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Original Research

Miracle Drug or Quack Remedy? Unpacking the Effect of Central Environmental Protection Inspection on Green Innovation

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Abstract

As an innovative regulation of environmental governance, the role of environmental protection inspection in green innovation has received limited attention. This paper adopted DID (difference-in-difference) model to address the effect of central environmental protection inspection (CEPI) and explored why and how the CEPI affects corporate green innovation. We further investigated the moderating roles of firm size and firm age as organisation-level factors. With a sample of China's listed companies from 2014 to 2019, the empirical results show that the CEPI is significantly and positively associated with green innovation and that both firm size and firm age strengthen the positive effect of the CEPI on green innovation. We conducted PSM (propensity score matching) model to mitigate the endogenous problem and found our results are robust. This paper contributes to the literature about the CEPI and green innovation, and sheds light on environment policy enactment for the government.

Keywords: central environmental protection inspection, green innovation, firm size, firm age

Introduction

Environmental pollution and deterioration are the greatest challenges facing the world, and corrective regulations are being implemented to remedy this environmental damage [1]. Such regulations highlight the protection of ecological resources and the treatment of environment problems to improve environment quality [2]. The concept of inspection regulations, such as Central Environmental Protection Inspection (CEPI), have recently been being pursued and adopted in China. Actually, the CEPI is a campaign-style of environment enforcement, which is a strategic environmental regulation in the Chinese multi-level environment governance system [3]. It has been passed to establish the CEPI mechanism since 2015, by which local government held accountable for environmental problems [4]. It aims to undertake various intensive inspections and targeted actions in a short period of time to deal with weak environmental governance. As an innovative regulation of environmental governance, the role of the CEPI received limited attentions in green innovation.

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Green innovation is an effective and preventive approach to environmental pollution and the development of ecological civilisation and the economy [5]. Prior studies have reflected the impact of environmental regulation on green innovation, and presented mixed findings [6,7], and few studies examine the drivers of green innovation from the CEPI and their boundary conditions [8]. Moreover, the effect of the CEPI on corporate green innovation may vary in different size and age of firms, as large firms or older firms often have sufficient resource, which are benefit for green investment under the pressure of the CEPI. Therefore, we examined the moderating roles of firm size and firm age as organisation-level factors.

This paper adopted DID (difference-in-difference) model to address these issues and explored why and how the CEPI affects green innovation and considers the moderating roles of firm size and firm age as organisation-level factors. With a sample of China's listed companies from 2014 to 2019, this paper finds that the CEPI is significantly and positively associated with corporate green innovation and that both firm size and firm age strengthen the positive effect of the CEPI on green innovation.

This paper makes three contributions. First, this paper contributes to the CEPI literature. The CEPI is an innovative regulation which aims to improve corporate environmental performance, and we thus examined the effect of the CEPI on green innovation and provide new insights and better understandings of the the CEPI policy. As such, our study enriches the CEPI literature. Second, this study extends the literature about green innovation, firm size, and firm age. We help to identify the driver and the boundary conditions of green innovation by addressing the role of the CEPI and firm size and firm age. We explored how the CEPI affects green innovation and how firm size and firm age moderate the CEPI-green innovation relationship, which fills these voids and advance the studies of green innovation, firm size and firm age. Third, we test the hypothesis by considering the context of China, a typical emerging country with excessive environment damage and weak environment governance. China's context is different from that of Western developed countries. Our research shows that the Environmental Protection Inspection can improve green innovation. Thus, we are adding to the research on China as well as shedding light on contexts that could be parallel to other emerging economies.

Literature Review and Hypotheses

The China's government has passed the CEPI policy in 2015 to establish the CEPI mechanism, by which local governments were held accountable for environmental problems. Fig. 1 is the coverage of the CEPI in China [4].

The CEPI and Green Innovation

Environmental regulations aim to improve substantial environmental quality by technology-based innovation and the ambient environmental quality standard [9]. Environmental regulation can impact the firms' R&D investment [10]. China has achieved much

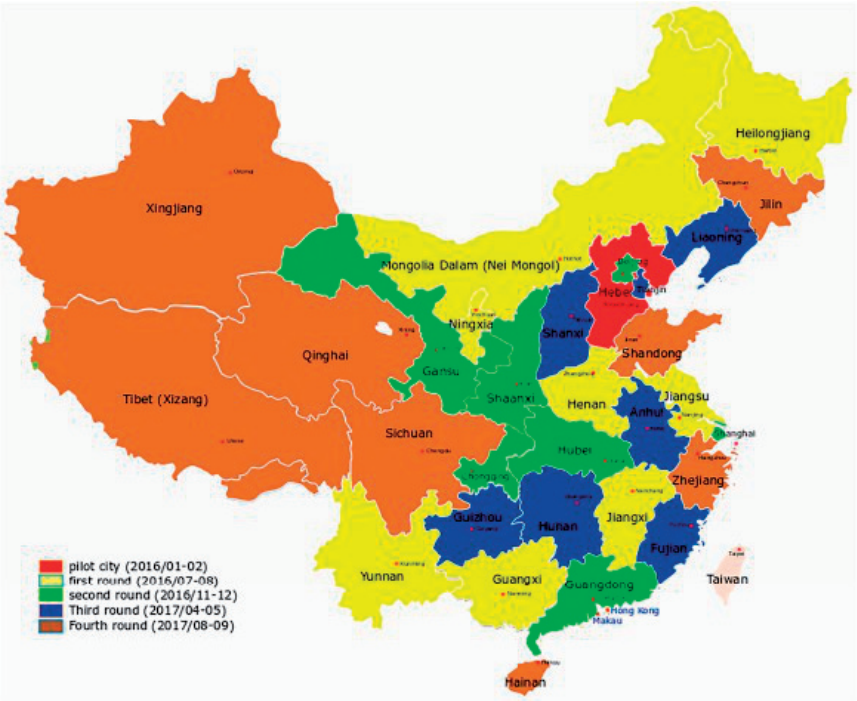

Fig. 1. The full achieved coverage of the CEPI in 31 districts (source: Wu and Hu's research).

effective environment protection work by implementing environmental regulation in ecological environmental protection [11]. China's government approved the CEPI Plan in 2015, which is an innovative and strategic environmental regulation. The central government appointed the CEPI teams to do special local inspection to solve cases of environmental pollution and ecological destruction.

Green innovation refers to the development, application and introduction of new idea, product and process by relevant stakeholders and firms that contribute to reducing corporate damage on the environment or achieving ecologically sustainability goals [12, 13]. The literature pointed out that the determinants of green innovation may be roughly divided into two categories: external-level factors and internal-level factors. The external factors are mainly described as a series of pressures, including social norms, regulations and policies, and stakeholder pressures; internal factors include firm size, firm performance and corporate governance [14, 15].

The CEPI, as environmental regulation, can increase external pressure on local environment governance and improve corporate environmental accountability. The CEPI requires the local government and firms to disclose environmental information to the public, which may put pressure on the government and the firm. The CEPI bring more and more regulation pressure to corporate green innovation. As a type of campaign environmental inspection, the CEPI includes both the internal administrative inspection system improvement and an expansion of the scope of environmental accountability. The CEPI is a crucial and useful supplement to the weakness of the traditional and conventional environmental governance mechanism. In such strict central environmental inspection, firms are under a high level of environmental legitimacy pressure, and they are required to be responsible for high environmental costs by improving green innovation [16].

The CEPI may encourage firms to carry out green innovation projects, thereby reducing firms' costs and improving efficiency and quality, so the CEPI can enable firms to produce environmentally friendly products and become more innovative. The CEPI can increase firms' investment in product technology and R&D, increase the cost effect of green innovation compensation, facilitate firms' efficient and environmental operation by technological green innovation and green development opportunities, and achieve a win-win situation, where both environmental performance and economic performance are improved. Thus, the CEPI triggers firms to eventually increase their investment in green innovation and improve green production processes in order to enhance environmental protection. Therefore, the CEPI presses firms on improving green innovation.

H1. The CEPI significantly and positively affects green innovation.

Moderating Roles of Organisation-Level Factors

We consider the boundary conditions of the relationship between the CEPI and green innovation at the organisation-level factors.

Firm Size

Firm size may positively moderate the CEPI-green innovation relationship, by affecting firms' green strategic motivation under the environmental inspection. Large firms normally have motivation towards green innovation under the pressure of the CEPI regulation, as they obtain more resources. Large firms have superior finance as well as resource, and they are more resilient in facing certain regulation pressure [17], such as environmental inspection. Firms with higher levels of resources and capital can reduce stakeholder resistance about adopting green innovation activities. Thus, large firms can respond positively to the impact on their green innovation of the environmental requirements related to the CEPI. Large firms handle external environmental regulations and requirements flexibly, due to their maturity and experience [17]. More mature firms have a clear organisational structure, which is an important attribute for firms to implement green innovation. On the contrary, small firms are less efficient than large firms at handling environmental problems and environmental regulations; they have less incentive to resolve environmental issues and implement green innovation [14]. Small firms are under less pressure from the institutions and the government involved in environmental protection and environmental control. Firm size may affect the motivation and effectiveness of firms' strategies, thus moderating the effect of the CEPI on green innovation.

H2. Firm size significantly and positively moderates the positive relationship between the CEPI and green innovation.

Firm Age

Firms utilise different resources at different stages, which may cause them to apply different strategies at different stages. Firm age thus may moderate the effect of the CEPI and green innovation. Old firms obtain more experience and important social capital networks, these of which affect corporate strategic transformation [18]. Thus, old firms will have different effects on green innovation when they face the CEPI. Young firms have less experience and external capital connections than older firm [19]. These factors put young firms at a disadvantage when they face the CEPI policies, which affect green innovation. Older firms can easily take action on innovative projects, turning green goals into continuous innovation when they confront the CEPI. This, in turn, may allow older firms to become good leaders and pave the way to achieving high green innovation [18]. In the process and operations

of the CEPI, old firms may have accumulated experience, which can improve production processes, advance green innovation and increase the firms' return on investment. A higher and better return on old firms' green innovative may be some of the positive in responses to the action of the CEPI [20]. Therefore, old firms have more resources and obtain rich experience, which may strengthen the positive effect of the CEPI on green innovation. However, young firms can less attract external stakeholders to corporate with them and they have fewer resources for green innovation under the CEPI. Thus, the young firms can obtain fewer external resources and less support, which makes it more difficult to transform the CEPI requirements into green innovation. These resources can effectively enhance the positive impact of the CEPI on green innovation. Thus, we propose that:

H3. Firm age significantly and positively moderates the relationship between the CEPI and green innovation.

Material and Methods

Sample and Data

Our data is from the China Stock Market and Accounting Research (CSMAR). The CSMAR database has been widely used in prior research in the context of China. We selected a sample of Chinese publicly listed firms between 2014 and 2019. Our initial sample included 21,553 observations. We excluded specially treated (ST, PT) firms for their abnormal financial status and missed control variables. Our final sample included 17,874 observations corresponding to 3,451 unique firms.

Measurements

Dependent Variable: Corporate Green Innovation

Several indicators are used to measure green innovation, including green R&D and green patent [21, 22]. We adopted green patents as a proxy of green innovation, and we collected corporate green patents from the patent database of the China's Intellectual Property Office. It is denoted as 'GI'.

Independent Variable: CEPIxPOST.

We introduced a dummy variable to measure the treatment variable. 1 for the listed firms are in the province, which experienced central inspection, otherwise 0 [4], and denoted as 'CEPI'; POST is time variable, 1 for the listed firms are in the province, which experienced the CEPI in this year, and denoted as 'POST'. The interaction of CEPI and POST is to test the effect of central inspection. The CEPI achieved full coverage in 31 districts in China, and is shown in Fig. 1.

Moderating Variables: Firm Size and Firm Age

We use the natural logarithm of corporate total assets to measure firm size, denoted as 'Size' [1]. Firm age, which we measured as the natural logarithm of [set-up years +1] and denoted by 'Age'[15].

Control Variables

Leverage: We measure it by debt-to-assets ratio, and denoted as 'Leverage'. ROA: We measured as return on assets. It is denoted as 'ROA'. Firm growth: This variable was measured by the growth rate of firms' operating revenue from year t-1 to t, denoted as 'Growth'. Board independence: We measure it by the

Table 1. Descriptive statistics and correlations.

	GI	CEPI	Size	Age	Leverage	ROA	Growth	Independence	Managers
GI	1								
CEPIxPOST	0.01	1							
Size	0.126***	0.063***	1						
Age	-0.004	0.195***	0.150***	1					
Leverage	0.007	-0.005	0.152***	0.076***	1				
ROA	0.002	-0.007	0.043***	-0.021***	-0.888***	1			
Growth	-0.002	-0.012	0.030***	0.01	0.008	0.002	1		
Independence	0.006	0.027***	-0.019***	-0.030***	0.001	-0.01	-0.006	1	
Managers	0.073***	-0.029***	0.318***	-0.006	0.034***	0.034***	0.016**	-0.061***	1
Mean	0.722	0.648	22.277	2.907	0.443	0.022	0.466	0.377	6.319
SD	10.175	0.478	1.5	0.314	0.585	0.47	14.884	0.056	2.396

Table 2. Regression results.

	Model 1	Model 2	Model 3	Model 4	Model 5
Leverage	2.301***	-0.938***	-0.886***	-0.879***	-0.861***
	(12.21)	(-4.78)	(-4.52)	(-4.49)	(-4.39)
ROA	2.374***	-0.378	-0.327	-0.329	-0.313
	(7.76)	(-1.48)	(-1.27)	(-1.29)	(-1.23)
Growth	-0.298***	-0.208***	-0.216***	-0.216***	-0.215***
	(-4.58)	(-3.79)	(-3.84)	(-3.84)	(-3.83)
Independence	0.961	0.314	0.196	0.202	0.186
	(1.56)	(0.54)	(0.33)	(0.34)	(0.32)
Managers	0.214***	0.0964***	0.100***	0.102***	0.100***
	(14.74)	(7.21)	(7.51)	(7.60)	(7.53)
Size		0.843***	0.835***	0.829***	0.832***
		(28.08)	(27.77)	(27.48)	(27.67)
Age		-0.612***	-0.628***	-0.625***	-0.622***
		(-5.68)	(-5.78)	(-5.76)	(-5.72)
CEPIxPOST			0.865***	0.860***	0.880***
			(5.61)	(5.60)	(5.70)
CEPIxPOSTxSize				0.0747*	
				(1.81)	
CEPIxPOSTxAge					0.385*
					(1.73)
_cons	-5.413***	-19.82***	-19.61***	-19.52***	-19.62***
	(-13.37)	(-26.78)	(-26.45)	(-26.25)	(-26.45)
Year fixed	yes	yes	yes	yes	yes
Industry fixed	yes	yes	yes	yes	yes
N	17874	17874	17874	17874	17874

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

ratio of independent director on the board, and denoted as 'Independence'. Top managers team size: we used the logarithm of current top managers to measure this variable, denoted as 'Managers'.

Empirical Models

Main Effect Model

We adopted DID model for main effect test, and the baseline model is presented as follows, and GI is the dependent variable: green innovation; the CEPIxPOST is the interaction of treatment variable and time variable, control is our control variables, such as Leverage, ROA, Growth, Independence, Managers; size and age are moderating variables. This paper also controls for the industry and the year fixed effect in each regression.

$$GI = \alpha_0 + \alpha_1 CEPIxPOST + \alpha_2 \text{Size} + \alpha_3 Age + \alpha_n Control_n + \varepsilon$$

Moderating Effect Model

The moderating models are presented as follows, and the interaction of the CEPIxPOST and Size is the moderating effect of firm size; the interaction of the CEPIxPOST and Age is the moderating effect of firm age. Other variables are similar with main effect model. We control for the industry fixed effect and the year fixed effect in the models.

$$GI = \alpha_0 + \alpha_1 CEPIxPOST + \alpha_2 Size + \alpha_3 Age + \alpha_4 CEPIxPOSTxSize + \alpha_n Control_n + \varepsilon$$

Table 3. Robustness test.

	Model 6	Model 7	Model 8	Model 9	Model 10
Leverage	0.476***	-0.111***	-0.131***	-0.128***	-0.130***
	(62.54)	(-3.21)	(-3.75)	(-3.67)	(-3.74)
ROA	0.564***	0.619***	0.606***	0.611***	0.605***
	(58.65)	(17.85)	(18.06)	(18.16)	(18.06)
Growth	-0.223***	-0.202***	-0.214***	-0.219***	-0.214***
	(-16.06)	(-14.24)	(-14.63)	(-14.82)	(-14.65)
Independence	1.551***	-1.162***	-1.088***	-1.111***	-1.091***
	(17.54)	(-12.78)	(-11.95)	(-12.19)	(-11.98)
Managers	0.221***	0.0912***	0.0909***	0.0918***	0.0907***
	(142.06)	(52.73)	(52.19)	(52.50)	(52.02)
Size		0.785***	0.781***	0.779***	0.781***
		(206.56)	(203.51)	(202.40)	(203.51)
Age		-0.129***	-0.0827***	-0.0851***	-0.0823***
		(-6.29)	(-3.95)	(-4.06)	(-3.93)
CEPIxPOST			0.524***	0.469***	0.526***
			(15.73)	(13.51)	(15.79)
CEPIxPOSTxSize				0.0324***	
				(5.66)	
CEPIxPOSTxAge					0.107***
					(2.63)
_cons	-3.190***	-18.04***	-18.05***	-17.96***	-18.06***
	(-33.56)	(-136.47)	(-135.62)	(-134.24)	(-135.65)
Year fixed	yes	yes	yes	yes	yes
Industry fixed	yes	yes	yes	yes	yes
N	17874	17874	17874	17874	17874

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

$$GI = \alpha_0 + \alpha_1 CEPIxPOST + \alpha_2 Size + \alpha_3 Age + \alpha_4 CEPIxPOSTxAge + \alpha_n Control_n + \varepsilon$$

Results and Discussion

Descriptive Statistics Analysis

Table 1 is the descriptive and summary statistics of the main variables. The pairwise Pearson correlations among the variables and the correlations are not very high. We calculated the variance inflation factor (VIF) of the variables and all the VIF values were lower than 5 and the mean of them was 1.26. There is not a serious multicollinearity problem in all variables.

Hypotheses Testing

We adopted a series of regressions to test our hypotheses. Table 2 reports the results of the empirical test. Model 1 is the result of the relationship between the control variables and dependent variable, while Model 2 adds the moderating variables (firm size and firm age). Model 3 shows that the CEPI positively affects green innovation ($\beta = 0.865$, $p<0.01$), which indicates that the H1 is supported. The CEPI can improve green innovation performance. Model 4 shows that the moderating effect of firm size on the relationship between the CEPI and green innovation is significantly positive ($\beta = 0.0747$, $p<0.1$), suggesting that firm size enhance this positive relationship between the CEPI and green innovation. The effect of the CEPI on green innovation can be enhanced in large firms. The moderating effect

Table 4. Results with PSM-DID model.

	Model 16	Model 17	Model 18	Model 19	Model 20
Leverage	2.528***	-0.520**	-0.513**	-0.493**	-0.489**
	(11.00)	(-2.19)	(-2.16)	(-2.09)	(-2.07)
ROA	3.866***	0.793	0.796	0.796	0.801
	(7.51)	(1.60)	(1.60)	(1.60)	(1.61)
Growth	-0.331***	-0.221***	-0.226***	-0.228***	-0.227***
	(-4.13)	(-3.29)	(-3.32)	(-3.33)	(-3.32)
Independence	1.207*	0.986	0.846	0.880	0.812
	(1.66)	(1.40)	(1.20)	(1.25)	(1.16)
Managers	0.241***	0.122***	0.122***	0.124***	0.122***
	(13.74)	(7.55)	(7.59)	(7.67)	(7.56)
Size		0.800***	0.798***	0.803***	0.794***
		(22.33)	(22.30)	(22.29)	(22.18)
Age		-0.834***	-0.814***	-0.820***	-0.767***
		(-6.33)	(-6.17)	(-6.22)	(-5.72)
CEPIxPOST			0.552***	0.544***	0.583***
			(3.16)	(3.12)	(3.32)
CEPIxPOSTxSize				0.105**	
				(2.20)	
CEPIxPOSTxAge					0.486*
					(1.87)
_cons	-5.495***	-18.62***	-18.64***	-18.78***	-18.73***
	(-11.71)	(-21.07)	(-21.09)	(-21.06)	(-21.14)
Year fixed	yes	yes	yes	yes	yes
Industry fixed	yes	yes	yes	yes	yes
N	12192	12192	12192	12192	12192

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

of firm age on the relationship between the CEPI and green innovation is significant and positive in model 5 ($\beta = 0.385$, $p<0.1$), showing that firm age strengthen the CEPI-green innovation relationship. Hence, the impact of the CEPI on green innovation can be strengthened in older firms. Therefore, both H2 and H3 are supported.

Robustness Tests

This paper conducted further robustness by alternative regression model for robustness checks from Model 6 to Model 10. We adopted the Poisson model for our robustness. Table 3 is the empirical results, and it can be seen that the sign and significance level of all models of coefficients are similar with Table 2.

Endogeneity Issues

We conducted endogeneity test by propensity score matching (PSM), and we adopted the regression to matched treated sample and control sample. After the test of the matched regression, we sort out the matched samples and we then rerun the DID model. Table 4 is the results of matched samples, which shows that the sign and significance level of all models of coefficients are similar with Table 2.

Conclusion

This study is intended to investigate the effect of the CEPI on green innovation and the boundary conditions at organization-level factors. With a sample of China's

publicly-listed firms from 2014 to 2019, the results show that the CEPI have a positive effect on green innovation, both firm size and firm age enhance the positive relationship. First, the CEPI positively affects green innovation. This result is consistent with the view that environment regulation may foster green innovation [1, 2]. The stringent environmental regulation bring pressure to firms and render firm increasingly prioritise their green innovation [5]. The CEPI requires firms to reduce damage to the environment and take action to protect environment, and thus it plays a significant role in green innovation. Second, both firm size and firm age enhance the positive effect of the CEPI on green innovation. These findings confirm that the CEPI-green innovation relationship is more pronounced when the firm is larger and older, as large firms can attract more external stakeholders and old firms obtain accumulated experience to get more resource for green innovation. Our findings deepen the understanding of the positive effect of the CEPI on green innovation.

This study provides various practical implications. First, China's environmental regulations have lower efficiency for the perversion of the incentive structure. The CEPI can improve the efficiency and adjust the perversion of the incentive structure, which can reduce environment damage and benefit green innovation. In fact, the CEPI has achieved success in current environmental protection. For example, the supervise department of the CEPI has punished the firms which destroy the natural environment. Moreover, the CEPI renders firms' operation become greener Thus, flexible environment regulation can foster green innovation, and Chinese government can enact similar regulation to stimulate corporate green innovation and environmental protection. Second, as China's government pays more and more attention to environmental problems, firms should consider more environment issues to their operation. For example, firms can develop their green innovation. Third, the CEPI can improve green innovation, and other countries can make use of China's experience, and they can enact the CEPI policy to address environmental issues. Furthermore, other countries should carry out flexible CEPI according to the current situation.

This study has several limitations, and they can serve as promising directions for future study. First, we only study the effect of the CEPI regulation on green innovation. We do not compare the different of CEPI regulation and other environment regulation, and we do not explore whether the CEPI can affect corporate environmental performance. Further study can compare the difference between the CEPI and other environmental regulations, and test the effect of the CEPI on corporate environmental performance. Second, this study mainly investigates the moderating effects of firm size and firm age on the focal relationship, do not examine the mediating roles, such as resource allocation. The mediating mechanism can be explored in future study. Third, this paper is drawn merely from the China's listed firms, and thus future study could extend our findings across west countries and other emerging countries.

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Conflicts of Interest

The authors declare no conflicts of interest.

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