The Influence of Environmental Regulation on Air Quality—Empirical Analysis Based on Prefecture-level City

Ming-Hai YANG\textsuperscript{a}, Song-Shuang XIE\textsuperscript{\ast} and Kai-Qing LIU\textsuperscript{b}

Shandong University of Finance and Economics, Ji’nan, P.R. China
\textsuperscript{a}yangminghai@sina.com, \textsuperscript{\ast}Songshuang1996@126.com, \textsuperscript{b}741014247@qq.com

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Abstract. With the rapid advancement of industrialization and urbanization, environmental pollution problems, such as air pollution, water pollution, and soil pollution, have gradually emerged. Environmental regulation is an important means for the government to control pollution, and its relationship with air pollution has gradually become a hot issue of academic concern. Using the DID model and Panel Fixed Effect model, this paper chooses the first batch of cities in “the First Phase Monitoring Implementation Plan of the New Air Quality Standard” for evidence and found that the sulfur dioxide emissions are significantly reduced in these cities after the implementation of the policy. It provides a theoretical basis for developing effective environmental regulation policies in China.

Introduction
Since the reform and opening up, the extensive development mode has made China's economy achieve remarkable achievements and became the world's second largest economy. At the same time, it has caused serious depletion of natural resources, the air quality has gradually declined, and the living environment has been destroyed. According to the Bulletin of China's Ecological Environment, the ambient air quality of 217 cities exceeds the standard among 338 prefecture-level cities in 2018, accounting for 64.2\%, of which the annual average concentrations of PM2.5, PM10, SO2 and NO2 are respectively 39μg/m3, 71μg/m3, 14μg/m3 and 29μg/m3. It can be seen that China faces severe ecological and environmental challenges. Where to go? Government has adopted relevant environmental regulation policies and tools to deal with the worsening environmental problems. However, as an important means for the government to control pollution, is current environmental regulation effective in reducing environmental pollution?
Therefore, this paper selects the environmental policy—“the First Phase Monitoring Implementation Plan of the New Air Quality Standard” to study whether the air pollution indicators of the first batch of pilot cities have been effectively controlled after the policy is promulgated.

Literature Review and Hypothesis
At present, research on air pollution and environmental regulation has achieved fruitful results. The research on air pollution focuses on the analysis of the characteristics of air pollution, the negative impact of air pollution, the causes of air pollution and air pollution control. As for the study of environmental regulation, the main themes are the type of environmental regulation, the influence and effectiveness of environmental regulation, etc. By reviewing the previous literature, it is found that most studies only focused on environmental regulation or air pollution. In other words, there were few literature on combining environmental regulation with air pollution and is no unified conclusion about the impact of environmental regulation on air quality.
Some scholars believe that the current environmental regulations do not have the effect of suppressing air pollution and achieve the desired goal. Wang Yanfang et al. [1] used synthetic control methods to assess the impact of environmental policies on Beijing’s air quality after the 2008 Beijing Olympics and compare it with the impact before 2008. The study found that the policy improved Beijing's air quality to a certain extent and reached its maximum in 2010, but did not
bring long-term effects to Beijing's air quality improvement. In addition, Xu Changlin [2] pointed out that despite there are positive effects of the interaction between environmental regulation intensity and implicit economic scale on environmental pollution, but overall, China's current environmental regulation is not conducive to environmental quality improvement. Gao Ming et al. [3] found that there are obvious regional differences in the effects of environmental regulation. Environmental regulation in the eastern region had a significant negative impact on air pollution reduction, while the positive effect is not significant in the central and western regions.

In contrast, some scholars believe that environmental regulations have a significant effect on the control of air pollution. Zhu Xiangdong [4] also found that environmental regulation is an important way to suppress air pollution by using the spatial Dubin model. Furthermore, Sun Kunxin [5] verified that environmental regulation will improve environmental quality through rationalization and high-level industrial structure and all influences have a U-shaped curve effect. Based on the threshold effect, the results of Li Shanshan’s [6] study showed that increasing the proportion of sewage charges in local GDP would help to improve the quality of the environment. The further research demonstrated that environmental regulation has a double threshold effect on the role of regional innovation in carbon pressure level. In a certain threshold range, regional innovation has a positive effect [7]. Under the framework of Copeland and Taylor model, Zhou Jieqi [8] revealed the internal mechanism of FDI affecting haze pollution, finding that informal environmental regulation is more critical to improve haze pollution than formal environmental regulation.

From the above, due to the differences in the selection of environmental regulation indicators and the differences in research background or condition settings, the conclusions of different literature on the effectiveness of environmental regulation levels on pollutant emissions are not consistent. This paper believes that environmental regulation can reduce air pollution by improving the attention of residents and the government to environmental protection. At this stage, the performance of local governments is not only related to economic benefits but also directly related to environmental performance. Under such circumstances, the government will tend to adopt environmental regulations to constrain corporate behavior and improve air quality. Therefore, this paper proposes the following hypothesis: The implementation of the new standard can effectively improve the air quality of cities monitored.

Data and Methods

Data Source and Sample Selection

This paper uses the data of all prefecture-level cities in China from 2003 to 2018. Considering that the provincial capitals and municipalities are significantly different from other prefecture-level cities, they are excluded. Data matching is carried out according to the city name and year. Meanwhile, it is necessary to delete missing data and unreasonable part. Data are all from CEIC.

Variable Description

Dependent variables, independent variables and main control variables of this paper are shown in Table 1. Both dependent variables and control variables take the natural logarithm to eliminate the heteroscedasticity.

| Variable type      | Variable name | Variable meaning                                           |
|--------------------|---------------|------------------------------------------------------------|
| Dependent variable | lnso2         | Natural logarithm of sulfur dioxide emissions              |
| Independent variable | dum_t       | It is 1 if the year is after 2013, otherwise 0             |
|                     | dum_a        | It is 1 if the city is the first batch of pilot cities, otherwise 0 |
| Control variable   | lnpgdp        | Natural logarithm of per capita gross national product      |
|                     | lnpopu        | Natural logarithm of total population at the end of the year|
|                     | linsecond     | Natural logarithm of the second industry's proportion       |
|                     | linforinv     | Natural logarithm of foreign investment                     |
Model

In order to estimate the impact of environmental regulations on air pollution, the most intuitive method is to compare the difference of sulfur dioxide emissions between cities before and after the implementation of the “New Air Quality Standards” policy. Therefore, the DID model and Panel Fixed Effect model are used in this paper. Based on the above analysis, this paper builds the following measurement model:

\[ y_{it} = \beta_0 + \beta_1 d_{it} + \beta_2 d_{it} + \beta_3 d_{it} * d_{it} + \beta_4 X_{it} + u_i + v_t + \epsilon_{it}. \]  

(1)

Among model (1), the subscript \( i \) represents prefecture-level city, and \( t \) represents year, \( y_{it} \) represents independent variable of prefecture-level city \( i \) in period \( t \). \( \beta_0 \) represents the intercept, \( u_i \) and \( v_t \) respectively represent the individual fixed effect and the year fixed effect, and \( \epsilon_{it} \) represents the random interference term subject to the standard normal distribution.

Results and Discussions

Descriptive Statistics

Table 2 reports the descriptive statistics for each variable. In addition, the most critical premise of using the DID mode is the parallel trend, that is, the trend of the treatment group and the control group is consistent before the policy event occurs. Therefore, it is necessary to test parallel trends before performing regression analysis. The results show that the coefficients before and after the implementation of the policy are not significant, so the parallelity test is passed. Due to limitations, the form is not shown in the paper.

Table 2. Descriptive Statistics.

| Variable type  | Variable name | Mean     | S.d.     | Min         | Max         |
|----------------|---------------|----------|----------|-------------|-------------|
| Dependent variable | lnso2         | 10.52258 | 1.071319 | 0.6931472   | 13.11509    |
| Independent variable | dum_t         | 0.2207834| 0.4148419| 0           | 1           |
|                  | dum_a         | 0.1719003| 0.3773548| 0           | 1           |
| Control variable  | lnpgdp        | 0.7164845| 0.850174 | -1.904689   | 3.89803     |
|                  | lnpopu        | 5.838513 | 0.6150197| 3.627004    | 7.126369    |
|                  | lnsecond      | 3.871734 | 0.2390066| 2.71932     | 4.476882    |
|                  | lnforinv      | 9.276749 | 1.835137 | 0.6931472   | 14.15231    |

Table 3. Basic Regression Results.

|                | lnso2         |
|----------------|---------------|
|                | (1)           | (2)           | (3)           | (4)           | (5)           |
| 1.dum_t#1.dum_a| -0.307***     | -0.306***     | -0.307***     | -0.266***     | -0.265***     |
|                | (-5.42)       | (-5.35)       | (-5.36)       | (-4.63)       | (-4.60)       |
| lnpgdp         | 0.000443      | 0.00487       | -0.146*       | -0.147*       |
|                | (0.01)        | (0.07)        | (-2.03)       | (-2.03)       |
| lnpopu         | 0.0721        | -0.0134       | -0.0133       |
|                | (0.33)        | (-0.06)       | (-0.06)       |
| lnsecond       | 0.581***      | 0.580***      |
|                | (5.65)        | (5.63)        |
| lnforinv       | 0.00180       |
|                | (0.15)        |
| _cons          | 10.27***      | 10.27***      | 9.853***      | 8.126***      | 8.113***      |
|                | (325.37)      | (304.08)      | (7.87)        | (6.34)        | (6.31)        |
| Fixed individual | Y             | Y             | Y             | Y             | Y             |
| Fixed year     | Y             | Y             | Y             | Y             | Y             |
| N              | 3089          | 3089          | 3089          | 3089          | 3089          |

* p < 0.05, ** p < 0.01, *** p < 0.001
Basic Regression Results

The empirical results are shown in Table 3. The model (1) is not added to the control variables, (2), (3), (4), (5) gradually join the control variables. The results show that the coefficient of the interaction term is significantly negative, indicating that the policy has effectively improved the carbon dioxide emissions in the policy coverage area; after the introduction of the control variables, although the coefficient has decreased, the significance has not changed. Hypothesis is confirmed.

Placebo Test

In order to ensure the robustness of the results, it is further tested whether the improvement of urban air quality in the policy implementation area is caused by the implementation of the “New Air Quality Standards.” This paper replaces the sulfur dioxide emissions with the amount of soot emissions that are not within the policy test indicators. The process was repeated and shown in Table 4. It was found that the coefficient of the interaction term was not significant, indicating that the improvement of air quality in the first batch of designated cities was indeed caused by the “New Air Quality Standards.” The hypothesis was tested.

|                         |  |  |
|-------------------------|---|---|
| lnynanchen              | 0.195 | (1.75) |
| lnpgdp                  | 0.0988 | (0.66) |
| lnpopu                  | 0.637 | (0.85) |
| lnsecond                | 0.156 | (0.64) |
| lnforinv                | -0.0399 | (-1.70) |
| _cons                   | 5.663 | (1.35) |
| Fixed year              | Y |
| Fixed individual        | Y |
| N                       | 3089 |

* t statistics in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Conclusion

This paper verifies and analyzes the relationship between environmental regulation and air pollution by the DID model and Panel Fixed Effect model. The results show that after the implementation of the “New Air Quality Standards,” the emission of sulfur dioxide in the first batch of cities has been significantly reduced. The conclusions of this paper are more reliable through the parallelity test and placebo test.

Firstly, the government should improve appropriate environmental regulation intensity. An important reason for the deteriorating air pollution in China is that the level of environmental regulation intensity is low, while whether the intensity of environmental regulation is reasonable is directly related to whether its effect is effective. Secondly, the government should formulate appropriate environmental regulation intensity and pay attention to the dynamic adjustment of environmental regulation intensity. The government should not blindly improve the intensity of environmental regulation but be gradual. According to the actual characteristics of regions, industries and air pollution levels, the intensity of environmental regulation should be different, and adjusted to a reasonable level in time. Finally, the impact of environmental regulations on air pollution is not only related to the severity of environmental regulations, but also depends on the choice of environmental regulatory tools. Therefore, the government should flexibly use...
environmental standards, sewage charges, tradable pollution permits, environmental taxes and other environmental regulations. For example, government can effectively combine management-oriented tools with market-based tools to increase the diversity and effectiveness.

References
[1] Wang Yanfang and Zhang Jun. The Impact of the Olympic Games on Beijing’s Air Quality: A Study Based on Synthetic Control Method. China Population, Resources & Environment, 24 (2014) 166-168.

[2] Yu Changlin, Gao Hongjian, Impact of Environmental Regulation on Environmental Pollution in China. China Industrial Economy, 20 (2015) 21-35.

[3] Gao Ming, Wu Xueping and Guo Shihong. Urbanization Process, Environmental Regulation and Air Pollution—An Empirical Analysis Based on STIRPAT Model. Industrial Technology Economy, 35 (2016) 110-117.

[4] Zhu Xiangdong, He Canfei, Li Wei and Mao Xiyan, Local Government Competition, Environmental Regulation and Urban Air Pollution in China. China Population, Resources and Environment, 28 (2018) 103-110.

[5] Sun Kunxin and Zhong Maouchu. Environmental regulation, industrial structure optimization and urban air quality. Journal of Zhongnan University of Economics and Law, 06 (2017) 63-72+159.

[6] Li Shanshan and Ma Yanqin. The Influence of Environmental Regulation on the Decomposition Factors of Total Factor Carbon Emission Efficiency—Based on the Threshold Effect. Journal of Shanxi University of Finance and Economics, 41 (2019): 50-62.

[7] Ma Wei, Xue Tiantian, Waqas Ali and Wang Jidong. Study on the Influence of Regional Innovation on Carbon Pressure Level under Environmental Regulation. Journal of Management, 16 (2019) 85-95.

[8] Zhou Jieqi, Liang Wenguang, Zhang Ying and Han Ying. Foreign Direct Investment, Environmental Regulation and Smog Pollution: Theoretical Analysis and Experience from China. Journal of Beijing Institute of Technology (Social Science Edition), 21 (2019) 37-49.