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Industrial Transfer and Overall Environmental Pollution in China

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Abstract

Since the implementation of regional development strategies in China, interregional industrial transfer has significantly accelerated. However, the relocation of pollution-intensive industries from eastern to central and western regions, driven by differential environmental regulations, has raised serious concerns about environmental sustainability. While existing studies have extensively examined foreign direct investment's environmental impacts, research on domestic industrial transfer remains limited, particularly regarding its potential nonlinear relationship with pollution. This study addresses this gap by incorporating relative environmental regulation stringency as a threshold variable within the Copeland-Taylor theoretical framework. Using provincial panel data from 2000 to 2016 and threshold regression analysis, we empirically investigate how pollution-intensive industrial transfer affects environmental pollution under varying regulatory intensities. The findings provide theoretical and empirical support for coordinating regional development with environmental protection.

Keywords

Pollution-intensive industrial transfer; Environmental regulation; Threshold effect

1. Introduction

Since the end of the 20th century, China has successively implemented regional development strategies such as the Western Development, the Revitalization of Northeast China, and the Rise of Central China, which have effectively promoted the process of domestic industrial transfer. In recent years, industrial transfer policies have been further deepened. Against the background of advancing the transformation and upgrading of national economic and technological development zones, the key focus is to guide the eastern regions to accelerate economic transformation relying on their own advantages and enhance the level of international economic cooperation; meanwhile, support the central and western regions to give full play to their comparative advantages such as abundant resources and low factor costs, and actively undertake industrial transfer to drive regional economic growth.

However, differences in environmental regulation intensity across regions may lead to resource misallocation, causing some high-pollution industries to transfer from the east to the central and western regions, which has caused significant damage to the local ecological environment. Although industrial transfer has promoted economic growth to a certain extent, the accompanying environmental problems have prompted us to reflect: if not guided by environmental sustainable development, is inter-regional industrial transfer sustainable? According to statistics, in December 2017, China remained the world's largest emitter of greenhouse gases, with carbon dioxide emissions reaching 105.37 million tons, approximately equal to the sum of those from the United States, India, Russia, and Japan. At the same time, various regions have gradually strengthened environmental regulations, which have exerted a certain regulatory effect on the transfer of high-pollution industries. Data from the China Environmental Statistics Yearbook shows that the industrial solid waste generation in China was 3.092 billion tons in 2016, a decrease of 4.21% compared with 2011, and has shown an overall downward trend since 2011. Therefore, under the constraint of environmental regulations, studying the impact of high-pollution industrial transfer on environmental pollution is of great significance for promoting the sustainable development of China's regions.

Based on the above background, this chapter first constructs a theoretical model of the impact of industrial transfer on environmental pollution, and introduces the relative environmental regulation intensity as a threshold variable; second, using panel data of 30 provinces in China from 2000 to 2016, it empirically analyzes the impact of high-pollution industrial transfer on environmental pollution from three dimensions: full-sample regression, regional heterogeneity, and period heterogeneity, and ensures the reliability of the results through robustness tests; finally, it evaluates the impact degree of high-pollution industries on environmental pollution and puts forward targeted policy recommendations for China to achieve coordinated regional and environmental development.

2. Literature Review

To a certain extent, industrial transfer can drive regional economic growth, and if environmental sustainable development can be taken into account, a "win-win" situation of economic growth and environmental sustainable development can be achieved. However, in reality, the result of inter-regional industrial transfer is often that the environmental conditions of developed regions are improved, while pollution transfer and agglomeration to underdeveloped regions are intensified. In the long run, regions undertaking industrial transfer will face huge environmental costs. At present, there is no consistent view on the impact of regional industrial transfer on environmental pollution, and there are different opinions on whether the relationship between regional industrial transfer and environmental pollution is linear or non-linear.

Walter & Ugelow (1979) proposed the "Pollution Haven Hypothesis", whose main idea is that due to regional environmental regulations and other reasons, developed regions will transfer high-pollution industries to underdeveloped regions with weaker environmental regulations. This will directly lead to a sharp increase in the environmental pollution level of underdeveloped regions, making them become pollution havens for developed regions, and ultimately intensifying environmental pollution across the whole society. Cole & Elliott (2006) argued that high-pollution industries will avoid regions with high environmental regulation intensity in pursuit of price competitive advantages in the market, so pollution-receiving regions are likely to become havens for pollution-exporting regions. Kheder & Zugravu (2012) used an economic geography model to analyze the impact of environmental regulations on enterprise location choice, and the results showed that some countries exhibited a pollution haven effect while receiving investment from France.

To sum up, most studies on environmental pollution caused by regional industrial transfer focus on the impact of foreign direct investment (FDI) on the environment of Chinese regions, while there are relatively few studies on environmental problems caused by the transfer of high-pollution industries between regions in China. Regarding the measurement methods of industrial transfer, most studies use static indicators such as location quotient and industrial competitiveness, which cannot well reflect the dynamic changes and transfer direction of high-pollution industries. Existing studies focus more on exploring the relationship between industrial transfer and environmental pollution, but the relative intensity of environmental regulations will affect the transfer of high-pollution industries between regions, thereby affecting environmental pollution in China. Therefore, there may be a non-linear relationship between high-pollution industrial transfer and environmental pollution. However, there is still a lack of theoretical model support for the relationship between industrial transfer and environmental pollution.

Therefore, this chapter explores the issue from the following three aspects: first, theoretically, drawing on the Copeland-Taylor model, it constructs a theoretical model of the impact of industrial transfer on environmental pollution, introduces the relative environmental regulation intensity as a threshold variable, and focuses on exploring the impact of high-pollution industrial transfer on environmental pollution; second, methodologically, according to the derivation of the theoretical model, it uses panel data of 30 provinces in China from 2000 to 2016, adopts a threshold panel regression model, supplemented by a linear regression model for comparison, so as to more comprehensively explore the impact of high-pollution industrial transfer on environmental pollution in China; finally, in the empirical analysis, it first conducts full-sample regression analysis, then carries out regional heterogeneity regression analysis based on eastern, central, and western regions of China, and period heterogeneity regression analysis based on the periods of 2000-2009, 2010-2013, and 2014-2016, and finally draws conclusions and puts forward reasonable policy recommendations.

3. Theoretical Analysis and Research Hypotheses

Industrial transfer is a pillar of economic growth, so many scholars have explored the impact of industrial transfer on environmental pollution. Copeland & Taylor (1994) initially established a static North-South model, and then expanded it to study the relationship between per capita income, foreign trade, and environmental pollution from the perspectives of scale effect, technology effect, and structure effect. This chapter draws on the idea of their North-South model to establish a theoretical model of the impact of industrial transfer on environmental pollution. Since the level of environmental regulation in different regions will affect the impact of industrial transfer on environmental pollution, the regional relative environmental regulation intensity is then introduced as a threshold variable to construct a non-linear threshold regression model, so as to explore the impact degree of industrial transfer on environmental pollution under different relative environmental regulation intensities.

3.1. Establishment of Production Function

Assume that the economic system has constant returns to scale, with capital and labor as input factors, i.e., the Cobb-Douglas production function, expressed as:

$$F(K, L) = K^{\alpha} L^{1-\alpha} \tag{3-1}$$

In the economic system, when industries from one region transfer to another, the original production function will change. Derived from the Copeland-Taylor model, industrial transfer will affect production enterprises through scale effect, technology effect, and structural effect. Therefore, the production function is modified due to industrial transfer as follows:

$$F(K, L) = g(tr) f(K, L) \tag{3-2}$$

It is assumed that two types of products are produced in the economic system, namely environmentally friendly products (X) and polluting products (Y). Pollutant Z is generated during the production of polluting products Y. Since the economic system is assumed to have constant returns to scale, and Y is a capital-intensive product, the emission of Y pollutants has a negative externality effect and will generate social costs. From the measures to solve externalities, such as Pigouvian tax, pollution discharge fee, and pollution permit trading, we can know that economic agents, as rational individuals, take profit maximization as their fundamental goal. Therefore, economic agents will not discharge pollutants arbitrarily, but will use some resources to reduce pollutant emissions. Here, M is used to represent the enterprise's pollution control intensity, i.e., the proportion of production factors used by the enterprise for pollution control in the total production factors, with $0 \leq M \leq 1$. When M is 0, it means the enterprise does not conduct pollution control, and the output F of the production enterprise can be expressed as its maximum production capacity. When the production enterprise begins to use part A of production factors for pollution control, the actual output of the enterprise is (1-M)F, and the pollutant Z = P(M)F, where P(M) is the pollution emission function.

3.2. Cost Minimization Decision

From Equation, as rational individuals, production enterprises always take profit maximization as their fundamental goal. At this time, the goals of producing polluting product Y are divided into two independent decisions: under the given conditions of capital cost R and labor wage W, select the optimal capital-labor ratio to minimize the cost CF of the potential output F of the production enterprise; under the given conditions of the potential production cost CF and pollutant emission cost CP of the production enterprise, select the optimal combination of potential output F and pollutant emission Z to minimize the production cost CY per unit of product Y.

4. Empirical Research Design

4.1. Econometric Model and Hypothesis Proposal

(1) Construction of Econometric Model

The threshold regression model mainly captures the critical point of jump in the economy. It divides the regression model into multiple intervals according to the threshold value, and there are different equations for different intervals. In the threshold regression model, when the explanatory variable reaches the critical value, the slope coefficient of the model will show a kink phenomenon, which is consistent with the actual economic phenomenon. This chapter uses the threshold panel regression model proposed by Hansen (1999) to analyze the corresponding data to determine the threshold value, which can capture the non-linear threshold characteristics of the economic system when structural mutations occur in the long run.

Basic panel threshold equation:

$$y_{it} = \mu_i + \beta_1 x_{it} I(q_{it} \leq \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + e_{it} \tag{4-1}$$

Among them, I(·) represents the indicator function. Due to different threshold values, the coefficients of the corresponding explanatory variables on the explained variable are different, which are and respectively.

(2) Hypothesis Proposal

Hypothesis 1: High-pollution industrial transfer has seemingly improved the environmental conditions of the transfer-out regions, but has rapidly intensified environmental pollution in the transfer-in regions, thus making the national environmental situation increasingly severe.

Hypothesis 2: There is a positive relationship between the regional relative environmental regulation intensity and overall environmental pollution. Based on the "Pollution Haven Hypothesis", regional environmental regulations cause the region to transfer high-pollution industries to other regions. Although this leads to a temporary decrease in local environmental pollution, it causes a rapid increase in pollution in the transfer-in regions, bringing serious environmental problems.

4.2. Indicator Selection and Data Sources

Explained Variable: Comprehensive Environmental Pollution (tp). Environmental pollution in China mainly comes from industrial waste gas, industrial wastewater, and industrial solid waste. Therefore, the "three industrial wastes" are used to measure the comprehensive environmental pollution index. Due to the different weight ratios of each indicator, before calculating the comprehensive environmental pollution index, the entropy weight method is used to calculate the respective weights of the three types of indicators. The specific steps are as follows: Step 1, standardize the total emission of the three types of pollutants; Step 2, use the entropy weight method to determine the proportion of the three types of pollutants in the comprehensive environmental pollution index; Step 3, calculate the annual comprehensive environmental pollution index.

$$tp_{it} = \sum_{j=1}^{3} w_j s_{tj} (t = 1{,}2 \cdots 18; \quad \mathrm{j} = 1{,}2{,}3) \tag{4-2}$$

Among them, tpit represents the comprehensive environmental pollution index of province i in year t, j represents the type of pollutant, stj represents the standardized value of the emission of the j-th pollutant in year t, and wj represents the proportion of the j-th pollutant in the total pollutants.

Table 4-1. Descriptive Statistics of Main VariablesTable Header

Category	Variable	Definition	Observations	Mean	Std. Dev.	Min	Max
Explained Variable	lntp	Comprehensive Environmental Pollution	510	-1.4786	0.8613	-4.1573	-0.1161
Core Explanatory Variable	lntr	High-Pollution Industrial Transfer	510	4.6174	0.0314	4.4842	4.9313
Threshold Variable	eri	Relative Environmental Regulation Intensity	510	1.0366	0.8978	0.0175	5.828
Control Variables	lngdp	Regional GDP	510	8.677	1.0453	5.5747	10.972

5. Empirical Results and Analysis

5.1. Threshold Condition Test

This chapter uses Hansen’s F-statistic and LR-statistic to test the number and authenticity of relative environmental regulation intensity thresholds. Table 5-1shows the results: the single threshold test rejects the linear null hypothesis at the 1% significance level; the double threshold test rejects the single-threshold null hypothesis at the 10% level; the multiple threshold test fails to reject the double-threshold null hypothesis. Thus, there is a double-threshold non-linear relationship between high-pollution industrial transfer and environmental pollution, with threshold values of 0.0764 and 0.6265.

Table 5-1. Threshold Effect Test Results of Relative Environmental Regulation

Threshold Type	F Value	P Value	1% Critical Value	5% Critical Value	10% Critical Value	BS Times	Threshold Value	95% Confidence Interval
Single Threshold	61.34	0.00	29.27	20.98	18.43	500	0.0764	[0.0699, 0.092]
Double Threshold	13.89	0.09	20.71	15.58	13.41	500	0.6265	[0.6003, 0.6287]
Multiple Threshold	14.99	0.29	70.42	34.11	25.02	500	—	—

5.2. Full-Sample Regression Results and Analysis

Stationarity tests show all variables are stationary; VIF values < 10 (no multicollinearity); GMM estimation uses the first lag of eri as an instrumental variable to address endogeneity. Table 5-2 presents threshold regression and linear regression (fixed effects, random effects, GMM) results

Table 5-2. Full-Sample Regression ResultsTable Header

Explanatory Variable	Threshold Regression	Linear Regression (Fixed Effects)	Linear Regression (Random Effects)	Linear Regression (GMM)
lntr (eri ≤ 0.0764)	0.4203 (0.2933)	—	—	—
lntr (0.0764 ≤ eri ≤ 0.6265)	0.5435* (0.291)	—	—	—
lntr (eri ＞ 0.6265)	0.5671** (0.2912)	—	—	—
lntr	—	0.8018*** (0.3096)	0.7429** (0.3143)	0.7753 (0.7418)
eri	0.1297 (0.019)	0.0448** (0.2145)	0.0564*** (0.021)	0.0042 (0.0293)
lngdp	-0.4929 (0.337)	0.1079 (0.351)	0.6673*** (0.2339)	0.1939 (0.1923)
ln2gdp	-0.3137*** (0.0108)	-0.0556*** (0.1111)	-0.0597*** (0.0101)	-0.0164* (0.0098)
lnks	0.7425*** (0.0809)	0.7412*** (0.8667)	0.6801*** (0.0807)	0.7719*** (0.111)
lnind	0.3334*** (0.1186)	0.3818*** (0.1268)	0.3709*** (0.1245)	-0.2774* (0.1514)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	(0.8276)	(0.8767)	(0.079)	(0.058)
lnfc	-0.3728*** (0.1237)	-0.5443*** (0.1309)	-0.9277*** (0.6138)	-0.9938*** (0.0679)
cons	-6.3923*** (1.6845)	-9.7722*** (1.7475)	-9.9591*** (0.0614)	-5.815 (3.6996)
R-squared	0.335	0.6444	0.8103	0.8376
F-test/Wald-test	38.68	34.86	436.38	2179.17
Observation	510	510	510	480

*Note: *, *, *** indicate significance at the 10%, 5%, and 1% levels respectively; values in parentheses are standard deviations.

Key findings:

Threshold effect: As eri increases (＜0.0764 → 0.0764-0.6265 → ＞0.6265), the impact coefficient of lntr on lntp rises from 0.4203 to 0.5671, confirming a non-linear relationship (Hypotheses 1 is supported).

Linear regression overestimates the coefficient (0.7429-0.8018) due to ignoring the threshold.

Control variables: lnks, lnec, and lnind (threshold/fixed/random effects) have significant positive impacts on pollution; lnfc has a significant negative impact; EKC is not significant in China.

6. Conclusions and Policy Recommendations

High-pollution industrial transfer and environmental pollution show a double-threshold non-linear relationship: as relative environmental regulation intensity increases, the pollution impact of transfer intensifies. Transfer mainly flows from eastern to central-western regions.Relative environmental regulation intensity has no significant impact on pollution; EKC does not exist in China.

Policy Recommendations

Differentiated environmental policies:

Low eri regions: Prioritize resource-efficient industries and optimize industrial layout.

High eri regions: Increase R&D of green technologies; appropriately lower regulation to mitigate transfer-induced pollution.

Inter-regional cooperation:

Establish technology-sharing mechanisms between transfer-out and transfer-in regions.

Eastern regions: Export green technologies while transferring industries.

Central-western regions: Improve energy efficiency and attract foreign enterprises with environmental protection technologies.

Comprehensive governance: Consider GDP, capital stock, industrial structure, energy consumption, and factor cost; build inter-regional industrial chains for coordinated development.

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