



# Study on the Influence of Central Environmental Protection Inspector on Green Patents of Heavily Polluting Enterprises

## Empirical Analysis Based on the Data of Listed Companies

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**Abstract.** The central environmental protection inspector is a major institutional innovation in the construction of ecological civilization in China, and it is also the strictest environmental protection system to promote the development of green innovation in enterprises. Based on CRNDS 2010–2020 data, taking the central environmental protection inspector as a quasi natural experiment, this paper uses the multi-stage double difference method to investigate the impact of the central environmental protection inspector on the green patents of heavily polluting enterprises. The empirical results show that the central environmental protection inspector has a significant negative impact on the green patents of heavily polluting enterprises; Further heterogeneity test found that the impact on green invention patents of heavily polluting enterprises was negative, but not significant; The impact on green patents of heavy polluting enterprises with different ownership is significantly negative. In view of this, this paper puts forward some suggestions, such as continuously strengthening the central environmental protection supervision system, optimizing and improving the environmental protection governance evaluation system, and implementing differentiated policies and measures for innovation and enterprise heterogeneity.

**Keywords:** Central Environmental Protection Inspector · Heavy Polluting Enterprises · Green Patent

## 1 Introduction

With the rapid development of China's economy, the problem of ecological environment has become increasingly prominent. In order to solve the problem of environmental pollution, the government has taken a series of supervision and management policies and measures. However, due to the externality of environmental governance, local governments have some problems in the process of implementing policies, such as "incomplete implementation", "free riding", "one size fits all", "formalization", falsification

of environmental quality data and so on. According to Porter hypothesis, reasonable and appropriate environmental regulation can improve enterprises' R&D investment in product technology and encourage enterprises to carry out ecological innovation [5]. In the face of misconduct in environmental governance, the central leading group for comprehensively deepening reform has established a central environmental protection supervision mechanism to actively promote the transformation of China's environmental supervision mechanism from "supervising enterprises" to "supervising government". Therefore, studying the impact of the central environmental protection inspector on the green patents of heavily polluting enterprises has important practical significance for supervising enterprises to change their development mode and realize green sustainable development.

This paper takes the first round of central environmental protection supervision action as a quasi natural experiment, takes the listed enterprises in the A-share manufacturing industry listed in Shanghai or Shenzhen Stock Exchange before 2012 as the object, and uses the multi period double difference method to investigate the impact of central environmental protection supervision on the green patents of heavily polluting enterprises according to the CRNDS data from 2010 to 2020. During the investigation, the data of listed manufacturing enterprises were used to promote the level of attention from meso to micro, deeply test and analyze the heterogeneous impact of the central environmental protection inspector on enterprises with different types of green patents and different ownership, so as to enrich the micro policy effect of the central environmental protection inspector, in order to provide a basis for formulating targeted environmental protection supervision measures.

## 2 Research Hypothesis

In order to strengthen the implementation of environmental protection policies of local governments, the central environmental protection inspector characterized by "political supervision" is an important measure taken in the field of environmental protection in China. With the continuous promotion of the central environmental protection inspector and the strong pressure of environmental protection inspector, local governments are bound to urge enterprises to increase investment in environmental protection and control environmental pollution through measures such as increasing environmental pollution tax, water and power outage. In order to achieve sustainable development, enterprises must actively respond to the government's policies, actively increase investment in environmental protection and increase the research and development of green patents. Based on this, the following assumptions are put forward:

**Hypothesis 1: the central environmental protection inspector can significantly increase the number of green patents of enterprises.**

There are some differences in the impact of policy regulation on different types of pollution enterprises. Therefore, it is of great significance to study the heterogeneous impact of central environmental protection inspectors more finely and concretely. Relevant research shows that the central environmental protection inspector has a more significant impact on the green innovation of heavy polluting enterprises. In the long run, heavy polluting enterprises will pay more attention to adjusting the industrial structure

and accelerating technological innovation [3]. To this end, the following assumptions are proposed:

**Hypothesis 2: the impact of central environmental protection inspectors on green patents of polluting enterprises with different degrees is heterogeneous.**

Facing the central environmental protection inspector, there are differences between state-owned enterprises and non-state-owned enterprises, which will have different effects on the green patents of enterprises with different ownership. Generally speaking, state-owned enterprises are more vulnerable to national policies and usually take the lead in implementing policies and regulations, such as actively assuming more social responsibilities, increasing R&D investment in green patents, promoting green development and transformation of enterprises, etc. Based on this, the following assumptions are put forward:

**Hypothesis 3: the impact of central environmental protection inspectors on green patents of heavy polluting enterprises with different ownership is heterogeneous.**

### 3 Research Design

#### 3.1 Sample Selection and Data Source

In order to improve the reliability of the research conclusion, the sample data are from the CRNDS database from 2010 to 2020. Firstly, due to the lagging effect of the policy on the intervention of enterprise environmental pollution, the A-share manufacturing industry listed companies listed on Shanghai or Shenzhen Stock Exchange before 2012 were selected, and the total number of observation samples was 18575 according to the industry classification results of Listed Companies in 2012. Secondly, heavy polluting enterprises are the main source of pollution and are more vulnerable to the influence of the central environmental protection inspector, which can more effectively reflect the impact of environmental protection inspector on enterprise green patents [5]. According to the classified management directory of environmental protection verification industry of listed companies issued in 2008, 1530 enterprises in heavy pollution industries such as textile, clothing, leather and wool industry, petrochemical and plastic industry were selected as samples from manufacturing enterprises. Finally, in order to ensure the integrity and effectiveness of the sample, the listed companies belonging to ST or PT are excluded, and the final number of samples is 1511.

#### 3.2 Variable Definition

##### 3.2.1 Explained Variable

The explanatory variable is the proportion of enterprise green patents (G patent ratio), which is measured by the proportion of enterprise green patents in the total patents, so as to accurately reflect the level of enterprise environmental protection technology.

### 3.2.2 Explanatory Variables

The explanatory variable is the Central Environmental Protection Inspector (Treat), and the dummy variable is used to indicate whether the enterprise accepts the central environmental protection inspector. When the central environmental protection inspector group inspects a province, the value of the enterprise in that province is 1 and the value of others is 0.

### 3.2.3 Control Variables

In view of the influence of many related factors on the number of green patents of enterprises, in order to enhance the reliability of the research, the following variables are selected as control variables. (1) The size of enterprise assets (Size) is measured by the natural logarithm of the total assets of the enterprise; (2) Enterprise asset liability ratio (Lev), expressed by the ratio of total liabilities to total assets of the enterprise; Return on net assets (ROE), expressed by the ratio of net profit to net assets; (3) The operating cash flow of an enterprise (Cash flow) is expressed by taking the natural logarithm of the operating cash flow; (4) The growth of an enterprise (Growth) is measured by the growth rate of its operating income; (5) The firm age (Firm age) is expressed by subtracting the year of establishment from the current year plus 1.

## 3.3 Descriptive Statistics

The descriptive statistical results of all enterprises, non heavily polluting enterprises and heavily polluting enterprises are shown in Table 1. In terms of the proportion of enterprise green patents, the average values of the three are 0.111, 0.113 and 0.089 respectively, indicating that the proportion of enterprise green patents in the total patents is small; In terms of enterprise asset scale, the average value of heavy polluting enterprises is 22.864, which is significantly higher than 22.115 and 22.061 of all enterprises and non heavy polluting enterprises, indicating that heavy polluting enterprises need to invest more and larger asset scale; In terms of enterprise growth capacity, the average value of heavily polluting enterprises is 0.147, which is significantly lower than 0.173 of all enterprises and 0.175 of non heavily polluting enterprises, indicating that the growth rate of operating income among different types of enterprises varies greatly, and the growth capacity of heavily polluting enterprises is significantly lower than that of other enterprises.

## 3.4 Model Setting

The study takes the central environmental protection inspector as a quasi natural experiment to analyze the effect of environmental protection inspector on green patents of heavily polluting enterprises. The central environmental protection inspector belongs to exogenous impact and meets the basic assumption of double difference method. From 2016 to 2017, the central environmental protection supervision group supervised each

**Table 1.** Descriptive statistical results

	variable	N	mean	Sd	min	max
All enterprises	G patent ratio	18575	0.111	0.210	0	1
	Size	30285	22.115	1.290	19.790	26.105
	Lev	30285	0.418	0.209	0.049	0.895
	ROE	30250	0.068	0.127	-0.628	0.351
	Cash flow	30285	0.045	0.070	-0.170	0.239
	Growth	28257	0.173	0.430	-0.586	2.789
	Firm age	30285	2.836	0.364	1.609	3.497
Non heavy polluting enterprises	G patent ratio	17045	0.113	0.213	0	1
	Size	28264	22.061	1.276	19.790	26.105
	Lev	28264	0.417	0.210	0.049	0.895
	ROE	28231	0.067	0.127	-0.628	0.351
	Cash flow	28264	0.044	0.070	-0.170	0.239
	Growth	26259	0.175	0.437	-0.586	2.789
	Firm age	28264	2.832	0.368	1.609	3.497
Heavily polluting enterprises	G patent ratio	1530	0.089	0.167	0	1
	Size	2021	22.864	1.247	19.790	26.105
	Lev	2021	0.437	0.199	0.049	0.895
	ROE	2019	0.084	0.121	-0.628	0.351
	Cash flow	2021	0.067	0.065	-0.170	0.239
	Growth	1998	0.147	0.332	-0.586	2.789
	Firm age	2021	2.893	.297	1.609	3.497

province in five batches. Enterprises in different provinces received supervision at different times, meeting the setting of multi-stage double difference model. Therefore, the following multi-stage double difference model is constructed:

$$Y_{it} = \alpha + \beta Treat_{it} + \lambda Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it}$$

Where,  $i$  represents the enterprise,  $t$  represents the year, and  $Y_{it}$  represents the proportion of green patents of enterprise  $i$  in period  $t$ ;  $Treat_{it}$  is double difference item;  $Controls_{it}$  is the control variable, including enterprise asset scale, enterprise asset liability ratio, etc.;  $\mu_i$  is enterprise fixed effect,  $\gamma_t$  time fixed effect and  $\varepsilon_{it}$  is random disturbance term.

## 4 Empirical Analysis

### 4.1 Benchmark Regression Analysis

According to the multi period double difference model, this paper empirically analyzes the impact of the central environmental protection inspector on the green patents of heavy polluting enterprises, and reports the regression results of all enterprises, non heavy polluting enterprises and heavy polluting enterprises respectively. The benchmark regression results are shown in Table 2.

First of all, the central environmental protection inspector has a positive impact on all enterprise green patents. Hypothesis 1 is established. With the addition of control variables and time fixed effect, the effect is still positive, but it is not statistically significant. Secondly, the central environmental protection inspector has different effects on the green patents of non heavy polluting enterprises and heavy polluting enterprises. Hypothesis 2 is established. The direct impact on the former is positive and significant, and becomes no longer significant after adding control variables and time fixed effect; The direct impact on heavy polluting enterprises is positive, but not significant. After adding control variables and time fixed effect, the impact coefficient is significantly negative, indicating that the central environmental protection inspector has a “crowding out” effect on the green patents of heavy polluting enterprises.

**Table 2.** Benchmark regression results

Explained variable G patent ratio	All enterprises			Non heavy polluting enterprises			Heavily polluting enterprises		
Treat	0.0247*** (8.14)	-0.00196 (-0.27)	0.000661 (0.09)	0.0273*** (8.29)	0.00268 (0.35)	0.00616 (0.76)	0.00244 (0.35)	-0.0571** (-2.43)	-0.0572** (-2.41)
Size			0.00416 (0.82)			0.00261 (0.48)			0.0155 (0.97)
Lev			-0.0167 (-0.91)			-0.0158 (-0.80)			-0.0543 (-0.96)
ROE			-0.0171 (-0.96)			-0.0167 (-0.87)			0.0280 (0.66)
Cash flow			0.00860 (0.30)			0.00730 (0.23)			0.0633 (0.82)
Growth			0.00190 (0.44)			0.00144 (0.31)			-0.000884 (-0.07)
Firm age			-0.00409 (-0.14)			-0.00764 (-0.25)			-0.00756 (-0.07)
Year	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Constant	0.0976*** (59.87)	0.0885*** (16.88)	0.0186 (0.16)	0.0981*** (55.24)	0.0886*** (15.83)	0.0601 (0.48)	0.0879*** (25.01)	0.0930*** (4.79)	-0.216 (-0.56)
N	18575	18575	17000	17045	17045	15489	1530	1530	1511

Note: *t* statistics in parentheses, \* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

The impact of environmental regulation on green patents of non heavy polluting enterprises and heavy polluting enterprises is different. Possible reasons: heavy polluting enterprises are the main source of environmental pollution and the key object of supervision. In the face of strong pressure from the central supervision, enterprises may be more inclined to choose response measures with faster effect and lower cost in the short term, such as temporary shutdown and transfer of plant areas in the short term; In the long run, enterprises need to invest a lot of R&D personnel and funds to carry out green patent R&D and adopt green technology production, which takes a long time, which is an “irrational” choice for enterprises. Therefore, it is difficult for the central environmental protection inspector to increase the number of green patents of heavily polluting enterprises.

## 4.2 Heterogeneity Analysis

### 4.2.1 Heterogeneity Test of Green Patent Types of Heavily Polluting Enterprises

Based on the green patent category and IPC classification number determined in the green patent classification list issued by the world intellectual property organization, the types of green patents of heavily polluting enterprises are divided into green invention patents and green utility model patents. According to the technical content, the technical level of green invention patents is higher than that of green utility model patents [2]. The classification regression results of the impact of the central environmental protection inspector on the green patents of heavily polluting enterprises are shown in Table 3. The regression coefficient of green invention patent is negative, but it is not statistically significant; Green utility model patents have a significant negative impact; The coefficient of enterprise scale is significantly positive, indicating that the larger the enterprise scale is, the more conducive it is for enterprises to improve the green utility model patent.

### 4.2.2 Heterogeneity Test of Ownership Types of Heavily Polluting Enterprises

Due to the different nature of property rights, there are some differences in the sensitivity and response measures of environmental policies between state-owned enterprises (SOE) and non-state-owned enterprises (Non-SOE). Therefore, according to the different nature of enterprise ownership, the heavily polluting enterprises are divided into state-owned and non-state-owned samples to test the impact of the central environmental protection inspector on the green patents of the two types of enterprises respectively. The regression results are shown in Table 4. The influence of central environmental protection inspector on the proportion of green patents of two types of heavy polluting enterprises is significantly negative, and hypothesis 3 is not tenable. The reason may be that at present, Chinese enterprises are facing increasing market competition pressure at home and abroad, and in the short term, in order to improve their competitiveness and achieve the goal of profit maximization, the funds for green innovation R&D are limited [4]. The effect coefficient of state-owned enterprises is greater than that of non-state-owned enterprises, which shows that state-owned enterprises pay more attention to environmental performance and the invention and creation of green patented technology.

**Table 3.** Heterogeneity test results of green patent types of heavily polluting enterprises

	Green invention patent ratio	Green utility model patent ratio
Treat	-0.0219	-0.0332***
	(-1.14)	(-2.77)
Size	0.00448	0.0114*
	(0.32)	(1.77)
Lev	-0.00322	-0.0335
	(-0.07)	(-1.26)
ROE	0.0321	-0.00533
	(0.92)	(-0.30)
Cash flow	0.0552	0.0166
	(0.83)	(0.51)
Growth	0.00502	-0.00362
	(0.48)	(-0.72)
Firm age	-0.0414	0.0107
	(-0.51)	(0.24)
Year	Yes	Yes
Constant	0.0751	-0.246
	(0.21)	(-1.57)
N	1511	1511

Note: t statistics in parentheses, \*p < 0.10, \*\*p < 0.05, \*\*\*p < 0.01

**Table 4.** Test results of ownership heterogeneity of heavily polluting enterprises

	SOE G patent ratio	Non-SOE G patent ratio
treat	-0.0529*	-0.0607*
	(-1.68)	(-1.76)
Size	0.0245	-0.00164
	(1.24)	(-0.08)
Lev	-0.0282	-0.0737
	(-0.36)	(-0.85)
ROE	0.0386	-0.00305
	(0.73)	(-0.04)

(continued)



**Table 4.** (continued)

	SOE G patent ratio	Non-SOE G patent ratio
Cash flow	0.146	-0.0408
	(1.47)	(-0.32)
Growth	-0.0148	0.0103
	(-0.97)	(0.45)
Firm age	-0.232	0.0891
	(-0.76)	(0.92)
Year	Yes	Yes
Constant	0.160	-0.0777
	(0.19)	(-0.15)
N	768	743

Note: t statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## 5 Main Conclusions and Policy Recommendations

Using CRNDS 2010–2020 data, this paper empirically analyzes the impact of the central environmental protection inspector on the green patents of heavily polluting enterprises by using the multi period double difference method. The conclusions are as follows: (1) the central environmental protection inspector has a significant negative impact on the green patents of heavily polluting enterprises. (2) The heterogeneity analysis of different types of green patents shows that the impact of environmental inspectors on green invention patents is negative, but not significant, and the impact on green utility model patents is significantly negative. (3) The heterogeneity analysis of enterprises with different ownership shows that the impact of central environmental protection inspectors on their green patents is significantly negative for both state-owned and non-state-owned enterprises.

At present, it is urgent to strengthen environmental regulation and build a good ecological civilization system. It is of great significance to exert environmental governance pressure on governments and enterprises at all levels, especially heavily polluting enterprises, promote enterprise green technology innovation and increase the number of green patents through environmental inspectors. To this end, the following policy recommendations are put forward:

(1) Continue to improve the central environmental protection supervision system. The central government should establish a normalization mechanism for the supervision and inspection of heavy polluting enterprises, correct the short-sighted behavior of enterprises and put an end to fluke response measures through long-term and continuous supervision and pressure. (2) Standardize and optimize the evaluation system of central environmental protection inspectors. The central environmental protection inspector mainly evaluates the results of pollution prevention and emission reduction

of enterprises, pays too much attention to the short-term effect evaluation, and enterprises take more short-term response measures such as stopping production and limiting production. Therefore, we should increase the assessment of enterprises' sustainable green innovation ability, guide heavily polluting enterprises to invest in the R&D of environmental protection technology products through preferential measures such as taxes, subsidies and green credit, and promote the transformation and upgrading of enterprise technology. At the same time, building a long-term mechanism of public participation in environmental governance can not only realize the continuous supervision of enterprises, but also standardize the enterprise information disclosure system and promote the development of green innovation of enterprises through the normalization and institutionalization of public participation [1]. (3) Implement differentiated policies and measures for the heterogeneity of patents and enterprises. Pay attention to the incentives for high-quality green patents. According to the innovation difficulty and practical use value of green invention patents, formulate process and continuous dynamic incentives, which can be used as an important condition for enterprises to issue shares and raise funds. In view of the objective reality that non-state-owned enterprises are limited by profit maximization and under great pressure of environmental regulation, the rectification period of polluting enterprises can be appropriately extended and the punishment can be reduced; For state-owned enterprises, we should increase the weight of green innovation performance evaluation, stimulate the enthusiasm of state-owned enterprises to take the lead in independent green innovation, and demonstrate and drive all enterprises to achieve green and sustainable development.

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