



Empirical Study on the Relations between China's Export Trade Development and Environmental Pollution

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ABSTRACT

China's foreign trade has greatly improved, and its export trade has grown steadily for a long time, thus providing a solid foundation for economic prosperity and development. However, environmental pollution caused by export trade has become increasingly prominent due to an extensive export trade model with low pollution punishment standards and ineffective government policy and management. To analyse the causes of environmental pollution caused by China's export trade and to quantitatively measure the relations between export trade and environmental pollution, the literature on the relations between China and other countries export trade and environmental pollution is firstly reviewed. Then, the cointegration measurement method is adopted to quantitatively measure the above relations. Existing literature indicates an uncertain relationship between foreign trade development and environmental pollution, wherein three viewpoints exist, namely, adverse, beneficial, and complex theories. Considerable pollution-intensive and resource-intensive industries, lacking of environmental protection awareness of enterprises, and insufficient environmental protection management of export trade by the government are the principal reasons for environmental pollution caused by export trade. Furthermore, a long-term cointegration relationship exists among industrial gas emissions, industrial solid waste emissions, industrial wastewater discharges, and total exports. Granger causality tests of industrial gas emissions and industrial solid waste emissions present the changes in total exports. The results have a positive reference value for further understanding the relationship between environmental pollution and export trade, thereby promoting the development of trade economy and ecological environment, and strengthening environmental regulation and supervision in export trade.

INTRODUCTION

In recent years, the rapid development of foreign trade has contributed considerably to China's economic growth and social welfare. However, environmental problems caused by the expansion of trade have become increasingly prominent. On the one hand, the expansion of economic activities has increased the consumption of resources as one effect of trade openness, resulting in the destruction of the ecological environment. Moreover, an upward trend in the export trade leads to increased pollution emissions because of the large proportion of pollution-intensive products. On the other hand, the further improvement of foreign trade can produce new technologies and methods that can contribute to the improvement of environmental conditions. Export trade can directly affect the environment through changes in resource consumption, or acting on income, international specialized division of labour, and technical regulations can also indirectly affect the environmental changes.

Table 1 shows that China's foreign trade has grown rapidly, with the total export of goods increasing by almost double from \$968.9 billion in 2006 to \$2097.4 billion in

2016. Thus, China has become the world's largest trading nation. Trade openness promotes economic exchange between China and other countries, enabling China to introduce innovative industries and efficient clean technologies, so as to promote the optimization of its industrial and energy structures, and reduce the negative effect of economic development on the environment. However, trade openness increases carbon emissions, which gives rise to a series of ecological and environmental problems.

PREVIOUS STUDIES

Considering the relationship between export trade and environmental pollution, a considerable amount of research has been conducted in all over the world, but conclusions are inconsistent. Three main views exist with regard to the effects of trade openness on the adverse, beneficial, and complex effects of pollution emissions. In terms of the increase in environmental pollution caused by foreign trade, Daly et al. (1994) believed that the damage caused by free trade to the environment free trade was particularly prominent in developing countries. Chichilnisky (1994) pointed out that in the case of unclear private property rights, free

Table 1: Foreign trade fast growth of China.

Years	Total Trade Volume (100 million US dollars)
2006	9689.40
2007	12180.15
2008	14285.46
2009	12016.12
2010	15779.32
2011	18985.95
2012	20490.00
2013	22100.00
2014	23427.00
2015	22749.50
2016	20974.37

(Data from the website of the National Bureau of Statistics of China: <http://www.stats.gov.cn>)

trade would lead to the further deterioration of the environment in developing countries, which in turn would threaten the global environment. Ang (2009) believed that developing countries such as China have low environmental standards with loose environmental controls, thus providing a "pollution shelter" for developed countries via import and export trades. Weber et al. (2008) considered the real situation of China and believed that carbon leakage and carbon export were the main reasons for carbon emission increase. Eisenbarth (2017) analysed whether China's export tax rebate and export tax were affected by environmental factors and found that almost no evidence could prove that export tax was imposed for environmental considerations. Solarin et al. (2017) showed that the gross product, foreign direct investment, urban population financial development, and international trade of Ghana had positive effects on CO₂ emissions. Liu et al. (2017) indicated that China's demand was the main factor in the increase in waste air emissions; a large number of construction projects were the major cause of increased SO₂ emissions. In research on the beneficial effects of trade openness on pollution emissions, Birdsall et al. (1993) believed that free trade allowed environmental standards of higher industrial countries to be transmitted to developing countries. Thus, the increased trade openness of a country would lead to a more conducive situation for the advancement of clean production technology, and the use of clean technology would inevitably improve the quality of the environment. Through an analysis of trade reforms in Indonesia, Anderson et al. (1999) divided the effect of trade on air pollution into total activity, interdepartmental, and technical effects, and found that trade liberalization was conducive to environmental improvement and increased social welfare. Antweiler et al. (2001) established a model that evaluated the effect of international trade on the environment. Empirical results showed that

trade liberalization may reduce overall pollution. Dean (2002) demonstrated that free trade would increase environmental pollution in the short term, but increase in national income brought about by free trade would alleviate this negative effect in the long run (Dean 2002). Hoffmann et al. (2005) held that trade openness affected the environment through scale, structural, and technological effects, and that whether the specific effect was positive or negative depended on the sum of the three effects. Fung et al. (2007) showed that the environmental effect of trade liberalization depended mainly on two factors, namely, the nature of pollution and the degree of national trade liberalization. McAusland et al. (2013) compared the different influences of China and international trade on the environment and found that the former would increase pollution emissions, whereas the latter could reduce pollution emissions. Existing literature has shown that the dynamic relationship between foreign trade development and environmental pollution is related to the researchers' index selection, research time, and research methods. Most scholars conducted linear regression analysis of the relationship between foreign trade and environmental pollution without considering that the overall effect of foreign trade may be nonlinear. In addition, most scholars used SO₂ or industrial emissions to measure the degree of environmental pollution or simply assigned a weight for the industrial "three wastes" indicator. A cointegration research method is adopted to explore whether a significant nonlinear effect exists in foreign trade and environmental pollution. Furthermore, the more indicators are selected for the comprehensive consideration of the emissions of exhaust gas, wastewater discharge, and solid waste to verify the scientific results.

REASONS FOR ENVIRONMENTAL POLLUTION CAUSED BY EXPORT TRADE

Pollution-intensive industries account for a large proportion of total exports: Pollution-intensive industrial products account for a relatively high proportion of China's export trade and cause many serious environmental pollution problems. Pollution-intensive industries are those that directly or indirectly produce large amounts of pollution that are not effectively treated during production. Such industries are marked by great damage to the ecological environment and human health, increased difficulty in handling, undeveloped pollution prevention and control, safety hazards to workers' health during operation processes, and inferior environmental management-related policies and regulations. Pollution-intensive products, such as textile, chemical, paper, and metal-rolled products, still account for a large proportion of the export structure in China and cause

excessive damage to water, atmosphere, and other ecological resources, as shown in Fig. 1. Such products have been exhibiting a relatively increasing trend in recent years, thereby imposing a heavy burden on the fragile ecological environment.

Considerable resource-intensive industries: Resource-intensive products have accounted for a relatively high proportion in China's exports. Although the proportion has declined in recent years, the absolute amount is still large. China is the world's largest exporter of rare earth resources,

such as precious metals, rare earth metals, radioactive elements, and other isotopic organic and inorganic compounds, shown in Fig. 2. The long-term export of rare earth resources at low prices and large quantities poses major challenges to resource protection. Some regions depend on cheap resources for export to develop their foreign trade due to financial and technological constraints. However, such actions are not conducive to the sustainable development of these regions and improvement of export competitiveness in the long run, and the effects on resource exhaustion and

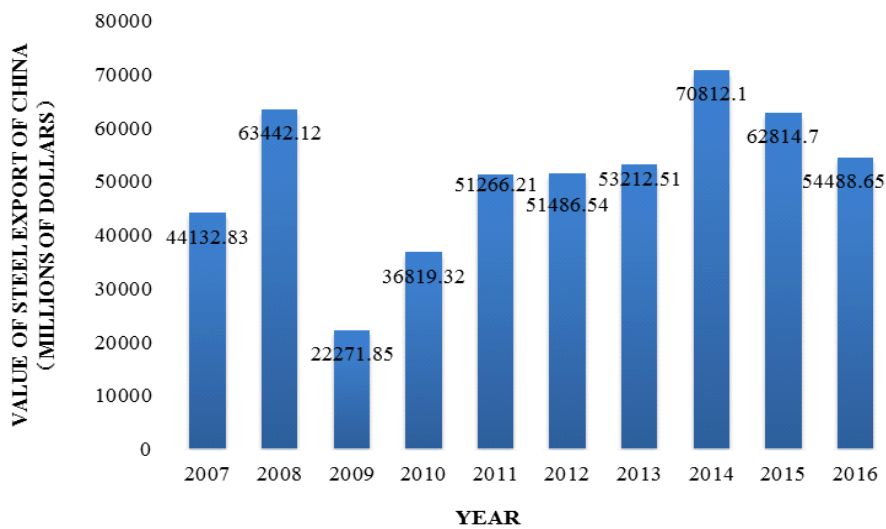


Fig. 1: Value of steel export of china in 2007-2016.

(Data from the website of the National Bureau of Statistics of China: <http://www.stats.gov.cn>)

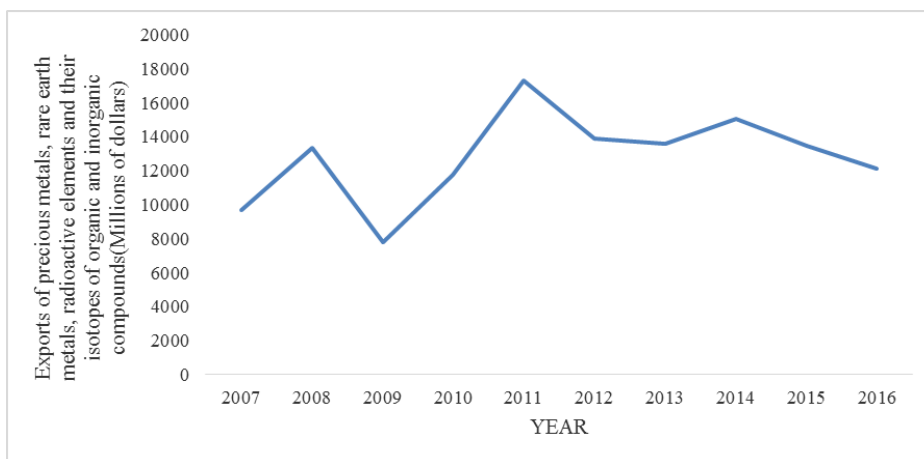


Fig. 2: Exports of precious metals, rare earth metals, radioactive elements and their isotopic organic and inorganic compounds in china from 2007 to 2016.

(Data from the website of the National Bureau of Statistics of China: <http://www.stats.gov.cn>)

environmental pollution are irreversible. The value of many resource-based products in the international market remains high and shows a rising trend year after year, policy adjustments have been unable to curb the substantial growth of resource-based product exports in the face of high profits, which has also led to the increasing depletion of resources in China.

Lack of environmental protection awareness of export enterprises: China has been pursuing its economic interests for a long time. A general lack of environmental protection awareness among export enterprises and the neglect of production technology improvement and economic efficiency have caused the long-term problems of slow progress in legislation and loose management of resources and environmental protection. Many export townships and village enterprises are mainly engaged in copper, papermaking, processing, coking, cement, and electroplating industries, which brings great security risks and environmental damage to their areas. Accordingly, the government is also beset with issues, such as one-sided pursuit of export indicators regardless of environmental protection and law enforcement.

Insufficient environmental protection management of export trade by the government: At present, the situation of China's environmental use system and government management policies has led to the externalization of corporate environmental costs to a certain extent. The current environmental management policy is insufficient and a complete system that considers the environmental cost of enterprises is lacking, thus causing the price of knowledge to deviate from the cost, which further leads to an unreasonable structure in China's industrial trade. Internalization of environmental costs can alleviate problems and conflicts caused by the serious mismatch between export trade development and environmental carrying capacity, which is an effective way to solve the above mentioned problems. Strengthening environmental legislation as the focus of government environmental work is necessary in future government legislative processes, so as to ensure that internalization of environmental costs can be effectively implemented.

RELATIONSHIP BETWEEN CHINA'S FOREIGN TRADE AND ENVIRONMENTAL POLLUTION

Indicator selection and data description: On the basis of available and scientific data, the following three indicators are selected to measure the degree of environmental pollution: industrial waste gas emissions (Y1), industrial solid waste emissions (Y2), and industrial wastewater discharge (Y3). Total export (X) is used as an indicator of export trade. The relationship between China's export trade and environ-

mental pollution was empirically analysed by using cointegration and Granger causality tests based on EViews7.0 software. The data are obtained from the National Bureau of Statistics website (<http://www.stats.gov.cn>).

Unit root test: Before examining the cointegration relationship between the total export value and the environmental pollutant emission index, the stability of each variable needs to be checked. Otherwise, spurious regression errors may occur. The ADF method is used to test the sequence stability. The results are shown in Table 2.

Table 2 shows that the variables are unstable under the horizontal sequence. After the first-order difference, the variables tend to be stable, which establishes a foundation for further cointegration testing.

Cointegration test: In time series analysis, time series data that are traditionally required to be used must be stable, without a random trend or a certain trend. Otherwise, spurious regression errors may occur. However, time series data in a real economy are usually nonstationary. Therefore, nonstationary time series data can be differentiated as stable, but this will lose the long-term information of the total, which is necessary for analyzing the problem. Hence, the cointegration test can be used to solve the problem. The study attempts to test each variable and determine whether a long-term stable relationship exists between them, that is, whether the variables are cointegrated. Based on the EViews 7.0 calculation, the results are shown in Table 3.

Table 3 presents a satisfactory goodness of fit of the straight line among industrial waste gas emissions and total exports, and industrial solid waste emissions and total exports, reaching more than 90% to 96%. The result indicates that export trade has a direct influence on environmental pollution. Positive coefficient values imply that the growth of export volume increases the environmental pollution. The regression coefficient T value is greater than 2, thereby also reflecting the significance of the coefficient. However, the influence of export trade growth on industrial wastewater is unclear. Although the P value of regression analysis passed the test, the goodness of fit is only approximately 45%, which cannot directly explain the influence of export trade on environmental pollution, especially on industrial wastewater discharge.

Granger causality test: The Granger causality test analyses the causal relationship between time series variables. The results of cointegration analysis reflect whether a long-term stable equilibrium relationship exists among the variables, but whether the relationship constitutes causality needs further verification. Considering the effective time lag that usually occurs in an economy, the relationship between X and Y1, Y2, and Y3 of each period of lag order in

Table 2: ADF stability test.

Variable	ADF Value	Critical Value	Conclusion
X	-2.84	-3.18**	Unstable
Y1	-1.64	-3.47***	Unstable
Y2	-0.68	-2.98*	Unstable
Y3	-3.41	-3.64**	Unstable
D(X)	-4.14	-3.45**	Stable
D(Y1)	-5.04	-3.65*	Stable
D(Y2)	-5.74	-4.52**	Stable
D(Y3)	-3.25	-3.84*	Stable

(*, **, and *** represent the significance levels of 1%, 5%, and 10%, respectively. D represents the first-order difference.)

Table 3: Cointegration regression results of total exports and environmental pollution.

Variable	Constant Term	Regression Coefficient	T value	Adjusted R-Square
Y1	8475.41	6.54	10.24	0.92
Y2	5412.52	3.65	4.54	0.96
Y3	49.65	0.014	3.12	0.45

Table 4: Granger causality test.

Null hypothesis	Lag Order	P Value	Conclusion
Y1 is not the Granger cause of X	2	0.006	Accept
X is not the Granger cause of Y1	2	0.142	Refuse
Y2 is not the Granger cause of X	2	0.045	Accept
X is not the Granger cause of Y2	2	0.472	Refuse
Y3 is not the Granger cause of X	2	0.007	Accept
X is not the Granger cause of Y3	2	0.006	Accept

the test of causality of time series is examined. Table 4 presents the results.

The test results show that in the case of the second phase of lag, at the 5% significance level, it is rejected. Thus, X is not the Granger cause of Y1 and Y2, that is to say, X is the Granger cause of Y1 and Y2. Therefore, the null hypothesis is accepted. The finding shows that changes in total exports are responsible for changes in industrial emissions and industrial solid waste emissions, and changes in total exports do not result in changes in industrial wastewater discharges. The conclusions are inconsistent with the existing literature, and the length of time selected affects the results to a certain extent.

MEASURES TO CONTROL ENVIRONMENTAL POLLUTION CAUSED BY EXPORT TRADE

Accelerate industrial restructuring and develop environmentally friendly export industries: China is a country with relatively abundant labour resources. Thus, effecting

short-term qualitative changes is difficult. Therefore, promoting scientific and technological progress and technological innovation is the fundamental way to change the country's commodity structure. The government should strengthen guidance from export-oriented enterprises at the policy level and introduce a series of related planning measures to encourage the development of environmental protection and green industries, enhance the incentives for enterprises to strengthen innovation, and enable enterprises to quickly adapt to the continuously changing international market environment. In the context of technological advancement characterized by the Internet and Big Data, China should strengthen its investment in advanced technology research and development, and selectively introduce and absorb foreign advanced theories. Various financial means must be used to encourage enterprises and increase investment in innovation research, increase the introduction of talents, focus on the absorption of imported technologies, and encourage enterprises and individuals to innovate. Protecting the intellectual property rights of enterprises can stimulate the innovation potential of enterprises and individuals, thus improving the technical content and added value of export commodities and reducing the energy consumption per unit product.

Enhance the scientific and technological content of export products and improve the environmental protection standards of products: At present, low labour cost is mainly stated as the comparative advantage of China's export products, but such an advantage does not predominate in environmental competitiveness with low environmental standards. Export trade development strategy, which depends heavily on price advantage and is bound to continue, must be improved to strengthen the international competitiveness of exports. A sustainable economic and foreign trade strategy is necessary and environmental protection must be considered an opportunity to enhance the capability of foreign trade enterprises, explore the international market, and obtain excess profits. On the basis of the environmental protection standards of developed countries, appropriately improving China's environmental standards is necessary for export commodities to build a platform that enhances communication with foreign buyers and increases international competitiveness of Chinese export products. The structure of export commodities must be adjusted to reduce the proportion of primary products. The export value of primary products with low added value and harmful to natural resources must be limited or reduced. The technical content and added value of products should be improved to promote technological innovation for traditional products with comparative advantages. Unification of export and environmental benefits must be pursued to strengthen the environmental com-

petitiveness of China's export products by improving environmental quality and the environmental standards for export products and form a non-price advantage.

Strengthen environmental management investment of export enterprises and international environmental protection cooperation by the government: To ensure economic development and effective operation, the Chinese government should adopt a series of measures to appropriately increase export enterprises' investment in pollution control. The promulgation and implementation of preferential policies for environmental protection industry on finance, credit, and taxation will improve the risk investment mechanism, create diversified financing channels and other means, coordinate the pollution control behaviour of enterprises, encourage enterprises to improve production technology through tax reduction and preferential tax rates, and reduce the burden to enterprises from other countries by providing more cost space for implementing environmental cost accounting. The government must focus on the latest developments in global environmental protection and the effect of these changes on China's economic and trade to seize opportunities for foreign trade development. The government should also actively seek cooperation with other developing countries to optimize their collective strength and continuously expand the country's influences on international environmental protection and trade legislation. Substantial efforts must be made to reduce the differential treatment faced by developing countries in international trade, seek fairness and justice, and prevent trade protectionism. Foreign trade policies must be adjusted and environmental protection regulations must be improved in a timely manner according to the international situation, and corresponding responsibilities and obligations must be conscientiously fulfilled.

Vigorously develop low-carbon trade industries and strengthen environmental pollution control by the government: China should accelerate the development of low-carbon trade industries and reduce the proportion of pollution-intensive products in exports and the import of intermediates with higher carbon emissions to form a trade chain with its own characteristics. Reducing carbon emissions under open conditions is not only the responsibility of a single economy but also a joint effort among different countries. On the issue of carbon emissions, China should strive to strengthen cooperation with other countries, actively formulate relevant emission reduction conventions, and jointly promote the establishment of a carbon emission trading system. The lack of a positive role in government regulation is closely related to insufficient regulation. Therefore, continuously strengthening the government's control over carbon emissions is the current focus of the government's ef-

forts to promote energy conservation. The neglect of environmental costs has given China a comparative advantage in pollution-intensive products, resulting in the over-expansion of high-pollution and high-energy industries. However, China does not have the advantage of resources and environmental carrying capacity. Therefore, government regulation must be strengthened further. The enhancement of the legislative work on carbon emissions can provide the government with legal support, and the implementation of a carbon rights trading system can strictly control the carbon emissions of enterprises within a certain range.

CONCLUSION

Although the export trade of China continues to grow, labour-intensive and resource-intensive products are still dominant, and low-end industrialization has caused environmental degradation and ecological damage. The causes of environmental pollution due to the export trade are analysed by adopting the cointegration measurement method to quantitatively investigate the relationship between foreign trade and environmental pollution. Existing literature indicates that the relationship between foreign trade development and environmental pollution has three viewpoints: adverse, beneficial, and complex theories. The main reasons for environmental pollution caused by the export trade are a large number of pollution-intensive and resource-intensive industries, lacking of environmental protection awareness of export enterprises, and insufficient environmental protection management of the export trade by the government. A long-term cointegration relationship exists among industrial waste gas emissions, industrial solid waste emissions, industrial wastewater discharges, and total exports. The change in total volume is the Granger cause of industrial waste gas emissions and industrial solid waste emissions, which can be reduced by developing environmentally friendly export industries, enhancing the scientific and technological content of export products and investment in environmental management of export enterprises, and vigorously developing low-carbon trade industries to alleviate environmental pollution caused by the export trade. In-depth research can be conducted on calculating the environmental cost of the export trade, air pollution caused by the export trade, product structure of the export trade, regional differences in trade system, and spatial econometrics to measure the regional and spatial differences caused by the export trade.

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