

# Export trade and Environmental Pollution: An Analysis from a Spatial Perspective

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**Abstract.** Based on the panel data of 31 provincial units in China from 2001 to 2015, the paper employs the spatial econometric model to examine the relationship between China's export trade and industrial SO<sub>2</sub> emissions. Research results conclude that export trade is negatively correlated with industrial SO<sub>2</sub> emissions when considering spatial effect. Participation in international trade is beneficial to China's pollution abatement. The results do not support the pollution havens hypothesis. China needs to be actively involved in the global economy as the world economy becomes increasingly interconnected.

## 1. Introduction

Since the reform and opening up, China has made great achievements in foreign trade. In 1978, China's export trade volume was only 9 billion 570 million US dollars, the twenty-ninth largest in the world. In 2007, it broke through trillions of dollars and ranked second in the world. In 2009, it jumped to the top of the world and contributed about 9% of the world trade volume in the same period. Open policy is seen as one of the most important catalysts for China's rapid economic growth. However, with China's opening up and rapid economic growth, environmental pollution has become increasingly prominent. In the case of free trade, the international commodity trade enables the transfer of resources consumption and pollutant emissions through the carrier of commodities, covering up the real responsible person for environmental pollution. Developed countries with strict environmental rules may specialize in the production of "clean" products and export them, and import pollution intensive products from developing countries with looser environmental rules to make the developing countries a pollution havens for specialized production of pollution intensive products.

A lot of scholars have studied the issue of trade and environment and have drawn quite different conclusions. The first is that trade is beneficial to the environment, and that trade liberalization is not the primary cause of environmental degradation [1]. To solve environmental problems by restricting trade will only cause further distortion. The second is that trade is harmful to the environment and that free trade seeks to maximize profits and that its production does not take into account the social and environmental costs, so trade is the direct cause of environmental problems [2]. The third is that trade is neutral. Studies have shown that the impact of trade liberalization on the environment will depend on the type and the comparative advantage of the country [3].

In the empirical study of China, different results have also been obtained [4, 5, 6]. In the process of literature review, we find that when scholars use provincial or Prefecture level city units to conduct



empirical tests, they seldom consider the effects of geographical spatial dependence. The first law of geography points out that things are related to each other, but the closer things are more relevant. In real economic operation, spatial data often has spatial autocorrelation. Therefore, using the panel data of 31 provincial units in China from 2001 to 2015 (excluding Taiwan, Hongkong and Macao in China), the paper employs the spatial econometric model to examine the relationship between China's export trade and environmental pollution.

## 2. Model setting, variable and data

### 2.1. Model setting

In the study of the relationship between export trade and environmental pollution, this paper uses the related research of Cole et al [7] and Lau et al [8], and joins control variables such as per capita GDP, regional research and development intensity, pollution control level and so on, and construct the following econometric model.

$$\ln P_{it} = \beta_1 trade + \beta_2 \ln y_{it} + \beta_3 (\ln y_{it})^2 + \beta_4 rd_{it} + \beta_5 \ln pc_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Subscripts  $i$  and  $t$  represent province and year respectively,  $P$  is the emission of pollution,  $trade$  represents export trade openness,  $y$  is per capita GDP,  $rd$  is the intensity of research and development, and  $pc$  represents pollution control level.  $\mu_i$  and  $\lambda_t$  represent the spatial fixed effect and time-period fixed effect respectively.

When the spatial autocorrelation exists, the classical econometric estimation method is not effective. Compared with the traditional econometric models, the spatial econometric model takes into account the spatial correlation that exists universally in economics. Usually, two models are used to characterize the spatial correlation. The first one is the spatial lag model (SLM) and the second is spatial error model (SEM). We extend the model (1) to the spatial econometric model. The SLM model of the influencing factors of environmental pollution is formulate as

$$\ln P_{it} = \rho W \ln P + \beta_1 trade + \beta_2 \ln y_{it} + \beta_3 (\ln y_{it})^2 + \beta_4 rd_{it} + \beta_5 \ln pc_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$\rho$  is the spatial autocorrelation coefficient.  $W$  is a spatial weight matrix. Generally speaking, the closer the distance between space units is, the stronger the spatial effect is. Therefore, we choose the inverse distance spatial weight matrix. The SEM model of the influencing factors of environmental pollution is formulate as

$$\begin{aligned} \ln P_{it} &= \beta_1 trade + \beta_2 \ln y_{it} + \beta_3 (\ln y_{it})^2 + \beta_4 rd_{it} + \beta_5 \ln pc_{it} + \mu_i + \lambda_t + \varepsilon_{it} \\ \varepsilon_{it} &= \lambda W \varepsilon + \mu_{it}, \quad \mu_{it} : (0, \delta^2 I_n) \end{aligned} \quad (3)$$

### 2.2. Variable and data

Specifically, industrial sulfur dioxide ( $SO_2$ ) emission is chosen as proxy variable of environmental pollution. The degree of openness of export trade is represented by the ratio of regional export to GDP. Since the statistical unit of regional export is US dollar, we need to convert it into yuan according to the average annual exchange rate of RMB against the US dollar in different years. International trade mainly affects the environment through scale effect, technology effect and structural effect [9]. Therefore, the total impact of export openness on industrial  $SO_2$  emissions cannot be predefined. Many papers have confirmed the existence of environmental Kuznets curve hypothesis for economic growth and environmental pollution. We use per capita GDP to test it. When the EKC hypothesis is established, the estimated values of the coefficients of the first-order term and the square term of the per capita GDP are positive and negative respectively. The intensity of research and development is measured by the ratio of R&D funds of Industrial Enterprises above scale in each province to GDP. The greater the value is,

the stronger the innovation capability of the enterprises in the province, the more output they can get with less input, and which is beneficial to the reduction of pollution emissions. The level of pollution control is represented by the completed investment in waste gas projects of each province.

The relevant data are derived from the Chinese Statistical Yearbook, China Environmental Yearbook, China's annual statistical yearbook, and the economic statistics yearbook of various provinces. Table 1 gives a descriptive statistics of the main variables.

**Table 1.** Descriptive statistics

variable	unit	mean	sd	Maximum	Minimum
Lnp	ton	12.851	1.413	14.355	6.599
Trae	%	15.721	18.898	91.587	0.842
Lny	yuan	9.964	0.773	11.58	8.001
Rd	%	0.674	0.478	2.149	0.0003
Lnpc	Ten thousand yuan	10.579	1.689	14.063	3.85

### 3. Results and analysis

#### 3.1. Model estimation

In spatial econometrics, the fixed effect model is usually more suitable than the random effect model. Since the study area in this paper is the 31 provincial administrative unit in China, the fixed effect model is more suitable. We perform a likelihood ratio (LR) test to investigate the hypothesis that the time-period fixed effects are jointly insignificant. The result ( $p < 0.01$ ) indicates that this hypothesis must be rejected. Meanwhile, the hypothesis that the spatial fixed effects are jointly insignificant must be rejected ( $p < 0.01$ ). This shows that the model should be extended to time-period and spatial fixed effects.

**Table 2.** Joint test of spatial and time-period fixed effects

	spatial fixed effect	time-period fixed effect
LR	1043.434	87.264
Df	31	15
P	<0.01	<0.01

Matlab is used to estimate the parameters of the econometric model using the code provided by Elhorst. The result is in Table 3. The first column in Table 3 reports the estimation results when adopting a non-spatial panel data model.

We can use Lagrange Multiplier tests for a spatially lagged dependent variable (LM-Lag) and for spatial error autocorrelation (LM-Error) to determine whether the SLM or the SEM is better to describe the data than a model without any spatial interaction effects. The results show that both the hypothesis of no spatially lagged dependent variable and the hypothesis of no spatially auto correlated error term must be rejected at 1% significance. In this case, we need to use the robust LM-tests. The test result of robust LM shows that the hypothesis of no spatially lagged dependent variable must be rejected at 15% significance. However, the hypothesis of no spatially auto correlated error term should be accepted ( $p=0.673$ ). According to Anselin's proposed criteria, SLM is more appropriate. The second column in Table 3 reports the estimation results of the SLM with two-way fixed effects.

**Table 3.** The estimation results

Determinants	(1) Pooled OLS	(2) SLM
intercept		
trade	-0.0036 (-1.5706)	-0.0041* (-1.7127)
lny	1.6197*** (3.2872)	1.4353*** (2.8142)
(lny)^2	-0.0696*** (-2.5995)	-0.0562** (-2.0300)
rd	-0.2555*** (-3.9481)	-0.2018*** (-3.0246)
lnpc	0.0598*** (3.4565)	0.0644*** (3.6219)
W*lny		0.3236*** (4.9250)
spatial fixed effect	Y	Y
time-period fixed effect	Y	Y
sigma^2	0.0500	0.0527
R-squared	0.1627	0.9760
logL	39.3630	44.2262
LM-Lag	11.7940	
LM-Error	9.8036	
Robust LM-Lag	2.1688	
Robust LM-Error	0.1784	

Note: T-statistics are in parentheses.

\*, \*\*, \*\*\* refer to 10%, 5% and 1% levels of significance respectively.

### 3.2. Model estimation

The estimated results show that the coefficient of the spatial parameter of the SLM is 0.324, and pass a 1% significance level test which shows that there is spatial correlation between industrial SO<sub>2</sub> emissions in different provinces. In the SLM, the trade openness variable is significantly negatively correlated with the industrial SO<sub>2</sub> emissions, and in the general model (1), the trade openness variable is not statistically significant, indicating that the impact of trade openness on SO<sub>2</sub> emissions is underestimated without considering the spatial effect. Our results show that international trade has a positive impact on the environment. In the three effects of international trade on the environment, the effect of the positive effect is greater than that of the negative effect. The coefficient of the first-order term and the square term of the per capita GDP is 1.4353 and -0.0562 respectively, and it is statistically significant, indicating that there is an inverted U-shaped Kuznets relationship between per capita GDP and industrial SO<sub>2</sub> emissions. The coefficient of the intensity of research and development is -0.2018, and pass a 1% significance level test. This is in line with our expectation. The coefficient of the level of pollution control is positive and significant, which is not consistent with our expectation. This may be due to the fact that the amount of the completed investment in waste gas projects of various regions is relatively small, which is not a major factor affecting the industrial SO<sub>2</sub> emissions.

## 4. Conclusion

Based on the panel data of 31 provincial units in China from 2001 to 2015, the paper employs the spatial econometric model to examine the relationship between China's export trade and industrial SO<sub>2</sub> emissions. The result shows that the export openness variable is significantly negatively correlated with

the industrial SO<sub>2</sub> emissions when considering spatial effect, which do not support the pollution havens hypothesis. Participation in international trade is beneficial to China's pollution abatement.

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