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Directors' and officers' liability insurance and corporate environmental investment: empirical evidence from the most polluting Chinese listed firms

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Abstract

Purpose – This study empirically investigates the impact of directors' and officers' liability insurance on corporate environmental investment.

Design/methodology/approach – This paper takes A-share listed firms in the most polluting industries from 2013 to 2019 as the research sample. The authors perform multiple regression analysis to examine the research question, and other approaches such as PSM and Heckman two-stage model are applied to test the robustness of the main results.

Findings – The authors find that D&O insurance insured firms significantly decrease the level of corporate environmental investment. The results keep consistent after alleviating potential endogenous concerns. Further analysis shows that the negative association between D&O insurance and environmental investment is more pronounced in firms facing greater environmental pressure and stronger market supervision, and firms located in regions with a rich legal environment.

Research limitations/implications – This research extends the literature on the antecedents of corporate environmental investment and the consequences of D&O insurance.

Practical implications – The study may deepen people's understanding of D&O insurance and inform them of its negative effects. This research sheds light on the potential factor resulting in a relatively low level of corporate environmental investment in China, which has an important policy implication for government to carry out some regulations to make a difference.

Originality/value – Against the backdrop that more importance has been attached to environmental protection globally, this paper is the first study to examine the impact of D&O insurance on corporate environmental investment in the context of the transitional and emerging market-China.

Keywords D&O insurance, Corporate environmental investment, Environmental pressure, External monitoring, Legal environment

Paper type Research paper

1. Introduction

Directors' and officers' liability insurance (hereinafter, D&O insurance) is a kind of professional liability insurance purchased by a firm to protect the professional activities of directors and officers. When the insured directors and officers who behave in good faith and abide by loyalty duty are involved in legal actions due to negligence or wrongful behavior, the related legal costs and civil compensation liability shall be reimbursed by the insurance company (Cao and Narayanamoorthy, 2014). The coverage of D&O insurance in developed capital markets like the United States and Canada is over 90% (Zeng, 2017). However, there are relatively scant public firms carrying D&O insurance in China. With the litigation risk confronted by the D&Os

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becoming higher, D&O insurance has attracted extensive attention in China recently (Jia *et al.*, 2019). Particularly after the occurrence of the Luckin Coffee incident, more and more Chinese listed companies begin to purchase D&O insurance (Su, 2020), which shows the big potential development room for D&O insurance in China in the future.

The essential intention for listed companies purchasing D&O insurance is to transfer the risk that directors and officers take in the process of fulfilling their duty, encourage them to take positive actions, and ultimately enhance firm value. However, the issue that whether D&O insurance plays a positive role in elevating the functionality of managers is not beyond controversy. Some studies document that D&O insurance strengthens external supervision and improves corporate governance in the insured companies (O'Sullivan, 1997; Yuan *et al.*, 2016). Whereas some scholars argue that D&O insurance provides excessive protection for the directors and officers, which aggravates their opportunistic behavior to seek private interests, and also deepens the agency conflict (Chung and Wynn, 2008; Li and Liao, 2017; Chen *et al.*, 2016). Given researchers and practitioners have attached increased attention to D&O insurance, and a growing emphasis on firms' environmental protection activity in the corporate finance literature, we are motivated to explore the important research question of whether D&O insurance affects corporate environmental investment in the largest emerging capital market-China.

The past few decades have witnessed the enormous development of the economy in China, but at the same time, it has also induced great deterioration to the ecological environment. Governments have gradually increased environmental protection law enforcement and environmental-related investment (Jia, 2012). However, enterprises are the main producers of environmental pollution (Shi *et al.*, 2019; Li *et al.*, 2020). According to the "polluter pays" principle, firms have an undeniable responsibility to bear in the process of environmental protection. With public awareness of environmental protection building up, firms are urged to respond to their stakeholders' requests for environmental responsibility (Du, 2015). As the decision-maker of corporate environmental protection investment, D&Os' individual behavior and characteristics have an important influence on determining corporate environmental policies (Boiral *et al.*, 2018). D&O insurance changes D&Os' risk preference and decision-making behavior (Lin *et al.*, 2011; Zeng, 2017; Yuan *et al.*, 2016), which may ultimately affect the decision on environmental policy. Whether D&O insurance exerts a positive effect to stimulate firms to engage in more environmental-related investments or does it provide excessive protection for managers' opportunistic behavior to evade environmental responsibility? This research question has not been unexplored in the literature.

The most polluting industries have been accused as the main producer of pollutants. We employ the data of China's A-share companies in the most polluting industries from 2013 to 2019 to investigate the impact of D&O insurance on corporate environmental investment. It is found that D&O insurance aggravates the opportunistic behavior of managers in environmental investment decision-making. Specifically, the insured firms significantly reduce the level of environmental investment. Taking the endogenous problems into account, the conclusion of this paper is still valid. Further analysis shows that the negative impact of D&O insurance on enterprise environmental investment is more pronounced in enterprises with higher environmental pressure and stronger capital market supervision, and in firms located in regions with a rich legal environment.

The potential contributions of this paper are as follows. First, we extend the literature on the consequences of D&O insurance and particularly on how D&O insurance affects people's decision-making. Prior studies document various benefits (Yuan *et al.*, 2016; Hwang and Kim, 2018; Otto and Weterings, 2019) and some negative sides (Lin *et al.*, 2013; Gillan and Panasian, 2015; Chen *et al.*, 2016) of D&O insurance. We complement the research by providing evidence that D&O insurance affects a firm's environmental investment.

Second, this paper enriches the growing literature on the determinants of corporate environmental policy. Recent studies have found several factors that may affect corporate

environmental responsibility, including institutional shareholders (Kim *et al.*, 2019; Chen *et al.*, 2020), top executives' experience (Hong *et al.*, 2022) and firm-level characteristic (Abeysekera and Fernando, 2020; Li *et al.*, 2020; Tian *et al.*, 2021). We document that D&O insurance significantly affects firms' environmental investment, adding to this stream of literature to some extent.

Third, our research shows a negative association between D&O insurance and corporate environmental investment in China, which can deepen people's understanding of the consequences brought by D&O insurance. And it may also offer some significant implications for corporations in other emerging markets to navigate the positive effects of D&O insurance and increase engagement in environmental protection activities.

The rest of this paper is structured as follows. Section 2 reviews the related literature and proposes the hypotheses. Section 3 describes the dada and sample construction and regression model. Section 4 shows and discusses the empirical results. Section 5 presents the results of further analysis. And Section 6 concludes.

2. Literature review and hypothesis development

2.1 The consequences of D&O insurance

Directors and officers who breach the fiduciary duties or violate the securities law may be sued by stakeholders (Lin *et al.*, 2019). Firms can purchase Directors' and officers' liability insurance (D&O insurance) to protect the sued D&Os from bearing personal financial liabilities (Chen *et al.*, 2016; Yuan *et al.*, 2016). The primary intention of D&O insurance is to motivate D&Os by offering protection for them at the firm's cost. Some studies document that D&O insurance brings various benefits to the firm. Core (1997) shows that D&O insurance can motivate directors to perform their duty more diligently and can deter them from behaving in a myopic manner. O'Sullivan (1997) finds that compare with the high cost of external monitoring, D&O insurance is effectively utilized to supervise managers in large companies, which supports the notion that with the introduction of insurers' external monitoring, managers have a compelling force to act with sufficient care. Yuan *et al.* (2016) find that the stock price crash risk is smaller for insured firms in the Chinese setting, indicating that D&O insurance can improve corporate governance. Otto and Weterings (2019) claim D&O insurance can serve as a signal of the quality of corporate governance in that investors and other parties can obtain valuable information, such as a firm's risk profile, from the premium of D&O insurance. Using the sample of Korean listed firms between 2002 and 2008, Hwang and Kim (2018) empirically explore the effect of D&O insurance on firm value, and the results exhibit that D&O insurance significantly reduces managers' risk averseness on investing and help the decision-makers seize growth opportunities to achieve higher firm value.

However, the consequences of D&O insurance are not without controversy in academics. A strand of literature has pinpointed the negative effects of D&O insurance. Lin *et al.* (2011) detect a negative association between the outcome of merger and acquisition and D&O insurance coverage. They argue that D&O insurance weakens the disciplining effect of shareholder litigation and triggers unintended moral hazards. Using the listed firms in Taiwan from 2008 to 2012 as the empirical sample, Wang and Chen (2016) find that D&O insurance worsens the agency problem for it attenuates the positive relationship between directors' compensation and firm performance, which deviates the essential idea and purpose of purchasing this insurance. Gillan and Panasian (2015) find that firms purchasing D&O insurance have a higher probability of being sued relative to uninsured firms and accordingly insurers charge higher premiums on these firms, confirming the view that D&O insurance exaggerates managerial opportunism and moral hazard. Lin *et al.* (2013) document that D&O insurance is positively correlated to risk-taking and financial restatements, which induces a higher level of loan spread in insured firms. In a similar vein, Chen *et al.* (2016) find that D&O insurance leads to higher risk-taking and information asymmetry, and ultimately results in an increase in the cost of equity. Auditors perceive purchasing D&O insurance as a higher possibility of moral hazard and litigation threat, so they charge higher audit fees on clients that carry D&O insurance (Li and Liao, 2017).

2.2 The determinants of corporate environmental responsibility

In recent years, corporate social responsibility has increasingly drawn public attention. As one important dimension of CSR, a majority of studies have focused on the behavior of corporations toward natural environmental responsibility, and research on its antecedents has proliferated. Based on resource dependence theory, Kassinis and Vafeas (2006) detect that firm's environmental performance is positively associated with community stakeholder pressure. Adopting stakeholder theory, Darnall *et al.* (2010) find that stakeholders play a positive role in pressuring firms to fulfill more environmental responsibility, and smaller firms with a simplified decision-making process are more responsive to stakeholder pressures. Similarly, using the data of 167 manufacturing firms in the UK, Yu and Ramanathan (2015) show that stakeholder pressure positively affects green operations practices, and finally firms' environmental performance increases. Focusing on the key stakeholder-institutional shareholders, Chen *et al.* (2020) find a positive relationship between institutional ownership and corporate social responsibility, suggesting that institutional shareholders can generate a real social impact on environmental protection. Corporate environmental investment is a critical way to undertake firms' environmental responsibility. Some research examines the effects of factors such as firm-level characteristics and the external environment on environmental investment. For example, it's found the level of environmental investment is higher in cross-shareholding firms (Tian *et al.*, 2021) and firms whose top executives have military experience (Hong *et al.*, 2022). But firms invest less in environmental projects when local officials under high pressure of economic growth target relax environmental regulation intensity (Zhong *et al.*, 2022). Abeysekera and Fernando (2020) find that family firms' altitudes toward environmental investment depend on whether shareholder interests and societal interests coincide or diverge. Li *et al.* (2020) document a negative association between environmental investment and the separation of controlling shareholder's control right and cash flow right, shedding light on how corporate governance affects corporate environmental investment in the context of China.

2.3 Hypothesis development

Given the ongoing debates about the merits of D&O insurance in extant research, this paper analyzes the effect of D&O insurance on corporate environmental investment decisions from two distinct perspectives.

On the one hand, D&O insurance may have a positive effect on corporate environmental investment. The fiduciary duties of D&Os to shareholders are to manage a firm and oversee business decisions (Lin *et al.*, 2019). Because they cannot fully diverse risks specific to their claims in a firm and risks related to their human capital, D&Os tend to be risk-averse for the sake of career trajectory, personal reputation and assets (Smith and Stulz, 1985; Amihud and Lev, 1981). Corporate environmental investment is one risky decision making with a large amount of capital investment, long cycles and high uncertainty, in spite of the benefits to firms' long-term development (Maxwell and Decker, 2006). The potential bad outcomes of environmental investment undoubtedly weaken D&Os' motivation to engage in environmental protection. However, D&O insurance provides protection for D&Os against bearing personal liabilities when they are sued for the bad outcomes of their business decisions (Chen *et al.*, 2016). Hence, in insured firms, D&Os are encouraged to invest in risky environmental investment projects. In addition, insurers can exert a monitoring effect on corporate environmental investment in firms covered by D&O insurance. Although the fact that investing in environmental protection projects reduces the short-term performance may weaken D&Os' motivation to invest in environmental protection projects, the wrongdoing in environmental responsibility is likely to induce negative market reaction or even violation cost with the building up of public awareness on environmental-friendly (Kassinis and

Vafeas, 2006). D&O insurers act as deep-pocket, last-chance payers of managerial mistakes (Lin *et al.*, 2011). Given that insurers incur costs when a client firm involves in environmental-related litigation, they have financial incentives to monitor the insured firms to ensure environmental legitimacy so as to avoid possible loss (Gillan and Panasian, 2015). Based on the above analysis, we propose the following hypothesis:

H1a. Firms purchasing D&O insurance invest more in environmental protection, other things being equal.

On the other hand, D&O insurance may aggravate managers' opportunistic behavior on environmental investment. D&O insurance helps to reduce the level of D&Os' risk averseness, but the excessive protection provided by this insurance also shields D&Os from the threat of litigation and personal financial liability resulting from their decisions on behalf of the corporation, which intensifies D&Os' incentives to obtain personal gains at the cost of shareholders rather than acting in the best interest of shareholders (Parsons, 2003; Lin *et al.*, 2011). Investing in environmental protection projects may squeeze other profitable investments, lower the short-term performance, and the cost of environmental protection investment far outweighs its economic benefits (Li *et al.*, 2020). The inherent conflict of corporate environmental investment with financial performance maximization inevitably weakens the short-sighted managers' motivation to engage in environmental investment. Although reducing environmental investment may trigger potential violation penalties due to non-compliance with environmental regulations (Chen *et al.*, 2020), the legal institution and litigation system in China are relatively poor (Allen *et al.*, 2005), which limits the actual litigation risks of directors and officers. And if they are sued by stakeholders for wrongful behavior in environmental protection, the related losses are beard by the D&O insurance insurers, reducing the expected financial and legal liabilities along with the bad outcome of directors' and officers' decisions (Baker and Griffith, 2011). Despite insurers may conduct monitoring on their clients, anecdotal evidence shows the incidence of D&O insurance claims is very low in China, which constrains insurance institutions' enthusiasm to monitor the insured firms. In summary, D&Os are in a better position to abuse corporate indemnification provisions for self-interest by making a lower level of environmental investment in D&O insurance insured firms. Based on the above analysis, we propose the following hypothesis:

H1b. Firms purchasing D&O insurance invest less in environmental protection, other things being equal.

3. Research design

3.1 Sample and variable

3.1.1 Sample. China suffered serious smog in 2013, and the severe air pollution aroused widespread concerns about environmental protection (Zhou *et al.*, 2015). Before 2013 a very small number of firms report their environmental expenditures. And 2019 was the latest year for which the full texts of annual reports were available at the time our study was carried out. So we take Chinese A-share listed firms in the most polluting industries from 2013 to 2019 as the preliminary research sample. According to Dong *et al.* (2021), 16 industries are classified as high polluters. We drop firms under special treatment (ST and *ST) and the missing observations of the main variables. The final sample consists of 5,269 firm-year observations. Table A1 (in Appendix) presents the distribution percentages based on industry. A majority of firms belong to the chemical raw materials and products manufacturing (23.50%), biomedicine (18.83%) and non-metal mineral products (10.21%), the other industries have a relatively low distribution

percentage. The data of D&O insurance is collected from the announcements of listed firms. The data of corporate environmental investment is manually collected from listed firms' annual reports. Other financial data are mainly from the China Stock Market and Accounting Research (CSMAR) database. In addition, in order to mitigate the bias caused by outliers, continuous variables are winsorized on the 1% quantile. Stata 14.0 is used as the statistical software.

3.1.2 Measurement of environmental investment. The dependent variable is corporate environmental investment. Environmental investment includes related expenses and capitalized expenditures aimed at reducing waste at the source, and reducing direct or indirect pollution of organizational processes and the entire life cycle of products (Orsato, 2006; Patten, 2005; Tian *et al.*, 2021), such as investment in cleaner production technology and environmental protection equipment. We take the logarithm of one plus the firm's annual environmental investment to measure corporate environmental investment (*EPI1*). An alternative measure (*EPI2*) is applied for robustness checks.

3.1.3 Measurement of D&O insurance. According to Zou *et al.* (2008), if the firm purchases D&O insurance in a certain year, *INS* is 1, otherwise, it is 0. We take the first year when the firm announces to purchase D&O insurance as the start point of purchasing and assume that unless the firm announces to cancel, suspend or stop the purchase of D&O insurance, the firm will provide this insurance for D&Os continuously.

3.2 Empirical model

To empirically examine the impact of D&O insurance on corporate environmental investment, we construct the following regression model:

$$\begin{aligned} EPI1_{i,t} = {} & \alpha_0 + \alpha_1 \times INS_{i,t} + \alpha_2 \times SIZE_{i,t} + \alpha_3 \times LEV_{i,t} + \alpha_4 \times ROA_{i,t} + \alpha_5 \times GROW_{i,t} \\ & + \alpha_6 \times CASH_{i,t} + \alpha_7 \times OCF_{i,t} + \alpha_8 \times DUAL_{i,t} + \alpha_9 \times Top1_{i,t} + \alpha_{10} \times SOE_{i,t} \\ & + \sum Ind + \sum Year + \varepsilon_{i,t} \end{aligned} \tag{1}$$

where i indexes the firm, t indexes the year, and ε denotes the error term. We specify the dependent variable as the level of corporate environmental investment (*EPI1*) and the independent variable of interest as D&O insurance (*INS*). Following prior literature (Li and Lu, 2016; Li *et al.*, 2020), a series of firm characteristics that may affect a firm's environmental investment policies are controlled: Firm size (*SIZE*) is the natural logarithm of a firm's total assets at the end of year t. We control Debt ratios (*LEV*, the ratio of total liabilities to total assets at the end of the fiscal year) to capture the impact of the creditors and financial risk. Profitability (*ROA*) is controlled to remove the effect of profitability on environmental investment, which equals the ratio of net profits to total assets. To control the potential influence of future growth opportunities, we introduce the variable of sale growth (*GROW*), measured as the annual change of sales revenue divided by lagged sales. *CASH* is the ratio of monetary assets to total assets. Cash flow (*OCF*) is net cash flow from operating activities scaled by total assets. CEO-duality (*DUAL*) is an indicator variable equal to one if the CEO and chairman of the board are the same person, zero otherwise. Ownership concentration (*TOP1*) is defined as the ratio of the largest shareholder's shares. In addition, to exclude the effect of government ownership on firms' environmental practices, ownership type (*SOE*), a dummy variable set to one if the company is state-owned is also controlled in the regression model. We also include industry dummies to remove the industry effect and include year dummies to control for the time effect. Table 1 presents the definitions and measures of the main variables.

Variable	Measurements
EPI1	Natural logarithm of 1 plus the firm's environmental investment in year *t*
EPI2	Environmental investment divided by total assets of year *t*, and multiplied by 100
INS	Taking 1 if the firm purchases D&O insurance in year *t* 0 otherwise
SIZE	Natural logarithm of total assets in year *t*
LEV	The ratio of total debt to total assets in year *t*
ROA	Net profit divided by total assets in year *t*
GROW	The annual change of sales revenue divided by the lagged sales
CASH	The balance of monetary assets divided by total assets at the year end
OCF	Net operating cash flow divided by total assets of year *t*
DUAL	A dummy variable that equals one if the CEO and board chairman are the same person, zero otherwise of year *t*
TOP1	The shareholding percentage of the largest shareholder
SOE	Taking 1 if the company is state-owned, zero otherwise
IND	Industry dummy variable
YEAR	Year dummy variable

Table 1.
Variable definitions

4. Empirical analysis

4.1 Descriptive statistics

The descriptive statistics for the main variables in our model are presented in Table 2. The results show that the average and median of *EPI1* are 9.274 and 13.51 respectively, and the difference between the maximum and minimum values is 21.46, suggesting that there are substantial differences in the level of environmental investment among firms. The mean of the full sample for *INS* is 0.072, demonstrating that the proportion of firms purchasing D&O insurance in China is considerably lower than in the United States and Canada.

4.2 Baseline analysis

Table 3 reports the regression results of the ordinary least square (OLS) method. The results show that the coefficient on *INS* is −1.705 and statistically significant at the 1% level, revealing that corporate environmental investment is negatively associated with D&O insurance. The above results provide evidence supporting the conjecture of H1b that firms purchasing D&O insurance invest less in environmental projects. In terms of economic

Variables	N	Mean	Median	SD	Min	Max
EPI1	5,269	9.274	13.51	8.384	0	21.46
EPI2	5,269	0.512	0.018	1.314	0	8.452
INS	5,269	0.072	0	0.259	0	1
SIZE	5,269	22.400	22.220	1.307	19.970	26.250
LEV	5,269	0.432	0.427	0.205	0.059	0.920
ROA	5,269	0.036	0.034	0.060	−0.228	0.193
GROW	5,269	0.156	0.091	0.396	−0.518	2.559
CASH	5,269	0.121	0.093	0.097	0.007	0.493
OCF	5,269	0.057	0.055	0.064	−0.122	0.232
DUAL	5,269	0.240	0	0.427	0	1
TOP1	5,269	0.351	0.331	0.146	0.098	0.755
SOE	5,269	0.391	0	0.488	0	1

Table 2.
Descriptive statistics

Variable	*EPI1*
INS	−1.705***
	(0.455)
SIZE	1.399***
	(0.111)
LEV	1.936***
	(0.721)
ROA	−6.758***
	(2.268)
GROW	0.327
	(0.284)
CASH	−9.069***
	(1.206)
OCF	11.310***
	(1.843)
DUAL	−0.278
	(0.258)
TOP1	−0.438
	(0.814)
SOE	2.407***
	(0.264)
Constant	−21.848***
	(2.384)
YEAR	Yes
IND	Yes
Observations	5,269
Adjusted R^2	0.158

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

Table 3. D&O insurance and environmental investment

significance, the coefficient estimate implies that the level of environmental investment in D&O insurance insured firms is lower. For perspective, given the mean level of corporate environmental investment (*EPI1*) in a given firm is 9.274, this magnitude is about 18% relative to the mean. In short, the negative relation between corporate environmental investment and D&O insurance is economically material as well.

4.3 Robustness test

We perform the following tests to validate the robustness of the baseline results.

4.3.1 Alternative measure of environmental investment. First, we replace *EPI1* in Eq. (1) with *EPI2*, an alternative measure of the dependent variable to examine the association between D&O insurance and environmental investment. The results in Column (1) of Table 4 show that D&O insurance still exhibits a significant negative effect on environmental investment (the coefficient is −0.192 and statistically significantly different from zero at the 1% level), identical to the results of baseline analysis.

Second, to address the endogenous concern that a lower environmental investment results in a firm's incentive to purchase D&O insurance, following Hwang and Kim (2018), we empirically test the effect of D&O insurance on the lead measure of corporate environmental investment (*FEPI1*). In Column (2) of Table 4, we continue to find a negative and highly statistically significant coefficient on *INS*, consistent with the prediction of H1b.

4.3.2 Propensity score matching. Third, the number of listed firms purchasing D&O insurance is very small in China, and firms' decisions on whether subscribe to D&O insurance

Variable	(1) *EPI2*	(2) *FEPI1*
INS	−0.192***	−1.749***
	(0.065)	(0.508)
SIZE	0.029	1.370***
	(0.018)	(0.123)
LEV	0.382***	1.255
	(0.114)	(0.791)
ROA	0.094	−5.482**
	(0.291)	(2.624)
GROW	0.051	0.385
	(0.047)	(0.303)
CASH	−0.731***	−9.996***
	(0.164)	(1.298)
OCF	1.193***	8.962***
	(0.281)	(2.072)
DUAL	−0.029	−0.140
	(0.039)	(0.287)
TOP1	0.323**	−0.325
	(0.143)	(0.889)
SOE	0.117***	2.183***
	(0.044)	(0.292)
Constant	−0.579	−20.844***
	(0.378)	(2.638)
YEAR	Yes	Yes
IND	Yes	Yes
Observations	5,269	4,412
Adjusted R^2	0.060	0.143

Table 4.
Alternative measure of the dependent variable

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

are not random and may be endogenously determined by existing regression equation covariates, which may hinder the estimate of a causal effect due to biased and inconsistent regression coefficients. Following prior literature (Dehejia and Wahba, 2002; Bermiss and Greenbaum, 2016), this paper applies a propensity score matching (PSM) approach to alleviate the potential endogenous problem caused by potential self-selection bias. We select the control variables of model (1) as covariates to conduct 1:3 nearest-neighbor matching procedure between the treatment group (i.e. *INS* = 1) and the control group (i.e. *INS* = 0). We re-estimate Eq. (1) based on the propensity score-matched samples. The results in Table 5 show the coefficient of D&O insurance is significantly negative, which is consistent with the baseline result.

4.3.3 Heckman two-step method. In addition, firms with certain characteristics may be likely to purchase D&O insurance and simultaneously be inclined to invest less in environmental protection. Following the related literature (Hwang and Kim, 2018), we adopt Heckman two-step estimation procedures to cope with this endogenous problem. In the first step, we build a probit model to estimate the likelihood of a firm's D&Os being covered by the D&O insurance with *INS* as the dependent variable. We include *INS_mean* (the mean incidence of D&O insurance purchase for firms in the same industry in the same year, excluding the firm concerned) as an additional determinant of D&O insurance purchase (Yuan *et al.*, 2016). Because *INS_mean* is likely to be an important factor for a firm when deciding whether to purchase D&O insurance, but less likely to be closely correlated with corporate environmental investment, it satisfies the

Variable	*EPI1*
INS	−0.986**
	(0.499)
SIZE	1.191***
	(0.196)
LEV	1.791
	(1.542)
ROA	−7.286
	(5.224)
GROW	0.455
	(0.605)
CASH	−4.942*
	(2.910)
OCF	7.455*
	(4.188)
DUAL	0.896
	(0.612)
TOP1	−5.351***
	(1.786)
SOE	2.671***
	(0.590)
Constant	−15.935***
	(4.372)
YEAR	Yes
IND	Yes
Observations	1,153
Adjusted R^2	0.169

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

Table 5. Propensity score matching method

exogenous and relative attributes of Heckman's estimator. The inverse mills ratio obtained from the first step is then included in the second-step model to alleviate potential endogeneity. The specification of the second-step model is the same as Eq. (1) described in Section 3.2.

The results of the first-step regression in Table 6 show that *INS_mean* has a significant and positive impact on a firm's decision to purchase D&O insurance. The results of the second-step regressions show that the coefficient of the variable D&O remains significantly negative. The coefficient of the inverse Mills ratio is significant and negative, suggesting that the unobserved factors that motivate firms to purchase D&O insurance are negatively related to environmental investment.

5. Further analysis

5.1 Environmental pressure, D&O insurance and environmental investment

Enterprises are the main producers of pollution (Shi *et al.*, 2019; Li *et al.*, 2020). With the deepening promotion of ecological civilization, the government strengthens environmental regulation and elevates environmental priorities (Wang, 2013). Meantime, with the enhancement of public awareness of environmental protection, enterprises are urged to respond to stakeholders' expectations on environmental protection more actively (Kassinis and Vafeas, 2006). It's no doubt that environmental pressure exerts an important effect on corporate environmental investment. This paper finds that D&O insurance provides protection for managerial opportunism in

Variable	(1) *INS*	(2) *EPI1*
INS_mean	8.900***	
	(2.403)	
INS		−1.709***
		(0.455)
IMR		−0.727
		(1.114)
SIZE	0.349***	1.166***
	(0.036)	(0.349)
LEV	−0.279	2.202***
	(0.239)	(0.773)
ROA	−1.031	−5.999**
	(0.736)	(2.564)
GROW	0.060	0.260
	(0.084)	(0.296)
CASH	0.115	−9.115***
	(0.345)	(1.215)
OCF	0.774	10.707***
	(0.577)	(2.028)
DUAL	−0.093	−0.263
	(0.078)	(0.277)
TOP1	−0.171	0.064
	(0.199)	(0.842)
SOE	0.278***	2.231***
	(0.068)	(0.374)
Constant	−10.679***	−15.359
	(0.853)	(9.922)
YEAR	Yes	Yes
IND	Yes	Yes
Observations	5,202	5,202
Pseudo/Adjusted R^2	0.142	0.155

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

Table 6.
Heckman two-step method

environmental governance. According to this rationale, we predict that the negative association between D&O insurance and environmental investment shall be more pronounced in firms confronting greater environmental governance pressure.

Extant research finds that exposure to fine particulate matter (PM2.5) has negative effects on health and mood, and this health risk perception increases people's demand for better environmental quality and pollution reduction (Power *et al.*, 2015; Tu *et al.*, 2020). So we use the value of PM2.5 at the provincial level as the proxy for environmental pressure. We separate the sample into subsamples of high environmental pressure group and low environmental pressure group based on the median of PM2.5, then re-estimate the impact of D&O insurance on environmental investment. Table 7 reports the results. In the group with a high degree of environmental pressure, the coefficient of *INS* is negatively significant, while the coefficient in the group with a low degree of environmental pressure isn't significant. And the difference between the two coefficients is significant ($p < 0.01$), which is consistent with the view that the sheltering effect of D&O insurance on corporate negative environmental policy is pronounced in firms under greater environmental pressure.

Variables	*EPI1* (1) High	(2) Low
INS	−3.135***	−0.502
	(0.749)	(0.560)
SIZE	1.369***	1.529***
	(0.160)	(0.163)
LEV	2.080**	1.562
	(1.031)	(1.031)
ROA	−4.687	−9.390***
	(3.385)	(3.109)
GROW	−0.027	0.747**
	(0.413)	(0.374)
CASH	−11.823***	−6.250***
	(1.779)	(1.660)
OCF	14.237***	8.892***
	(2.719)	(2.517)
DUAL	−0.309	−0.322
	(0.379)	(0.356)
TOP1	1.196	−1.099
	(1.224)	(1.090)
SOE	1.971***	2.748***
	(0.365)	(0.387)
Constant	−22.521***	−23.485***
	(3.460)	(3.425)
YEAR	YES	YES
IND	YES	YES
Observations	2,552	2,717
Adjusted R^2	0.164	0.159
T-test of difference in Coef	0.0046***	

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

Table 7. The effect of environmental pressure

5.2 Capital market monitoring, D&O insurance and environmental investment

With the deterioration of the ecological environment, the capital market participants have attached more attention to corporate environmental responsibility. Prior literature finds that investors consider firms' environmental performance when deciding their investing strategies and firms investing more in environmental projects are more attractive to long-term institutional investors (Li and Lu, 2016). Additionally, financial analysts also take firms' corporate environmental performance into account when they assess firms' earnings-related disclosures (Hsu *et al.*, 2019). In order to increase external legitimacy in environmental protection, firms facing strong supervision of the capital market have strong motivation to make proactive environmental investments to send a positive signal of managerial ethics and integrity and reduce future risks. The aforementioned analysis finds a negative association between D&O insurance and environmental investment. Intuitively, for firms with stronger capital monitoring, the sheltering effect of D&O insurance on managerial opportunism to reduce environmental investment would be highlighted.

Analysts, one important type of stakeholder who transfers firms' information to investors, media and regulators via their information production and interpretation activities, can directly or indirectly monitor firms' business activities and managers' behavior (Miller, 2006). So we use analysts' coverage to proxy the degree of capital market supervision. We split the

sample into two groups according to the sample median of analyst coverage. Table 8 shows that in the subsample of firms with stronger market monitoring, D&O insurance and environmental investment are negatively correlated at the level of 1%, while in the group with low analyst coverage, the coefficient is not significant. The results imply that D&O insurance has little effect on environmental investment for firms under weak external monitoring, but the sheltering effect of D&O insurance on negative environmental investment decision is salient in firms with strong capital market monitoring, supporting our prediction.

5.3 Legal environment, D&O insurance and environmental investment

In the past decades, with the growing emphasis on environmental protection, the government in China has constructed an expansive environmental law framework to address environmental problems (Wang, 2013). However, the implementation of laws and regulations in practice has substantial differences in various regions (Yuan *et al.*, 2016). In regions where the legal environment is notoriously weak, the probability of listed firms' D&Os being sued due to reduced vigilance or diligence is relatively low. Likely, firms located in a weak legal environment will not take positive actions to invest in environmental projects. However, firms domiciled in regions with rich law environment are more likely to involve in lawsuits against their wrongful behavior in environmental

	EPI1	
Variables	(1) Strong	(2) Weak
INS	−2.299***	0.058
	(0.622)	(0.666)
SIZE	1.023***	1.812***
	(0.196)	(0.159)
LEV	4.256***	0.380
	(1.315)	(0.872)
ROA	−10.939**	−5.128*
	(4.698)	(2.697)
GROW	0.269	0.174
	(0.506)	(0.345)
CASH	−8.276***	−10.182***
	(1.822)	(1.609)
OCF	13.771***	10.676***
	(3.013)	(2.394)
DUAL	−0.239	−0.195
	(0.394)	(0.343)
TOP1	−2.078*	1.507
	(1.237)	(1.075)
SOE	2.742***	2.223***
	(0.423)	(0.345)
Constant	−14.302***	−29.519***
	(4.221)	(3.371)
YEAR	YES	YES
IND	YES	YES
Observations	2,477	2,792
Adjusted R^2	0.153	0.168
T-test of difference in Coef	0.0093***	

Table 8.
The effect of capital market monitoring

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

protection, so they may have to keep a high level of environmental investment to seek external legitimacy (Hirshleifer and Thakor, 1992). The firms' purpose of purchasing D&O liability insurance is to protect D&Os by covering expenses and damages when the firm is sued (Chen *et al.*, 2016). The coverage of D&O insurance decreases the perceived litigation risk of D&Os. We speculate that the protective effect of D&O insurance is more prominent in regions with a rich legal environment, in other words, the negative association between D&O insurance and corporate environmental investment will be stronger.

The full sample is divided into two subsets: the rich legal environment group with the law index above the median and the poor legal environment group with the index below the median (Fan *et al.*, 2011). We carry out regression on the subsamples separately. Table 9 demonstrates that the coefficient of *INS* in Column (1) is −1.415 and significantly negative at the 1% level, but the coefficient is not significant in Column (2). The results indicate that D&O insurance limits the deterrent effect of legal risks on firms and provides sufficient protection for D&Os' opportunistic behavior in environmental investment in regions with rich legal environment, while in regions with weak legal environment, the sheltering effect of D&O insurance is not significant, providing evidence for our conjecture.

	EPI1	
Variables	(1) Rich	(2) Poor
INS	−1.415***	0.585
	(0.509)	(1.100)
SIZE	1.291***	1.879***
	(0.134)	(0.201)
LEV	2.318***	−2.814**
	(0.862)	(1.368)
ROA	−4.542	−12.529***
	(2.803)	(3.925)
GROW	0.450	0.158
	(0.371)	(0.452)
CASH	−7.692***	−14.911***
	(1.427)	(2.285)
OCF	12.031***	9.992***
	(2.277)	(3.142)
DUAL	−0.092	−0.434
	(0.300)	(0.517)
TOP1	−2.227**	3.340**
	(1.016)	(1.395)
SOE	1.892***	3.207***
	(0.330)	(0.459)
Constant	−20.133***	−30.674***
	(2.937)	(4.252)
YEAR	YES	YES
IND	YES	YES
Observations	3,719	1,550
Adjusted R^2	0.116	0.254
T-test of difference in Coef	0.0961*	

Note(s): Robust standard errors are presented in parentheses; *, **, and *** indicate $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively

Table 9.
The effect of legal environment

6. Conclusions

D&O insurance is the product of the separation of ownership and management in modern enterprises, and purchasing D&O insurance is prevalent in developed capital markets. The essential idea and purpose of implementing D&O insurance are to encourage officers and directors to diligently fulfill their duties and improve the firm value. However, previous literature is controversial on this issue. With the greater litigation exposure D&Os face in the transitional and emerging market, D&O insurance has significant development potential in China. Meanwhile, with the deepening promotion of green sustainable development in China, listed firms are confronted with great pressure in environmental investment to meet stakeholders' expectations. Against this backdrop, this paper employs the data of A-share listed firms in the most polluting industries from 2013 to 2019 to explore the impact of D&O insurance on corporate environmental investment. The study shows that D&O insurance insured firms invest less in environmental projects, indicating that D&O insurance induces unintended moral hazards by shielding the insured firms from undertaking environmental responsibility. The above result maintains after a series of robustness tests. Further analysis shows that the relationship between D&O insurance and environmental investment is more pronounced in firms facing higher environmental governance pressure, stronger market supervision and located in regions with a richer legal environment.

This paper has several theoretical and policy implications. We find that firms purchasing D&O insurance make less environmental investment, providing new evidence for research on the negative effects of D&O insurance, and enriching literature on the determinants of corporate environmental practices. This study helps to deepen people's understanding of D&O insurance, but also gives insight into the phenomenon that the government plays a dominant role in environmental investments, while the level of corporate environmental investments is relatively low in China, which has an important policy implication for supporting firms' disclosure of D&O insurance and active engagement in environmental protection. And the government can optimize environmental regulations to encourage firms to take the initiative in environmental governance.

Some limitations of our research could be addressed in future studies. First, several external validity threats with which this single-country research confronted may limit the generalizability of the findings to other countries. However, some characteristics in China are also prevalent in other emerging economies. Second, firms can engage in various corporate social responsibility activities, but we only focus on corporate environmental investment, one small dimension of corporate social responsibility. It's still unexplored whether D&O insurance affects firms' decision-making in other CSR policies. Third, we find that the insured firms decrease environmental investment, but we do not identify whether the reduced environmental investment is related to alleviating environmental concerns and protecting the interests of shareholders, or the reduced environmental investment is the part that is beneficial to the public but not beneficial to shareholders.

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Appendix

Industry	N	%	Cum
Chemical raw materials and products manufacturing	1,238	23.5	23.5
Chemical fiber manufacturing	132	2.51	26
Biomedicine	992	18.83	44.83
Non-ferrous metal smelting and processing	391	7.42	52.25
Non-ferrous metal mining	167	3.17	55.42
Coal mining	185	3.51	58.93
Water–electricity–gas	429	8.14	67.07
Leather, fur and feather	49	0.93	68
Petroleum processing and coking	94	1.78	69.79
Fossil oil and gas mining	33	0.63	70.41
Textiles	294	5.58	75.99
Pulp–paper–printing	175	3.32	79.31
Metal products	338	6.41	85.73
Non-metal mineral products	538	10.21	95.94
Ferrous metal smelting and processing	181	3.44	99.37
Ferrous metal mining	33	0.63	100

Table A1. Industrial distribution of the sample

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