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The Impact of Trade on Environmental Pollution of China -An Empirical Analysis Based on Double Difference Model

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China has joined the WTO for almost fifteen years so far. It is no doubt that WTO does great help in boosting China's economic growth. However, with the rapid development of our trade and economy, the environmental problem in China has drawn increasing attention. This paper investigates the impact of joining the WTO on environmental pollution and analyzes whether coastal cities are more affected than inland cities. We use difference-in-differences approach to analyze data from approximately 300 cities from 1997 to 2006 in China, taking the emission of industrial SO_2 and the discharge standard-meeting rate of industrial wastewaters as an example, and then examine that the environmental pollution has been relieved since China joined the WTO. Also, the improvement effect on the environment of coastal cities is greater than that of inland cities.

1. Introduction

Since 2001, China's accession to the WTO, China has quickly integrated into the global liberalization of the world market (Bischoff et al., 2015). The trade growth has become the most important macroeconomic goals of governments, and WTO is also seen as promoting the majority of China's cities in the economic prosperity and progress of the catalyst (Nishigaki et al., 2015). However, behind the prosperity, China's serious environmental degradation has also aroused our thinking. In China, the pollution-intensive industries account for a large proportion of the import and export trade volume (Galati et al., 2015). As the State Environmental Protection Administration has pointed out, the contradiction between environment and development has become more and more prominent (Wang et al., 2013). There are two major international environmental economics. According to the environmental impact of trade: environmental protection factions believe that foreign trade is bound to exacerbate the consumption of resources and worsen the natural environment (Guo, et al., 2016). On the other hand, the trade protectionists believe that the globalization of trade liberalization is not the root cause of environmental pollution intensified (Caimo and Lomi, 2015). In order to further answer this question, in this paper, we have established a double difference model, using 1997 to 2006 China 251 cities.

The ecological environment of the earth is becoming worse and worse. The greenhouse effect, ozone hole, acid rain and soil erosion have brought serious threat to the survival and development of mankind, and this challenge is worldwide, occurring in every corner of the world (Borghesi et al., 2015). According to a 2012 report by the United Nations Environment Programme, in twenty-first Century, there were many extreme events of environmental pollution, such as the European heat wave in 2003 and the flood disaster in Pakistan in 2010 (Bi et al., 2014). The report says annual emissions of greenhouse gases worldwide will reach 580 tonnes if no action is taken in 8 years. The problem of global environmental pollution has been involved in air, ecology, energy, water, waste and many other aspects, and there is a growing trend. In many countries, especially in developing countries, environmental pollution is becoming more and more serious with the continuous development of economy. As the largest developing country, China has also paid a huge price for environmental pollution while the economy is developing at a high speed (Al-Mulali, and Ozturk, 2015).

In recent years, the ecological environment in our country is deteriorating day by day. The emission of major pollutants exceeds the carrying capacity of the environment, and the natural resources are destroyed in varying degrees. This can also be seen from an endless stream of reports about China's growing environmental pollution. Fog and haze clearly show that China's pollution problem is increasing. The

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Environmental Status Bulletin issued by the Ministry of environmental protection of China also shows that the area of acid rain in the country accounts for 10.6% of the total land area (Katircioglu, 2014). Among the 74 cities monitored under the new air quality standards, air quality standards in 3 cities, namely Haikou, Zhoushan and Lhasa, were up to standard. The proportion of cities exceeding the standard is 95.9%. In 2014, the central economic work conference also mentioned that China's current environmental carrying capacity has reached or near the upper limit. Therefore, the situation of environmental pollution in China is no longer optimistic.

2. Literature review

In trade policy, the impact of trade on the environment this topic is very research value and research significance. In the 1990s, Krueger and Grossman studied the impact of NAFTA on the environment and explained the per capita GDP in terms of GDP per capita. With SO_2, dust and suspended particles as the explanatory variables, supplemented by population density, time trend, geographical position and other control variables, the analysis shows that environmental pollution and economic growth in the long-term show inverted U-shaped curve (EKC), inspired by this literature, we add per capita GDP and its square term to the model as the control variable, which is called the environmental Kuznets Curve (EKC). In 2003, Copeland and Taylor proposed the "Pollution Shelter Hypothesis" (PHH) by comparing the two sets of data between the developed countries of the North and the developing countries of the South. There are many literatures supporting this hypothesis abroad. For example, Rock (1996), after studying the relationship between trade policy and pollution intensity, concluded that open trade policy is more pollution-intensive than inward trade policy. The same view was supported in some literature using the input-output model of the empirical analysis model: some scholars have concluded that the carbon content of non-energy products in Brazil is less than Export content. The "slope effect" hypothesis proposed by Revesz in 1992 is also a dynamic extension of the "pollution shelter hypothesis". The developing countries will gradually "degenerate" in the face of the loosening of environmental policy, and will gradually "degenerate" and raise the standard of environmental protection, and for the developed countries, they are likely to gradually missing the competitiveness of strategic industries, and structural unemployment and other social problems, forced to reduce the environmental standards. In general, increased competitiveness resulting from trade liberalization will force countries to relax their environmental protection policies and move towards the lowest levels.

However, in the domestic and foreign literature research on the relationship between domestic trade and environment, the conclusions are very different from the pollution shelter hypothesis (Xiao, et al., 2015). The first is the use of Grossman as a regression model to analyse it. They use three years of industry panel data and OECD developed countries data show that exports from OECD countries make China's carbon emissions increased (Yao et al., 2015), while the OECD Imports but reduce China's carbon emissions. In 2007, Mukhopadhyay and Dietzenbacher found that India is a net importer of carbon under the I-O model, which means that trade mitigates India's pollution emissions also used in the input-output model is carbon emissions as an explanatory variable. Moreover, some scholars have creatively used four types of pollutants through the input-output model. The study found that China's export products contain less pollution than imported products, thus proving more forcefully (Sánchez-Franco and Roldán, 2015).

Based on the literature, we can find that the econometric model and the input-output model are the main models for studying trade and environmental problems at present. However, the dual-difference model is very rare in related research. In recent years, some foreign scholars have used the DID model to analyze the impact of regional trade agreements (RTA) with or without environmental policies on carbon emissions in 182 countries from 1980 to 2008 (Tang et al., 2012), only the RTA with environmental provisions can improve the environment. Inspired by this article, we argue that the impact of China's trade on the environment under the double-differencing model is particularly innovative and provides a more comprehensive understanding of the relationship between the two.

3. The empirical analysis

3.1 Model settings

We will be 251 prefecture-level cities in China are divided into coastal cities and inland cities, respectively. In contrast to the Baghdadi study, the variables selected in this paper are all exogenous variables and do not involve endogeneity. Therefore, we can test that the rapid trade development of the coastal and inland cities after entering WTO is exacerbating the environmental pollution or to improve their environmental conditions.

We will begin with a simple list of determinants of environmental pollution, such as per capita GDP, urban land area, secondary industry as a percentage of GDP, total urban population, and distance from the city to the port as a control variable. Taking into account that these control variables are not necessarily linearly related to emissions, we have also made some logarithms or squares of variability for some indicators, such as incorporating square values of GDP per capita and population logarithms into the control variables to better explain pollution emission. In order to measure the impact of trade on China's urban environmental pollution emissions, we estimated the following simple linear regression equation: the industrial SO_2 emissions per unit GDP, the industrial wastewater discharge compliance rate as the explanatory variable,

$$\mathrm{Em}_{jc} = \beta_0 + \beta_1 City_{jc} + \beta_2 WTO_{jc} + \beta_3 Interact_{jc} + \varepsilon_{jc} \quad (1)$$

$Interact_{jc} = City_{jc} \cdot WTO_{jc}$ is the interactive term, j means before and after the accession to the WTO, c is the coastal city, Em_{jc} is the explanatory variable, and ε_{jc} is the residual term.

There are two dummy variables in the model. The variable "$City_{jc}$" indicates whether the sample city is a coastal city. If the value is 1, that is, the city is coastal, if it is 0, the city is inland city; "WTO_{jc}" that the process of accession to the WTO, if taken 1, then said that accession to the WTO, if taken 0, then that before joining the WTO, in order to test the effect of accession to the WTO, the establishment of "WTO_{jc}". The interactive item "WTO" refers to the interaction of the coastal cities after the accession to the WTO. In other cases, the interactions between the two variables is 0.

On the basis of (1), we also need to add related control variables. Considering the different levels of development of each city, it is necessary to include per capita GDP ($Income_{jc}$) as a control variable. The environmental Kuznets curve (EKC) also tells us that income and the environment Pollution is a curve, rather than a simple linear relationship, so we need to join the quadratic GDP per capita GDP to better explain the variables; followed by the total urban population, taking into account the natural population growth rate, where we select the logarithm The proportion of secondary $In(Pop_{jc})$ industry to GDP is also an important control variable, because the greater the proportion of urban industry, the greater the amount of pollution emissions; Finally, according to the trade gravity The principle of the model, the logarithm of the distance from city to port, $In(Dis_{jc})$ can also be counted as a control variable. In summary, the final model is set as follows:

$$\mathrm{Em}_{jc} = \beta_0 + \beta_1 City_{jc} + \beta_2 WTO_{jc} + \beta_3 Interact_{jc} + \beta_4 Income_{jc} + \beta_5 Income_{jc}^2 + \beta_5 In\left(Pop_{jc}\right) + \beta_6 Ratio_{jc} + \beta_7 In\left(Dis_{jc}\right) + \varepsilon_{jc} \quad (2)$$

Based on the model (2), this paper will test the related data.

3.2 Data analysis and typical facts

In this model application, since China's accession to the WTO in December 2001, we use data of 251 prefecture-level cities in China between 1997 and 2006, which is derived from the years of China's urban statistical yearbook. In the model (2) the variable data sources are: GDP (million), industrial output value (million), the end of the total population (million), land area (square kilometers), industrial sulfur dioxide emissions Ton), industrial wastewater discharge compliance rate (%) and the distance to the coastal ports (km). In this paper, we choose two explanatory variables, one is SO_2 emission per unit GDP (SO_2 EM_{jc}), and the other is industrial wastewater discharge compliance rate (WW EM_{jc}). Table 1 is the descriptive statistics of the relevant explanatory variables in this paper.

In this paper, we use the twice-calculated data and the double-difference model to regress the Eq(2). Through the inspection, we observe the coastal cities and inland cities after the accession to the WTO after the environmental pollution emissions are not systematic differences, if any, then the WTO does have a significant impact on environmental pollution. Specific test results are in Table 2 and Table 3:

Table 1: describes the statistical results

Variable Name	Explanation	Mean	Standard Deviation
SO_2 EM_{jc}	Emissions per Unit of GDP	0.0346078	0.1611538
WW EM_{jc}	industrial wastewater discharge compliance rate	74.76253	29.57979
$City_{jc}$	coastal dummy variable	0.149682	0.356816
WTO_{jc}	time dummy variable	0.5	0.50008
$Interact_{jc}$	Interaction Item	0.074841	0.263176
$Income_{jc}$	GDP per capita	9.398173	0.906007
$Income_{jc}^2$	GDP per capita2	89.1462	16.79063
Ln (Pop_{jc})	The population logarithm	4.747621	1.050338
$Ratio_{jc}$	Proportion of the secondary industry	0.494814	0.126863
Ln (Dis_{jc})	Distance to harbor	6.200698	0.904956

Table 2: Regression analysis of SO_2 emissions per unit of GDP under mixed effects, random effects and fixed effects (2)

	POOLED SO_2 EM_{jc}	POOLED SO_2 EM_{jc}	Random SO_2 EM_{jc}	Random SO_2 EM_{jc}	Fix SO_2 EM_{jc}	Fix SO_2 EM_{jc}
$City_{jc}$	-0.00000245	0.0118	-0.0174	0.0113	0	0
	(-0.00)	(1.25)	(-0.79)	(0.91)	(.)	(.)
WTO_{jc}	0.0831***	0.0786***	0.0643***	0.0779***	0.0609***	0.0816***
	(11.89)	(13.38)	(12.18)	(13.95)	(11.52)	(9.07)
$Interact_{jc}$	-0.0721***	-0.0461***	-0.0535***	-0.0448***	-0.0502***	-0.0442***
	(-4.24)	(-3.40)	(-4.27)	(-3.87)	(-4.02)	(-3.77)
$Income_{jc}$		0.0372		0.0408*		0.0286
		(1.53)		(1.79)		(1.08)
$Income_{jc}^2$		-0.00227*		-0.00246**		-0.00187
		(-1.80)		(-2.08)		(-1.37)
$Ln(Pop_{jc})$		-0.00353		-0.00470		-0.00881
		(-0.63)		(-0.86)		(-1.36)
$Ratio_{jc}$		-0.00709		0.00407		0.0621
		(-0.31)		(0.15)		(1.34)
$Ln(Dis_{jc})$		0.00561*		0.00588		0
		(1.91)		(1.35)		(.)
_cons	0.00000434	-0.0405	0.0176**	-0.0423	0.00903***	0.108
	(0.00)	(-0.36)	(2.01)	(-0.36)	(2.76)	(0.59)
N	2407	1028	2407	1028	2407	1028
R^2	0.062	0.200	0.0922	0.1676	0.060	0.238

Note: The standard deviation estimates for heteroskedasticity and autocorrelation in parentheses, *, **, ***, respectively, are significant at the 1, 5 and 10% confidence levels.

Table 3: Regression analysis of model (2) for mixed effect, random effect, fixed effect on industrial effluent discharge compliance rate

	POOLED WW EM_{jc}	POOLED WW EM_{jc}	Random WW EM_{jc}	Random WW EM_{jc}	Fix WW EM_{jc}	Fix WW EM_{jc}
$City_{jc}$	4.953**	-8.217**	5.826**	-8.393*	0	0
	(2.53)	(-2.06)	(2.24)	(-1.77)	(.)	(.)
WTO_{jc}	23.82***	12.08***	24.64***	10.97***	25.46***	15.07***
	(21.26)	(4.75)	(23.73)	(4.38)	(24.21)	(3.59)
$Interact_{jc}$	1.201	1.327	0.45	1.379	-0.335	2.27
	(0.44)	(0.23)	(0.18)	(0.26)	(-0.13)	(0.44)
$Income_{jc}$		21.51**		18.47*		3.073
		(2.09)		(1.82)		(0.25)
$Income_{jc}^2$		-0.976*		-0.785		0.0412
		(-1.83)		(-1.49)		(0.07)
$Ln(Pop_{jc})$		-10.78***		-11.70***		-15.20***
		(-4.48)		(-4.79)		(-5.06)
$Ratio_{jc}$		-31.29***		-35.81***		-28.11
		(-3.23)		(-3.25)		(-1.30)
$Ln(Dis_{jc})$		-2.260*		-2.105		0
		(-1.79)		(-1.30)		(.)
_cons	61.37***	-67.42	60.34***	-49.95	61.46***	91.83
	(75.42)	(-1.40)	(57.02)	(-1.00)	(89.96)	(1.08)
N	2790	1012	2790	1012	2790	1012
R^2	0.169	0.248	0.222	0.3061	0.222	0.311

Note: The standard deviation estimates for heteroskedasticity and autocorrelation in parentheses, *, **, ***, respectively, are significant at the 1%, 5%, and 10% confidence levels

In the choice of regression model, we used the Hausman test, as shown in Table 4:

Table 4: Hausman test

	—— Coefficients ——			
	(b) m6	(B) m4	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
WTO_{jc}	.0816473	.0779483	.003699	.0070242
$Interact_{jc}$	-.0442493	-.0448478	.0005985	.0015117
$Income_{jc}$	.0285651	.0408404	-.0122753	.0130408
$Income_{jc}^2$	-.001865	-.0024627	.0005977	.0006554
$Ln(Pop_{jc})$	-.0088137	-.0047009	-.0041128	.0034168
$Ratio_{jc}$	.0620859	.0040688	.058017	.0375997

b = consistent under Ho and Ha; obtained from xtreg;
B = inconsistent under Ha, efficient under Ho; obtained from xtreg;
Test: Ho: difference in coefficients not systematic;
Chi2 (7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 9.54;
Prob>chi2 = 0.2163>0.05.

According to the results of Hausman test, we choose random effects as our regression analysis model. From the third and fourth columns of Table 2 and Table 3, it can be seen that the trade has a significant mitigation effect on the industrial SO_2 emission of coastal cities in China, but the improvement rate of industrial wastewater discharge is not significant.

4. Conclusions

This paper examines the impact of China's accession to the WTO on China's environmental pollution. We use the double difference model to analyze the impact of foreign trade on China's environmental pollution from 1997 to 2006, taking two kinds of pollution as the observed value-GDP per unit of GDP, which is the dummy variable, with several related control variables. Industrial sulfur dioxide emissions and industrial wastewater discharge compliance rate, inland cities as a control, focusing on the coastal city trade on its environmental impact. As the variables involved in the model are exogenous variables, so there is no need to explore the endogenous problems. From the results of the random effects regression, China's accession to the WTO on the coastal cities of sulfur dioxide emissions has played a very significant role, but for its industrial wastewater discharge compliance rate did not significantly improve the role. This shows to a certain extent the trade of the Chinese environment is played a certain role in improving the trade and the more developed the coastal city environment benefit more from trade.
Based on the conclusions drawn in this paper, some pertinent suggestions are put forward. First of all, technological innovation is one of the important factors to solve environmental problems. Trade promotes technology transfer. While adapting to globalization and liberalizing trade development, China must seize the opportunity to learn from it or develop more efficient environmental management technology to improve it. On the other hand, we also need to enhance the comparative advantage of technology-intensive industries, to reduce the advantages of pollution-intensive industries in China and to improve the overall trade environment. Second, China needs to accelerate the upgrading of industrial structure, the waste discharge of high-waste industries is phased out, and thus to speed up the upgrading of energy structure, to develop the proportion of services to rise, so that China's domestic industry more green. Moreover, in the international market, the "green barrier" of the developed countries to developing countries still has certain restrictions on the development of China's economy.
The results of this study show that trade has a certain mitigation effect on the environmental pollution of coastal cities in China. It also proves the importance of double difference model in the field of trade and environment research. Through this study of the relationship between trade and environment in China, the understanding of the role of trade in the environment has been improved. In this paper, based on relevant literature, the author sums up the viewpoints of all parties, and test and prove to some extent that the "pollution shelter hypothesis" cannot be established in China. However, the level of pollution chosen in this paper is not comprehensive enough. In 2002, SO_2 emissions data is missing, thus a more robust conclusion remains to be further proved.

Reference

Al-Mulali U., Ozturk I., 2015, The effect of energy consumption, urbanization, trade openness, industrial output, and the political stability on the environmental degradation in the MENA (Middle East and North African) region. Energy, 84, 382-389.

Bi G.B., Song W., Zhou P., Liang L., 2014, Does environmental regulation affect energy efficiency in China's thermal power generation? Empirical evidence from a slacks-based DEA model. Energy Policy, 66, 537-546.

Bischoff F., Emrich E., Pierdzioch C., 2015, Universities of cooperative education between facts and fictions: an empirical analysis based on an example of the sports and fitness sector. , 14(1), 83-106.

Borghesi S., Cainelli G., Mazzanti M., 2015, Linking emission trading to environmental innovation: evidence from the Italian manufacturing industry. Research Policy, 44(3), 669-683.

Caimo A., Lomi A., 2015, Knowledge sharing in organizations: a bayesian analysis of the role of reciprocity and formal structure. Journal of Management: Official Journal of the Southern Management Association, 41(2), 665-691.

Galati A., Crescimanno M., Giacomarra M., Tinervia S., 2015, Organizational models in the sicilian ornamental plant industry: an empirical analysis based on transaction cost theory. New Medit, 14(4), 58-64.

Guo X., Ren D., Shi J., 2016, Carbon emissions, logistics volume and gdp in china: empirical analysis based on panel data model. Environmental Science & Pollution Research International, 23(24), 24758.

Katircioglu S.T., 2014, International tourism, energy consumption, and environmental pollution: The case of Turkey. Renewable and Sustainable Energy Reviews, 36, 180-187.

Nishigaki Y., Maki D., Satake M., 2015, Capital adjustment and limit cycles: an empirical analysis based on the threshold autoregressive model. Acta Scientiarum Mathematicarum, 42.

Sánchez-Franco M.J., Roldán J.L., 2015, The influence of familiarity, trust and norms of reciprocity on an experienced sense of community: an empirical analysis based on social online services. Behaviour & Information Technology, 34(4), 392-412.

Tang K., Yang Z., Yang H., Fan X., 2012, Environmental cost of pond aquiculture in shanghai: an empirical analysis based on double-bounded dichotomous cvm method. Acta Ecologica Sinica, 32(7), 2212-2222.

Wang C.L., Zhang W., Statistics S.O., 2013, Financial development, capital formation and differential regional effects: an empirical analysis based on dynamic panel data model. Mathematics in Practice & Theory, 43(18), 17-27.

Xiao Y., Zheng X., Hu L., Hen Q., 2015, Research on the factors of trade growth between china and india — an empirical analysis based on constant market share model. Journal of Service Science & Management, 08(4), 569-577.

Yao W., Wu H., Kinugasa T., 2015, Financial deepening, asset price inflation, and economic convergence: empirical analysis based on china’s experience. Emerging Markets Finance & Trade, 51(sup1), S275-S284.