

Article

Environmental Regulation and Foreign Direct Investment: Evidence from China's Eleventh and Twelfth Five-Year Plans

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Abstract: This paper investigates environmental regulation and its impact on inward foreign direct investment (FDI) in developing countries. Based on the Chinese province-industry-level panel data in the period 2001 to 2015, we use a difference-in-difference-in-differences (DDD) model to evaluate pollution haven behavior in the context of China's 11th and 12th Five-Year Plans SO₂ emissions reduction policy. The results show that the policy leads to fewer FDI inflows to its highly-polluting industries in provinces with tougher pollution reduction targets. In addition, the environmental policy has significantly inhibited FDI inflows in provinces with stricter environmental enforcement, while investment in provinces with worse environmental enforcement is insensitive to environmental policy. These findings are consistent with pollution haven behavior. In contrast, FDI in industries with high levels of technology is not significantly influenced by the policy, whereas the FDI in industries with low levels of technology shows a negative response to environmental policy. This is overall evidence confirming a pollution haven effect (PHE), although technology differences could alleviate the negative effects of environmental regulation on inward FDI.

Keywords: environmental regulation; 11th Five-Year Plan and 12th Five-Year Plan; pollution haven effect; FDI

1. Introduction

Environmental pollution and environmental damage are becoming major concerns in countries around the world, with the result that in many cases, national environmental regulation is being made more stringent to try to improve environmental quality. However, stricter environmental regulation may drive firms to shift their pollution-intensive industries to areas with laxer environmental regulations to reduce the costs related to the regulation; this has been described as the pollution haven effect (PHE) [1]. Therefore, in many developing countries, less strict environmental regulation is seen as a way to greater inflows of foreign direct investment (FDI) in pollution-intensive industries. Such a phenomenon will lead to overall ecological degradation and make global environmental governance ineffective. The trend towards more FDI and the attention being paid to environmental pollution make an investigation of the impact of environmental regulation on inward FDI important in the context of developing countries.

Several theoretical and empirical studies have investigated the impact of environmental regulation on FDI. However, their findings regarding the PHE are inconclusive. Some empirical works find evidence of a PHE [2–5]. For example, Cai et al. used the Two Control Zones (TCZ) policy and Chinese samples to support the PHE through the difference-in-difference-in-differences (DDD) method [5]. Millimet and Roy's research also shows a similar view; that is, the severity of regulatory policies is

inverse to the inflow of FDI [6]. Others refute its existence [7–10], resulting in a lack of consensus. Jaffe et al. consider the cost of environmental regulation and pollution control to be insignificant and not enough to constitute an incentive for cross-border transfers [7]. Eskeland and Harrison, using a sample of four developing countries—Mexico, Venezuela, Morocco, and Côte d’Ivoire—show that FDI inflows are not linked to environmental governance costs, and find no evidence of a PHE [9].

Keller and Levinson argue that these different results are due to how differences in national environmental regulation are quantified in some empirical studies [3]. Given the complexities related to environmental regulation, identifying a single measure that can be used across countries to proxy for environmental stringency is problematic [11]. Other issues related to the existing empirical work are the problem of endogeneity, such as the reverse causal relationship between environmental regulation and trade [12], and the unobserved determinants of location choice correlated to environmental regulation [13]. In addition, since joining the WTO in 2001, China has gradually become one of the most attractive FDI destinations in the world [14]. The large inflow of FDI in China provides a good realistic basis for our research on this topic.

Our study in the context of China’s 11th and 12th Five-Year Plans (11th and 12th FYP) SO₂ emissions reduction policy uses a DDD model to investigate the PHE and province-industry panel data for the period 2001 to 2015. The results show that the 11th and 12th FYP SO₂ emissions reduction policy leads to reduced inflows of FDI to highly-polluting industries in the provinces with more stringent pollution reduction targets. The heterogeneous analysis shows that the impact of environmental regulation on FDI is more significant in provinces with stronger environmental enforcement, while in provinces with weaker environmental enforcement, this effect is not significant. In contrast, the environmental policy does not have a significant effect on FDI in industries with high levels of technology, but, in the case of industries with low levels of technology, environmental policy has a negative effect on FDI. Overall, our results are robust across a range of different specifications, such as instrument variables (IV) and to the exclusion of concurrent external shocks.

We believe that our study provides reliable empirical evidence of a PHE, and contributes in two ways to work on environmental regulation and FDI flows. First, we use China’s 11th and 12th FYP SO₂ emissions reduction policy to overcome the problems related to measuring the environmental regulation stringency across different countries. This policy was formulated by the Chinese central government and implemented simultaneously in all provinces; that is, the whole country is subject to the same environmental policy. Differences in the stringency of provincial emission reduction targets are set under the same national conditions. Our focus on a single country avoids problems related to measuring the stringency of environmental regulations in different countries. Also, since China is the largest developing country in the world, there are huge differences in both inward FDI and environmental regulation across provinces, which provide sufficient variation to determine the impact of environmental regulation on the location of inward FDI [15]. The stringency of China’s 11th and 12th FYP SO₂ policy varies widely across provinces; therefore, if reduced compliance costs matter to investors, then we should see a clear location choice effect on investment behavior across provinces [14], so as to give credible evidence for the investigation of PHE.

Secondly, the endogeneity of environmental regulation is an issue for empirical studies [16]. For instance, using sewage charges or pollutants to identify environmental regulation can lead to reverse causality and concerns about endogeneity [17]. This paper uses China’s 11th and 12th FYP SO₂ policy as a quasi-natural experiment and employs a DDD strategy to investigate the PHE. Specifically, the DDD model explores three dimensions, i.e., variations across provinces in policy targets, variations in pollution intensity across industries, and time variations, which should account for the reverse causality arising from the measurement of environmental regulation [18]. Our DDD strategy allows us to control for province-industry fixed effects, province-year fixed effects, and industry-year fixed effects, controlling for potential omitted variables all varying at the provincial (time-varying and time-invariant) and industry (time-varying and time-invariant) levels [5].

The rest of the paper is structured as follows. Section 2 reviews the literature and introduces the policy; Section 3 describes the research design; Section 4 presents the empirical results; Section 5 discusses some heterogeneity effects. Section 6 concludes the paper.

2. Literature Review and Policy Background

2.1. Environmental Regulation and FDI

FDI is a special form of capital flow that includes both capital and intangible assets such as management skills [11]. The determinants of FDI flows include some common influencing factors such as differences in the marginal return to capital, market size of the host country, exchange rate risk, trade impediments, market power [19]. However, the increasing prominence of environmental pollution and related regulation has an effect on FDI flows and has been attracting the attention of academics.

Research on the pollution haven hypothesis (PHH) goes back to Walter and Ugelow [2], who first proposed the idea of an impact of differences in the intensity of environmental regulation between countries on international capital flows. Specifically, in response to strict environmental regulations and in order to reduce pollution control costs, developed countries may shift pollution-intensive industries or polluting processes to developing countries with less strict environmental regulations. Thus, these host countries become pollution havens for developed countries. Copeland and Taylor proposed the PHE based on the PHH. [1]. Copeland and Taylor show that differences in environmental regulation affect flows of international trade as the result of a PHE. Therefore, they suggest that the PHE is a necessary and insufficient condition for the PHH. The present paper focuses on the PHE. The PHE is based on the logic that due to their lower pollution control costs; host countries with more lax environmental regulation will provide a comparative advantage for the polluting industry's operations. Similarly, stricter environmental regulation may reduce the polluting industry's international competitiveness and reduce FDI inflows.

There is a lack of agreement about the empirical significance of the theoretical PHE. There is a stream of work that provides evidence of a PHE. For instance, Keller and Levinson's study of environmental regulation in the United States over a period of 18 years shows that environmental governance costs have an inhibiting effect on FDI [3]. Xing and Kolstad consider that lax environmental regulation in the host country is a significant determinant of US FDI in the case of heavily polluting industries, and is insignificant for less polluting industries [11]. Chung examined the case of South Korean FDI during the period 2000 to 2007 and found strong evidence that polluting industries tend to invest more in countries with laxer environmental regulation [4]. Cai et al. investigate the PHE using China's TCZ policy; they showed that a one-standard-deviation increase in pollution intensity causes the negative effect of environmental regulation on FDI flows to be 8 percentage points lower, confirming the PHE [5].

However, the literature includes some contrasting findings. For instance, Jaffe et al. argued that the proportion of pollution control costs is small and is not sufficient to influence international trade [7]. Smarzynska and Wei consider the level of corruption in the host country using firm-level data on investment projects in 24 transition economies. They found weak support for the PHH; the overall evidence is relatively weak and failed several robustness checks [8]. Dean et al. found that FDI in highly polluting industries by ethnically Chinese (ECE) source countries tends to favor areas with less-strict pollution regulation, although, for non-ECE, there is no effect of regulations [14]. Based on empirical analysis of four developing countries (Mexico, Venezuela, Morocco, Côte d'Ivoire), Eskeland and Harrison show that FDI inflows are not related to the cost of pollution control in industrialized countries, which rejects the PHE [9].

The reasons for these contrasting findings include the complexity involved and lack of agreement about the multi-dimensional aspects related to the measurement of environmental regulation [20]. For example, different environmental regulation tends to target different pollutants, while the same regulation can have different governance effects due to the different levels of supervision and

enforcement involved. All of these elements make the measurement of environmental regulation difficult. Some studies use single proxies such as sewage charges and pollutant emissions for environmental regulations, which can cause endogeneity bias [21,22].

However, even where an accurate measure of environmental regulation is available, endogeneity might be a problem due to reverse causality [23]. Levinson argues that international trade has environmental consequences and that environmental policy can have international trade consequences [24]. In order to obtain multinational investment inflows from pollution-intensive industries, the authorities may relax regulatory controls and adopt less strict environmental regulation [25]; in turn, the strictness of the environmental policy can affect the inflow of FDI. In addition, the measurement of environmental policy may be correlated to unobserved determinants, [13] such as regional spillovers, agglomeration, corruption, local political activism, and energy prices.

A difference-in-differences (DD) or IV strategy is able to handle the empirical problem of potential endogeneity of environmental regulation [26]. We use China's 11th and 12th FYP SO₂ emissions reduction policy to test the PHE. The differences in the regulatory intensity of environmental policy across provinces can circumvent the intractable problem of cross-border environmental regulation. We also employ a DDD strategy to alleviate concerns about endogeneity and provide reliable empirical results.

2.2. Policy Background

China, the world's largest developing country, has grown at an unprecedented rate over several decades. Therefore, China has gradually become one of the most attractive FDI destinations in the world. Figure 1 is a line chart of China's 2001–2015 actual FDI inflow (Unit: USD 100 million). However, this growth has been accompanied by some of the worst ambient air conditions in the world, due largely to China's heavy reliance on coal-fired electricity generation. Sulfur dioxide (SO₂) emissions generated by coal combustion are the main source of air pollution in China. To improve environmental quality, the Chinese government formulated and implemented a series of environmental regulations, and for the first time, included the environmental pollution reduction requirements in its 10th Five-Year Plan (10th FYP), and set a 10% overall SO₂ emissions reduction target. However, due to the lack of enforcement and micro-level emissions targets, the environmental protection targets set out in the 10th FYP were not achieved, and SO₂ emissions have increased by 27.8% compared to 2000.

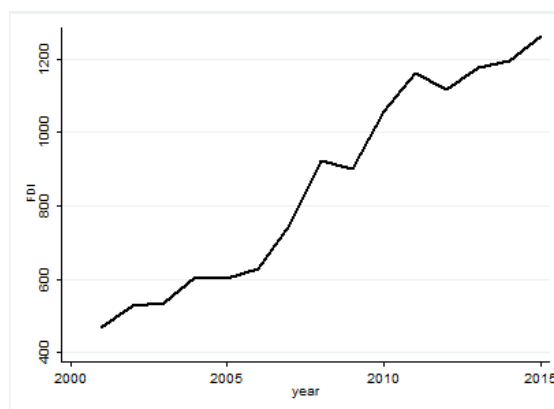


Figure 1. China's total foreign direct investment (FDI) inflows from 2001 to 2015. The data comes from China Statistical Yearbook.

In view of this, the 11th FYP sets a 10% SO₂ reduction goal, and, for the first time, decomposes the overall target into pollution reduction provincial level sub-goals. Initial environmental quality is the most important factor determining these provincial reduction targets [15]. Provincial governments have made further efforts to ensure the achievement of the environmental goals in the 11th FYP and have established environmental institutions and linked environmental performance to the performance

of local leaders. The 11th FYP (and 12th FYP) includes the following environmental governance measures. First, the desulfurization of coal-fired power plants, requiring power plants with excessive emissions to install flue gas desulfurization facilities. The new (expanded) coal-fired power plants must construct desulfurization and denitration facilities. Second, the government is recommending the relocation of polluting industries from urban areas and has established an urban no-burn zone related to heavily polluting fuel. Its environmental protection department is promoting the use of clean combustion technology, installation of cleaning facilities, and rapid implementation of the sewage permit system. Based on these measures, we predict that these stricter environmental policies may increase the costs for industry and reduce the revenue from production income, which will affect the inflow of FDI.

Following the implementation of these measures, in 2010, total SO₂ emissions decreased by 14.29% compared to 2005, and the 11th FYP SO₂ environmental protection targets and tasks more than achieved. Based on the goals in the 11th FYP, the 12th FYP established a national target of 8% reduction in SO₂ emissions; the reduction achieved was 18%. Thus, the main objectives and tasks set out in the 12th FYP have been achieved, and the environmental governance imposed by the 11th and 12th FYP has resulted in huge improvements to China's ecological environment.

Table 1 compares the initial pollution reduction targets (2005) and the actual emissions reductions (2010) related to the 11th FYP, and the initial pollution reduction targets (2010) and the actual emissions reductions (2015) related to the 12th FYP. The average target across provinces in the 11th FYP was 9.96%, with a standard deviation of 6.68%. In the 12th FYP, the average emission reduction target across provinces is 9.61%, with a standard deviation of 6.52%. With the exception of Qinghai, Hainan, and Xinjiang, which had a target of a zero reduction in emissions, all other provinces met or exceeded the 11th FYP reduction targets. Most provinces have exceeded the targets set in the 12th FYP.

Table 1. The actual emission reductions and initial targets during the 11th and 12th FYPs.

Province	11th FYP		12th FYP	
	Actual Emission Reductions	Initial Targets	Actual Emission Reductions	Initial Targets
Beijing	−39.8%	−20.4%	−38.1%	−13.4%
Tianjin	−11.3%	−9.4%	−20.9%	−9.4%
Hebei	−17.5%	−15.0%	−10.2%	−12.7%
Shanxi	−17.6%	−14.0%	−10.3%	−11.3%
InnerMongolia	−4.3%	−3.8%	−11.7%	−3.8%
Liaoning	−14.6%	−12.0%	−5.2%	−10.7%
Jilin	−6.7%	−4.7%	1.9%	−2.7%
Heilongjiang	−3.5%	−2.0%	−6.9%	−2.0%
Shanghai	−30.2%	−25.9%	−52.3%	−13.7%
Jiangsu	−23.5%	−18.0%	−20.5%	−14.8%
Zhejiang	−21.1%	−15.0%	−20.7%	−13.3%
Anhui	−6.8%	−4.0%	−9.8%	−6.1%
Fujian	−11.3%	−8.0%	−17.4%	−7.0%
Jiangxi	−9.1%	−7.0%	−5.2%	−7.5%
Shandong	−23.2%	−20.0%	−0.8%	−14.9%
Henan	−17.6%	−14.0%	−14.5%	−11.9%
Hubei	−11.8%	−7.8%	−12.8%	−8.3%
Hunan	−12.8%	−9.0%	−25.7%	−8.3%
Guangdong	−18.8%	−15.0%	−35.4%	−14.8%
Guangxi	−11.6%	−9.9%	−53.4%	−7.9%
Hainan	31.0%	0.0%	12.1%	−34.9%
Chongqing	−14.0%	−11.9%	−31.1%	−7.1%
Sichuan	−12.9%	−11.9%	−36.6%	−9.0%
Guangzhou	−15.4%	−15.0%	−25.8%	−8.6%
Yunnan	−4.1%	−4.0%	16.6%	−4.0%
Shaanxi	−15.5%	−12.0%	−5.6%	−7.9%
Gansu	−2.0%	0.0%	3.4%	−2.0%
Qinghai	15.7%	0.0%	5.1%	−16.7%
Ningxia	−9.4%	−9.3%	15.1%	−3.6%
Xinjiang	13.4%	0.0%	32.3%	0.0%

Source: (1) The data of initial targets comes from the Reply of the State Council on the 11th FYP of the National Total Pollutant Discharge Total Control Plan, Reply of the State Council on the 12th FYP of the National Total Pollutant Discharge Control Plan. (2) The data of actual SO₂ emission comes from the China Statistical Yearbook.

3. Research Design

3.1. Sample and Data

Industry is both the main source of environmental pollution and the objective of SO₂ reduction policy. Our initial sample is two-digit industries across China's provinces.

First, based on the adjustment made to national economic industry classification in 2012, we exclude newly added two-digit industries and exclude the tobacco industries due to missing data. Second, we exclude Tibet, Hong Kong, Macao, and Taiwan because of the lack of data, leaving a sample of 30 provinces in mainland China. We identified 26 two-digit industries related to these 30 Chinese provinces during the period 2001 to 2015 (Appendix A Table A1 provides a list of the industries included in the analysis) and constructed a balanced panel dataset of 11,700 province-industry-year observations.

The data used for this analysis were collected from the following main sources. The pollution reduction targets for each province were collected from official documents issued by the China State Council. To respect the conditions of the DDD strategy, we applied the formula $c\% = a\% + (1 - a\%)b\%$ to convert "SO₂ emissions in 2015 compared to 2010" into "SO₂ emissions in 2015 compared to 2005". Details of SO₂ emissions and coal consumption related to our sample of two-digit industry were obtained the China Statistical Yearbook, and the FDI data were from the China Industrial Statistical Yearbook. The environmental enforcement and other data were collected from the China Environmental Yearbook and Economy Prediction System (EPS) database. To account for inflation, we used the CPI index with 2001 as the base period to derive a nominal-actual deflator for all the variables measured in monetary terms.

3.2. Variables

3.2.1. The Dependent Variable

Our dependent variable is foreign direct investment (FDI). To measure FDI, we use total inward foreign investment capital (CNY 100 million) at the province-industry level. In a robustness check, we use the alternative measure of the logarithm of FDI plus 1 ($\ln(\text{FDI} + 1)$) [5].

3.2.2. Independent Variable

Our independent variable is 11th and 12th FYP SO₂ emissions reduction policy (Target $\times$ Post $\times$ Pollution) which is used as the interacting term Target $\times$ Post $\times$ Pollution in the DDD model (see Section 3.3). Specifically, we explore variation across provinces in emissions reduction target stringency, variations in pollution intensity across industries, and time variations. Thus, Target denotes the stringency of environmental policy across provinces based on the 11th and 12th FYP, and is measured as each province's SO₂ emissions reduction targets. Post is a dummy variable that equals 1 for the period 2006 to 2015 (the 11th FYP was launched in 2006) and zero otherwise. Pollution proxies for the intensity of industrial pollution, and is measured as the SO₂ emissions ratios and the coal consumption ratios for each industry [27].

3.2.3. Other Variables

Environmental enforcement (EE) or the intensity of environmental law enforcement is measured by the number of penalties imposed in each province for breaking the environmental regulation in the period 2001–2015 [18].

The industry technology level (IT) is included in the analysis as a dummy variable which equals 1 if the industry is classified as high-tech according to the OECD standards, and zero otherwise. The high-tech sector includes manufacture of chemical materials and chemicals, pharmaceuticals, chemical fibers, transportation equipment, electrical machinery and apparatus, communications equipment, computers and other electronic equipment, instruments and meters, and office machinery; the remaining sectors are considered low-tech.

Export transactions (ET) are measured as the value of industry exports in the period 2001–2015 (CNY 100 million).

3.2.4. Descriptive Statistics

Table 2 presents the summary statistics. The mean, standard deviation, and minimum and maximum for our sample are reported in Table 2, panel A. Panel B compares these measures and other characteristics influencing FDI inflows, between provinces with high environmental targets and provinces with low environmental targets. Panel B shows that for most of these aspects, the average difference between high and low target provinces is relatively small. Although provinces with stronger regulation receive more FDI, this may be because provinces with stronger regulation are more trade-oriented and located in more developed regions. In the next section, we discuss how to control the heterogeneity between the treatment and control groups to determine the impact of environmental regulation.

Table 2. Descriptive statistics.

Panel A: All Sample of Variables Used in Our Analysis					
Variables	Mean	S.D.	Min	Max	
FDI	17.093	63.499	0	1511	
Ln (FDI)	1.366	1.520	0	7.321	
Target	12.816	8.651	0	36.050	
EE	3.377	4.962	0.008	38.434	
SO ₂ emissions	47.729	126.104	0.297	653.981	
Coal consumption	4283	11,000	25.600	57,000	
ET	2417	5926	0.090	46,000	
Panel B: Grouped Statistics of Variables					
Variables	Provinces with High Targets		Provinces with Low Targets		t-test
	Mean	S.D.	Mean	S.D.	
Variables Used in Our Analysis					
FDI	28.167	86.555	6.019	18.102	22.151 ***
Ln (FDI)	1.807	1.681	0.924	1.184	0.883 ***
EE	4.963	5.145	1.791	4.213	2.172 ***
Other Variables of Our Interest					
GDP	3.249	2.354	2.497	1.905	0.752 ***
Innovation	5.492	8.480	1.263	1.963	4.229 ***
Consume	1.146	0.873	0.832	0.520	0.314 ***
Foreign Company	1.880	2.262	0.468	0.526	1.412 ***

Note: Panel A present the descriptive statistics of all sample used in our analysis and Panel B present the grouped statistics of variables used in our analysis and other variables of our interest. The statistics compare the provinces with high targets and the areas with low targets; drawing on Shi and Xu (2018), we distinguish the intensity according to the median of emission reduction target. The data comes from the China Statistical Yearbook, China Environmental Yearbook, and China Industrial Statistical Yearbook. FDI is the total amount of inward foreign investment capital (CNY 100 million) at the province-industry level. The unit of Target is %. Units of industrial SO₂ emissions and industrial carbon emissions are 10,000 tons. ET is the value of export shipments of industry (CNY 100 million). EE is measured by the number of environmental administrative punishment cases in each province (1000). GDP is the provincial GDP per capita (CNY 100,000). Innovation is measured with the number of innovation patents by province (10,000). Consume is measured by the consumption of residents by province (CNY 100,000). Foreign Company is measured with the number of foreign-funded enterprises by province (10,000).

3.3. Estimation Strategy

Combining the time variation and the variation in pollution reduction targets across provinces, allows us to employ a DD strategy to estimate the effects of environmental regulations on FDI. This might raise concern about whether the parallel trend assumption is established. Since the macroeconomics also change over time, the before-and-after change in the dependent variable is not

necessarily a treatment effect. To reduce this concern, we use DDD estimation as our main identification strategy. Specifically, we use the provincial variable (e.g., provinces with high pollution reduction targets versus provinces with low targets), time variation (e.g., before and after the 11th FYP launched in 2006), and the industry variable (e.g., more polluting relative to less polluting industries). The DDD specification can be written as

$$FDI_{pit} = \beta \times Target_p \times Post_t \times Pollution_i + \eta_{pt} + \gamma_{it} + \varphi_{pi} + \varepsilon_{pit} \quad (1)$$

where p is the province, i is the industry, and t is the year. FDI_{pit} is the province two-digit industry FDI. We are interested in the triple interaction term coefficient β . If the parameter is significantly negative, it can be inferred that the policy suppresses the inflow of FDI, and vice versa, that the policy attracts FDI. The DDD strategy allows us to control for province-year fixed effects η_{pt} , industry-year fixed effects γ_{it} , and province-industry fixed effects φ_{pi} . That means we can control not only for all time-invariant and time-varying province characteristics but also for all time-invariant and time-varying industry characteristics. We control too for time invariant differences among industries in different provinces. ε_{pit} is a random error term. To deal with heterogeneity and serial correlation, we calculate the standard error by clustering at the province-industry level.

4. Empirical Analysis

4.1. Baseline Results

Table 3 presents the impact of the 11th and 12th FYP SO₂ policy on FDI flows. We find the triple interaction term β is significantly negative. Column 1 presents the regression results for the degree of industrial pollution measured as the proportion of SO₂ emissions: it is significantly negative at the 10% statistical level with a coefficient of -0.023 . Column 2 presents the results for degree of industrial pollution measured as the proportion of coal consumption: this is significantly negative at the 5% statistical level, with a coefficient of -0.025 . This result that the policy leads to fewer FDI inflows to more heavily polluting industries in provinces with high emissions reduction targets which confirms the PHE. In addition, in order to eliminate possible heteroscedasticity, we define Equation (1) in logarithm: our results remain robust (see Table 3, columns 3 and 4).

Table 3. Baseline results.

Variables	FDI		LnFDI	
	(1)	(2)	(3)	(4)
Target $\times$ Post $\times$ Pollution (SO ₂)	-0.023^* (0.012)			
Target $\times$ Post $\times$ Pollution (Coal)		-0.025^{**} (0.012)		
LnTarget $\times$ Post $\times$ Pollution (SO ₂)			-0.410^{***} (0.158)	
LnTarget $\times$ Post $\times$ Pollution (Coal)				-0.269^* (0.141)
Province-year fix effects	YES	YES	YES	YES
Province-industry fix effects	YES	YES	YES	YES
Industry-year fix effects	YES	YES	YES	YES
Observations	11,700	11,700	11,700	11,700
R-squared	0.806	0.806	0.917	0.917

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. *, **, and *** represent significance levels at 10%, 5%, and 1%, respectively.

It seems that the 11th and 12th FYP SO₂ emissions reduction policy may have reduced FDI inflows. First, to reduce SO₂ emissions, the policy aims at eliminating polluting facilities that produce emissions that exceed a particular standard. Second, it requires installation of desulfurization equipment in existing power plants, and enforces collection of sulfur dioxide emissions fees which greatly increases the environmental costs of polluting industries in high-emissions reduction provinces. Third, it prohibits power plants from using low-quality coal. Since coal is still the main source of fuel for China's electricity production this requirement has led to an increase in electricity costs. The above measures have likely increased the cost to industry and reduced production income which will reduce FDI inflows.

4.2. Parallel Trend Assumption

The reason for using a DDD strategy is that it allows the parallel trend assumption that in the absence of policy intervention, inward FDI inflows should be consistent with provinces with high emissions targets and provinces with low emissions targets; otherwise, it would be impossible to distinguish between the “time effect” and the “policy treatment effect”. To test this parallel trend assumption using the method in Fu et al. [28], we analyze the subsamples before the policy (2001–2005) to test whether the treatment and control groups satisfy it. We estimate the following regression:

$$FDI_{pit} = \beta \times Target_p \times Trend_t \times Pollution_i + \eta_{pt} + \gamma_{it} + \varphi_{pi} + \varepsilon_{pit} \quad (2)$$

where $Trend_t$ is the time trend, and assigned $Trend_t$ takes the respective values 1, 2, 3 ... 5 in 2001, 2002, 2003 ... 2005. The definition of other variables is the same as for Equation (1). If the coefficient of β is not significant, this indicates that the provinces show similar trends. Table 4 column 1 presents the results for the test of the parallel trend assumption; the coefficient of β is statistically insignificant. Column 2 presents the results for the parallel trend assumption where intensity of industrial pollution is measured by the proportion of coal consumption. Overall, these results show that the parallel trend assumption is not violated.

Table 4. Testing for parallel trend assumption.

Variables	FDI	
	(1)	(2)
Target $\times$ Trend $\times$ Pollution (SO ₂)	−0.003 (0.003)	
Target $\times$ Trend $\times$ Pollution (Coal)		−0.004 (0.003)
Province-year fix effects	YES	YES
Province-industry fix effects	YES	YES
Industry-year fix effects	YES	YES
Observations	3900	3900
R-squared	0.910	0.910

Note: Standard errors of clustering at the province-industry level are indicated in parentheses.

4.3. Robustness Checks

4.3.1. Concurrent External Shock

A potential threat to our findings is that the PHE might be driven by other concurrent national or local environmental policy changes. For example, in 2007, the Chinese Ministry of Ecology and Environment implemented a SO₂ emissions trading scheme in 11 provinces which might have increased the pressure for reducing pollution in these provinces, and might be confounding our estimation

results. To address this, we exclude 11 pilot areas—Jiangsu, Tianjin, Zhejiang, Hubei, Chongqing, Hunan, Inner Mongolia, Hebei, Shaanxi, Henan, and Shanxi—and re-estimate our baseline model. Another shock that might have affected our results was the 2008 international financial crisis which could be related to FDI inflows. If cross-border investment was inhibited by the crisis, this would overestimate the effect of the policy. To eliminate the shock related to the financial crisis, we excluded the years 2008 and 2009 and re-estimated our baseline model.

The results are reported in Table 5. Columns 1 and 2 present the results when we exclude the sub-samples related to the SO₂ emissions trading pilot areas; our triple interaction coefficient remains negative. Columns 3 and 4 report the estimation results for the reduced sample excluding observations between 2008 and 2009. The estimates show negative and statistically significant effects of the policy on inward FDI, and estimated impacts similar to those in the baseline regressions.

Table 5. Concurrent external shock.

Variables	FDI			
	Subsample Excluding for the SO ₂ ETS		Subsample Excluding for Financial Crisis	
	(1)	(2)	(3)	(4)
Target × Post × Pollution (SO ₂)	−0.014 * (0.008)		−0.024 ** (0.012)	
Target × Post × Pollution (Coal)		−0.015 * (0.008)		−0.026 ** (0.013)
Province-year fix effects	YES	YES	YES	YES
Province-industry fix effects	YES	YES	YES	YES
Industry-year fix effects	YES	YES	YES	YES
Observations	7410	7410	10,140	10,140
R-squared	0.854	0.854	0.781	0.781

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. * and ** represent significance levels at 10% and 5%, respectively.

4.3.2. Other Robustness Checks

We conducted two additional robustness checks. First, we used the ratio of FDI to provincial GDP (FDI/GDP) and the ratio of FDI to the provincial population (FDI/HUMAN) [29] as alternative variables to test the impact of the 11th and 12th FYP policy on inward FDI. Second, by definition, our measurements of FDI are non-negative, and in some years, there are industries which receive no FDI inflows and a few in the east of China that attract considerable FDI. The average FDI in this sample is 17.09 with standard deviation of approximately 63.5. To account for these distribution characteristics, following the method of Rong et al. [30], we employ a Tobit model as a robustness test.

The results of these robustness checks are presented in Table 6. Columns 1–4 report the results of the estimations that include FDI/GDP and FDI/HUMAN as alternative variables. The coefficient of β is significantly negative at the 5% (or 10%) statistical level. Columns 5 and 6 report the estimation results for the Tobit model, which show that the triple interaction term is negatively significant at the 1% statistical level, indicating that our estimates are robust.

Table 6. Other robustness checks.

Variables	FDI/GDP		FDI/HUMAN		Tobit Model	
	(1)	(2)	(3)	(4)	(5)	(6)
Target $\times$ Post $\times$ Pollution (SO ₂)	−0.225 *		−0.042 **		−0.033 ***	
	(0.118)		(0.021)		(0.001)	
Target $\times$ Post $\times$ Pollution (Coal)		−0.245 **		−0.043 **		−0.034 ***
		(0.122)		(0.022)		(0.001)
Province-year fix effects	Yes	Yes	Yes	Yes	Yes	Yes
Province-industry fix effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fix effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,700	11,700	11,700	11,700	11,700	11,700
R-squared	0.800	0.800	0.898	0.898	N	N

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. *, **, and *** represent significance levels at 10%, 5%, and 1%, respectively.

4.3.3. Instrumental Variable Estimation

To further address possible endogeneity related to omitted variables at the province-industry-year level, we adopt an IV strategy [5,15]. IV should meet two points. One is that IV needs to have a strong correlation with endogenous variables, and the other is that it does not have a correlation with residuals [11]. Similar to the approach in Cole and Elliott [31], we use the 2001 standard energy consumption at the provincial level as our IV. Adopting a single year can effectively avoid the model endogenous problems caused by cross-year panel data. Provincial energy consumption is likely to be correlated to the emissions reduction target in the same province, while it is unlikely that FDI flows into a sector are influenced directly by the province's energy consumption. Appendix A Table A2 reports the correlation test. We find that IV was significantly correlated with the independent variables and not correlated with the residuals. Therefore, we believe that the choice of IV is reasonable.

Table 7 presents the regression results; the first-stage estimation results show that the IV is related positively to the main variable of interest, Target. The second-stage results show that the coefficient of Target $\times$ Post $\times$ Pollution is negative and significantly increased (columns 1 and 2). These results provide further support for our hypothesis that the policy leads to reduced FDI inflows into highly-polluting industries.

4.3.4. Hong Kong and Macau Investment

The analysis in this article focuses on FDI. Does Hong Kong and Macao investment as a special domestic investment supported by the central government also have a PHE? We use Hong Kong and Macau investment capital for regression testing. Table 8 reports the regression results, and the triple interaction term coefficients are not significant, which shows that the SO₂ emission reduction policy has not negatively affected Hong Kong and Macau investment.

Table 7. Instrumental variable estimation.

Panel A: First-stage estimations		
Variables	Target × Post × Pollution (SO ₂)	Target × Post × Pollution (Coal)
	(1)	(2)
IV × Post × Pollution (SO ₂)	1.134 *** (0.0985)	
IV × Post × Pollution (Coal)		1.139 *** (0.100)
Province-year fix effects	Y	Y
Province-industry fix effects	Y	Y
Industry-year fix effects	Y	Y
Observations	11,700	11,700
F statistics	3574.59	570.16
Panel B: Second-stage estimations		
Variables	FDI	
	(1)	(2)
Target × Post × Pollution (SO ₂)	−0.0420 * (0.0219)	
Target × Post × Pollution (Coal)		−0.0472 ** (0.0229)
Province-year fix effects	Y	Y
Province-industry fix effects	Y	Y
Industry-year fix effects	Y	Y
Observations	11,700	11,700
R-squared	0.806	0.806

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. *, **, and *** represent significance levels at 10%, 5%, and 1%, respectively.

Table 8. Hong Kong and Macau investment.

Variables	FDI	
	(1)	(2)
Target × Post × Pollution (SO ₂)	−0.007 (0.006)	
Target × Post × Pollution (Coal)		−0.009 (0.006)
Province-year fix effects	YES	YES
Province-industry fix effects	YES	YES
Industry-year fix effects	YES	YES
Observations	11,700	11,700
R-squared	0.875	0.875

Note: Standard errors of clustering at the province-industry level are indicated in parentheses.

This may be because, compared to FDI, China has formulated a series of more favorable economic and trade policies for domestic investment in Hong Kong and Macao to continue to promote investment facilitation. For example, in 2003, the central government and Hong Kong and Macau respectively signed the Closer Economic Partnership Arrangement (CEPA) and a series of supplementary agreements.

These preferential policies compensate the environmental costs and expenditures of Hong Kong and Macao investors and relieve the negative effects of environmental regulations on investment.

5. Heterogeneous Effects

5.1. Environmental Enforcement

Improved environmental quality is related to the region's stricter legal supervision and enforcement intensity [32]. However, differences in local enforcement and regulatory capacity mean that policy implementation will vary across provinces. Therefore, we use the number of environmental penalties in each province to test the enforcement of environmental regulation, splitting the sample into provinces with high levels of enforcement and provinces with low levels of enforcement.

Table 9 reports the results. We find that in the provinces with high levels of environmental enforcement, the 11th and 12th FYP SO₂ reduction policy has a significant deterrent effect on inward FDI, and compared to the benchmark regression, the estimated coefficient increases to 0.030. However, we find that provinces with weaker environmental enforcement are not sensitive to the policy. This evidence provides further support for the PHE.

Table 9. Heterogeneity effects of environmental enforcement.

Variables	FDI			
	(1) High	(2) Low	(3) High	(4) Low
Target × Post × Pollution (SO ₂)	−0.030 *** (0.010)	−0.030 (0.021)		
Target × Post × Pollution (Coal)			−0.031 *** (0.010)	−0.033 (0.021)
Province-year fix effects	Y	Y	Y	Y
Province-industry fix effects	Y	Y	Y	Y
Industry-year fix effects	Y	Y	Y	Y
Observations	4992	6708	4992	6708
R-squared	0.916	0.763	0.916	0.764

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. *** represents significance levels at 1%.

5.2. Industry Technology Level

The PHE assumes that strict environmental regulation will increase companies' compliance costs, and thus, will have a negative effect on economic investment. However, if the industry is a high technology sector, it may be better able to combine its superior technology with the R&D experience of multinational companies [14]. When faced with stricter environmental regulations, high-tech industries are likely to be better able to adapt quickly to clean technology to control pollutant emissions. This tends to blur the seemingly negative impact of environmental regulation on international trade. Does the technology level counter the effect of environmental regulation? We examine technology level differences by splitting the sample into high-tech and low-tech industries, according to the OECD manufacturing technology categories.

Furthermore, it is possible that differences in exports may be related to the industry technological level. Engaging in exporting activity can facilitate access to advanced foreign technology, management experience, and higher profits [33]. Therefore, the greater the sector's engagement in export activity, the more likely it will acquire advanced foreign technologies and achieve a higher level of technology. We investigated export activity using the median value to split the sample into high exporting and low exporting groups.

The sample split according to the OECD technology definitions are presented in Table 10. We find that in low-tech industries, environmental regulation reduces FDI inflows at the 10% statistical level while high-tech industries are not sensitive to environmental regulation. The results for exporting activity are reported in Table 11 and are in line with our expectations. In industries with low levels of exports, the policy reduces FDI inflows significantly, while industries with high levels of exports are not sensitive to environmental regulation. This indirect evidence shows that a higher technology level, to an extent, reduces the deterrent effect of environmental regulation on FDI inflows.

Table 10. Heterogeneity effects of industry technology.

Variables	FDI			
	(1) High	(2) Low	(3) High	(4) Low
Target × Post × Pollution (SO ₂)	0.217 (0.236)	−0.011 * (0.006)		
Target × Post × Pollution (Coal)			0.243 (0.233)	−0.012 * (0.007)
Province-year fix effects	Y	Y	Y	Y
Province-industry fix effects	Y	Y	Y	Y
Industry-year fix effects	Y	Y	Y	Y
Observations	3150	8550	3150	8550
R-squared	0.843	0.785	0.843	0.785

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. * represents significance levels at least 10%.

Table 11. Heterogeneity effects of export transactions.

Variables	FDI			
	(1) High	(2) Low	(3) High	(4) Low
Target × Post × Pollution (SO ₂)	−0.008 (0.005)	−0.013 * (0.008)		
Target × Post × Pollution (Coal)			−0.008 (0.005)	−0.015 * (0.008)
Province-year fix effects	Y	Y	Y	Y
Province-industry fix effects	Y	Y	Y	Y
Industry-year fix effects	Y	Y	Y	Y
Observations	6240	6240	6240	6240
R-squared	0.887	0.855	0.887	0.855

Note: Standard errors of clustering at the province-industry level are indicated in parentheses. * represent significance levels at 10%.

6. Conclusions

This paper investigates the impact of China's 11th and 12th FYP SO₂ emissions reduction policy on FDI inflows. Using a DDD strategy, we show that this policy reduced the inflow of FDI to more heavily polluting industries in provinces with more stringent reduction targets, confirming the PHE. A series of robustness tests showed that our findings are robust. We found also that the PHE is more pronounced in provinces with stronger enforcement of environmental regulation. Also, a higher level of technology (measured according to OECD definitions and differences in exports) can alleviate the deterrent effect of environmental regulation on FDI.

The findings from our study have several important implications: First of all, we used differences in the stringency of environmental regulation across Chinese provinces to provide evidence of a PHE.

Environmental protection is the foundation of sustainable development. We suggest that developing countries should work towards avoiding becoming a pollution haven. Specifically, first, governments should set appropriate environmental standards to reduce the inflow of FDI in heavily polluting sectors. They should also link the effects of the implementation of environmental regulation to local officials' performance evaluations to remove the limitations of local governments only pursuing economic effects. Second, governments should increase the frequency and intensity of monitoring of pollution sources to ensure the accurate collection of pollution information. Meanwhile, the state should be flexible and targeted to use different types of environmental regulatory tools, such as emissions trading schemes and collection of sewage charges, to mediate the contradiction between international trade and environmental regulations.

Secondly, is there a contradiction between FDI and environmental quality? We found that improving the industry technical level alleviates the negative effects of environmental regulation on inward FDI, and is conducive to both better environmental quality and economic growth. We put forward the following suggestions on this basis: First, China should further set more specific emission reduction targets and form a deep-level paradigm for pollution control through clean technology innovation. Second, governments should vigorously cultivate technical innovation talents and encourage enterprises to fully develop pollution control technologies, so as to solve the problem of excessive pollution emissions from the source. Third, governments should encourage enterprises to develop export transactions vigorously and learn from export activity [34]. This would contribute to reducing excessive pollution by absorbing foreign advanced technology experience and balancing the effects of environmental regulation on FDI.

Third, Hong Kong and Macao investments did not appear the PHE with the support of state policy subsidies. Therefore, the premise of governments to formulate environmental regulations should be based on the actual situation of the country and have clear rewards and penalties. Governments should implement preferential policies for foreign investors who meet environmental protection standards and fully encourage international investment inflows. They should also punish or expose the polluters who violate the emission rules and strictly control the pollution within the ecological threshold.

This paper investigates environmental regulation and its impact on inward foreign direct investment (FDI) in developing countries. This academic direction has strong practical significance and is worthy of further exploration. First, future literature can explore the impact of environmental regulations on other socio-economic factors, such as exports, optimization of industrial structure, and the number of labor. Second, our data level is at the province–industry level, which is limited by the lack of FDI home country information. It makes it impossible for us to comprehensively examine the impact of environmental regulations in different countries on FDI. Future research can observe company-level or country-level data to investigate PHH and PHE more thoroughly. Third, future literature can distinguish different types of environmental regulations in detail, such as whether the impact of command-controlled environmental regulations and market-based environmental regulations on FDI differs. This exploration is of great significance for optimizing environmental regulatory tools.

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Appendix A

Table A1. The 2-digit industry list.

2-Digit Industry Name	2-Digit Industry Code	2-Digit Industry Name	2-Digit Industry Code
Coal mining and washing industry	B06	Pharmaceutical manufacturing	C27
Petroleum and natural gas mining industry	B07	Chemical fiber manufacturing	C28
Ferrous metals mining industry	B08	Non-metallic mineral products industry	C31
Non-ferrous metals mining industry	B09	Ferrous metal smelting and processing industry	C32
Non-metallic mining industry	B10	Non-ferrous metal smelting and processing industry	C33
Agricultural and sideline food processing industry	C13	Metal products industry	C34
Food manufacturing industry	C14	General machinery manufacturing	C35
Beverage manufacturing	C15	Special equipment manufacturing	C36
Textile industry	C17	Transportation equipment manufacturing	C37
Textile and garment, shoes, cap manufacturing industry	C18	Electrical machinery and apparatus manufacturing	C39
Paper-making and paper products industry	C22	communication equipment, computer and other electronic equipment manufacturing	C40
Petroleum processing and coking industry	C25	Instruments and meters, office machinery manufacturing	C41
Chemical materials and chemical products manufacturing	C26	Electricity, heat production and supply industry	D44

Note: Due to the first, second, and third revisions of the National Standards for National Economic Industries in 1994, 2002, and 2011, in order to link up to the revision of the three national standards, this paper uses the 2002 version of the 2-digit industrial codes.

Table A2. Testing for correlation.

Correlation	Target $\times$ Post $\times$ Pollution (SO ₂)	Residuals	Target $\times$ Post $\times$ Pollution (Coal)	Residuals
IV $\times$ Post $\times$ Pollution (SO ₂)	0.822 ***	−0.004		
IV $\times$ Post $\times$ Pollution (Coal)			0.822 ***	−0.005

Note: *** represents significance levels at 1%.

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