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Do state subsidies increase corporate environmental spending?

Yang Wang, Yifei Zhang

Abstract

This study investigates the impact of state subsidies on corporate environmental spending of Chinese listed firms between 2011 and 2018, using a hand-collected data from corporate annual and environmental responsibility reports. We find a positive relationship between state subsidies and corporate environment spending, indicating firms receiving government subsidies are more likely to behave more environmentally responsible. In addition, the positive relationships are more pronounced among the non-state-owned enterprises (non-SOEs) and the firms experiencing financial constraints. It is because, non-SOEs are more likely to lose government support comparing to their SOE peers, thus making more efforts to address corporate pollution. Moreover, firms subject to financial difficulties tend to build an environmental responsible image and to contribute more in environment protection.

Keywords State subsidies, Environmental spending, State-owned enterprises, Financial constraints

JEL classification: G18, G32, G38, H23, P26

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1. Introduction

State subsidy is a common and important instrument to realize the government's economic and social goals. A statistic from the World Bank shows that there is a steadily upward trend of the state subsidies worldwide in the last decade, and state subsidies account for more than 40% of government expenditures on average (Luo *et al*., 2019). Compared to other emerging economies, state subsidies are more pervasive in China (Lee *et al*., 2017). A recent report indicates that 97.76% listed firms were granted state subsidies in 2018, with a total amount of nearly 152.74 billion yuan (about 22.03 billion USD) (Zhang & Liang, 2019). State subsidies are a form of policy tool for the government to direct financial resources to the firms or sectors that it supports. Previous studies have examined the relationship between the impact of state subsidies on market value (Lee *et al*., 2014), investment efficiency (Hu *et al*., 2019), stock market refinancing (Huang, 2019), and financial reporting quality (He, 2016). However, as far as we are aware, there is no formal study that specifically examines how state subsidies affect a firm's environmental spending. China is facing the dual environmental pressures, including both energy shortages and environmental pollution. The mode of economic growth accompanying by high energy consumption and high pollution is unsustainable (Bai *et al*., 2018). Subsequently, it is relevant to examine whether the allocation of government subsidies can make Chinese listed firms increase their environmental investment to introduce a long-term sustainable growth model. Using a unique hand-collected dataset of Chinese listed firms' environmental spending data from 2011 to 2018, our study examines the impact of state subsidies on firms' corporate environmental spending.

Our study focuses on the impact of state subsidies on corporate environmental spending for the following reasons. State subsidies are important external resources for firms' survival and growth. State subsidies are crucial fiscal tools to reallocate resources, which facilitate the development of economy and social welfare (Frye & Shleifer, 1997).

In addition, they have been found to significantly affect financial performance and social responsibility of listed firms (Luo *et al*., 2019). For instance, government subsidies are more likely to be allocated to firms that pay more tax and offer more public goods (Tang & Luo, 2007). Corporate environmental spending is demonstrably a crucial dimension of corporate social responsibility (CSR).

Environmental pollution, such as landscape destruction, groundwater contamination, carbon emissions, and industrial waste, has become a great concern to the society worldwide, which threatens employee health and safety and disrupts local communities (Peng *et al*., 2020). Given these outstanding environmental problems, listed firms are standing at the forefront of addressing environmental protection issues, in order to make their activities fit into a sustainable framework. Consequently, the government is increasingly encouraging and intervening listed firms to perform corporate environmental responsibilities in recent years (Kao *et al*., 2018). One of the major objectives of government intervention through subsidies is to increase corporate performance. However, whether the provision of state subsidies can encourage corporate environmental performance remains an open question, as the corporate commitment to CSR remains relatively weak in Chinese listed firms (Wu, 2015). Moreover, most Chinese listed firms have a highly concentrated ownership structure, with a single shareholder having effective control. Many of these controlling shareholders are state or state agencies (Wang *et al*., 2019). In addition, the empirical literature is still silent on financially constrained firms and their CSR engagement (Shahab *et al.*, 2019). Subsequently, it is vital to assess how state subsidies affect corporate environmental spending and their heterogeneous impacts in the firms with different ownership structure and financial condition.

Corporate environmental performance has been previously examined in the western context, but mainly on its relationship with corporate innovation or firm financial performance. For instance, using a sample of UK manufacturing firms, Ramanathan (2018) finds that when firms improve their environmental performance, a higher level of financial performance can be achieved. Alam *et al*. (2019) examine the impact of

research and development (R&D) expenditures on corporate environmental performance for the period 2004–2016 from G-6 countries (i.e., Canada, France, Germany, Japan, the UK, and the US), and find that R&D investment improves the firm's environmental performance measured by energy and carbon emissions intensities. However, the impact of state subsidies on corporate environmental spending receives little attention, mainly because the scale of state subsidies is not large in the developed economies and the differences within corporate ownership structure between Chinese and western listed firms (Luo *et al.*, 2019). In addition, state subsidies are applied by governments worldwide to overcome market imperfections, but the decisions to offer subsidies in China can be driven significantly by political motivations (Lee *et al*., 2017). Moreover, as firm environmental spending is a voluntary disclosure item in China, only about 24% of Chinese listed firms have disclosed their environmental responsibility report by 2017 (Yang, 2019). From this perspective, our research findings not only reveal the influence of state subsidies on environmental reporting but also highlight that firms should attach greater importance to the disclosure of their environmental activities to better communicate to stakeholders.

This study makes several contributions to literature. First, our study is among the first to identify a significant determinant of corporate environmental spending: state subsidies. In particular, we find that state subsidies are beneficial to firms by increasing environmental spending. These findings have implications to other emerging economies like China, where listed firms tend to prioritize profits over environmental responsibility. This is because one would expect that direct regulatory interventions are necessary to encourage firms spending more environmental related expenditures. Second, our study extends Lee *et al.* (2017) and Kao *et al.* (2018)'s research by revealing that the positive impact of state subsidies on environmental expenditures are more pronounced among firms that the state does not control (i.e., non-state-owned firms) or those subject to financial constraints. For firms with stronger government connections, they may perceive themselves as less likely to lose state support. Consequently, they are less likely to increase environmental spending. In addition,

firms with financial constraints tend to increase their environmental spending for the purpose of building good environmental responsible image, so as to in exchange for more subsidies. Third, we further report that the positive impact of state subsidies on environmental spending is more pronounced in central state-owned enterprises (SOEs) comparing to local SOEs, as they subject to more scrutiny and tend to actively assume corporate environmental responsibilities. Fourth, our study complements the stream of state subsidies literature by addressing the impact of green subsidies i.e. environmental relevant subsidies on corporate environmental spending. This enables policy setters to assess whether the provision of this specific type of subsidies can make firms actively assume their corporate environmental responsibilities.

This paper is structured as follows. Section 2 reviews the literature and proposes hypotheses. Section 3 describes data and variables, and presents our main model specifications. Section 4 presents the empirical results and the discussions, and Section 5 concludes the paper.

2. Literature Review

2.1 Institutional background

State subsidies

State subsidies shape resource allocation decisions, income distribution, expenditure productivity and sectoral adjustment (Schwartz & Clements, 1999). The primary objective of state subsidies is to develop national priority areas such as agriculture, public utilities and high-tech sectors. It serves as the government's visible hand, in order to relax firms from their capital constraints (Lee *et al.*, 2014; Lee *et al.*, 2017). From an economic perspective, several reasons can be provided to explain why government prefers to use subsidies as a policy instrument. First, subsidies are used to address market imperfections, as capital markets might not be sufficient to allocate resources in

the most efficient manner. Second, subsidies can be used to obtain the economies of scale in productions. This is because firms in some important industries could be small in domestic markets, and cannot compete with large competitors in the global market. Third, subsidies can be used to achieve social policy objectives such as lowering unemployment rate and narrowing income gaps (Lim *et al.*, 2018). In summary, state subsidies help business sectors to promote the growth of economy, to offset market imperfections, to develop economies of scale and to meet social policy objectives.

Environmental responsibility

China has experienced remarkable economic growth during last two decades, but this growth comes with high environmental costs. Chinese government has been actively involved in addressing severe pollution problems and encouraging firms to engage in 'green' practices. For instance, both Shanghai and Shenzhen Stock Exchanges launched guidelines to encourage firms to disclose environmental activities in their annual reports. In addition, the Ministry of Environmental Protection and the China Securities Regulatory Commission launched the 'green securities' policy, which imposed extra constraints (i.e. environmental evaluation) on firms from high-polluting sectors when they apply the initial public offering (Farag *et al*., 2015). In fact, such environmental movement is a global phenomenon and multinational companies nowadays take environmental standards into consideration when selecting their suppliers (Li *et al.*, 2013). The 'green' concept was brought to Chinese listed firms in the last decade mainly through two channels. First, when multinational companies launched branches in China, they tended to adopt the same environmental policies as their headquarters, thus discharged a wider range of environmental accountabilities and influenced their domestic peers to engage in environment protection activities. Second, when Chinese firms operate globally and list on foreign stock exchanges, they have the obligations to meet the social and environmental standards in order to do business with companies in the western world (Kao *et al.*, 2018).

2.2 Theoretical framework

The political economy framework provides the theoretical foundations to explain a firm's environmental related decisions. It implies that firms operate within a social, political and economic framework and they are affected by the society where they operate. In other words, firms need to engage in environmental responsible activities and voluntarily disclose environmental related information in order to respond to the anticipations from the society. The political economy framework mainly includes the stakeholder theory and the legitimacy theory. The stakeholder theory mainly emphasizes the reasons behind corporate environmental information on the basis of stakeholders' information demand, while the legitimacy theory explains the incentives that drive corporate environmental spending based on firms' maintaining their legitimacies within the society (Nurhayati *et al.*, 2016).

The stakeholder theory focuses on firms responding to the stakeholders' demands for the sake of gaining competitive advantages (Roy & Goll, 2014). The maximization of shareholders' profits can no longer be the only objective of firms; rather, shareholders' needs should be obtained in coexistence with the interests of other stakeholders. Consequently, firms need to participate in socially and environmentally sustainable activities in order to meet stakeholders' demands. The stakeholder theory also views corporate environmental sustainability disclosure as a good instrument to openly communicate with stakeholders. To illustrate, corporate environmental activists may concern about the risks of polluting environment and the contributions that firms make to sustainable development (Gallego-Álvarez & Ortas, 2017).

The legitimacy theory is defined as a condition that exists when a firm's norms and values are congruent with the norms, values and beliefs of the larger social system where the firm is in part of. In other words, the legitimacy theory implies that the survival and success of firms depend on the extent of their operations within the bounds and norms of the society (Hooghiemstra, 2000). Firms can gain support from stakeholders and continue to exist as far as their activities provide benefits to the society.

That is, firms need to make sure that their activities are perceived by outside parties such as environmental groups as being 'legitimate' (Muttakin & Khan, 2014). There are two types of legitimacies, including the pragmatic and the social legitimacy. The pragmatic legitimacy can be achieved by firms if they can provide products with appropriate prices and qualities, in order to satisfy their customers' needs. However, to obtain a long-term support from stakeholders, firms need to gain social legitimacy through actively engaging in socially and environmentally responsible activities, as it is consistent with the social norms of communities (Handelman & Arnold, 1999). In the case that disparity exists between corporate and social values on environment protections, firms' legitimacy will be jeopardized and a legitimacy gap will appear. Therefore, firms should be able to recognize the legitimacy gaps in time, and carry out environmental practices such as increasing corporate environmental spending to mitigate legitimacy threats and discharge their accountabilities to stakeholders (Muttakin & Khan, 2014, Sun *et al.*, 2019).

2.3 Prior empirical findings: CSR activities

Similar to other corporate disclosure channels, CSR reporting enables a firm to communicate with its stakeholders. CSR disclosure is important as it can reduce information asymmetry between managers and shareholders, thus it can be used to legitimize a firm's activities for its stakeholders. In addition, CSR disclosure improves monitoring against self-interested managers, thus agency conflicts can be mitigated (Lee *et al*., 2017). Existing studies have provided mixed evidence regarding the determinants and consequences of CSR disclosure. For instance, greater CSR disclosure attracts more external investors and reduces firms' cost of equity capital (Dhaliwal *et al*., 2011). Moreover, socially responsible firms that focus on improving employees' welfare can better retain talented employees, resulting in greater productivity and better financial performance (Banker & Mashruwala, 2007). In terms of the determinants of CSR disclosure, previous empirical findings have suggested that larger firms are more likely to provide more CSR disclosures (Naser *et al*., 2006); firms

in the industries that face less stakeholder pressure of CSR performance tend to show a lesser degree of CSR disclosure activism (Reverte, 2009); firms with female occupying top management positions and a higher level of foreign ownership tend to have greater CSR performance (McGuinness *et al*., 2017).

So far, there are very few studies that examine the implications of state subsidies on corporate disclosure or CSR disclosure. Lee *et al.* (2014) find that state subsidies are value relevant, indicating that the information about state subsidies contributes to valuation decisions made by investors. In contrast, Raghunandan (2018) finds that firms receiving subsidies in the form of tax break are more likely to engage in fraud than the non-recipient firms, subsequently the corporate information disclosure quality is decreased. Makni *et al*. (2009) use a sample of 179 publicly held Canadian firms and suggest that as CSR activity is costly, state subsidies are required to neutralize its adverse effects. Moreover, Lee *et al.* (2017) provide evidence that state subsidies have a significant impact on CSR disclosure. This effect is more pronounced among private firms, especially when subsidies are granted through non-tax based rather than tax-based channels in China.

2.4 Hypothesis development

For Chinese listed companies, managing political costs are important for their survivals. This is because both central and local governments have the power to influence corporate wealth redistributions through regulations, taxations, quotas and permissions (Milne, 2002). Listed firms that are granted government subsidies tend to be more likely to engage in desirable behaviors in order to reduce the impact of adverse actions on politicians (Deng *et al.*, 2019). State subsidies, as an easy access to capital, are subject to fiscal budgeting. State subsidies are not provided to each firm. Firms are driven to cater government and behave more socially and environmentally responsible, in order to improve their social image (Zhao *et al.*, 2019). Given the increasing concerns about environmental issues in China recent years, more environmental investment allows

firms to show stakeholders that they are actively addressing environment issues. In addition, firms receiving state subsidies are propped up by the funding from taxpayers and the government, thus are expected to take more considerations to address relevant political costs (Lee *et al.*, 2017). Therefore, we posit our first hypothesis as follows:

H_1: There is a positive relationship between state subsidies and corporate environment spending.

The impact of government subsidies on firms' environment spending is expected to be different between SOEs and non-SOEs. On the one hand, firms with a higher proportion of state ownership are more likely to engage in socially responsible activities as it is necessary for SOEs to act as a role model for their counterparts. That is, SOEs are considered to have stronger signaling effects on other firms. SOEs receive more media attention and have the responsibility to perform for the good of society. Subsequently, they face more normative pressures that would lead them to greater participation in environmental protection activities (Lau *et al.*, 2016). A high level of state ownership also creates incentives for management in SOEs to pursue more non-financial objectives, such as the resolution of regional environmental challenges (Li & Zhang, 2010). In addition, many large SOEs are in environmentally sensitive sectors, for instance, the petrochemical sector. Practically, they have to do more in order to protect the environment (Lau *et al.*, 2016).

On the other hand, comparing to non-SOEs, SOEs enjoy greater financial resources provided by the government. For instance, SOEs have easier and preferential access to make equity offerings (Gordon & Li, 2003) and bank loans (Wang *et al.*, 2019). Thus, SOEs might not concern firms' long-run survival and have fewer incentives to increase environmental spending for attracting state subsidies. For non-SOEs, political capital reflected through subsidies is more valuable to them, as non-SOEs are less likely to receive government supports like their SOE counterparts. Consequently, non-SOEs make more efforts to build an environmentally responsible image. Second, non-SOEs

are more likely to be market-oriented and try to maximize firm values, thus they have strong incentives to improve firms' reputations and build a good relationship with stakeholders via more environmental investment (Kao *et al.*, 2018). In addition, non-SOEs are motivated to use corporate environmental responsibility for effective corporate governance in resolving conflicts between managers and non-investing stakeholders (e.g., customers, environmental activists). For SOEs, they have to shoulder policy burdens, such as increasing employment rate and wages, promoting regional development, and ensuring national security (Wang *et al.*, 2019). Therefore, shareholder interests' maximization might not be their primary goal. Consequently, SOEs are less likely to enhance reputations as environmentally responsible citizenship through engaging in environmental protection activities. Therefore, we present these two competing hypotheses as follows:

H_2(a): The positive relationship between state subsidies and corporate environment spending is more pronounced in non-SOEs.

H_2(b): The positive relationship between state subsidies and corporate environment spending is more pronounced in SOEs.

Financial constraints are referred to those market frictions that can prevent firms from funding their desired investments. Corporate inability to receive funding may result from its credit constraints, inability to borrow funds or issue equity or illiquidity of assets (Lamont *et al*., 2001). Financially constrained firms may be forced to forgo the investments that they would otherwise make. In particular, although the norms of environmental protection have been widely accepted, the participation of such activities are regarded as 'luxury good'. This is because the engagement of environmentally responsible activities will consume a firm's resource that is supposed to be used for the core operation of the business. In addition, environmental protection activities put firms in a position of competitive disadvantages compared to their competitors due to increased costs (Cheng *et al.*, 2014). Subsequently, firms have to divert their resources

away from these activities when they face a higher level of financial constraints (Peng *et al.*, 2020).

Listed firms tend to actively seek for financial assistance when they are in financial constraints, as extra cash flows can alleviate their financial constraints. State subsidies provide companies with a free interest cash flow, which is helpful to overcome their temporary financial constraints (Hu *et al.*, 2019). In particular, state subsidies can increase productivity in companies with financial constraints, thus improving investment efficiencies and injecting extra cash flows. Firms with better environmental performance can attract more investments from stakeholders (e.g., state), thus relieving them from financial constraints (Zhao & Xiao, 2019). For instance, Goss & Roberts (2011) find that listed firms perform greater environmental and social responsibility could achieve lower bank call rates and longer loan terms. As a result, firms with financial constraints tend to increase their environmental spending for the purpose of constructing a good reputation, thereby increasing the chance of obtaining state subsidies and lowering the degree of financial constraints. Therefore, we present these two competing hypotheses as follows:

H_3(a): The positive relationship between state subsidies and corporate environment spending is more pronounced in firms with financial constraints.

H_3(b): The positive relationship between state subsidies and corporate environment spending is more pronounced in firms without financial constraints.

3. Methodology

3.1 Data and variables

Our data of environmental spending (i.e. sewage fees) is hand-collected from the notes of firms' annual reports as well as their corporate environmental responsibility reports. As firms started to disclose their environmental expenditures only in recent years, our

sample starts from year 2011 and ends with the latest available year 2018. In addition, as corporate environmental information is still a voluntary disclosure item, which reduces our initial firm-year sample size from 18,972 to 1,781 observations. The government subsidies and other control variables are from The China Stock Market & Accounting Research (CSMAR) Database. After precluding the missing values from subsidies and all control variables, our final sample shrinks to 1,575 in most regression specifications.

The dependent variable is corporate environmental spending. The composition of corporate environmental spending may differ among companies, but this composition generally includes sewage fees, landscaping fees, water and electricity fees, flood protection fees, cleaner fees, environmental insurance fees, and other fees. In particular, among different types of environmental spending, a firm's sewage fee accounts for 90% of total environmental expenditures on average. Subsequently, following Shen *et al.* (2019), a firm's sewage fee is used to measure corporate environmental spending. The charge of sewage fee has a uniform standard for each type of waste and emission per unit, thus it is suitable to measure the situation of corporate environmental spending.[1] Specifically, the higher sewage fee a firm has been charged, the more money a firm has to spend to address pollution and environment protection.

Our independent variable is lagged state subsidies, which is measured as the natural logarithm of the state subsidies received by a firm in the previous fiscal year. To examine the hypotheses 2 and 3, variables Non-SOEs and SA are introduced. Non-SOEs is a dummy variable that equals to one if the ultimate controller of a listed firm is a private owner and zero otherwise. SA is a dummy variable equals to one if the financial constraint index is above the sample median and zero otherwise. Financial constraint index for each firm-year observation is following Hadlock & Pierce (2010)'s formula: $-0.737 \times \text{Firm Size} + 0.043 \times \text{Firm Size}^2 - 0.04 \times \text{Firm Age}$.

[1] Environmental tax has been applied to replace Sewage charge since 2018. According to the new *"Environmental Protection Tax Law of the People's Republic of China"*, the basic standard of environmental tax for air pollutants is 1.2 RMB per air pollution equivalent (Lu *et al*., 2019).

Several variables are controlled in our model. First, CEO duality is controlled. This is because CEOs who hold the chairmen position tend to prioritize their own interests and less concern about stakeholders' interests, leading to less environmental investment. Board independence is controlled, as outside directors are more likely to pursue the long-term success of firms (Wang & Dewhirst, 1992). Board meeting is a proxy for the board diligence and more environmental policies and strategies are discussed with greater number of board meetings (Giannarakis, 2014). Managerial ownership and Z-index are controlled. Oh *et al.* (2011) find that managerial ownerships have a negative effect on corporate social and environmental disclosures, as managers may collude with controlling shareholders in order to expropriate wealth from other shareholders. Financial variables such as stock returns and Tobin Q are also included, as firms with better financial performance are more likely to be stakeholder orientated and provide more environmental disclosure (Nekhili *et al.*, 2017). Financial leverage is included, which is defined as companies' total liabilities to total assets. For companies with high leverage, managers need to legitimate their actions not only to creditors but also to stakeholders (Haniffa & Cooke, 2005). Lastly, firm age is included. This is because a longer established firm is more concerned about its reputations and thus increasing their environmental spending.

3.2 Model specification

We employ the following fixed-effect model to estimate the impact of government subsidies on firm's environmental spending:

$$Ln(\mathrm{Y_{it}}) = Ln(\mathrm{Subsidy})_{i,t-1} + \boldsymbol{X}_{it} + \alpha_{\mathrm{i}} + \gamma_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \qquad (1)$$

where $Ln(\mathrm{Y_{it}})$ is the natural logarithm of the sewage fees made by firm *i* in year *t*. $Ln(\mathrm{Subsidy})_{i,t-1}$, our main independent variable of interest, is the lagged one year (*t-1*) natural logarithm of total subsidies for firm *i*. $\boldsymbol{X}_{it}$ is a vector of firm *i*'s time-varying control variables and their detailed definitions are presented in Table 1. In addition, we include the industry (α_{i}) and year (γ_{t}) fixed effects in all specifications. The standard

error is clustered at industry level to account for arbitrary serial autocorrelations.

To investigate the heterogeneous effects of government subsidies on enterprises' green spending, we further include an interaction term to our baseline model (1):

$$Ln(\mathrm{Y_{it}}) = \psi_{\mathrm{i,t-1}} \times Ln(\mathrm{Subsidy})_{i,t-1} + \psi_{\mathrm{i,t-1}} + Ln(\mathrm{Subsidy})_{i,t-1} + \boldsymbol{X}_{it} + \alpha_{\mathrm{i}} + \gamma_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (2)$$

where $\psi_{\mathrm{i,t-1}}$ is the firm *i*'s lagged time-varying or time invariant characteristics such as non-state ownerships or financially constrained status. Control variables, fixed effects and cluster standard errors are similarly as (1).

Table 1 Variable definitions.

Variable Type	Variable name	Definition
Dependent variable	Environment spending	Natural logarithm of the firm's sewage fees
Main variables	Subsidy	Natural logarithm of the state subsidies received by a firm
	Non-SOEs	A dummy variable equals to one if the ultimate controller of a listed firm is a private owner rather than state or state agencies and zero otherwise
	SA	A dummy variable equals to one if the financial constraint index is above the sample median and zero otherwise. Following Hadlock and Pierce (2010), financial constraint index for each firm-year observation is calculated as $-0.737 \times \mathrm{SIZE} + 0.043 \times \mathrm{SIZE}^2 - 0.04 \times \mathrm{AGE}$, where SIZE stands for natural logarithm of a firm's total assets, and AGE stands for firm age.
Control variables	Duality	A dummy variable equals to one if a CEO also serve as the chairman and zero otherwise
	Independence	The proportion of independent directors in the board of directors
	Board meeting	The number of meetings held by board of directors annually
	Managerial ownership	The proportion of total outstanding shares held by managers
	Z Index	The ratio of the proportion of shareholdings held by the largest shareholders to the proportion of shareholdings held by the second largest shareholder
	Stock returns	Annual firm stock returns
	Tobin Q	The ratio of market value of common equity divided by the book value of total assets
	Firm age	The number of years since the establishment of a firm
	Leverage	The ratio of total liabilities to the company's total assets

Table 2 Panel A: Descriptive statistics.

Variables	N	Mean	SD	Minimum	Maximum
Environment spending	1,575	14.748	1.551	12.024	17.008
Subsidy	1,575	16.291	1.454	13.296	18.157
Non-SOEs	1,575	0.361	0.481	0.000	1.000
SA	1,575	0.641	0.480	0.000	1.000
Duality	1,575	0.170	0.376	0.000	1.000
Independence	1,575	0.369	0.056	0.250	0.750
Board meeting	1,575	9.332	3.581	2.000	40.000
Managerial ownership	1,575	0.049	0.127	0.000	0.696
Z Index	1,575	10.544	9.970	1.246	28.903
Stock returns	1,575	0.054	0.489	-0.658	5.107
Tobin Q	1,575	1.493	1.380	0.113	13.417
Firm age	1,575	17.155	4.872	3.090	35.130
Leverage	1,575	0.522	0.231	0.016	2.992

Table 2 Panel B: Industry classification

Industry	**No.**	**Percent**	**Industry**	**No.**	**Percent**
Agriculture	23	1.46	Machinery, equipment	26	1.65
Mining	122	7.75	Special machinery	31	1.97
Agriculture products processing	20	1.27	Automobile manufacturing	36	2.29
Food	1	0.06	Railways	46	2.92
Wine and beverage	42	2.67	Electrical manufacturing	43	2.73
Textile	47	2.98	Electronics	45	2.86
Apparel	11	0.70	Other manufacturing industries	13	0.83
Leather products	7	0.44	Waste resources recycling	4	0.25
Timber	8	0.51	Power, gas, and water	72	4.57
Paper making	69	4.38	Construction	24	1.52
Printing	1	0.06	Wholesale and retail	23	1.46
Petroleum	38	2.41	Transportation	11	0.70
Chemical materials	280	17.78	IT	5	0.32
Medicine and biological products	101	6.41	Finance	11	0.70
Chemistry	31	1.97	Leasing	3	0.19
Plastics	8	0.51	Tech services	8	0.51
Nonmetal mineral	126	8.00	Irrigation and environment	2	0.13
Ferrous metals	72	4.57	Culture, sports and entertainment	4	0.25
Nonferrous metals	133	8.44	Comprehension	6	0.38
Metal	22	1.40	**Total**	**1575**	**100.00**

4. Empirical Findings

4.1 Descriptive statistics

The descriptive statistics for all the variables are reported in Panel A of Table 2. The average environmental spending for Chinese listed firms is about 2.54 million yuan (about 370,000 USD). 36.1% firms are non-SOEs, indicating that the state still plays a dominant role in Chinese listed firm's ownership structure. In addition, on average, 36.3% board of directors are independent directors and they hold about 9 times board meetings annually. Z index indicates that controlling shareholders dominate the corporate ownership structure, with firms' largest shareholding almost 10.54 times larger than the second largest shareholding. Firms' average leverage is 52.2% and average stock returns are 5.4%. A further Variance Inflation Factor (VIF) test indicates that there is no multicollinearity problem in our models. Panel B of Table 2 shows the industry distribution of firm-year observations.[2] It is reported that firms in the chemical materials, nonferrous metals, nonmetal mineral and mining industries are more likely to disclose their corporate environmental expenditures than firms in other industries.

4.2 Main results

We first present our baseline results in Table 3. The coefficient of lagged government subsidy is positively significant at 1%, showing a strong statistical association between government assistance and corporation's environmental spending. In terms of economic magnitude, it suggests a 0.22 elasticity, after controlling industry, year fixed effects and conventional firm year-varying controls. That is, one percentage increase in the government subsidy, on average, promotes 0.22 percentage in firm's sewage fees. Next, we turn to the discussion of the potential heterogeneous effects of subsidies on firms'

[2] Following Zhang (2018), We use the China Securities Regulatory Commission (CSRC) industry classification guidelines published in 2012. Since most of the observations belong to the manufacturing industry, the code for which begins with "C", therefore, we use first three codes to classify the industries within the manufacturing industry. For other industries, we use the first one code to classify observations.

environmental spending. It is reported that there is a positive relationship between the interaction variable Subsidy*Non-SOEs and environmental spending. This is in line with hypothesis 2(a), indicating non-SOEs make more efforts in building an environmental responsible image and state subsidies play a more pronounced role in promoting non-SOEs' environmental spending. In addition, we also find that the positive relationship between subsidy and environmental spending is more salient in the firms with financial constraints. This is consistent with hypothesis 3(a), implying firms with financial constraints tend to demonstrate their contributions to society's well-beings and increase environmental spending after receiving state subsidies.

Some control variables are also significant in explaining corporate environmental spending. For instance, Table 3 reports negative and significant coefficients on board meetings. The results suggest that more frequent board meetings reduce corporate environmental expenditures. This is in line with Vafeas (1999)'s argument that higher number of board meeting may indicate directors' overstepping their powers, leading to negative environmental spending. Table 3 also shows that stock returns have a positive impact on corporate environmental spending. The results indicate that firms with higher stock returns increase their environmental expenditures to demonstrate their contribution to environment protections and society's well-beings. Moreover, financial leverage is positively related to environmental spending. In other words, highly leveraged firms spend more in the environmental related activities. This is because highly leveraged firms need to assure creditors that shareholders and managers will meet lenders' needs rather than bypassing their covenant claims (Haniffa & Cooke, 2005).

Table 3 Main regressions.

Variables	Model 1	Model 2	Model 3
Subsidy	0.220***	0.177***	0.083***
	(0.031)	(0.029)	(0.019)
Subsidy*Non-SOEs		0.130***	
		(0.023)	
Subsidy*SA			0.098**
			(0.036)
Duality	0.149	0.152	0.223
	(0.143)	(0.140)	(0.150)
Independence	0.167	0.289	0.243
	(0.435)	(0.440)	(0.376)
Board meeting	-0.018***	-0.018***	-0.018**
	(0.005)	(0.006)	(0.006)
Managerial ownership	-0.231	-0.058	-0.085
	(0.454)	(0.445)	(0.386)
Z Index	0.009***	0.009***	0.008***
	(0.003)	(0.003)	(0.002)
Stock returns	0.238***	0.239***	0.170**
	(0.073)	(0.078)	(0.074)
Tobin Q	-0.288***	-0.291***	-0.170***
	(0.014)	(0.014)	(0.017)
Firm age	0.003	0.004	0.016
	(0.019)	(0.019)	(0.017)
Leverage	0.555***	0.543***	0.392***
	(0.102)	(0.102)	(0.067)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	1,575	1,575	1,575
Adjusted R-squared	0.175	0.177	0.218

This table shows the baseline results of the impact of government subsidies on firms' environmental spending and its heterogeneous effects. Variables 'Non-SOEs' and 'SA' are included in the models 2 and 3 respectively. Industry and year fixed effects are included in all specifications. Robust standard errors, clustered at industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

4.3 Robustness tests

Several additional analyses have been done to ensure the robustness of the results. To mitigate any sample selection bias, we re-estimate the models using the environmental responsibility score as the dependent variable. This score is compiled by the Hexun database, which takes into consideration each firm's awareness of environmental protection, certification of environmental management, expenditures on environmental protection, the amount of emission, and energy saving. In total, we have 16,783 observations available. We re-run our H2 and H3 using the Hexun index. Models 1-3 of Table 4 present the results, and they are consistent with our main findings.[3]

Second, in the baseline results, our control variables are all contemporaneous, and one could argue that the effects of controls on firms' environmental spending might not be instantaneous. To show the robustness, we change the original controls to a lagged one-year version. It could be displayed in Models 4-6 of Table 4 that all the statistical significance of the previous results (including the heterogeneous impacts) remain the same, and their magnitudes are quantitatively similar as well. Thus, our conclusions are unaltered to the lagged control variables.

Third, we use two alternative proxies of financial constraints, the KZ index and the WW index, to test the robustness of results. Firms with a higher KZ index,[4] a higher WW index,[5] and a higher SA index are considered to be more financially constrained.

[3] It is important to notice that we intend to use firm environmental spending data in the main result analysis, as the data is hand-collected from the corporate environmental responsibility report and rarely adopted in the previous studies. From this perspective, we extend previous findings such as Cheng & Liu (2018) by observing how one percent change of state subsidies affects the changes of the percent in firm environmental spending.

[4] Following Li (2011), the KZ index is calculated as follows: KZ = −1.001909 ∗ (income before extraordinary items + depreciation and amortization) / property, plant, and equipment + 0.2826389 ∗ Tobin's Q + 3.139193 ∗ debt / total capital − 39.3678 ∗ (dividends from common shares + dividends from preferred shares) / property, plant, and equipment − 1.314759 ∗ cash and short-term investments / property, plant, and equipment.

[5] Following Whited & Wu (2006), the WW index is computed using the following formula: WW = −0.091 ∗ CF − 0.062 ∗ DIVPOS + 0.021 ∗ TLTD − 0.044 ∗LNTA + 0.102 ∗ ISG

Models 1-3 of Table 5 present the results, and they are consistent with our previous findings. These results indicate that state subsidies could be helpful for firms to overcome their temporary financial constraints so that they have the incentive to be more environmentally responsible.

Fourth, we scale both the government subsidy (the main independent variable) and the sewage fee (the dependent variable) by the firm size. Columns 4-6 of Table 5 exhibit the empirical result. The results show that our conclusions are robust to scaling.

Fifth, we replace the dependent variable by a dummy variable indicating whether a firm discloses its sewage fee. The three hypotheses are re-estimated using the logit models. The results are presented in Table 6, and our main findings still hold.

$-0.035 * SG$, where CF is the ratio of cash flow to total assets; DIVPOS is an indicator that takes the value of one if the firm pays cash dividends and zero otherwise; TLTD is the ratio of the long-term debt to total assets; LNTA is the natural log of total assets; ISG is the firm's two-digit industry sales growth; and SG is firm sales growth. All variables are deflated by the replacement cost of total assets as the sum of the replacement value of the capital stock plus the rest of the total assets.

Table 4 Robustness tests: alternative dependent and lagged independent variables

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Subsidy	0.646***	0.758***	0.198***	0.233***	0.204***	0.079***
	(0.130)	(0.184)	(0.055)	(0.025)	(0.023)	(0.016)
Subsidy*Non-SOEs		0.235**			0.095***	
		(0.110)			(0.019)	
Subsidy*SA			0.361**			0.125***
			(0.127)			(0.035)
Duality	-0.437***	-0.265	-0.285**	0.114	0.110	0.191*
	(0.118)	(0.164)	(0.116)	(0.092)	(0.086)	(0.095)
Independence	2.605***	2.651***	2.494**	0.756	0.848	0.847
	(0.892)	(0.872)	(0.973)	(0.662)	(0.661)	(0.634)
Board meeting	0.011	0.024**	-0.008	-0.025***	-0.026***	-0.029***
	(0.010)	(0.009)	(0.012)	(0.006)	(0.006)	(0.008)
Managerial ownership	-1.743***	-0.910**	-0.897***	0.103	0.153	0.165
	(0.272)	(0.357)	(0.248)	(0.602)	(0.596)	(0.507)
Z Index	0.004	-0.004	0.001	0.010***	0.009***	0.008***
	(0.006)	(0.007)	(0.006)	(0.003)	(0.003)	(0.003)
Stock returns	-0.388***	-0.309***	-0.285***	0.175**	0.175**	0.073
	(0.068)	(0.072)	(0.056)	(0.063)	(0.061)	(0.074)
Tobin Q	-0.002	-0.001	0.001	-0.244***	-0.244***	-0.123***
	(0.004)	(0.003)	(0.001)	(0.019)	(0.020)	(0.035)
Firm age	0.004	-0.004	0.020	-0.001	0.001	0.013
	(0.022)	(0.018)	(0.020)	(0.022)	(0.023)	(0.020)
Leverage	-0.011	-0.259	-0.122	0.693***	0.698***	0.491***
	(0.054)	(0.265)	(0.082)	(0.186)	(0.187)	(0.131)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,783	16,783	16,783	1,542	1,542	1,542
Adjusted R-squared	0.138	0.141	0.158	0.171	0.171	0.218

Variables' Non-SOEs' is controlled in the models 2 and 5, and 'SA' is controlled in the models 4 and 6, respectively. In Model 1-3, the dependent variable is replaced by the environmental responsibility score, and it is obtained from the He Xun database. Specifically, He Xun evaluates a firm's overall environmental responsibility performance based on the following criteria: (i) the awareness of environmental protection, with a valuation score ranging from 0 to 2; (ii) the certification of environmental management, with a valuation score ranging from 0 to 3; (iii) the expenditures on environmental protection; (iv) the number of different types of emission treated; and (v) the number of different types of energy-saving. Each of the last three items has a valuation score ranging from 0 to 5. The overall environmental responsibility score is the sum of the individual component scores, ranging from 1 to 30. In Models 4-6, independent and control variables are lagged for one period. Industry and year fixed effects are included in all specifications. Robust standard errors, clustered at the industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Table 5 Robustness tests: alternative financial constraint index and scaled subsidy and environmental spending

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Subsidy*SA Index	0.026**					
	(0.012)					
Subsidy*KZ Index		0.030***				
		(0.008)				
Subsidy*WW Index			0.467***			
			(0.093)			
Subsidy(%)				0.119*	0.005	1.113***
				(0.066)	(0.006)	(0.017)
Subsidy(%)*Non-SOEs					0.008**	
					(0.003)	
Subsidy(%)*WW Index						1.120***
						(0.075)
Duality	0.234**	0.137	0.126	0.019	0.015**	0.054**
	(0.108)	(0.128)	(0.187)	(0.012)	(0.007)	(0.022)
Independence	-0.709	0.279	-2.753***	-0.154	0.034	-0.484***
	(0.684)	(0.508)	(0.813)	(0.099)	(0.022)	(0.092)
Board meeting	-0.016***	-0.006	-0.019*	-0.007***	-0.002***	-0.005**
	(0.003)	(0.010)	(0.009)	(0.001)	(0.001)	(0.002)
Managerial ownership	0.008	-0.355	-1.675***	0.192	0.007	0.757***
	(0.216)	(0.586)	(0.507)	(0.121)	(0.023)	(0.078)
Z Index	0.005***	0.009***	-0.003	0.001	0.001**	-0.001
	(0.001)	(0.003)	(0.005)	(0.001)	(0.001)	(0.001)
Stock returns	0.142*	0.297***	0.157	-0.094***	-0.001	-0.104**
	(0.074)	(0.035)	(0.087)	(0.028)	(0.003)	(0.043)
Tobin Q	-0.024**	-0.358***	-0.304***	0.084***	0.005***	0.100***
	(0.009)	(0.023)	(0.027)	(0.016)	(0.002)	(0.023)
Firm age	0.024**	-0.005	-0.039	0.001	0.001	0.003
	(0.010)	(0.023)	(0.023)	(0.002)	(0.001)	(0.002)
Leverage	0.186***	1.219***	0.420***	0.441***	0.008	0.559***
	(0.044)	(0.084)	(0.095)	(0.068)	(0.005)	(0.096)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,572	1,431	829	1,575	1,575	829
Adjusted R-squared	0.402	0.157	0.214	0.302	0.047	0.506

Variable' Subsidy' is controlled from the models 1 to 3. In Model 1-3, the independent variables are the continuous SA, KZ, and WW indexes, respectively. In Models 4-6, the dependent variables are environment spending (%), which are defined as the total sewage fee scaled by firm size. The independent variables are subsidy (%), which are measured as the total sewage fee scaled by firm size. Robust standard errors, clustered at the industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Table 6 Robustness tests: alternative dependent variable

Variables	Model 1	Model 2	Model 3
Subsidy	0.021*	0.014	0.020
	(0.011)	(0.016)	(0.023)
Subsidy*Non-SOEs		0.084***	
		(0.030)	
Subsidy*KZ Index			0.035***
			(0.004)
Duality	-0.068	0.006	-0.074**
	(0.047)	(0.051)	(0.032)
Independence	-0.409	-0.290	-0.796
	(1.007)	(0.359)	(0.786)
Board meeting	-0.015	-0.010**	-0.018**
	(0.010)	(0.005)	(0.008)
Managerial ownership	-1.158***	-1.154***	-1.571***
	(0.165)	(0.112)	(0.163)
Z Index	0.013***	0.009**	0.013***
	(0.004)	(0.004)	(0.003)
Stock returns	-0.006	-0.011	0.022
	(0.028)	(0.027)	(0.037)
Tobin Q	-0.104***	-0.066***	-0.122***
	(0.028)	(0.016)	(0.012)
Firm age	0.003	0.001	-0.001
	(0.002)	(0.003)	(0.004)
Leverage	0.469***	0.053***	0.100***
	(0.133)	(0.017)	(0.009)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	16,066	15,056	12,702
Pseudo R-squared	0.154	0.171	0.095

In Models 1-3, the dependent variable is the dummy variable that equals to one when the firm discloses the sewage fee and zero otherwise. Robust standard errors, clustered at industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

One potential concern is the endogeneity of government subsidies. There could be some unobserved firm-level characteristics that affect both the subsidy level and environmental spending. To deal with this endogeneity problem, we choose the industry median as our IV following Lee *et al.* (2017), which is the industry median subsidies in firm *i*'s province in year *t*.[6] The justification is as follows. Firms in the same location and industry may compete for the government subsidies at the regional level. Then whether a firm receives state subsidy or not may depend on the province or industry nature rather than firm-specific elements. Lee *et al.* (2017) point out that firm *i* is more likely to be subsidized if the provincial industry median subsidy level is more pronounced, while it is implausible that the overall industry × province subsidies have direct impacts on firms' cross-sectional variations in environmental spending. Moreover, Fisman & Svensson (2007) and Lin *et al.* (2011) point out that if the endogeneity problem is not at the industry or the location level but specific for firms, then canceling out the firm-specific term (*i.e.*, first stage estimates) would generate a measure which only dependents on industries and locations' characteristics. Mathematically, our first-stage estimation is as follows:

$$Ln(\text{Subsidy})_{i,t-1} = Ln(\text{Median Subsidy})_{i,t-1} + \boldsymbol{X}_{i,t-1} + \alpha_i + \gamma_t + \pi_{it} \qquad (3)$$

where $Ln(\text{Median Subsidy})_{i,t-1}$ denotes the natural logarithm of industry level median subsidies in firm *i*'s province in year *t-1* and π_{it} is the first-stage idiosyncratic error term. We use firm *i*'s first-stage predicted government subsidies as the main independent variable in the second-stage estimation:

$$Ln(Y_{it}) = Ln(\widehat{\text{Subsidy}})_{i,t-1} + \boldsymbol{X}_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \qquad (4)$$

where $Ln(\widehat{\text{Subsidy}})_{i,t-1}$ is the estimated value of firm *i*'s subsidy obtained from the first stage model (3). The first-stage as well as the second-stage results are presented in Model 1 of Table 7. Our second stage baseline IV estimate is 0.238, which is on par

[6] Our main interest is to establish the causal impact of state subsidy to firms' environment spending. Indeed, there is a possible reverse causality issue that corporate environment spending can also affect state subsidies.

with the result of the aforementioned fixed effect model. The first-stage IV (industry median) coefficient and standard error are 0.720 and 0.045 respectively, which show a statistical significance at 1% level. The Cragg-Donald Wald F statistic is 183.95 and is well above 10% critical value of the maximal IV size (Stock & Yogo, 2005). Moreover, the F-Statistics of excluded instruments in our first-stage estimation is 258, which also passes the rule of thumb suggested by Sanderson & Windmeijer (2016) and Staiger & Stock (1997). All these evidences indicate that industry × province subsidies could serve as a strong and valid IV in our identifications, which echoes Lee *et al.* (2017). In addition, Model 2 of Table 7 presents the 2SLS results for the alternative dependent measure. Likewise, the result is still robust for the environmental responsibility performance complied by the He Xun index.

In addition to the IV method, following Tan *et al.* (2017) and Wintoki *et al.* (2012), we adopt a dynamic generalized method of moments model (GMM) to account for the potential endogeneity. Specifically, our GMM equation is estimated as follows:

$$\Delta Y_{it} = \beta_0 \, L.\Delta Y_{it} + \beta_1 \, \Delta \text{Subsidy}_{i,t-1} + \beta_2 \, \Delta \boldsymbol{X} \, + \alpha_i + \, \gamma_t + \, \Delta\varepsilon \qquad (5)$$

where Δ is the period differencing operator and L is one-period lag operator. Other variables are similarly determined as model (1). Following Arellano & Bond (1991) and Roodman (2009), our choice of instruments are two lags of the potentially endogenous variable ($\Delta \text{Subsidy}_{i,t-1}$) and the one lag of predetermined exogenous variables is one. According to Kripfganz & Schwarz (2019), we also include time-invariant regressors such as the industry and year effects into our dynamic GMM model.

Our second stage results are presented in Table 8. Columns 1 and 2 of Table 8 present the two-step GMM estimates for our two dependent variables: sewage fees and the He Xun environmental responsibility index respectively. Both the coefficients of interests are statistically significant, suggesting that our baseline results are qualitatively similar even if we use the lagged dependent variables as additional instruments.

Table 7 Endogeneity: Two-stage least squares methods

First-stage results	Model 1	Model 2
Subsidy industry median	0.720	0.747
	(0.045)	(0.037)
Control variables	Yes	Yes
Cragg-Donald Wald F-Statistic	183.95	407.82
Kleibergen-Paap Wald rk F statistic	258.00	2926.84
Second-stage results		
Subsidy	0.238***	0.439**
	(0.073)	(0.193)
Duality	0.116	-0.494***
	(0.080)	(0.123)
Independence	0.750	2.475**
	(0.637)	(0.990)
Board meeting	-0.026**	0.031***
	(0.010)	(0.010)
Managerial ownership	0.108	-1.462***
	(0.568)	(0.331)
Z Index	0.010***	0.005
	(0.003)	(0.005)
Stock returns	0.175**	-0.207**
	(0.066)	(0.086)
Tobin Q	-0.243***	-0.003
	(0.030)	(0.003)
Firm age	-0.001	-0.004
	(0.021)	(0.022)
Leverage	0.688**	-0.081
	(0.245)	(0.394)
Year and Industry FE	Yes	Yes
Observations	1,542	15,990
Adjusted R-squared	0.147	0.0332

Subsidy industry median is natural logarithm of the industry median subsidies in firm *i*'s province in year *t*. In Model 1, the dependent variable is natural logarithm of a firm's sewage fee. In Model 2, the dependent variable is He Xun's environmental responsibility score. Industry and year fixed effects are included in all specifications. Robust standard errors, clustered at industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Table 8 Endogeneity: The GMM approach.

Variables	Model 1	Model 2
Δ Subsidy	0.031*	0.104***
	(0.016)	(0.025)
Δ Lag environmental spending	0.940***	
	(0.015)	
Δ Lag environmental index		0.547***
		(0.010)
Δ Duality	-0.018	-0.046
	(0.072)	(0.088)
Δ Independence	-0.687	0.679
	(0.440)	(0.705)
Δ Board meeting	-0.025***	0.001
	(0.008)	(0.008)
Δ Managerial ownership	0.443**	0.171
	(0.204)	(0.175)
Δ Z Index	-0.001	-0.001
	(0.002)	(0.003)
Δ Stock returns	0.152	-3.141***
	(0.114)	(0.415)
Δ Tobin Q	-0.039**	0.001
	(0.020)	(0.001)
Δ Firm age	-0.005	-0.001
	(0.005)	(0.004)
Δ Leverage	-0.087	-0.025
	(0.124)	(0.189)
Year FE	Yes	Yes
Industry FE	Yes	Yes
No. of observations	1,268	15,362
No. of firms	305	2,670
J-Statistics	96.83	307.4
Arellano-Bond AR(1)	-4.697***	-17.784***
Arellano-Bond AR(2)	-0.507	-0.757

Coefficients are from a two-step GMM estimation, with the inverse of the variance-covariance matrix of the moment conditions as the weighting matrix. In Model 1, the dependent variable is natural logarithm of a firm's sewage fee. In Model 2, the dependent variable is He Xun's environmental responsibility score. Time-invariant regressors such as industry and year fixed effects are included in all specifications, according to Kripfganz & Schwarz (2019). The HAC robust two-step standard errors, incorporating the Windmeijer (2005) small-sample correction are included in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Moreover, we examine the differences of the impact of state subsidies on corporate environmental spending between central and local SOEs. Central SOEs refer to the SOEs whose ultimate controller is central government, and local SOEs refer to the SOEs that are ultimately controlled by the local (i.e. provincial and municipal) governments. The results are presented in the Models 1-2 of Table 9. It is reported that the interaction variables Central SOEs*Subsidy are significantly positive, indicating the impact of state subsidies on increasing environmental spending is more pronounced in the central SOEs. This is because central SOEs represent the state image and subject to more scrutiny and regulations on fulfilling environmental responsibilities, thus increasing their input to demonstrate their contributions to address pollutions (Marquis & Qian, 2013).

Besides, we use an alternative measure of the independent variable, *i.e.*, green subsidies, to re-run the models. State subsidies include different types in the CSMAR database, such as: technology-related subsidies, tax-related subsidies, project-related subsidies, import/export-related subsidies and environment-related subsidies. This section only focuses on green subsidies (i.e. environment-related subsidies) and teases out other subsidies to re-estimate the results. Green subsidies are obtained through searching key words e.g. 'green', 'environment protection', 'sewage', 'energy saving', 'emission reduction', 'air', 'water', 'plants', 'ecology', 'nature' in CSMAR's subsidy database. The results are reported in Models 3-4 of Table 9. We find that our findings remain unchanged.

Finally, we re-estimate our baseline result by dividing samples into the heavily polluted industry and non-heavily polluted industry. The results are presented in Models 1-4 of Table 10. It shows that the results are all statistically significant to both classifications. More importantly, the economic magnitude of the heavily polluted industry is stronger than that of the non-heavily polluted industry, which shows that state subsidies do incentivize firms in the heavily polluted industry to be more environmentally responsible.

Table 9 Robustness tests: central versus local SOEs and green subsidies

	Model 1	Model 2	Model 3	Model 4
Subsidy	0.135**	0.532**		
	(0.054)	(0.197)		
Central SOEs*Subsidy	0.152**	0.192*		
	(0.066)	(0.096)		
Green subsidies			0.107***	0.302***
			(0.013)	(0.050)
Duality	0.135	-0.105	0.229**	-0.348**
	(0.198)	(0.262)	(0.100)	(0.125)
Independence	0.303	2.878**	0.106	2.371*
	(0.674)	(1.049)	(0.526)	(1.237)
Board meeting	-0.013*	0.021	0.001	0.030**
	(0.006)	(0.014)	(0.014)	(0.013)
Managerial ownership	-4.073**	-6.524***	-0.657	-0.933**
	(1.384)	(1.575)	(0.522)	(0.335)
Z Index	0.004	-0.017*	0.012***	0.021**
	(0.003)	(0.010)	(0.003)	(0.009)
Stock returns	0.309***	-0.527***	0.094***	-0.129
	(0.028)	(0.094)	(0.025)	(0.163)
Tobin Q	-0.413***	-0.239***	-0.265***	-0.130***
	(0.045)	(0.062)	(0.030)	(0.043)
Firm age	0.001	-0.062**	-0.002	0.042*
	(0.024)	(0.026)	(0.017)	(0.023)
Leverage	-0.014	-1.703***	0.279	0.071
	(0.165)	(0.431)	(0.164)	(0.080)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	1,006	7,809	893	5,749
Adjusted R-squared	0.195	0.179	0.121	0.127

Central SOEs is a dummy variable that equals to one if the ultimate controller of a listed firm is the central government and zero otherwise. Green subsidies are the state subsidies received by a firm specifically for the purpose of addressing relevant environmental issues. Green subsidies are obtained by searching key words e.g. 'green', 'environment protection', 'sewage', 'energy saving', 'emission reduction', 'air', 'water', 'plants', 'ecology', 'nature' in the CSMAR subsidy database. Variables 'Central SOEs' are controlled in the models 1 and 2. In Models 1 and 3, the dependent variables is the natural logarithm of a firm's sewage fee. In Models 2 and 4, the dependent variable is the environmental responsibility score. Industry and year fixed effects are included in all specifications. Robust standard errors, clustered at industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Table 10 Robustness tests: heavily and non-heavily polluted industry

	Model 1	Model 2	Model 3	Model 4
Variables	Heavily pollution	Non-heavily pollution	Heavily pollution	Non-heavily pollution
Subsidy	0.257**	0.170***	0.693**	0.591***
	(0.047)	(0.033)	(0.139)	(0.130)
Duality	0.105	0.341	-0.790***	-0.263
	(0.113)	(0.371)	(0.051)	(0.210)
Independence	-0.658	3.098**	1.320	3.498***
	(0.659)	(1.093)	(1.739)	(1.175)
Board meeting	-0.001	-0.042**	0.041	0.001
	(0.011)	(0.015)	(0.017)	(0.017)
Managerial ownership	-0.846	-1.038	-2.434**	-1.448***
	(0.398)	(1.225)	(0.546)	(0.318)
Z Index	0.011***	-0.005	0.016	-0.007
	(0.001)	(0.007)	(0.009)	(0.008)
Stock returns	0.239**	0.138	-0.405*	-0.314***
	(0.046)	(0.148)	(0.118)	(0.092)
Tobin Q	-0.291***	-0.123***	-0.201***	-0.001
	(0.016)	(0.027)	(0.014)	(0.002)
Firm age	-0.020	0.027	-0.034	0.017
	(0.020)	(0.022)	(0.044)	(0.024)
Leverage	0.403**	0.438*	0.123	-0.050
	(0.089)	(0.211)	(0.069)	(0.233)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	1,108	467	5,218	11,565
Adjusted R-squared	0.202	0.118	0.150	0.133

Models 1 and 2 show the results for the heavily and non-heavily pollution industry when the dependent variable is the sewage fee. Models 3 and 4 show the results for the heavily and non-heavily pollution industry when the dependent variable is the Hexun firm environmental index. Robust standard errors, clustered at the industry level, are reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

5. Conclusion

This paper examines the impact of state subsidies on corporate environmental spending for Chinese listed firms between 2011 and 2018. We find that a consistently positive relationship between state subsidies and corporate environment spending, indicating firms receiving government supports tend to behave more environmentally responsible to cater their governments. In addition, the positive relationship between state subsidies and corporate environment spending is more pronounced in non-SOEs. In other words, non-SOEs make more efforts to build their reputations in environmental protections. Moreover, we find that the positive relationship between subsidy and environmental spending is more salient in financially constrained firms, implying firms with financial constraints tend to contribute more in addressing pollutions.

These results are robust to alternative measures of dependent and independent variables. For instance, when we lag independent and control variables for one period, or use alternative financial constraint indexes, or use environmental related subsidies i.e. green subsidies to replace total state subsidies, the results remain unchanged. We also examine the heterogenous impacts of state subsidies on environmental spending between central and local SOEs and find the more positive effects among the central SOEs. In addition, as state subsidies and firm's environmental spending could be endogenous determined and thus lead to bias estimates, we employ two approaches, the instrumental variable method and a dynamic generalized method of moments, to explicit account for the potential endogeneity. We find that the baseline results remain the same under both approaches: the more state subsidies, the higher corporate environmental spending. Moreover, the results are also robust when we replace the dependent variable by the environmental responsibility index from the He Xun database. Furthermore, we find that state subsidies incentivize firms in the heavily polluted industry to be more environmentally responsible.

State subsidy is an important way that governments often use to influence corporate policies of Chinese listed firms. Our evidence show that the provision of state subsidies

can increase corporate environmental spending, especially among firms that the state does not control and those subject to financial constraints. In other words, this confirms that state subsidies could be an effective policy instrument for governments to guide or influence corporate environmental decisions. Therefore, our findings present a positive impact of state subsidies, which are in line with Lee *et al.* (2017)'s results that state subsidies have a material influence on firms fulfilling corporate social responsibilities. However, we also acknowledge there are negative impact brought by state subsidies. For instance, state subsidies lead to overproduction of subsidized goods, as production has been largely expanded beyond the point where marginal benefits of consuming goods equal to the marginal costs of production (Hu *et al.*, 2019). In addition, subsidies can significantly increase the chance firm overinvestment (Han *et al*., 2019). Moreover, they may cause the recent profound China-U.S. trade war: one of the main disputes in the negotiation is China's state subsidies to its exporters, and the Trump administration insists on imposing tariffs on imports from heavily subsidized Chinese industries (Bradsher & Swanson, 2019). Therefore, policy makers should be aware of both the potential benefits and the costs of offering subsidies.

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