade can support pollution reduction by mediating environmental regulation depends on the type of environmental regulation instrument, which has only an indirect inhibitory effect on environmental pollution by influencing market-incentivized regulation, while the mediating effect of government-administered and public-supervised regulation is insignificant. (iii) Export trade has a strong negative moderating influence on environmental pollution via routes such as compelling technical innovation and encouraging energy structure transformation, which has the effect of further enhancing environmental quality. (iv) In terms of the mediating effect, the heterogeneity test results indicate that general trade exacerbates environmental pollution through market-incentivized regulation, whereas processing trade has a significant negative mediating effect on environmental pollution by influencing government administrative regulation and market-incentivized regulation. In terms of the regulation effect, the positive effect of general trade on pollution emission is diminished by the regulation effect of energy structure upgrading, industrial structure optimization, and R&D competition effect, whereas processing trade can only negatively regulate environmental pollution via the interaction effect with technological innovation. The significance of the preceding findings is as follows:

(i) Local governments should provide stronger policy and financial support for firms to carry out green technology research and development innovation in order to play a role in expanding international trade, to consolidate the scale of trade on the basis of further enhancing the quality of exports, and to optimize the trade structure, particularly for those with high value-added low-carbon sectors.

(ii) Considering the indirect restraining effect of export trade on environmental pollution by influencing market incentive-type regulation, the government should also create

a good market environment for the development of foreign trade companies when collecting emission fees on the condition of adhering to the established criteria. In addition, the government should use economic leverage to compel enterprises to prioritize pollution reduction and emission reduction in their production processes, so as to foster an environment conducive to the realization of the competitive imitation effect of foreign trade enterprises, and it should be consistent in its environmental policies. In order to discourage rent-seeking behavior, the government should maintain uniformity in the policy implementation process.

(iii) Promote cooperation and exchange between foreign trade enterprises and advanced energy enterprises around the world; aid inter-country energy cooperation and new energy research and development; encourage enterprises to use clean energy and renewable energy, and realize industrial structure upgrading to a greater extent. However, in order to create a win-win situation of transformation and upgrading and green growth, local governments in China need to actively give financial, technical, and policy support for processing trade transformation firms, encourage enterprises to carry out green technological innovation and promote trade transformation enterprises.

(iv) The following must be put into practice: emphasizing the beneficial regulatory impact of general trade exports on environmental pollution; optimizing the international market layout and trade export structure based on the strategic deployment of the international and domestic double cycle; incorporating scientific and technological innovation in the field of foreign trade with the high-quality development of the domestic market, and strengthening domestic and international cooperation in the high-tech industry chain; realizing the optimal allocation of resources in the global context, and further enhancing the value chain and industrial chain. The degree of the domestic industry will elevate the premium market. In the process of transforming and upgrading processing trade to general trade, the short-term worsening effect of environmental pollution must be sensibly evaluated. In addition to supplementing certain regulations of foreign trade transformation enterprises with policy support and moderate regulation, and actively encouraging and guiding enterprises to innovate and upgrade green technology, government departments should provide relevant policy support to such enterprises.

Although this paper provides some references and draws some meaningful conclusions for the impact of export trade on China's environmental pollution through empirical analysis, However, the measurement of environmental regulation has always been a difficulty in the study of environmental regulation and economic development, which is the main reason why many empirical studies have not reached the same results. Therefore, the research results may be biased because the selection of environmental regulation proxy indicators can not fully measure the rigor of environmental regulation, resulting in some deviations in the results. In future studies, we will continue to devote ourselves to solving the above problems and find scientific measurement methods to measure environmental regulation variables more accurately. In addition, in future studies, we will take micro enterprises as the basis to study the impact of export trade on China's environmental pollution at the enterprise level, so that the research conclusions of this paper can be supported by micro evidence.

Author Contributions: H.L.: Review & Editing & methodology; X.Q.: supervision & software; Y.H.: funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Chinese Ministry of Education Philosophy and Social Science Research Major Project Fund (18JZD035), Social Science Foundation of Shaanxi Province (2021D054, 2021D053), Social Science Foundation of Shaanxi province Department of Education (2022HZ1118), China Statistical Science Research Project (2022LY061), Fundamental Research Funds of Xi'an Jiaotong University (Special Project of the 20th National Congress of the CPC) (SK2022133).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

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