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The Effects of Central Environmental Supervision and Inspection on the Green Innovation of Industrial Firms in China

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Abstract: Environmental problems such as poor air quality has recently drawn great attention in China. China's government has proposed plenty of regulations to alleviate these problems. Central environmental supervision and inspection (CESI), a kind of campaign-style command-and-control regulation, started in 2016 and is still underway. By dispatching central inspectors in groups to provinces in batches, CESI is much stronger and more direct than other command-and-control regulations in the past. There are many papers about CESI, but few examine the relation between it and green innovation from the microfirm perspective. Since firms' green innovation (FGI) is a vital driver of the green transformation, the author examines whether and how the first round of CESI influenced the industrial FGI in this paper, based on Time-Varying Difference-in-differences (TDID) model and Mediation Effect model. The 2011-2019 panel data of industrial firms that are listed in A-share market is used, and it is selected from China Stock Market and Accounting Research (CSMAR) database. Besides, FGI is measured by the quantity of green patents, including green utility and invention patents. Unfortunately, the results of both descriptive and empirical analysis show that CESI negactively affected FGI partly because the financial condition of firms worsened due to CESI. Moreover, according to heterogeneity analysis, the policy effect is still weak on firms in underdeveloped cities. The author offers some suggestions for improving relevant policies based on these findings.

Keywords: green innovation, central environmental supervision, inspection, financial condition, urban development level

1. Introduction

1.1. Research background

China has achieved rapid economic development since the reform and opening up in the late 20 century, and industrialization played a vital role in such a big success. However, industrialization requires high capital investment and high resource consumption [1-2]. It brings high pollution to the environment, leading to the great deterioration of the environment. According to Environmental Performance Index ranking, China is one of the countries with severe pollution and ecology damage problems. Confronted with the gradual worsening of environmental conditions, The State Council

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has incorporated the ecology concept into "Five-in-One" construction and basic national policies to suggest the importance of environmental protection and provide overarching guidance to all government officials [3]. Realizing firms' green transformation to improve their environmental performance becomes significant, and green technology innovation is thought to be one of the main solutions and drivers [4]. Besides, green innovation can help firms to achieve a win-win situation regarding environmental and economic benefits [5]. However, firms' willingness to actively make green innovations is still weak because innovation is costly and risky, which probably causes great financial loss in the short term.

In such a context, plenty of environmental regulations have been proposed to encourage firms' green transformation. They can generally be classified into three main types — market-oriented regulations, command-and-control regulations, and voluntary regulations [6]. Command-and-control regulations include legislation, standards, and supervision. The other two consist of economic instruments such as environmental levies and carbon emission permit trading market [7]; they are the voluntary behaviors of enterprises such as environmental information disclosure [6]. Compared with another two, although command-and-control regulations are much less cost-efficient [8], they play an important role in those countries lacking developed capital markets. Especially in China, capital markets are less completed, and governments are authoritarian with a powerful vertical cadre management system [9-10].

However, the effects of command-and-control regulations are sometimes undermined by local governments' poor supervision and passive response [11]. For example, some local governments tend to cover up the environmentally unfriendly production to sustain the area's economic growth [12]. The conspiracy between local government and firms also heavily hinders the actual implementation of regulations, particularly in underdeveloped regions [9]. To strengthen the power of environmental regulation, the State Council (SC) and the Chinese Communist Party Central Committee (CCPCC) launched CESI in 2016. Unlike the past regulations, CESI requires central environmental inspectors dispatched to provincial and municipal governments in the form of inspection groups. Each group stays in each province for around one month, listening to local officials' reports, reviewing relevant materials, visiting, inquiring, spot-checking, and accepting reports from the masses. It generates rigid constraints on local government leaders and firms' environmentally hazardous behaviors by imposing great pressure on local officials regarding their promotion assessment, putting heavy punishment, and so on. [13-14]. The first round was initiated in 2016 and finished by the end of 2017, lasting two years. After "Looking Back", the reflection and summary of the first round in 2018, the second one started in 2019 and is still underway currently, with "Looking Back" of the second round not started. Besides, CESI is carried out in provincial batches with considerable time intervals — four batches in the first round after one pilot and six batches in the second round, as Table 1 and Table 2 elaborate.

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Table 1: The First Round of CESI.

Batches	Inspected Provinces	Period
Pilot (1 province)	Hubei	01/04/2016-05/02/2016
1st batch (8 provinces)	Heilongjiang; Inner Mongolia; Jiangsu; Jiangxi; Guangxi; Henan; Yunnan; Ningxia;	12/07/2016-19/08/2016
2nd batch (7 provinces)	Beijing; Shanghai; Guangdong; Chongqing; Hubei; Shanxi3; Gansu	24/11/2016-30/12/2016
3rd batch (7 provinces)	Shanxi1; Anhui; Tianjin; Fujian; Hunan; Liaoning; Guizhou	24/04/2017-28/05/2017
4th batch (8 provinces)	Jilin; Shandong; Zhejiang; Hainan; Sichuan; Qinghai; Tibet; Xinjiang	07/08/2017-15/09/2017

Table 2: The Second Round of CESI.

Batches	Inspected Provinces	Period
1st batch (6 provinces)	Fujian; Shanghai; Hainan; Gansu; Chongqing; Qinghai	10/07/2019-15/08/2019
2nd batch (3 provinces)	Beijing; Zhejiang; Tianjin	30/08/2020-01/10/2020
3rd batch (8 provinces)	Shanxi1; Liaoning; Jiangxi; Anhui; Henan; Hunan; Yunnan; Guangxi	06/04/2021-09/05/2021
4th batch (5 provinces)	Jilin; Hubei; Shandong; Guangdong; Sichuan	31/08/2021-09/10/2021
5th batch (4 provinces)	Heilongjiang; Guizhou; Shanxi3; Ningxia	01/12/2021-05/01/2022
6th batch (5 provinces)	Hebei; Jiangsu; Inner Mongolia; Tibet; Xinjiang	23/03/2022-04/25/2022

1.2. Literature Review

CESI, the campaign-style command-and-control regulation, has drawn much attention from researchers. Although there are significant short-term effects because of the massive usage of resources, including workforce and capital, the effects of such campaign-style environmental governance are unsustainable [3]. For instance, the air quality improved in the inspected provinces in the short term, but it fell after CESI [15]. However, CESI has made a great positive difference in environmental performance by generating deterrent effects, increasing punishment levels, and enhancing public participation [16]. It is also concluded that the positive policy effect persisted even after the inspection [17]. In addition to direct environmental performance, the unit energy consumption is proved to be reduced in the industrial economy, improving the "quality" of production without significant impact on "quantity" in the long run [18]. Besides, local environmental governance generally became more active under CESI, and investors became more concerned about firms' environmental in-formation disclosure and updating after CESI, with the environmental awareness enhanced [19-20]. CESI also improved the listed company's performance level of social

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responsibility [21], which could further improve green innovation [22], a relatively long-term indicator to suggest the effects of CESI.

Generally, the positive relationship between green innovation and inspection is proved. Direct environmental regulations such as normal environment supervision and inspection significantly incentivize green innovation [23]. Besides, CESI is conducive to firm green innovation, but the effects vary among batches, the earlier ones performing better than the later ones [24-25].

1.3. Research Gap

Although there are already many papers on CESI [15][17], there are still relatively few on CESI and green innovation. To fill this gap, the author will study the effectiveness of CESI from the microfirm perspective in this paper, focusing on whether CESI positively stimulated the green innovation behaviors of industrial firms and provide further guidance for choosing and implementing environmental regulations. Since the second round is still underway and the sudden epidemic can be another big shock for the green behaviors of firms, the paper will only examine the first round. Besides, the author will further examine the influence mechanism in terms of financial condition by mediation effect analysis. Finally, based on the idea that CESI is more direct and stronger than command-and-control policies in the past, it probably does better when faced with underdeveloped cities. The author does a heterogeneity analysis to study the differences between firms in developed cities (DC) and underdeveloped cities (UC) to determine whether CESI can solve the problem in UC.

1.4. Research Framework

The following is divided into 5 sections. Section 2 states the author's hypotheses. Section 3 demonstrates the research design and methods, including the model, the basic information about data and variables, and the results of descriptive analysis. Moreover, the result of empirical analysis is displayed in Section 4, in which a parallel trend test and a robustness check are done to testify the reliability of the empirical analysis' results. In Section 5, the author analyzes both the mediation effect and heterogeneity. Finally, findings and limitations are shown in Section 6.

2. Hypothesis

As mentioned above, CESI positively successfully affects long-term incentives, such as firms' social responsibility undertaking, environmental awareness, public participation, and investors' concerns about green information disclosure [19, 20, 22]. Besides, according to the Porter Hypothesis, green transformation helps firms gain commercial competitiveness. Also, it benefits firms' financial performances by improving their resource usage efficiency [18], promoting their legitimacy and continuity, and positively signaling to stakeholders concerned with environmental problems [26].

However, in the short time (less than 3 years), the punishment of CESI may also aggravate the financial burden of the high-polluting firms by leading to a drop in profit, causing it even harder to do green transformation [27]. Regarding this, the author hypothesizes that the positive effects on innovation may be lagged. Instead, CESI probably limits firms' green innovation (FGI). Besides, the significance level of policy effects is similar in developed cities (DC) and underdeveloped cities (UC).

Based on these views, the author presents the hypotheses as follows:

Hypothesis 1: CESI negatively affects FGI by worsening firms' financial conditions.

Hypothesis 2: CESI has similar significant effects on FGI in DC and UC.

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3. Research Design and Method

3.1. Model

Since it is carried out in batches at different times, the Time-Varying Difference-in-differences (TDID) methods will be employed. Referring to existing literature, the paper chooses the individual and time-point double fixed-effect model.

$$FGI_{it} = \alpha_0 + \theta * CESI_{it} + X_{it}' * \beta + \mu_i + \rho_t + \varepsilon_{it} \quad (1)$$

$$CESI_{it} = Treat\_fhp_i * Treat\_year_{it} \quad (2)$$

In the equation (1), α_0 and ε_{it} are the intercept term and random disturbance term, respectively. Besides, $CESI_{it}$ is the policy variable, the product of $Treat\_fhp_i$ and $Treat\_year_{it}$, as equation (2) shows. $CESI_{it}$ equals to 1, when the firm is in the treated group ($Treat\_fhp_i$=1) after treating ($Treat\_year_{it}$=1), otherwise, it equals to 0. X_{it}'denotes the controlled variables including SIZE, ROE, FINLEV,TOBINQ and MARCOM. μ_i and ρ_t denote individual fixed effects and time-point fixed effects, respectively.

To further examine the influential mechanism, mediation model is set as follows.

$$FINCON_{it} = \tau_{21} + \varphi_2 * CESI_{it} + D_{it}' * \gamma_{21} + \mu_i + \epsilon_{1,it} \quad (3)$$

$$FGI_{it} = \tau_{22} + \omega_2 * FINCON_{it} + D_{it}' * \gamma_{22} + \mu_i + \rho_t + \epsilon_{2,it} \quad (4)$$

In the models, τ is the intercept term. ϵ_{it} and δ_{it} are the random disturbance terms. $FINCON_{it}$ denotes the financial condition. The controlled variables D_{it}' are different from the first model, only including SIZE, ROE, FINLEV, and MARCOM. Moreover, the time-point fixed effect is involved only in the equation where the number of patents is the explained variable.

3.2. Data and Variables

The paper uses the 2011-2019 panel data of industrial firms that are listed in A-share market. The original data is obtained from China Stock Market and Accounting Research (CSMAR) database. Although the second round started in 2019, it started in the latter half of 2019, and innovation is a long-term activity, so the disturbance of the second round is so small that it can be ignored.

Variables are explained as follows: First, green innovation is measured by the number of firms' green patents, a widely used indicator in the existing literature on innovation [25, 27]. The date of application is regarded as when the innovation successfully occurred.

Second, the policy time dummy variable (Treat year) measures whether the time is after the policy implementation time.

Third, referring to the existing literature, the firms in heavy-polluting industries (FHPs) are the prime targets of CESI [24], so the paper takes FHPs as the treatment group and non-HPFs as the controlled group. 16 industries, including coal, oil, metal, wine, textile, chemical materials, and electricity, are listed as heavy-polluting industries [28]. The individual policy dummy variable (Treat_fhp) shows whether the firm is HPFs.

Fourth, in some existing literature, controlled variables consist of the following variables [13, 24, 25, 27]. (1) Firm size (SIZE). Based on the marginal cost theory, larger firms tend to have the ability to control costs better. The natural logarithm of the value of total assets is used to measure firm size. (2) Financial leverage (FINLEV). The paper uses financial leverage, the ratio of debts and assets, to measure financial risk, which also impacts innovation. (3) Return on equity (ROE). Profitability is

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also important; return on equity is used to measure it. (4) Tobin Q (TOBINQ). Tobin Q reflects firms' performance and growth, measured by the market value to asset book value ratio. (5) Market competition (MARCOM). The market competition level is also an important factor that contributes to innovation. Industry Lerner Index is used to measure it.

Fifth, the mediation variable (FINCON) reflects the financial condition of firms, which the Z-score measures.

In addition, the author has done the following steps to clean the data: (1) since the paper is focused on industrial firms, the author only retains the data related to industries, including mining, manufacturing, electricity and fuel supply, and construction, according to The Guidelines for Classification of Listed Companies (Amended in 2012). (2) The firms that have ever stopped going to the public and that are titled with "ST" or "PT" are excluded. (3) The firms lacking data in terms of the year are deleted, making the data balanced. Finally, the sample consists of 11205 firm-year observations, including 1245 firms.

Table 3: Variables definition.

Variables		Definition
Explained Variable	FGI	The quantity of green patents, which equals to the sum of green utility and green invention patents.
Key Explaining Variables	Treat_fhp	Dummy variable, if the firm is in a heavy-polluting industry, it is in the treated group, treat_fhp= 1, otherwise 0.
	Treat_year	Dummy variable, if the firm is in the province that has already been inspected, treat_year = 1; otherwise, 0.
	CESI	The policy dummy variable. CESI=Treat_fhp*Treat year.
Controlled explaining variables	SIZE	The size of a firm is measured by the natural logarithm of the value of total assets.
	FINLEV	The debt measures the firm's financial leverage to asset ratio.
	ROE	Return on Equity measures the profitability of the firm.
	TOBINQ	Tobinq of the firm, an indicator of the firm's performance, is measured by the market value to book value ratio.
	MARCOM	Industrial Lenner Index measures the market competition intensity level.
Mediation Variable	FINCON	Zscore measures the financial difficulty of the firm. The greater it is, the better the financial condition the firm is in.

3.3. Descriptive Analysis

The basic descriptive statistical results, including number, range, mean and standard deviation, are shown in Table 4. Moreover, to see the general trend in the number of patents over time and offer

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guidance for further empirical analysis. The author calculates the number of patents of 1245 firms each year and draws a scatter diagram, as Figure 1-3 demonstrates. Figure 1 shows the trend in the treated group, and Figure 2 shows that in a controlled group, and Figure 3 illustrates the trend in all firms. Figures 4 and 5 offer a general sense of the difference between developed cities (DC) and underdeveloped cities (UC).

It can be discovered in Table 4 that the average innovation level of firms in DC is higher than that of firms in UC, while the average financial condition is a little worse.

Table 4: Descriptive statistical results.

Variable	N	Range	Mean	Mean in DC	Mean in UC	Sd
FGP	11205	1234.000	9.845	12.709	4.351	46.664
SIZE	11205	10.287	22.388	22.408	22.350	1.335
FINLEV	11205	1.584	0.460	0.458	0.462	0.209
ROE	11195	70.569	0.047	0.046	0.050	0.728
MARCOM	11189	19.581	0.101	0.102	0.098	0.206
TOBINQ	10937	22.846	1.919	1.932	1.894	1.228
FINCON	11068	306.323	4.853	4.769	5.017	8.508

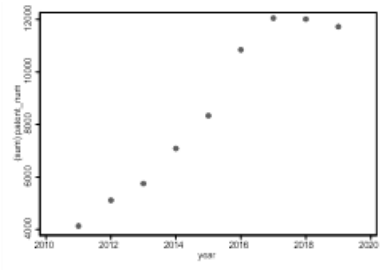

Figure 1: Treated group.

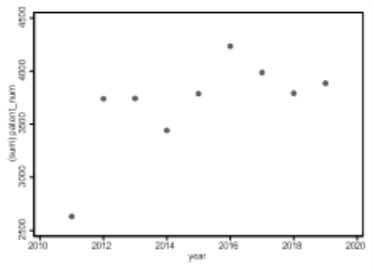

Figure.2: Controlled group.

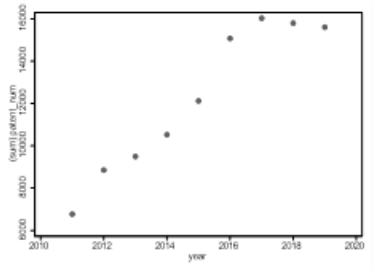

Figure 3: Both groups.

Based on the three Figures, generally, the number of green patents has been going through an ascending trend over these years, both in FHPs and non-FHPs. This is an optimistic phenomenon regarding environmental causes in the whole society and green transformation in each industrial firm. In detail, it can be found that there was a great shock to the treated group in 2012 and 2013, which made it deviate from the general trend. Therefore, in the further empirical analysis, the author would only analyse the six-year data from 2014 to 2019 to avoid the effects of the irrelevant shock. The negative effects of CESI can be concluded according to Figures 1 and 2 because, compared with the controlled group, the treated group went through a significant drop after the treating years 2016 and

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2017, and there is a renounce in 2019. It can also be speculated that the trends of the treated and controlled groups would generally be the same if the effects of the two shocks were removed.

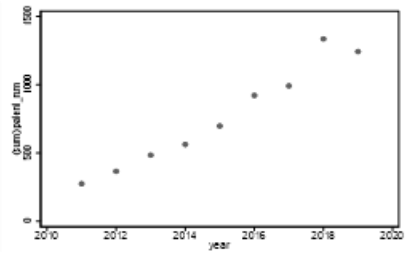

Figure 4: Treated group in DC.

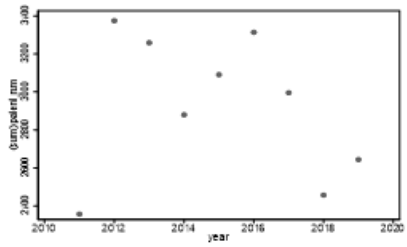

Figure 5: Treated group in UC.

The scatters in Figures 4 and 5 illustrate that the general trend of the treated group in UC is similar to that of the controlled group, free from shock in 2012 and the influence of CESI.

4. Empirical Analysis

4.1. The result of empirical analysis

The result of the empirical analysis is shown in Table 5, according to which the significant negative effects of CESI are demonstrated. Besides, the significance level and direction of influence remain the same regardless of the controlled variables involved.

In addition, among controlled variables, SIZE and TOBINQ of the firm have a positive relationship with the number of green patents. In contrast, financial leverage has a negative one.

Table 4: The Results of the baseline model and TDID model.

	(1)	(2)
	B_CESI	CESI
CESI	-3.594***	-3.909***
	[0.9040]	[0.9507]
SIZE		6.535***
		[0.9924]
ROE		0.0815
		[0.1399]
FINLEV		-7.266***
		[2.1937]
MARCOM		-0.413
		[0.2607]
TOBINQ		0.620***
		[0.2069]
Constant	12.06***	-133.3***
	[0.2930]	[22.0595]
N	7470	7242
adj. R-sq	0.8254	0.8262

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

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4.2. Parallel test

The prerequisite for DID is that the trend of the treated and controlled groups before the treating year should not be significantly different. Therefore, the author does the Parallel Test to prove the feasibility of DID model. The data for the first year (2014) is dropped to avoid multicollinearity problems. As Figure 6 and Table 6 suggest, the policy effects become significant merely from the treating year.

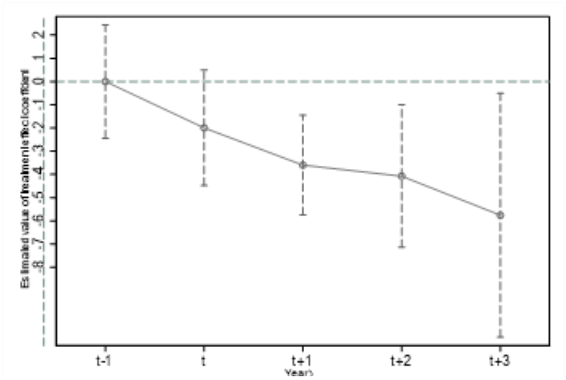

Figure 6: Parallel test.

Table 5: Parallel test.

	FGI
t-1	-1.672
	[1.2438]
t	-3.668***
	[1.2690]
t+1	-5.274***
	[1.0959]
t+2	-5.747***
	[1.5655]
t+3	-7.432***
	[2.6789]
Contant	-126.9***
	[21.5422]
Control	yes
Firm	yes
Year	yes
N	7242
adj. R-sq	0.8263

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

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4.3. Robustness check

The author does the robustness check by testing a smaller sample selected randomly from the whole sample. The result suggests that even in a smaller sample, the negative effects of CESI are still significant at the 1% level. Besides, the direction of controlled variables' influence is the same as that tested among the sample. Therefore, the results are verified.

Table 6: Robustness check.

	(1)	(2)
	RB_CESI	R_CESI
CESI	-2.214***	-2.564***
	[0.7072]	[0.7522]
SIZE		6.069***
		[1.0747]
ROE		0.125
		[0.1510]
FINLEV		-6.232***
		[2.2960]
MARCOM		-0.562*
		[0.3251]
TOBINQ		0.868***
		[0.2007]
Contant	11.19***	-124.5***
	[0.2535]	[23.8856]
N	6000	5819
adj. R-sq	0.8715	0.8731

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

5. Mediation Effect and Heterogeneity Analysis

5.1. Mediation Effect Analysis

The results of mediation effect model suggest that CESI negatively impacts firms' financial condition at a significance level of 1%, which means the influence is critical. Moreover, green innovation behaviour has a positive relationship with financial conditions. This means the firm in a better financial condition also does better in green innovation. In this way, by worsening the financial condition of these firms, CESI limited their green innovation behaviours, at least in the short term. However, there should be some other influence paths because only approximately 0.82% of CESI effects are conveyed in this path.

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Table 7: The results of the mediation effect model.

	(1)	(2)	(3)
	FGI	FINCON	FGI
CESI	-3.909***	-0.962***	
	[0.9507]	[0.1767]	
FINCON			0.0332**
			[0.0132]
SIZE	6.535***	-1.588***	6.003***
	[0.9924]	[0.2186]	[0.9404]
ROE	0.0815	-0.0811**	0.0925
	[0.1399]	[0.0344]	[0.1546]
FINLEV	-7.266***	-19.56***	-5.485***
	[2.1937]	[1.4028]	[2.1006]
MARCOM	-0.413	-10.68***	-15.39*
	[0.2607]	[4.0749]	[8.4350]
TOBINQ	0.620***		
	[0.2069]		
Constant	-133.3***	51.46***	-120.1***
	[22.0595]	[5.1451]	[20.6193]
ID	yes	yes	yes
YEAR	yes	no	yes
N	7242	7345	7345
adj. R-sq	0.8262	0.5501	0.8262

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

5.2. Heterogeneity Analysis

According to Tables 9 and 10, there are two main findings.

Firstly, the effects of CESI still fail to be significant in UC. CESI negatively impacts the financial condition of firms in UC, but it is not as significant as it has on firms in DC. Although it seems good to see that the negative effects are not significant, it indicates the failure of policy implementation at UC. As Tian et al. suggest, command-and-control environmental policies are hard to influence underdeveloped regions [9]. Although CESI is much stronger than other policy actions, confronted with inefficient governments and citizens with poor awareness, its influence is still weak.

Secondly, the influence of financial condition on firms' green innovation is significant in firms in DC. Still, it is insignificant in firms in UC. The factors contributing to such a difference are possibly that the innovation level of firms in UC is generally lower than that of firms in DC, and the willingness to innovate in green fields is also weaker. As the descriptive analysis demonstrates, even if firms in UC have a better financial condition on average, their green patents are much less than that of firms in DC.

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Table 8: Firms in DC.

	(1)	(2)	(3)
	FGI	FINCON	FGI
CESI	-6.915***	-1.090***	
	[1.5378]	[0.2033]	
FINCON			0.0879***
			[0.0265]
SIZE	7.283***	-1.732***	7.770***
	[1.1228]	[0.2149]	[0.8702]
ROE	0.0279	-0.0403	-0.00692
	[0.1294]	[0.0314]	[0.1256]
FINLEV	-9.730***	-15.87***	-8.016***
	[3.0828]	[1.1563]	[3.0032]
MARCOM	-7.885	-10.84**	-2.588
	[6.5063]	[5.0240]	[4.6373]
TOBINQ	0.872***		
	[0.2931]		
Constant	-145.3***	52.94***	-157.6***
	[25.0083]	[5.0109]	[19.1424]
ID	yes	yes	yes
YEAR	yes	no	yes
N	4771	4852	4852
adj. R-sq	0.8288	0.6551	0.8282

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

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Table 9: Firms in UC.

	（4）	（5）	（6）
	FGI	FINCON	FGI
CESI	0.894	-0.788*	
	[0.7406]	[0.4092]	
FINCON			0.0103
			[0.0063]
SIZE	4.845**	-1.487***	6.160**
	[2.4287]	[0.5409]	[2.6258]
ROE	0.752*	-0.436***	0.971*
	[0.4350]	[0.1536]	[0.4976]
FINLEV	-1.628	-27.38***	-2.693
	[2.8816]	[3.6434]	[2.7610]
MARCOM	-0.295	-11.12*	-34.65
	[0.1886]	[6.6519]	[28.5746]
TOBINQ	0.268		
	[0.1790]		
Constant	-104.0*	53.01***	-128.4**
	[53.9218]	[12.9447]	[55.0849]
ID	yes	yes	yes
YEAR	yes	no	yes
N	2467	2489	2489
adj. R-sq	0.7629	0.4945	0.7664

Standard errors in brackets
* p<0.1, ** p<0.05, *** p<0.01

6. Conclusion

6.1. Findings

The green transformation has been emphasized in China for a long time. According to the descriptive analysis, the green innovation level has also been rising. However, the empirical analysis results indicate a significant negative effect of CESI on firms' green innovation. Besides, it is partly because that CESI leads to a worse financial condition, which has a positive relationship with innovation since a good financial condition is necessary for innovation activities. The heterogeneity analysis shows that CESI is also inefficient when confronted with undeveloped cities.

According to the findings, several policy suggestions are proposed. (1) Punishment may be a straight and efficient way to regulate behaviours, but it is also likely to constrain firms' independent actions, such as innovation. Therefore, it can be used as a deterrent but must be employed carefully. (2) To transform green innovation into a voluntary activity, other regulations such as policies based on capital markets and publicity for environmental protection through social media need to be implemented in coordination with CESI. (3) Mere command-and-control policy is inefficient in underdeveloped cities. It should be designed specifically to influence the behaviours in these cities.

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6.2. Limitations

There are still many blanks that this paper cannot cover, which can be filled in the future.

(1) Other influential mechanisms can be further examined.

(2) The reason why CESI is still weak in underdeveloped cities remains to be studied, and some suggestions about improving environmental governance efficiency in these places can be further provided.

(3) Whether the innovation level would rise significantly after a long time is also a meaningful and interesting topic.

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