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# Environmental Regulation and Regional Industrial Transformation and Upgrading: A DID Test Based on the "Two Control Zones" Policy

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***Abstract:*** *Based on the "two control zones" policy, this paper selects the panel data of Chinese prefecture-level cities and national patent data from 1994 to 2005, and establishes a DID model to explore the impact of environmental regulation on regional industrial transformation and upgrading from the city level. It is found that environmental regulation significantly promotes the transformation and upgrading of regional industries, and this conclusion is consistent in a series of robustness tests. Further study shows that the policy effect of environmental regulation has regional heterogeneity, that is, it significantly promotes the industrial transformation and upgrading in the eastern and central regions, but has no significant impact on the western and northeastern regions. Meanwhile, the mechanism study finds that environmental regulation promotes the transformation and upgrading of regional industries through technological innovation rather than capital investment.*

***Keywords:*** *environmental regulation; industrial transformation and upgrading; "two control zones" policy*

## 1. Introduction

Since the reform and opening up, China has promoted the rapid economic development by relying on the development strategy of heavy industry first, but the environmental pollution problem caused by it is also very prominent. The Party Central Committee attaches great importance to this. After the 18th National Congress proposed "Beautiful China" as the great goal of ecological civilization construction, the 19th CPC National Congress further elevated the construction of ecological civilization to a "Millennium Plan". In order to achieve this goal as soon as possible, China needs to improve its environmental regulatory system to ensure that it promotes sustained and healthy economic development while enjoying "clear waters and green mountains". However, sustainable development needs industrial transformation and upgrading as support. Can China's environmental regulation force industries to transform and upgrade while controlling environmental pollution, so as to achieve a win-win situation between environmental protection and economic development?

Existing studies mainly focus on the following two perspectives. First, it follows the "cost theory", which believes that environmental regulation increases the production costs of enterprises, reduces their production efficiency and profits, and affects the industry structure through such behaviors as enterprise entry or exit, production scale adjustment and resource reallocation[1]. In order to avoid environmental regulation or reduce environmental costs, polluting enterprises will move to the surrounding areas with low environmental regulations, thus causing the adjustment of regional industrial structure, namely "pollution haven" effect[2]. Second, it verifies the "Porter hypothesis", that is, moderate environmental regulations not only do not make enterprises lose competitiveness, but also induce them to make technological innovations and produce the innovation compensation effect to achieve Pareto improvement[3]. Therefore, the government can encourage enterprises to make technological innovations by means of innovation subsidies, thus promoting the transformation and upgrading of traditional industries[4].

In order to deeply explore the relationship between environmental regulation and regional industrial transformation and upgrading, this paper takes the "two control zones" policy as a natural experiment, selects China's prefecture-level city panel data and national patent data from 1994 to 2005, and establishes a DID model to discuss the impact of environmental regulation on regional industrial

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transformation and upgrading from the city level. Compared with existing studies, the possible contributions of this paper are as follows: firstly, in terms of research method, this paper regards the "two control zones" policy as exogenous impact and establishes a DID model to examine the impact of environmental regulation on regional industrial transformation and upgrading in detail, which not only effectively avoids the problem that environmental regulation cannot be objectively measured in previous studies, but also overcomes the subjectivity and endogeneity of indicator selection as much as possible, enhancing the persuasiveness of the empirical research. Secondly, in terms of research sample, this paper takes prefecture-level cities as the research subject, and manually collects the industrial transformation and upgrading data of 262 cities from 1994 to 2005, so that the sample is systematic and comprehensive and the statistical caliber is unified, which ensures that the conclusions are authentic and reliable. Finally, this paper not only analyzes the heterogeneity of environmental regulations on industrial transformation and upgrading in different regions, but also explores the microscopic mechanism of environmental regulation forcing industrial transformation and upgrading, which further verifies the "Porter hypothesis".

## 2. Research Design

### *2.1 Model Specification*

In order to deal with the increasingly serious problems of acid rain and sulfur dioxide pollution in China's industrialization process, in 1997, the State Environmental Protection Bureau submitted to the State Council a “Request for Approval of the Division of Acid Rain Control Zones and Sulfur Dioxide Pollution Control Zones”. In January of the following year, the State Council approved the "Acid Rain Control Zone and Sulfur Dioxide Pollution Control Zone Division Program", and classified 175 prefecture-level cities into the "two control zones". Since then, the state has promulgated a series of supplementary regulations to ensure the smooth implementation of the "two control zones" policy. According to statistics, in 2000, 102 cities in the "two control zones" met the national statutory secondary standard, and 84.3 percent of polluting enterprises met the sulfur dioxide emission standard. In 2010, sulfur dioxide concentrations in about 95 percent of cities in the "two control zones" met the national statutory secondary standard. In order to study the impact of environmental regulation on regional industrial transformation and upgrading, this paper regards the "two control zones" policy as exogenous impact, and whether the city is classified as "two control zones" by the state as a criterion to distinguish the experimental group from the control group, and selects the panel data of Chinese prefecture-level cities to establish the following DID model:

$$Y_{\mathrm{it}} = \alpha P * T + \sum \beta X_{\mathrm{it}} + d_i + d_t + \mu_{it} \tag{1}$$

In the above equation, i and t represent city and year respectively. Yit represents the industrial transformation and upgrading status of city i in year t. P and T are dummy variables. P is a time dummy variable that takes as 1 if $t \geq 1998$ and 0 otherwise. T is a grouping dummy variable that takes as 1 if the city belongs to the "two control zones" and 0 otherwise. The interaction term P * T is used to identify the policy effect of environmental regulation on the industrial transformation and upgrading of local cities, so its coefficient α is the focus of this paper. In addition, Xit is a series of other control variables that affect industrial transformation and upgrading. di is a city fixed effect, dt is a time fixed effect, and μ is a random error term.

### *2.2 Data sources*

This paper obtains the list of cities in the "two control zones" from the "Reply of the State Council on Issues Related to Acid Rain Control Zone and Sulfur Dioxide Pollution Control Zone", and selects the panel data of 262 prefecture-level cities in China from 1994 to 2005 for empirical testing (excluding cities with excessive data missing due to changes of administrative divisions). The city-level data are obtained from the China City Statistical Yearbook from 1995 to 2006, and the patent data of prefecture-level cities are obtained from the patent data of the State Patent Office.

### *2.3 Variable Selection*

The index of industrial transformation and upgrading is measured by the comprehensive index method with reference to the study of Deyun Xu[5]. Specifically, its calculation formula is as follows.

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$$R = \sum y_i * i = y_1 * 1 + y_2 * 2 + y_3 * 3 \quad (2)$$

Here yi represents the proportion of the output value of industry i to the total output value of regional industry, and R represents the degree of upgrading of regional industrial structure. The "two control zones" policy is a dummy variable, which takes as 1 if a city is classified as a "two control zones" city and 0 otherwise. The control variables refer to the study of Yijun Yuan and Ronghui Xie[6], and four variables of regional economic development level (GDP), human capital level (Hc), urbanization level (Urban) and population concentration degree (Densitypop) are selected. In order to further study the influence mechanism of environmental regulation on regional industrial transformation and upgrading, four intermediate variables, namely fixed asset investment (Fixcap), foreign direct investment (Lnfdi), invention patent grant (Lnipb) and utility model patent grant (Lnumb) are selected in this paper.

### *2.4 Descriptive Statistics*

Table 1 reports the results of descriptive statistics of the main variables in this paper. The mean value of industrial transformation and upgrading index is 2.14, which indicates that from 1994 to 2005, the country was in a state of transformation from the secondary industry to the tertiary industry. From the trend of the mean value of each index, the degree of industrial transformation and upgrading and the level of technological innovation of cities in the "two control zones" are significantly higher than those in the non-"two control zones".

*Table 1: Descriptive statistical results for major variables*

| Variables | Variable Symbols | Observations | Mean value | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|---|
| Industrial transformation and upgrading indicator | R | 3062 | 2.140 | 0.152 | 1.610 | 2.797 |
| Interaction item | P*T | 3144 | 0.387 | 0.487 | 0.000 | 1.000 |
| Economic development level | GDP | 2990 | 8.892 | 0.710 | 4.344 | 12.514 |
| Human capital level | Hc | 2674 | 3.420 | 1.179 | 0.521 | 6.849 |
| Urbanization level | Urban | 2996 | 3.303 | 0.757 | 1.199 | 5.857 |
| Population concentration degree | Densitypop | 2997 | 5.783 | 0.814 | 1.552 | 9.356 |
| Fixed asset investment | Fixcap | 2996 | 13.131 | 1.245 | 8.434 | 16.744 |
| Foreign direct investment | Lnfdi | 2835 | 8.715 | 1.930 | 1.099 | 14.239 |
| Number of invention patents granted | Lnipb | 3119 | 1.587 | 1.289 | 0.000 | 6.850 |
| Number of utility model patents granted | Lnumb | 3119 | 3.985 | 1.274 | 0.000 | 8.127 |

Note: The Data are from China City Statistical Yearbook and Patent Statistical Database of China Patent Office

## 3. Analysis of regression results

### *3.1 Basic regression results*

In table 2, the basic regression results show that after the control variables are added successively, the estimated coefficient of the interaction term P*T is always positive and passes the significance test of 1%, indicating that environmental regulation has a positive promoting effect on regional industrial transformation and upgrading, and the industrial transformation and upgrading level of cities in the "two control zones" is significantly higher than that of other cities. The reason for this is that, compared with other cities, the environmental regulation in the "two control zones" is stronger, and the regulated enterprises have to carry out energy-saving and emission reduction technology transformation or technological innovation to improve the production process and pollution control level, reduce the emission of pollutants, and thus promote the transformation and upgrading of regional industries[7]. At the same time, enterprises with high pollution and high energy consumption are forced to withdraw from the market due to the sharp increase in costs, which also forces the industry to transform and upgrade.

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*Table 2: Basic regression results*

| Variables | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| P*T | 0.0716*** | 0.0142*** | 0.0104*** | 0.0221*** | 0.0225*** |
| | (0.00377) | (0.00364) | (0.00357) | (0.00353) | (0.00343) |
| GDP | | 0.114*** | 0.0412*** | 0.0531*** | 0.0607*** |
| | | (0.00353) | (0.00477) | (0.00467) | (0.00459) |
| Hc | | | 0.0542*** | 0.0365*** | 0.0323*** |
| | | | (0.00249) | (0.00270) | (0.00265) |
| Urban | | | | 0.0406*** | 0.0260*** |
| | | | | (0.00288) | (0.00306) |
| Densitypop | | | | | 0.0691*** |
| | | | | | (0.00587) |
| Constant | 2.113*** | 1.125*** | 1.593*** | 1.411*** | 1.002*** |
| | (0.00200) | (0.0307) | (0.0367) | (0.0376) | (0.0505) |
| Observations | 3062 | 2989 | 2671 | 2670 | 2670 |
| $R^2$ | 0.114 | 0.366 | 0.459 | 0.501 | 0.528 |

Note: The figures in parentheses are standard errors. ***, ** and * respectively indicate significance at the levels of 1%, 5% and 10%, and the tables below are same.

### *3.2 Robustness tests*

Firstly, the parallel trend hypothesis is tested. The results are shown in Figure 1. Before the implementation of the policy, there was no trend of industrial transformation and upgrading of cities in the "two control zones", but in the year of policy implementation, the trend of industrial transformation and upgrading appeared, and with the increase of years, the policy effect enhanced, until three years later, it became stable, indicating that the "two control zones" policy effectively promoted the industrial transformation and upgrading of the cities. Secondly, replace the index for robustness test. Referring to the research of Wu Fenghua and Liu Ruiming, the ratio of the output value of the tertiary industry to the output value of the secondary industry and the ratio of the sum of the output value of the secondary and tertiary industries to the regional GDP were used to replace the original industrial transformation and upgrading indicators for regression test. The results show that the estimation coefficient of the interaction term P*T is still positive and passes the significance test.

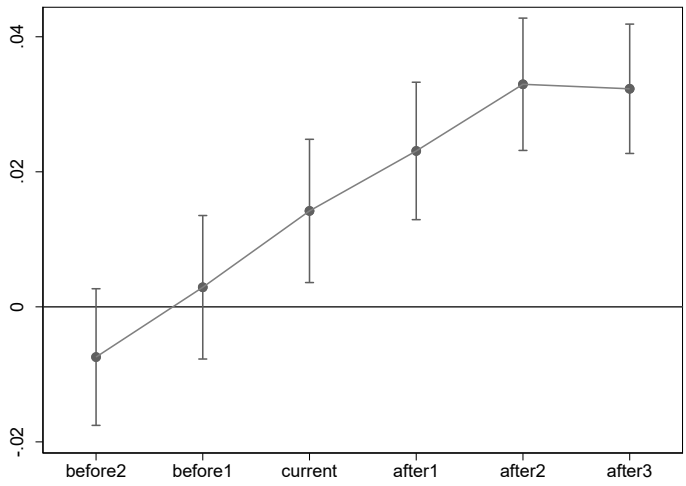


*Figure 1: Parallel trend hypothesis test*

### *3.3 Heterogeneity test*

Previous studies have shown that the impact of environmental regulation on regional industrial transformation and upgrading varies with different regions and economic development levels. For this

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reason, this paper divides the sample into four parts: East, Central, West and Northeast, according to the division criteria of the National Bureau of Statistics, so as to test the heterogeneity of different regions. The regression results in table 3 show that, controlling for other conditions, the "two control zones" policy significantly promotes industrial transformation and upgrading in the eastern and central regions, while the impact on the western and northeastern regions is not significant. This may be because the eastern and central regions have a higher level of economic development, and the competition between enterprises is more intense. Under the background of the overall improvement of national environmental regulation intensity, enterprises tend to reduce production costs and improve production efficiency through technological innovation, thus improving the overall industrial development level of the region. However, in the face of strong environmental regulation, the western and northeastern regions tend to relocate pollution-oriented enterprises to reduce production costs, so the effect of industrial transformation and upgrading is not obvious.

*Table 3: Regional heterogeneity test*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variables | East | Middle | West | Northeast |
| P*T | 0.0101** | 0.0579*** | 0.00835 | 0.00755 |
| | (0.00452) | (0.00679) | (0.00717) | (0.0117) |
| GDP | 0.0904*** | 0.0465*** | 0.0658*** | 0.0712*** |
| | (0.00686) | (0.00879) | (0.00951) | (0.0138) |
| Hc | 0.0190*** | 0.0331*** | 0.0378*** | 0.0131* |
| | (0.00370) | (0.00494) | (0.00628) | (0.00766) |
| Urban | 0.0138*** | 0.0252*** | 0.0235*** | -0.0277 |
| | (0.00422) | (0.00604) | (0.00581) | (0.0244) |
| Densitypop | 0.0682*** | 0.158*** | 0.0197** | 0.0257 |
| | (0.0109) | (0.0140) | (0.00844) | (0.0386) |
| Constant | 0.791*** | 0.560*** | 1.253*** | 1.435*** |
| | (0.0751) | (0.115) | (0.0906) | (0.209) |
| Observations | 911 | 821 | 593 | 345 |
| $R^2$ | 0.656 | 0.639 | 0.457 | 0.249 |

### *3.4 Mechanism Testing*

*Table 4: Mechanism of environmental regulation on regional industrial transformation and upgrading*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variables | Fixcap | Lnfdi | Lnipb | Lnumb |
| P*T | -0.0855 | 0.121 | 0.151*** | 0.108** |
| | (0.0555) | (0.120) | (0.0533) | (0.0494) |
| GDP | 0.643*** | 0.360** | 0.0615 | 0.0367 |
| | (0.0792) | (0.166) | (0.0654) | (0.0713) |
| Hc | -0.164*** | 0.00624 | -0.0335 | 0.000995 |
| | (0.0373) | (0.0723) | (0.0422) | (0.0396) |
| Urban | -0.488*** | -0.461*** | 0.114** | 0.0748 |
| | (0.0629) | (0.0917) | (0.0546) | (0.0503) |
| Densitypop | -0.290*** | -0.139 | 0.0366 | 0.0650 |
| | (0.0831) | (0.108) | (0.0822) | (0.0556) |
| Constant | 10.54*** | 8.054*** | -0.0685 | 2.986*** |
| | (0.723) | (1.443) | (0.700) | (0.728) |
| Observations | 2,669 | 2,559 | 2,654 | 2,654 |
| $R^2$ | 0.870 | 0.298 | 0.715 | 0.557 |

In order to further understand the micro mechanism of environmental regulation on the transformation and upgrading of regional industries, this paper examines two channels: capital investment and technological innovation. The regression results in table 4 show that the "two control zones" policy promotes the transformation and upgrading of regional industries through technological innovation rather than capital investment. This is because environmental regulation increases the pollution control investment of regulated enterprises, thus crowding out their productive investment and reducing their investment in machinery, equipment and plants for normal production expansion, thus making it difficult to generate economies of scale, improve total factor productivity and promote the

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transformation and upgrading of regional industries. However, with the strengthening of environmental regulations, enterprises are forced to eliminate inferior, inefficient and outdated technology and equipment, use clean coal technology, install sulfur scrubber and other equipment, and improve the existing production process, improve product quality, enrich product categories, forcing enterprises to promote the transformation and upgrading of regional industries through technological innovation. This regression result is an effective verification of the Porter hypothesis mentioned above.

## 4. Conclusions and Policy Recommendations

Based on the "two control zones" policy, this paper selects the panel data of Chinese prefecture-level cities and national patent data from 1994 to 2005, and establishes a DID model to explore the impact of environmental regulation on regional industrial transformation and upgrading from the city level. The findings are as follows. Firstly, environmental regulation significantly promotes the transformation and upgrading of regional industries, and this conclusion is consistent in a series of robustness tests. Secondly, further study shows that the policy effect of environmental regulation has regional heterogeneity, that is, the "two control zones" policy significantly promotes the industrial transformation and upgrading in the eastern and central regions, but has no significant impact on the western and northeastern regions. Last but not least, the mechanism study finds that environmental regulation promotes the transformation and upgrading of regional industries through technological innovation rather than capital investment. In other words, environmental regulation forces innovation-driven regional industrial transformation and upgrading, which is an effective verification of Porter's hypothesis.

As for how to improve the environmental regulation system to promote the transformation and upgrading of regional industries, this paper has the following policy implications. Firstly, build a more complete environmental regulatory system. In addition to strengthening central government's supervision and management of local environmental protection, environmental performance should be given greater weight in the performance assessment of officials, so that localities can promote sustainable economic development while protecting environment. Secondly, implement differentiated environmental regulation policies. For the eastern and central regions, an innovation-driven industrial development strategy should be implemented, and enterprises should be encouraged to make technological innovations in the form of innovation subsidies and research and development subsidies. As for the western and northeastern regions, efforts should be made on strengthening the supervision of enterprises' pollution emissions and improving the relevant management system. Finally, strengthen the supervision of the public and social opinion. The public and the media should be encouraged to supervise the formulation and implementation of environmental regulation policies by local governments and local officials, so that the public can participate in the supervision and implementation of environmental protection and ensure the implementation of environmental protection.

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