

# Environmental Protection Investment and Enterprise Innovation: Evidence from Chinese Listed Companies

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#### **Research Article**

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# Abstract

China has emerged as the world's second-largest economy due to its rapid industrial expansion and phenomenal economic growth in recent decades. Though, this exponential economic turnaround has been fueled by widespread energy consumption, making China among the largest pollutant emitters in the world. Chinese enterprises have come under greater scrutiny and the government has mandated Chinese companies to undertake environmental protection investment. However, little is known that how these mandatory environmental investments affect Chinese firms' ability to undertake R&D expenditures. This study employs data of China's A-share listed firms during 2008-2016 to examine the nexus between environmental protection investment and corporate innovation. Our findings conjecture the crowding-out effects of environmental investments on enterprise innovation-related expenditures. Furthermore, additional empirical testing reveals that R&D undertakings of state-owned and politically connected firms are not affected by environmental investments. Likewise, corporate innovation activities are not negatively influenced by environmental investments in polluting industries. The study findings offer fresh insights to regulators, corporate managers, and stakeholders. Our results are robust to alternate econometric specifications and alternate variable specifications.

## 1. Introduction

Heightened industrial activity around the globe, especially in recent decades brought to fore the urgency of environmental protection. On one hand there are countries and regions considered as the major industrial hubs until recently (North America, Europe, Japan, and Russia), and newly included countries such as China, that adversely impact the environment with pollutant emissions and industrial waste (K.-m. Zhang & Wen, 2008). Similarly, there is the issue of the increasing population that again negatively contributes to the environment (Saqib & Benhmad, 2021). Hence, keeping the right balance between environmental protection and sustainable resource use is a challenging endeavor in itself (Bringezu, 2017). Being crucial at the domestic level, environmental protection is an imperative concern in the international sphere that requires the right financial instruments and policies to achieve the optimal condition with cost-effectiveness. Therefore, R&D of environmental friendly technologies will be the mainstream in the future (Juan, 2011).

China has experienced remarkable industrial expansion and exponential economic growth in recent decades emerging as the second-largest economy in the world. This phenomenal economic turnaround has been fueled by widespread energy consumption which led to heightened pollutant emissions (Akbar et al., 2020a). China is now one of the largest pollutant emitting economy in the world which has negative implications for human health, quality of life, and well-being (Akbar et al., 2020d, Shah et al., 2021). Corporate environmental investments significantly diminish the financial performance of financially constrained firms (Akbar et al., 2021). The increased financial burden can escalate the bankruptcy risk of firms (Akbar et al., 2020c, Akbar et al., 2019) and decrease corporate investment efficiency (Ahmed et al., 2021).

Research on enterprise innovation has gained traction in recent years. According to Schumpeter's theory, big firms are more innovative as there are returns to scale in R&D among large firms (Schumpeter, 1942), implying that the developed economies are more likely to have an appropriate climate for innovation rather than the developing countries (Rehman et al., 2020). Moreover, a strong economy and well-established institutions can be the key determinants of an innovation climate (Alfaro et al., 2019). The specialists of the British Standards Institution (2008), stated that among the principal reasons for incorporating innovation into the organization's core competencies was also the fulfillment of social and environmental responsibility. This is one of the main approaches concerning R&D and environmental activities that emphasize a positive link among them. McWilliams and Siegel (2001) support this association due to highly rated firm's reputation among the stakeholders because of investment in environmental preservation. Whereas, King and Lenox (2002) assert that improved productivity, cleaner environment in environmental issues would drive significant economic returns for the businesses and better financial performance (Esty and Porter, 1998), which in some cases may be ignored by the managers (Hart, 1997).

Firms have limited financial resources which need to be efficiently allocated among a range of investment activities (Akbar et al., 2021, Khan et al., 2016, Akbar et al., 2020b). Li et al. (2019) observe that R&D investments can stimulate enterprises to invent fundamental technologies and, thus enhance their financing environment to surpass the problem of financial inefficiency (Zhang et al., 2020). Environmental technology forms the basis of the environmental protection industry (Gaoxia, 2011). Moreover, investment in R&D can significantly affect the profitability of the enterprise through technological innovation (Zhang and Chen, 2017).

However, from a managerial standpoint, there is a preference for R&D investments over environmental protection investments due to uncertainty of how such investments will influence the economic performance of the firms. Due to the high initial costs of R&D, and long-term return on such investments, firms might struggle while deciding the share of investments they have to devote for environmental preservation. This decision of spending more on environmental protection and having less money for investment in core business operations for the upcoming year is a trade-off that might depend on other internal and external factors. For instance, being a polluting industry enterprise, having strong political connections (Tao, 2017), or being a fully state-owned enterprise (Lin et al., 2011), may drive different outcomes of environmental protection investments.

Extant literature has focused on the use of environmental innovation and technologies to curb emissions (Alam et al., 2019). However, little is known about how firms manage the trade-off between investing in environmental protection and R&D expenditures. This study makes the following contributions toward the extant literature. First, it investigates if there is a crowding-out effect of spending on environmental protection in the current period and the innovation expenditure in the upcoming period. Empirical results confirm that there exists a trade-off between both spendings, implying that the spending on environmental protection will negatively influence the spending on innovation. Secondly, the study

deepens the analysis in considering other influencers in this relationship. For instance, we separately consider the aforementioned trade-off in state-owned enterprises and non-state-owned enterprises. In line with this last consideration, the study examines the mediating influence of corporate political connections and whether or not these connections influence the relationship between the actual spending on environmental protection and the upcoming spending on innovation. Furthermore, the study presents new insights on this relationship for enterprises from polluting industries and non-polluting industries. Therefore, our study provides additional empirical evidence in the investment on environmental preservation and spending on innovation debate by incorporating the firm-specific attributes in our econometric analysis.

The remainder of the paper is structured as follows. Section 2 focuses on both the theoretical and empirical literature review and specific hypothesis development. Section 3 highlights the research design, empirical model, and data employed, while Section 4 focuses on the empirical results and discussions. Section 5 concludes the paper and provides some recommendations and future research directions.

# 2. Literature Review And Hypotheses Development

Several studies have explored the relationship between R&D and sustainability. For instance, Bretschger and Smulders (2012) show that knowledge spillovers can sustain long-run growth more likely for highly innovating sectors rather than less innovative sectors because highly innovative sectors are more flexible about input substitution. Fernández et al. (2018) employed ordinary least squares (linear regression method) for years between 1990 and 2013 for EU, US, and China, and found that R&D spending positively contributes to the economic growth of any economy, and also at the sustainable development. This finding is supported by other empirical works (Arora and Cason, 1995; Chakrabarty and Wang, 2012). Based on the empirical findings for the US market, the study of Arora and Cason (1995) found a positive relationship between the firm's expenditure in R&D and its' impact on environmental management. Similarly, Chakrabarty and Wang (2012) examined the longitudinal panel data from 1989 to 2009 for multinational corporations, which confirmed that higher R&D investments are more likely to contribute to sustainability by implementing better sustainability practices.

While the resource-based view (RBV) of the firm is one of the main and dominant perspectives in strategic management (Newbert, 2007; Bertram, 2016) and is often used as a theoretical paradigm for achieving competitive advantage (Conner, 1991; Armstrong and Shimizu, 2007), yet it lacks considering the relationship between a firm and its natural environment (Alam et al., 2019).

Existing studies have discussed the influence of the internal firm resources and capabilities (Prahalad and Hamel, 1990) as well as the environmental factors (Porter, 1979) that contribute to a sustainable competitive advantage, and both of them are found to be crucial to the competitive success of firms (Hart, 1995). Pushed by the environmental pressures from the marketplace and regulatory authorities (Cheng et al., 2014), firms are more oriented toward long-term environmental-friendly products, processes, and technologies rather than short-term profits and benefits (Hart, 1995). To achieve sustainable

competitiveness, firms have to address the proper investment concerning R&D, which creates the right infrastructure to increase the firm's operational efficiency and to reduce environmental adversities at the same time.

Corporate social responsibility embedded investments have a profound impact on a firm's financial performance (Qureshi et al., 2021, Yang et al., 2019). There is an extended list of studies that investigated the link between R&D intensity and corporate social responsibility (CSR), by considering firm's environmental activities as a part of CSR (as such, McWilliams and Siegel, 2000; Rothenberg and Zyglidopoulos, 2007; Hull and Rothenberg, 2008; Padgett & Galan, 2010). Specifically, the study of McWilliams and Siegel (2000) found a positive and significant association between R&D intensity and CSR activities, by reporting that firms that spend more on R&D are more likely to have high CSR (Rothenberg and Zyglidopoulos, 2007; Hull and Rothenberg, 2008). The work of Padgett and Galan (2010) separated manufacturing industries and non-manufacturing industries, and found that the significant relationship existed only for manufacturing industries, but not for the non-manufacturing industries.

Being capital- and technology-intensive, the environmental protection industry needs high levels of investment in R&D that indeed represents long-term returns. Green enterprises are considered a promoter of economic growth (Ndiaye et al., 2018; Gromova et al., 2020), and efficacy in reducing environmental pollution (Lin et al., 2020). Likewise, Yi et al., (2020) indicate that the financial efficiency of environmental protection enterprises in China has decreased, and the reason for that was their low technological levels, and the only firms considered successful in financial efficiency were those with core technologies that could gain competitive advantage in the industry, and assist in sustainable development.

Zhang and Chen (2017) stated that excessive environmental R&D expenditures could greatly reduce profit margins for firms, which causes a competitive disadvantage in the market. Contrarily, the study of Cai and He (2014) reveal that environmentally responsible firms experienced significant long-term returns, to improve economic performance, increased operational efficiency, reputation, and risk reduction of environmental disasters (Hart and Ahuja, 1996; Peloza, 2006).

Therefore, in view of the dearth of empirical literature on the nexus between corporate environmental investments and their innovation oriented investment, we propose four hypotheses be further investigated through this research. First, in line with general logic, which considers a limited funds available to firms for various investments. Because if a firm considers to spend more resources on environmental protection, it will have less resources to undertake research and development projects.

# *H1:* Increased enterprise spending on environmental protection will decrease the innovation expenditure in the subsequent year.

Secondly, the negative relationship or the crowding-out effect is expected to be non-existent in stateowned enterprises, enterprises in polluting industries, and enterprises with political connections. The reason for this expectation is the government support available for the state-owned enterprises, thus, they have more financial resources available for the R&D expenditure (Lin, Ma, & Xuan, 2011). Therefore, even though these firms have to make more investments in environmental protection, they still have funds available for research and development endeavors. Hence we put forward the following hypothesis;

# *H2:* Environmental protection investment in state-owned enterprises do not has a negative impact on enterprise innovation activities compared with non-state-owned enterprises.

Thirdly, while considering a politically affiliated enterprise, implying a have good relations with the government, it is expected more preferential treatment and resources for these enterprises, as in the case of state-owned enterprises. Firms with political connections can avail subsidies and tax incentives which will create more financial cushion for such firms (Tao, Sun, Zhu, & Yang, 2017; Wu, Wu, Zhou, & Wu, 2012). Therefore, they can also increase investment in environmental protection without excessive reduction in R & D investment.

# *H3:* Environmental protection investment in enterprises with political connections do not has a negative impact on enterprise innovation activities compared with enterprises without political connections.

Lastly, polluting industry enterprises themselves need to invest a lot of resources in environmental protection, it expects environmental protection investment, can arrange funds more proactively. Since firms from polluting industries are subject to mandatory environmental investments so they have a more stable expectation of their future financing requirements. Whereas non-polluting industry enterprises usually do not spend a huge amount on environmental protection, thus fewer funds are reserved for environmental protection. When there is an increased investment in environmental protection, R&D investment becomes insufficient.

*H4:* Environmental protection investment in polluting industries enterprises do no negatively impact enterprise innovation activities compared with enterprises in non-polluting industries.

### 3. Empirical Model And Description Of Data

#### 3.1 Empirical model

To explore the impact of environmental protection investment on enterprise innovation, this paper uses the data of 2008-2016 A share list companies in China as a research sample and constructs the following regression model:

$$Innova = \alpha_{0} + \alpha_{1}EI + \alpha_{2}Size + \alpha_{3}Roe + \alpha_{4}Lev + \alpha_{5}Growth + \alpha_{6}First + \alpha_{7}State + \alpha_{8}Far \_r + \alpha_{9}Ocf + \alpha_{10}Board + \alpha_{11}Dual + \alpha_{12}Ddrate + \alpha_{13}Stime$$
(1)  
+  $\alpha_{14}GDP + \sum Year + \sum Ind + \varepsilon_{1}$ 

In model (1), *El* is a measure of a firm's environmental investment, similar to D. Zhang, Du, Zhuge, Tong, and Freeman (2019) and Jiang and Akbar (2018), we use two indices, one is the ratio of the total amount of environmental investment divided by the total assets; the other is the ratio of the total amount of environmental investment divided by the operating income. Wherein the environmental protection investment data is manually collected from each firm's "Social Responsibility Report" and "Sustainable Development report". *Innvoa* is enterprise innovation, measured by the ratio of the total amount of R&D investment divided by the total assets (Padgett & Galan, 2010). And we also control firm-specific variables that may affect corporate innovation behavior according to (Lee, 2012) and (Wang, Wei, & Song, 2017) including firm size, return on equity, asset-liability ratio, enterprise growth ability, operating cash flow ratio, the first major shareholder shareholding ratio, the duality of chairman and CEO, independent director ratio, the number of years that a company goes public, property rights, etc. Industry and Year dummy variables are also included. To alleviate the influence of endogeneity, all dependent variables use one-year ahead data. The specific variable definitions are shown in table 1.

#### Table 1: Variable definition

Variable	Definition
Innova	100×Company R&D investment/ total assets
El <sub>1</sub>	100×Total environmental protection investment/ total assets
El <sub>2</sub>	100×Total environmental protection investment/ operating income
Size	The natural logarithm of the total assets
Roe	Company net profit / net assets
Lev	Total Assets/ total Liabilities
Growth	Current operating income/ (current operating income-previous operating income)
First	Percentage of shares held by the largest shareholder
State	1 if the company is state-owned, otherwise 0
Fa_r	Fixed assets/ total assets
Ocf	Operating cash flow/ total assets
Board	The natural logarithm of 1 plus number of directors in the board
Dual	1 if the chairman and CEO are the same person, 0 otherwise
Ddrate	Percentage of independent directors on the board
Stime	Years elapsed since the firm was listed
GDP	GDP of provinces (Trillions)
Year	Year dummy variables
Ind	Industry dummy variables

#### 3.2 Description of data

The data for this research constitute 2568 Chinese A-share firms listed on Shanghai and Shenzhen stock exchanges during 2008-2016. We extract data of environmental investment manually from the CSR report of the respective firm. Furthermore, data of all the remaining variables of sample companies was acquired from the CSMAR<sup>[1]</sup> (China Stock Market & Accounting Research) database.

Table 2 reports the descriptive statistics of the variables in this paper. Through the analysis, we can see that the average value of enterprise R&D investment (*Innova*) is 1.630, means an enterprise in China spend 1.63% of their total assets on innovation, but the range of this variables is relatively large, which shows that the innovation behavior of different enterprises is quite different and whether there is the impact of environmental protection investment remains to be investigated. The mean value of the two environmental investment variables is 1.542 and 3.856 respectively, and the range of each variable is

also relatively large, which shows that different enterprises have different environmental investment preferences. The values of control variables are generally consistent with the previous literature.

Variable	Ν	Mean	SD	Min	Median	Max
Innova	2568.000	1.630	1.365	0.009	1.452	9.710
EI <sub>1</sub>	2568.000	1.542	2.981	0.000	0.333	18.252
El <sub>2</sub>	2568.000	3.856	8.917	0.001	0.576	58.351
Size	2568.000	22.375	1.222	19.503	22.214	25.726
Roe	2568.000	0.049	0.134	-1.076	0.058	0.347
Lev	2568.000	0.476	0.200	0.056	0.486	1.352
Growth	2568.000	0.295	0.987	-0.826	0.103	10.849
First	2568.000	0.363	0.154	0.036	0.349	0.860
State	2568.000	0.461	0.499	0.000	0.000	1.000
Fa_r	2568.000	0.290	0.166	0.006	0.266	0.751
Ocf	2568.000	0.080	0.148	-0.978	0.071	0.809
Board	2568.000	2.284	0.168	1.609	2.303	2.890
Dual	2568.000	0.222	0.416	0.000	0.000	1.000
Ddrate	2568.000	0.370	0.054	0.231	0.333	0.667
Stime	2568.000	10.089	6.227	1.000	9.290	26.052
GDP	2568.000	3.599	2.125	0.115	2.960	8.085

#### Table 2: Description of variables

### 4. Results And Discussion

#### 4.1 Baseline regression

Table 3 reports the regression results of model (1). The dependent variable is *Innov*, it can be seen that  $EI_1$  and  $EI_2$  are all negatively correlated with *Innov*, which means when the enterprise spent more on environmental protection, the innovation expenditure will decrease in the next year. The more funds a firm spends on environmental protection, the fewer funds they have for research and development. Hypothesis 1 is thus supported by empirical evidence.

#### Table 3: Environmental investment and enterprise innovation

	(1)	(2)
El 1	-0.036***	
	(-11.94)	
El <sub>2</sub>		-0.016***
		(-16.07)
Size	-0.108***	-0.106***
	(-8.84)	(-8.46)
Roe	1.076***	1.028***
	(5.53)	(5.21)
Lev	-0.269***	-0.298***
	(-2.68)	(-3.02)
Growth	-0.020	-0.022
	(-1.23)	(-1.45)
First	-0.014	-0.032
	(-0.13)	(-0.30)
State	0.224***	0.221***
	(5.58)	(5.42)
Fa_r	-0.509***	-0.473**
	(-2.80)	(-2.52)
Ocf	-0.085	-0.073
	(-0.35)	(-0.30)
Board	0.266	0.236
	(1.44)	(1.27)
Dual	-0.010	-0.006
	(-0.20)	(-0.12)
Ddrate	0.059	0.056
	(0.16)	(0.15)
Stime	-0.025***	-0.025***
	(-8.12)	(-7.79)

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GDP	0.054***	0.052***
	(8.68)	(7.98)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2568.000	2568.000
R <sup>2</sup>	0.260	0.264
F	92.384	91.457

t statistics in parentheses

\* *p* < 0.1, \*\* *p* < 0.05, \*\*\* *p* < 0.01

#### 4.2 Further analysis

The cross-sectional heterogeneity may exist in the above conclusions. Innovation activities have the characteristics of a long cycle, high risk, etc., and need continuous capital investment. Therefore, financing constraints are an important reason to restrict innovation activities of enterprises (Czarnitzki & Hottenrott, 2011; Li, 2011). However, the existing literature shows that the financing constraints faced by enterprises with different ownership are quite different (Lin et al., 2011). Because state-owned enterprises are more subject to "paternalism" from the government, their financial support is more sufficient, and their financing constraints are less, so the impact of environmental protection investment on innovation activities may be negligible.

The innovation activities of non-state-owned enterprises are more affected by financing constraints, so environmental protection investment has a more crowding-out effect on the innovation behavior of enterprises. Here, this paper studies this question by constructing the interaction term of environmental protection investment and corporate ownership ( $El \times State$ ). The regression results are shown in Table 4. It can be seen that the coefficients of  $El_1$  and  $El_2$  are both significantly negative, the above conclusions have not changed. At the same time, the coefficients of  $El_1 \times State$  and  $El_2 \times State$  are significantly positive in both regressions, which means that compared with non-state-owned enterprises, environmental protection investment in state-owned enterprises has a less negative impact on enterprise innovation activities.

Table 4: Environmental investment and enterprise innovation: Moderating effect of corporate ownership

	(1)	(2)
El <sub>1</sub>	-0.042***	
	(-16.17)	
El <sub>1</sub> ×State	0.013***	
	(3.12)	
El <sub>2</sub>		-0.020***
		(-14.58)
El <sub>2</sub> ×State		0.011***
		(6.68)
State	0.238***	0.218***
	(3.94)	(4.07)
Size	-0.105***	-0.100***
	(-9.74)	(-9.03)
Roe	1.039***	0.986***
	(5.45)	(5.13)
Lev	-0.276**	-0.320***
	(-2.19)	(-2.61)
Growth	-0.023	-0.026*
	(-1.49)	(-1.80)
First	-0.057	-0.061
	(-0.57)	(-0.61)
Fa_r	-0.563***	-0.531***
	(-2.81)	(-2.60)
Ocf	-0.113	-0.120
	(-0.45)	(-0.48)
Board	0.293*	0.264
	(1.80)	(1.64)
Dual	-0.014	-0.006
	(-0.33) Page 12/27	(-0.14)

Ddrate	0.016	0.034
	(0.04)	(0.10)
Stime	-0.027***	-0.027***
	(-8.06)	(-7.43)
GDP	0.055***	0.054***
	(7.76)	(7.48)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2428.000	2428.000
R <sup>2</sup>	0.262	0.267
F	83.946	75.613

Furthermore, we investigate the influence of political connection on the relationship between environmental protection investment and enterprise innovation activities. Chinese enterprises will establish connections with the government in various forms (Fisman, 2001). Due to closer ties with the government, political connections can indeed bring various scarce resources for enterprises, such as government subsidies, tax preferences, etc. (Tao et al., 2017; Wu et al., 2012). These resources will greatly alleviate the financing constraints faced by enterprises, to reduce the negative impact of environmental protection investment on enterprise innovation activities.

Here, we measure the political connection of an enterprise by whether the CEO of the enterprise has ever served in a government department and examine the impact of political connection on the relationship between environmental protection investment and enterprise innovation by constructing the interaction term of environmental protection investment and political connection ( $EI \times Rela$ ). The regression results are shown in Table 5. It can be seen that the coefficients of  $EI_1$  and  $EI_2$  are also both significantly negative, and at the same time, the coefficients of  $EI_1 \times Rela$  and  $EI_2 \times Rela$  are significantly positive in both regression, which means that compared with enterprises without political connections, environmental protection investment in enterprises with political connections has a less negative impact on enterprise innovation activities.

Table 5: Environmental investment and enterprise innovation: Moderating effect of political connections

	(1)	(2)
El 1	-0.041***	
	(-10.60)	
El <sub>1</sub> ×Rela	0.022***	
	(4.07)	
El 2		-0.017***
		(-17.38)
El <sub>2</sub> ×Rela		0.006***
		(2.91)
Rela	-0.154***	-0.139**
	(-2.80)	(-2.47)
Size	-0.108***	-0.106***
	(-8.67)	(-8.39)
Roe	1.061***	1.011***
	(5.38)	(5.09)
Lev	-0.264***	-0.294***
	(-2.63)	(-2.99)
Growth	-0.020	-0.023
	(-1.35)	(-1.59)
First	-0.026	-0.039
	(-0.23)	(-0.34)
State	0.218***	0.215***
	(5.08)	(4.94)
Fa_r	-0.531***	-0.494**
	(-2.84)	(-2.57)
Ocf	-0.066	-0.055
	(-0.27)	(-0.22)
Board	0.286	0.254
	(1.51) Page 14/27	(1.36)

Dual	0.005	0.011
	(0.09)	(0.19)
Ddrate	0.103	0.106
	(0.26)	(0.28)
Stime	-0.025***	-0.026***
	(-8.04)	(-7.76)
GDP	0.055***	0.052***
	(9.05)	(8.28)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2560.000	2560.000
R <sup>2</sup>	0.260	0.263
F	1986.708	2003.234

Based on the perspective of financing constraints faced by enterprises, the above study examines the impact of the ownership and political connections on the relationship between environmental protection investment and enterprise innovation from the perspective of external resource access convenience. In fact, as an important enterprise development strategy, innovation activities will also be affected by the specific characteristics of enterprises. From the perspective of enterprise production attribute, the production process of enterprises in the pollution industry is more likely to produce pollutants, so it will be subject to more strict institutional supervision. Such enterprises will have a more stable expectation for their environmental protection investment amount, to reasonably arrange the investment, which will not have a strong crowding-out effect on innovation activities.

For non-polluting industry enterprises, they need less investment in environmental protection. When they need more investment in environmental protection due to external impact, it will intensify the crowdingout effect of environmental protection investment on innovation activities. Here, we make an empirical analysis of this question, and the regression results are shown in Table 6. It can be seen that the coefficients of  $EI_1$  and  $EI_2$  are both significantly negative, and at the same time, the coefficients of  $EI_1 \times Pollute$  and  $EI_2 \times Pollute$  are significantly positive in both regression, which means that compared with enterprises in non-polluting industries, environmental protection investment in polluting industries enterprises has a less negative impact on enterprise innovation activities.

#### Table 6: Environmental investment and enterprise innovation: Moderating effect of the industry attribute

	(1)	(2)
El 1	-0.052***	
	(-11.59)	
El <sub>1</sub> ×Pollute	0.042***	
	(6.67)	
El 2		-0.019***
		(-11.24)
El <sub>2</sub> ×Pollute		0.008***
		(4.07)
Pollute	-0.280***	-0.278***
	(-3.16)	(-2.84)
Size	-0.100***	-0.099***
	(-8.57)	(-7.70)
Roe	1.085***	1.045***
	(6.25)	(5.77)
Lev	-0.306***	-0.336***
	(-3.01)	(-3.22)
Growth	-0.019	-0.024
	(-1.18)	(-1.57)
First	-0.030	-0.040
	(-0.27)	(-0.36)
State	0.226***	0.226***
	(4.79)	(5.13)
Fa_r	-0.414**	-0.398**
	(-2.40)	(-2.12)
Ocf	-0.100	-0.099
	(-0.42)	(-0.41)
Board	0.283	0.248
	(1.52) Page 16/27	(1.32)

Dual	-0.011	-0.009
	(-0.21)	(-0.19)
Ddrate	0.047	0.020
	(0.13)	(0.06)
Stime	-0.026***	-0.026***
	(-7.86)	(-7.58)
GDP	0.054***	0.051***
	(8.75)	(8.10)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2568.000	2568.000
R <sup>2</sup>	0.262	0.265
F	3450.999	3315.796

#### 4.3 Robustness checks

Although the current environmental protection investment amount and the innovation investment of year t+1 are used for regression, which can reduce the endogenous problem to a certain extent, the regression result may still be affected by the omission of other company-level factors that do not change with time. Here, this paper controls the firm-level fixed effect, regression results show that the above conclusions have not changed.

#### Table 6: Environmental investment and enterprise innovation: Firm fixed effect

	(1)	(2)
El 1	-0.025***	
	(-5.30)	
El 2		-0.007***
		(-11.30)
Size	-0.151***	-0.140***
	(-3.04)	(-2.76)
Roe	0.146***	0.131***
	(2.98)	(3.08)
Lev	-0.009	-0.021
	(-0.10)	(-0.22)
Growth	0.001	-0.001
	(0.35)	(-0.29)
First	0.117	0.110
	(0.55)	(0.53)
State	0.071	0.064
	(0.65)	(0.59)
Fa_r	0.426*	0.454*
	(1.67)	(1.76)
Ocf	-0.072	-0.072
	(-0.80)	(-0.78)
Board	0.012	0.007
	(0.12)	(0.07)
Dual	0.085**	0.083**
	(2.33)	(2.25)
Ddrate	-0.257	-0.237
	(-1.42)	(-1.33)
Stime	0.396***	0.376***
	(4.41)	(4.11)

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GDP	-0.009	-0.008
	(-0.27)	(-0.24)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2568.000	2568.000
R <sup>2</sup>	0.029	0.026
F	14.334	28.616

In the baseline regression, we use the proportion of R&D investment in operating income to measure enterprise innovation. Here, referring to Fan and Wang (2019) we change the measurement method to measure enterprise innovation as the natural logarithm of the enterprise R&D investment amount plus 1. The regression result of changing the dependent variable also did not change.

#### Table 7: Environmental investment and enterprise innovation: change the dependent variable

	(1)	(2)
	Lnrd	Inrd
El <sub>1</sub>	-0.010**	
	(-2.40)	
El <sub>2</sub>		-0.009***
		(-4.08)
Size	0.921***	0.923***
	(31.36)	(31.09)
Roe	0.558**	0.536**
	(2.33)	(2.24)
Lev	-0.580***	-0.589***
	(-4.56)	(-4.59)
Growth	-0.049**	-0.050**
	(-2.52)	(-2.57)
First	-0.497***	-0.508***
	(-3.53)	(-3.54)
State	0.105***	0.099***
	(4.74)	(4.70)
Fa_r	-0.297*	-0.253
	(-1.73)	(-1.39)
Ocf	-0.469**	-0.466***
	(-2.55)	(-2.59)
Board	0.272**	0.253*
	(2.00)	(1.86)
Dual	0.007	0.015
	(0.20)	(0.41)
Ddrate	1.347***	1.339***
	(3.63)	(3.60)
Stime	-0.035***	-0.036***

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	(-19.17)	(-20.20)
GDP	0.078***	0.076***
	(14.02)	(13.10)
Year	Yes	Yes
Ind	Yes	Yes
Ν	2344.000	2344.000
N R <sup>2</sup>	2344.000 0.524	2344.000 0.526

## 5. Conclusions And Policy Implications

In the backdrop of increased pollutant emissions, the Chinese government has implemented stricter regulations on corporations for pollution abatement. Chinese enterprises are mandated by law to undertake investments for environmental preservation. Extant literature has examined the impact of R&D investments on corporate environmental investment. However, the influence of undertaking environmental investments on a firm's ability to allocate funds to R&D endeavors remained unknown. The present study fills this void in the literature by examining the data of China's A-share listed companies during 2008-2016. The study findings reveal that corporate environmental investments significantly diminish R&D expenditures by Chinese enterprises in the subsequent period. This is in line with the notion that firms have limited financial resources to be allocated to a range of investment activities. Hence environmental protection investments leave less financial cushion for a firm's R&D investments.

Nevertheless, we dig deeper into this nexus and observe the mediating influence of corporate ownership, political connections, and the nature of the industry. We find that environmental investments do not adversely affect enterprise innovation for state-owned rather it shows a positive impact on R&D activities of such firms. This is attributed to the fact that Chinese state-owned firms receive financial support from the government so these firms are not subject to financial constraints. Likewise, firms with political connections also exhibit a positive association between environmental protection investments and corporate innovation. These outcomes imply that politically connected firms can avail themselves of more favorable treatment from the government, such as subsidies and tax incentives. Hence such firms have sufficient resources both for environmental investments as well as R&D expenditures. Besides, environmental investments do not show crowding-out effects on corporate innovation expenditures in firms from polluting industries. Since these firms are subject to stricter institutional regulations to undertake environmental protection investments as compare to their counterparts, so the management is better prepared to make arrangements to allocate funds for environmental protection.

The outcomes of this research point to various implications for corporate regulators and stakeholders. First, the regulators should keep in mind the adverse effects of the excessive financial burden of corporate environmental investments on the innovation capacity of Chinese firms. Second, regulators in China shall be aware of the financial constraints faced by the private firms and should formulate policies following the financial capacity of firms. Third, the crowding-out effects of environmental investment on R&D spending are more pronounced in firms with less political connections also referred to as "Guangxi" in China. Hence such firms should receive a fairer and equitable treatment and regulations should be tightened to curb corrupt practices. Fourth, corporate managers should be aware of the adverse effects of additional investments allocated to environmental protection and should arrange funds for future investments more proactively to alleviate the negative fallout on corporate innovation.

Though the findings of this research can only be generalized to firms operating in China. Future studies can extend this line of research by observing the proposed relationships in an international panel of firms. Besides, it will be interesting to see the impact of environmental protection investments on the bankruptcy risk of a firm.

## Declarations

#### Ethics approval and consent to participate

Not Applicable

#### **Consent for publication**

Not applicable

#### Availability of data and materials

Dataset, analysis file, and codes are available upon request.

#### **Competing interests**

The authors declare that they have no competing interests

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#### Authors' contributions

AA conceptualized the idea and wrote the manuscript. XJ performed data collection, analysis and interpretation. EH wrote introduction and literature review sections. MA performed review and editing. All authors read and approved the final manuscript.

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