

# The Impact of Environmental Protection Tax on the Upgrading of Industrial Structure-- Based on Spatial Econometric Analysis

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**Abstract.** Based on the provincial panel data of 30 provinces in China from 2000 to 2017, this paper uses the spatial econometric model to analyze the impact of environmental protection tax on the upgrading of industrial structure under three spatial weight matrices. The results show that there are significant positive spatial correlations in the upgrading of provincial industrial structure in China, and environmental protection tax has a significant positive spatial spillover effects on the upgrading of industrial structure. The implementation of environmental protection tax in provinces and regions will promote the upgrading of local industrial structure, which will have a positive impact on the upgrading of industrial structure in neighboring provinces and regions.

## 1 Introduction

As an important form of environmental economic policy, the environmental protection tax was first implemented in European countries. China has been paying attention to the use of environmental protection taxes and fees as an important economic policy of environmental regulation and management, and has gradually established an environmental protection taxes and fees system suitable for China's actual situation. China officially introduced an environmental protection tax on January 1, 2018. The collection of environmental protection tax will affect the production behavior and production structure of enterprises, and then affect the transformation of regional industrial structure and economic development mode. The earliest study on the effect of environmental protection tax was to examine the existence of "double dividend" and discussed the effect of environmental protection tax on emission reduction and economic growth. It is widely believed that the environmental protection tax will not only reduce environmental pollution, but also promote the innovation of clean technology and the improvement of social productivity, so as to promote economic growth. [1-4] Relevant foreign studies mainly consider the relationship between environmental protection tax and enterprise production behavior from the micro level. In contrast, domestic scholars' studies are more concerned with the impact of environmental protection tax on industrial structure adjustment. The upgrading of industrial structure needs the guidance of policies, especially the tax policies that can accelerate the green development of the industry. The tax can affect the input, employment and investment of different industries in various regions, change the economic behavior of taxpayers, and adjust the proportion of industrial

structure. [5-6] Empirical evidences show that environmental protection tax is an important means to accelerate green development. Levying environmental protection tax can restrain the emission behavior of high-polluting enterprises, promote the internalization of environmental external costs, improve the utilization rate of water resources and energy, improve production technology, and force the transformation of high pollution and energy-consuming industries. [7-8] However, compared with developed countries, China's policy strength is obviously not strong enough. [9] In addition, Chen Hua and Zhang Ye (2012) have demonstrated that different environmental protection tax rates should be set for different industries and pollutants, and environmental protection industries should be encouraged to give priority to development to optimize the industrial structure. [10]

From the existing literature, most studies affirm the positive effect of environmental protection tax on industrial structure adjustment, but the attention to the spatial effect of environmental protection tax and the upgrading of industrial structure is obviously insufficient. Experience shows that provinces in China are not completely independent of other provinces in political and economic activities. Therefore, the upgrading of industrial structure in one province may also have an impact on the upgrading of industrial structure in neighboring provinces. To study the impact of environmental protection tax on the upgrading of industrial structure, spatial factors must be considered. Thus providing certain empirical basis for promoting the upgrading of industrial structure in China. Firstly, this paper analyzes the influencing mechanism of the impact of environmental protection tax on the upgrading of industrial structure, and then built a spatial panel econometric model based on the spatial correlation of the

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upgrading of industrial structure in different regions. Final empirical analysis the spatial effect of environmental protection tax on the upgrading of industrial structure, so as to provide some empirical evidences for promoting the upgrading of industrial structure in China.

## 2 METHOD AND DATA

### 2.1 Spatial Correlation Test

This paper uses Global Moran's I index to verify the spatial correlation of the upgrading of industrial structure in China's provinces. After standardization, the Global Moran's I index ranges from [-1, 1]. The Global Moran's I index greater than 0 indicates the existence of spatial positive correlation, while it less than 0 indicates the existence of spatial negative correlation. If the value is equal to zero, the space is random. The calculation formula is:

$$\text{Moran's } I = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} (Y_i - \bar{Y})(Y_j - \bar{Y})}{S^2 \sum_{i=1}^n \sum_{j=1}^n W_{ij}} \quad (1)$$

$$S^2 = \frac{1}{n} \sum_{i=1}^n (Y_i - \bar{Y})^2, \quad \bar{Y} = \frac{1}{n} \sum_{i=1}^n Y_i$$

Among them,

Where n is the number of regions;  $Y_i$  and  $Y_j$  are respectively the observed values of the upgrading of industrial structure indexes in area i and j. The index of the upgrading of industrial structure refers to the practices of Xu Deyun et al. (2008). [11] Specific indicators are:

$$Y = \sum_{i=1}^3 y_i \cdot i = y_1 \times 1 + y_2 \times 2 + y_3 \times 3 \quad (2)$$

Where,  $y_i$  is the proportion of the output value of the first industry to GDP; Y is the industrial structure level index, and it ranges from [-1, 1].  $w_{ij}$  is the spatial weight matrix. There are three kinds of spatial matrices commonly used in research:

1. Spatial adjacent weight matrix. This kind of matrix according to the provincial geographic adjacency relations. A province is assigned 1 if it adjacent to other provinces, and the other assigns 0.

2. Geographical distance weight matrix. The closer the distance between two provinces is, the larger the value is, and the value of the same province is 0. The formula is:

$$W_{ij} = \begin{cases} \frac{1}{d_{ij}}, & i \neq j \\ 0, & i = j \end{cases} \quad (3)$$

Where,  $d_j$  is the distance between area i and j. It can be calculated based on the longitude and latitude coordinates of each provincial capital.

3. Economic distance weight matrix. The larger the income gap between the two provinces is, the smaller the value is, and the value of the same province is 0. The formula is:

$$W_{ij} = \begin{cases} \frac{1}{|Z_i - Z_j|}, & i \neq j \\ 0, & i = j \end{cases} \quad (4)$$

Among them,  $Z_i$  and  $Z_j$  are the average annual per capita GDP in the observation period of i province and j province respectively.

In this paper, the above three matrices are constructed and normalized. Table 1 is the global Moran's I value of the industrial structure upgrade index of 30 provinces and regions in China from 2000 to 2017, which is measured by the above three spatial weight matrix.

**Table 1.** The global Moran's I value of the industrial structure upgrade index

Matrix type	Space adjacency weight matrix	Geographical distance weight matrix	Economic distance weight matrix
The global Moran's I value	0.1060*	0.2110***	0.0990**

Note: \*, \*\* and \*\*\* are statistically significant at 10%, 5% and 1% respectively.

From Table 1, it can be seen that the global Moran's I value of the industrial structure upgrade index calculated by three weight matrices is at least at 10% of the significant level.

This shows that there is a positive spatial correlation between China's industrial structure in 2000-2017, and the industrial structure of a region will be affected by the industrial layout of neighboring regions.

In addition, the industrial structure upgrading index has the most significant spatial correlation based on the geographical distance weight matrix, indicating that the industrial structure of the region with a closer geographical distance has a stronger spatial correlation.

## 2.2 Data

### 2.2.1 Environmental Protection Tax Index

At present, there is no environmental protection tax data in China, but considering the green taxes are based on the discharge of the transformation, that is imposed in China using discharge data is a good way to reflect the effect of green taxes. Most scholars, such as Liu Ye (2018), have adopted the total data of pollutant discharge fee for analysis. [8] Therefore, this paper takes pollutant discharge fee as the proxy variable of environmental protection tax.

### 2.2.2 Control Variables Index

The upgrading of industrial structure is affected by many factors, such as technological progress, human capital,

foreign direct investment and so on. This paper measures technological progress from the perspective of innovation output, and specifically adopts logarithmic

measurement of sales of new products in each province over the years.

(1) Technological Progress (TI), which is expressed by the perspective of innovation output, using the

**Table 2.** Descriptive statistics of variables

variable	Ave	Std.Dev.	Min	25% quantile	50% quantile	75% quantile	Max
Y	2.2941	0.1246	2.0690	2.2199	2.2696	2.3328	2.7972
ETAX	4.3661	4.1552	0.0771	1.5499	2.9740	5.6153	22.3380
TI	13.3973	2.6368	1.6094	11.8614	13.5444	15.3853	18.8617
HC	3.7697	0.9620	0.3001	3.2985	3.9366	4.4567	5.2963
FDI	0.3680	0.4481	0.0411	0.1324	0.1915	0.4947	4.7084
EX	0.2834	0.3477	0.0294	0.0749	0.1209	0.3293	1.5888
FD	1.1242	0.3778	0.2056	0.8640	1.0581	1.2865	2.5847

logarithmic measure of new product sales in various provinces over the years.

(2) Human capital (HC), which according to the education years, this paper respectively weights 6, 9, 12,16 to the number of primary school, middle school, high school and university, and takes logarithm form to measure; [12]

(3) Foreign direct investment (FDI), which is expressed as the proportion of FDI in regional GDP.

(4) Foreign trade (EX), which is expressed by the ratio of import and export to the regional GDP;

(5) Financial development (FD), which is expressed by the ratio of the deposit and loan of financial institutions to the regional GDP. [13]

Considering the integrity and availability of the data, this paper takes 30 provinces (cities and autonomous regions) in mainland China from 2000 to 2017 as the research sample (except Tibet). The dollar data in this paper are converted into RMB by the average exchange rate of the current year.

This paper select data from “China Statistical Yearbook”, “China Environmental Yearbook” and “China High-tech Statistical Yearbook” of corresponding years. The basic statistical characteristics of variables are shown in Table 2.

The panel data need to be tested for stationarity before spatial econometric regression. The results of Fisher-PP and Fisher-ADF tests show that all variables reject the original hypothesis at least at 5% of the significant level. The panel data is stationarity, and the model regression results are reliable.

### 2.3 Panel Method

Because of the spatial correlation of the upgrading of industrial structure, this paper introduces the spatial econometric model when studying the impact of environmental protection tax on the upgrading of industrial structure.

#### 2.3.1 Spatial lag model (SLM)

Spatial lag model (SLM) mainly examines the mutual influence of variables in the spatial range. The SLM of this paper is:

$$Y_{it} = \alpha_0 + \alpha_1 ETAX_{it} + \theta_1 X_{it} + \rho \sum_{j=1}^n W_{ij} Y_{jt} + \omega_1 + \xi_t + \varepsilon_{it} \quad (5)$$

Among them, the variable  $ETAX_{it}$  is the environmental protection tax in the region  $i$  of  $t$  year;  $Y_{it}$  is the index of the upgrading of industrial structure in the region  $i$  of  $t$  year; and other control variables are technology innovation (TI), human capital (HC), foreign direct investment (FDI), foreign trade (EX) and financial development (FD).  $W_{ij}$  is the spatial weight matrix;  $\rho$  is a spatial autoregressive coefficient;  $\omega_1$  is the regional fixed effect;  $\xi_t$  is the time fixed effect;  $\varepsilon_{it}$  is the random error term of normal distribution.

#### 2.3.2 Spatial error model (SEM)

The spatial error model (SEM) reflects the interaction and relationship of the error impact of explanatory variables in the adjacent region. The SDM of this paper is:

$$Y_{it} = \alpha_0 + \alpha_1 ETAX_{it} + \theta_1 X_{it} + \omega_1 + \xi_t + u_{it} \quad (6)$$

$$u_{it} = \lambda \sum_{j=1}^n W_{ij} u_{jt} + \varepsilon_{it}$$

Where,  $u$  is the disturbance term;  $\lambda$  is the space error coefficient. The other variables are explained in the same way as (5).

## 3 Empirical Analysis

In order to ensure the robustness and reliability of the test results, the spatial econometric analysis model is constructed by using spatial adjacent weight matrix, geographic distance weight matrix and economic distance weight matrix respectively, and the robustness between spatial lag model (SLM) and spatial error model (SEM) is tested by using the methods of Li Bin and Peng Xing (2013). [14] The test results show that the RLM-error value of the spatial error model passes the 5% significance test, the RLM-lag value is not significant.

The Hausman test showed that the estimator is negative (its value is -19.58). Therefore, the null hypothesis of random effects is accepted and the spatial

error model of random effects is considered to be more consistent with the model setting. The regression results are shown in table 3.

From Table 3, it can be seen that:

(1) The estimated values of the spatial term parameters of the model ( $\rho$  and  $\lambda$ ) is significant at the confidence level of 1%, which indicates that the upgrading of industrial structure in China's provincial regions has obvious spatial dependence characteristics,

and the regional industrial economic policies and environmental policies will generate externalities to neighboring regions. The spatial lag coefficient ( $\rho$ ) and the spatial error coefficient ( $\lambda$ ) are significantly positive, indicating that the environmental protection tax and the upgrading of industrial structure in China are not completely randomly

**Table 3.** Regression results of spatial econometric model

Variable	Spatial error model (SEM)			Spatial lag model (SLM)		
	(I) Spatial adjacent weight matrix	(II) Geographical distance weight matrix	(III) Economic distance weight matrix	(IV) Spatial adjacent weight matrix	(V) Geographical distance weight matrix	(VI) Economic distance weight matrix
cons	2.0445*** (0.0329)	2.0324*** (0.0308)	1.9749*** (0.0295)	1.0262*** (0.0862)	1.0005*** (0.0932)	0.9594*** (0.0993)
ETAX	0.0018*** (0.0006)	0.0017*** (0.0006)	0.0016*** (0.0006)	0.0009* (0.0005)	0.0007 (0.0005)	0.0008 (0.0005)
TI	0.0033** (0.0016)	0.0028* (0.0017)	0.0028* (0.0017)	0.0039*** (0.0015)	0.0038** (0.0017)	0.0044*** (0.0015)
HC	0.0274*** (0.0061)	0.0319*** (0.0060)	0.0458*** (0.0068)	0.0128*** (0.0042)	0.0133*** (0.0043)	0.0162*** (0.0042)
FDI	-0.0014 (0.0046)	-0.0009 (0.0046)	-0.0004 (0.0049)	0.0015 (0.0046)	0.0019 (0.0047)	0.0017 (0.0047)
EX	0.0413*** (0.0146)	0.0457*** (0.0148)	0.0345** (0.0155)	0.0261* (0.0141)	0.0272* (0.0143)	0.0304** (0.0146)
FD	0.0739*** (0.0093)	0.0741*** (0.0095)	0.0819*** (0.0096)	0.0717*** (0.0078)	0.0726*** (0.0079)	0.0729*** (0.0081)
$\lambda$	0.5359*** (0.0615)	0.5749*** (0.0573)	0.6265*** (0.0604)			
$\rho$				0.4699*** (0.0429)	0.4764*** (0.0460)	0.4929*** (0.0488)
R <sup>2</sup>	0.7646	0.7767	0.7567	0.6296	0.5981	0.5861
Log-L	1029.5343	1026.0888	1024.2413	1009.3554	1013.2175	1009.4102
Obs	510	510	510	510	510	510

distributed. The upgrading of industrial structure in one province has a positive spillover effects on the adjacent provinces. While implementing environmental protection tax to promote the upgrading of local industrial structure, the provinces also have a positive spillover effects on the industries in the adjacent provinces. In addition, by comparing the regression results of the SEM models (I), (II) and (III) constructed by three weights, this paper finds that the spatial error coefficient is gradually increasing, which means that compared with the spatial adjacent and geographical distance, the spatial spillover effects of the upgrading of industrial structure will significantly increase with the reduction of economic distance. This may be because of the similarity between provinces with higher level of economic development, which is conducive to the flow of information, technology and various resource elements among regions, thus promoting the industrial cooperation and development between provinces and regions.

(2) In the three spatial error models, the regression coefficients of environmental protection tax are positive, and all significant off them are at the confidence level of 1%, which shows that the implementation of environmental protection tax has a positive spatial

spillover effects on the upgrading of industrial structure. That is, environmental protection tax can produce the upgrading of industrial structure. This shows that the levy of environmental protection tax can promote enterprises to innovate production technology to a certain extent, and promote the continuous adjustment and optimization of industrial structure. However, it is also found that the regression coefficient of environmental protection tax has a relatively small impact, which also reflects that the environmental policy intensity in China is relatively loose during the sample period, which is not conducive to industrial structure upgrading. Especially for the western region of China, the backward level of economic development makes the western region choose to pursue economic development while ignoring environmental problems, which is more unfavorable to the upgrading of industrial structure. Theoretically, the environmental protection tax is superior to the pollutant discharge fee in terms of levy scope, adjustment means and levy link, so the positive impact on the upgrading of industrial structure will be enhanced continuously.

(3) Regression coefficients of technological progress, human capital, foreign trade and financial development are significantly positive in controlling variables, which

indicates that these factors have positive effects on the upgrading of industrial structure. Among them, financial development and technological progress have significantly promoted the upgrading of industrial structure; The impact of human capital on the upgrading of industrial structure should not be ignored; Foreign trade coefficient shows that foreign trade can significantly promote the upgrading of China's industrial structure, but considering the existence of foreign trade pollution shelter effect, coupled with the increase of China's foreign trade is mainly from the manufacturing, so the promotion of the upgrading of China's industrial structure is also limited. The coefficient value of FDI is negative, but it is not statistically significant. This may be due to the fact that the intensity of China's environmental policy is lower than the developed countries (regions), resulting in the transnational transfer of pollution intensive industries, the expansion of pollution intensive industries, the lack of R&D and innovation of enterprises, and the existence of production in foreign investment in China. Industry, region and industry bias, to a certain extent, is not conducive to industrial restructuring and upgrading. [15]

## 4 Conclusions

Based on the panel data of China from 2000 to 2017, this paper constructs a spatial econometric model to analyze the spatial correlation of the upgrading of industrial structure, and examined the spatial effect of environmental protection tax on the upgrading of industrial structure. The results show that there is a significant positive spatial correlation in the upgrading of China's industrial structure, and there is a certain similarity in the industrial structure of neighboring provinces, showing the characteristics of spatial clustering; environmental protection tax has a significant positive spatial spillover effects on the upgrading of industrial structure. While upgrading the local industrial structure, it will have a positive impact on the upgrading of the industrial structure in the neighboring regions. Human capital, technological progress, foreign trade and financial development have a positive impact on the upgrading of China's industrial structure, while foreign direct investment is not conducive to the upgrading of industrial structure, but not statistically significant.

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