Do financial constraints curb a firm's efforts to control pollution: Evidence from Chinese manufacturing firms

Abstract

Financial constraints have long existed in China's manufacturing and financial sectors. The growth of the manufacturing sector has been slowing in recent years because strict measures to curb pollution forces factories to cut production. In this paper, we discussed whether financial constraints were essential in a firm's decision to control pollution. We matched the Annual Surveys of Industrial Firms dataset with the Ministry of Environmental Protection survey data on firms' expenditures to combat air pollution. We calculated the investment-cash flow sensitivity (ICFS) and the ratio of firms' expenditures on pollution control to total assets, and we explored the relationship between them. We found that, overall, financial constraints had a significantly negative effect on a firm's efforts to reduce pollution. Nevertheless, state-owned enterprises relieved financial pressure mainly by seeking external financing, and for privately-owned or foreign-owned enterprises with efficient internal finances, they also avoided the repercussion of financial constraints. This paper provides useful suggestions for government and enterprises for investing in pollution control effectively.

Keywords

Corporate Environmental Behavior; China; Pollution control; Financial constraint; Manufacturing

1.Introduction

Corporate Environmental Behavior (CEB) has gradually become a research focus in China in recent years (He et al. 2018; Jiang et al. 2014; Wu et al. 2017)， because environmental conditions have stoked worries

among the public about air pollution and whether the situation is likely to improve (Tong et al. 2016); Figure 1). Of all the indicators that measure CEB, environmental investment is one of the most important (Wang et al. 2018). Nevertheless, given limited resources, the more an enterprise invests in environmental protection, the less it can invest in production. From this perspective, environmental investment would be a trade-off between production and social responsibility.

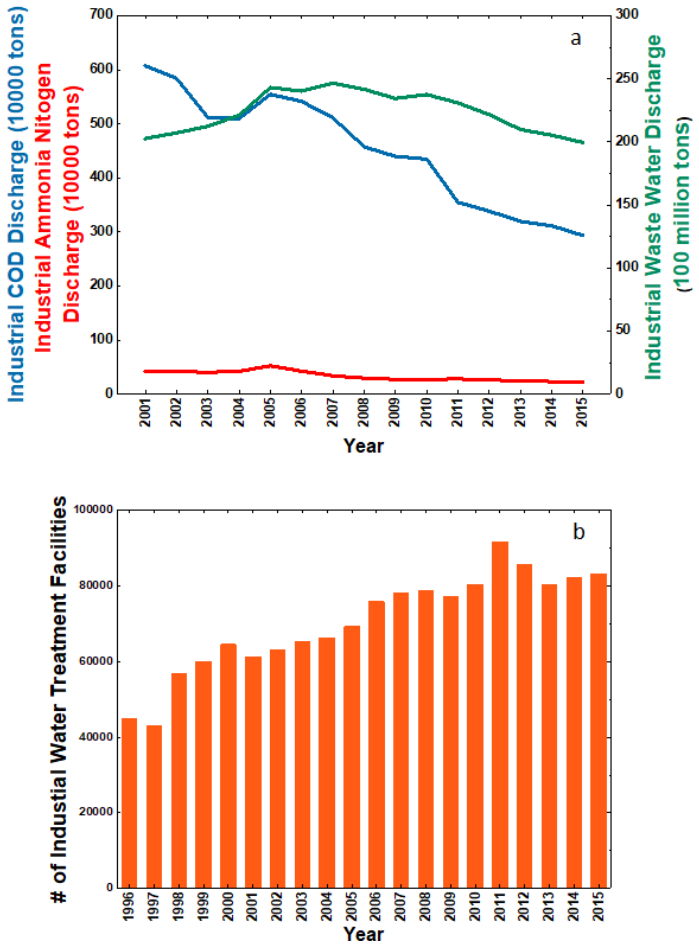

Fig. 1. The quantity of pollutant discharge (a) and the number of waste water treatment facilities by Chinese firms (b).

A few studies have analyzed factors that affect CEB, such as corporate environmental investment. For example, Murovec et al. (2012) developed a conceptual model, and they found that policy measures, past environmental investments, the importance of environmental technologies for customers, and firm performance had a positive effect on environmental investments. Costa-Campi et al. (2016) analyzed the determinants of environmental investments, which was conducted on 22 manufacturing sectors in Spain

during 2008–2013. Their main conclusion was that managerial strategy appeared as a relevant driver for environmental investments. Based on the survey data collected in 2013 from sixty energy companies in China, Wang et al. (2015) discovered that managers' seniority was positively correlated with corporate environmental behavior, which indicated that senior managers had higher environmental awareness and knowledge. Furthermore, ownership structure (Beladia and Chaob 2006; Tsai et al. 2016; Xu et al. 2016), shareholder pressures (Kassinis and Vafeas 2006), characteristics of CEOs (Cordano and Frieze 2000; Sun et al. 2012), firm size (Darnall et al. 2010; Nawaiseh 2015), government internal incentive mechanism (Ding et al. 2016) , and environmental regulations (He et al. 2016; Perez et al. 2009; Zhao et al. 2015) also contributed to CEB, as did environmental investment.

However, as mentioned in Fullerton and Kim (2008), other public spending "crowded out" environmental expenditure. Thus, financial constraints also affected environmental investment because the total cost needs to be less than the total budget for investment (Higgins et al. 2008). Although taking environmental responsibility has a significantly positive influence on corporate financial performance sooner or later (Li et al. 2017; Song et al. 2017), Reinhardt (2010) found that firms that volunteered to internalize costs did not survive. Therefore, a typical decision-making problem is how to allocate limited resources among a set of pollutant treatment projects to minimize total losses that include penal loss and vacancy loss (Yu et al. 2016). Environmental investments are trade-offs that can curb the ability to provide other necessities, which leads to a decision to question or even criticize environmental issues (El-Zayat et al. 2006; Julian and Ofori-Dankwa 2013, Tong et al. 2016). Nonetheless, few studies have focused on the relationship between financial constraints and environmental investment.

The main purpose of this study was to provide necessary quantitative analysis regarding the motives for financing environmental protection activities. Based on a brief review of the literature related to financial

constraints and investment behavior of firms, several hypotheses on environmental protection investment were developed. We employed a large dataset consisting of 34,000 firms from all manufacturing industries to test our hypotheses, which included a comprehensive set of internal and external financing variables. In addition, we matched those data with another dataset on firms' investment to combat air pollution. Thus, we constructed a complete dataset that included financial conditions of firms and their environmental investment. Our results showed that financial constraints, overall, significantly restricted investment in environmental protection. However, State-owned Enterprises (SOE) alleviated financial constraints that results in a positive impact on this investment. Private and foreign firms, on the contrary, suffered from financial constraints that hindered environmental protection investment. We investigated the mechanism and found that under financial constraints, SOEs mainly sought bank loans to finance environmental protection activities, but private and foreign firms used internal finance-cash flow to smooth financial constraints. Our paper contributes to the formation of policy by the government, where qualitative economic research provides a reliable result that can help develop general policy on this issue. Moreover, from our discussion on the relationship between financial constraints and environmental protection investment, an intelligent conclusion on restricting production to reduce pollution in Chinese manufacturing firms can be developed.

To achieve our purposes, several research hypotheses were developed based on a literature review, which are presented in Section two. In Section three, the research setting, models, and data are described. The results of model testing are presented in Section four. The paper concludes with discussion and implications.

2. Development of hypotheses

To discuss the relationship between financial constraints and firms' investment to combat pollution, we need to take a few essential features that exist in a firm's operation and business environment into consideration. Thus, we put forward three hypotheses that considered the roles that ownership structure and financing

modes played in how financial constraints impact a firm's environmental investment.

Hypothesis 1: Financial constraints have a significantly negative impact on environmental protection investment.

The key concept of financial constraints in the literature is that investment behavior is decided by a firm's expected future profitability, rather than a firm's net value or internal financing. Modigliani and Miller (1959) (1958) demonstrated that a firm's investment behavior was irrelevant to a financing decision in perfect capital and credit markets. However, due to the capital market's imperfections, financial constraints affected a firm's investment decisions. Environmental protection investment is recognized as a part of the cost, and it does not contribute to profit directly. In addition, financing resources are ranked for different purposes of investment, due to profitability and risk. Firms preferred to invest in low-risk, high return projects (Guariglia and Liu 2014), however, environmental investment usually contributed less profits. Therefore, firms with financial constraints would be restricted from an environmental protection investment.

Hypothesis 2: SOEs can alleviate financial constraints and significantly contribute to environmental protection investment, but private and foreign enterprises undergo severe financial constraints are at a disadvantage in environmental protection investment.

Ownership structure in China has a large impact on many perspectives, such as investment efficiency (Wei 2007), productivity and growth (Hallward-Driemeier et al. 2010), and level of internationalization (Ramasamy et al. 2012). SOEs are less constrained financially, because they typically benefit from soft budget constraints (Chen and Guariglia 2013; Zhang and Liu 2017). SOEs also have to adopt social responsibility, which includes environmental protection, and they can invest in environmental protection by alleviating financial constraints. In contrast, private firms in China face a high degree of financial constraint (Allen et al. 2005), and foreign firms also suffer from financial constraints. Foreign firms are less constrained

financially than private firms, because they can gain financial support from their homeland (Zhang and Liu 2017). Therefore, for non-SOEs, they finance their profitable investment projects first (e.g., fixed assets investment, innovation investment), and environmental protection investment will be restricted due to their ownership structure.

Hypothesis 3: Non-SOEs use cash flow to smooth financial constraints to finance environmental protection investment, but SOEs rely on bank loans to finance environmental protection investment.

Fazzari et al. (1988) theorized that financially constrained firms use cash flow to finance investment activities. When a firm is financially constrained, because it is unable to access external financing or it cannot afford expensive finance cost, it will have to reduce its less profitable investments and use cash flow to smooth investment activities. Investments of SOEs were not sensitive to cash flow, but private and foreign firms showed totally different sensitivities (Héricourt and Poncet 2009; Zhang and Liu 2017). For investments in environmental protection, SOEs might use bank loans to invest, because SOEs can access favorable treatment from banks and benefit from soft budget constraints. For financially constrained firms that may find it difficult or expensive to raise external financing, they need cash flow to smooth investments in environmental protection.

3. Empirical model and description of data

3.1 Empirical model

To explore the impact of financial constraints on environmental protection investment, we modified the fixed investment model used by Fazzari et al. (2000; 1988). Our empirical specification is shown as follows:

$$\frac{Envi}{K}_{i,t} = \alpha_0 + \alpha_1 ICFS_{i,t} + \alpha_i X_{i,t} + v_i + u_j + \varepsilon_{i,t} \quad (1)$$

where *ICFS* is the measurement of financial constraints, which will be discussed further in section 3.2. $X_{i,t}$ is the control variable matrix, which includes firm age, size, and the square of firm size. We also controlled

for firm and industry fixed-effects in our model, and $\varepsilon_{i,t}$ is error terms.

3.2 Measurement of financial constraints

Fazzari et al. (1988) demonstrated that financial constraints can be measured by the sensitivity of investment to cash flow. A number of studies have tested the validity of using the investment–cash flow correlation as a proxy for financial constraints (Allen et al. 2005; Ding et al. 2013). To account for financial constraints and to measure investment-cash flow sensitivity, in this section we followed the methodology introduced by Hovakimian and Hovakimian (2009) to calculate firm-level sensitivities of investment to cash flow. We calculated the investment-cash flow sensitivity (ICFS) as follows:

$$ICFS_i = \sum_{t=1}^{n} \left(\frac{\left(\frac{cash\ flow}{K}\right)_{it}}{\sum_{t=1}^{n}\left(\frac{cash\ flow}{K}\right)_{it}} * \left(\frac{I}{K}\right)_{it} \right) - \frac{1}{n}\sum_{t=1}^{n}\left(\frac{I}{K}\right)_{it} \qquad (2)$$

where *n* stands for the number of firms at time *t*. The *ICFS* is given by the difference between the cash flow, weighted time-series, average investment in fixed assets of a firm and its arithmetic time-series average ratio. Zhang and Liu (2017) substantiated that the firm-level *ICSF,* therefore, measured the degree of financial constraints across different firms theoretically and empirically.

3.3 Data description

Our database was constructed by two comprehensive datasets that covered 30 provincial regions. The manufacturing firm data were obtained from the Annual Surveys of Industrial Firms (ASIF) conducted by China's National Bureau of Statistics (NBS) in 2013. This database included all industrial firms, which can be divided into two groups: SOEs and non-state firms (with sales >10 million RMB per year). The industries in this database included mining, manufacturing, and public utilities. Due to our research goal, only manufacturing firms were selected in this study. The environmental protection data came from the industrial firms' survey conducted by the Ministry of Environmental Protection of the People's Republic of China. We used firm name, ID, address, and postal code to match the two datasets, and we obtained 34,235 observations

in total. The average expenditure on combating air pollution in each provincial region is presented in Figure 2.

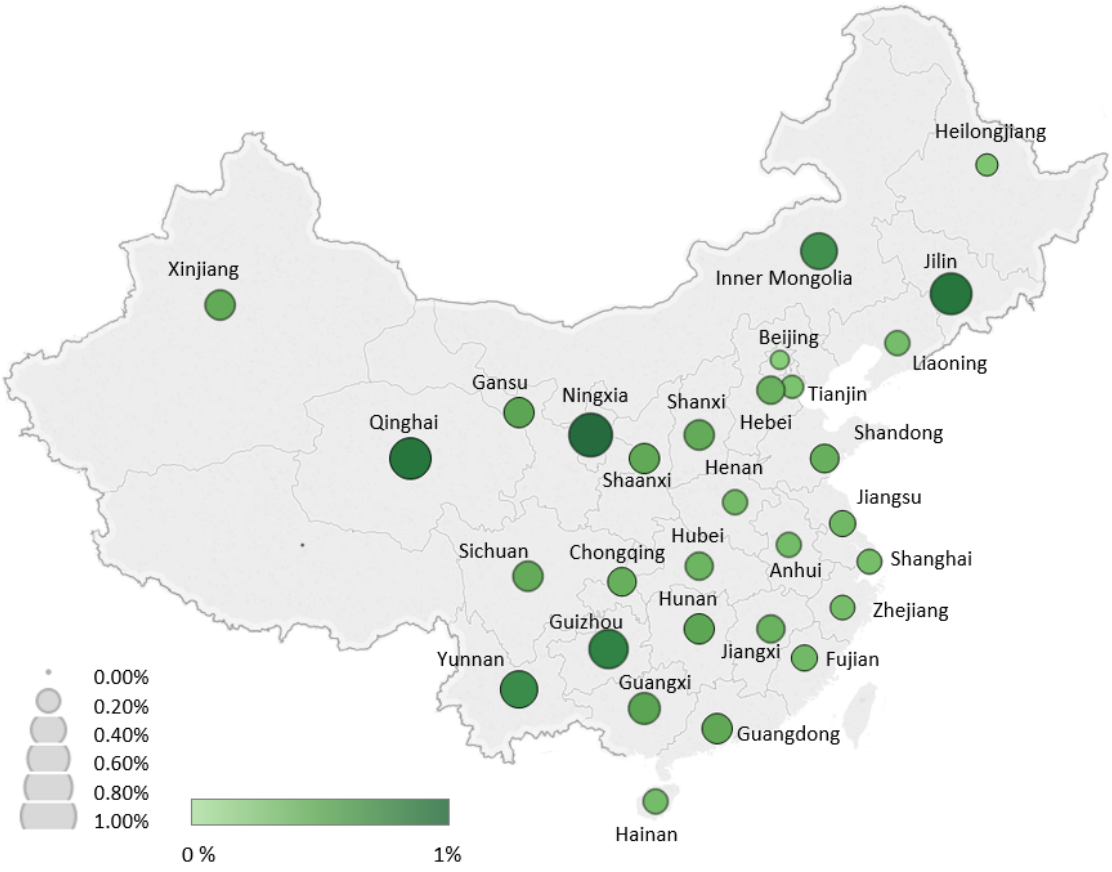

Fig. 2. Average environmental investment ratio of 30 provincial regions in China.

In this study, our dependent variable, environmental investment ratio, was defined as the ratio of the investment expense for environmental protection to total assets; because the number was rather small, we multiplied this variable by 1000. Firm size was defined by the logarithm of total assets. Firm age was measured by the logarithm of the observation year minus the year that the firm was established. Cash flow was the ratio of net profit over total assets. Bank loans were calculated as the interest expense over total assets. Apart from that, we noticed that firms that polluted at different levels confronted different challenges in environmental investment. Thus, we divided our samples into two groups: heavily polluting and lightly polluting, and we presented the number of lightly polluting firms (left side) and heavily polluting firms (right

side) in each province in the map below.

Fig. 3. Distribution of lightly (left side) and heavily (right side) polluting firms in 30 provincial regions in China.

Industrial scales and firm numbers varied in different regions in China (Fig. 3). In fact, development in China has been fairly uneven (Lim 2013). The difference was especially obvious in three geographic regions in China: east, middle, and west.

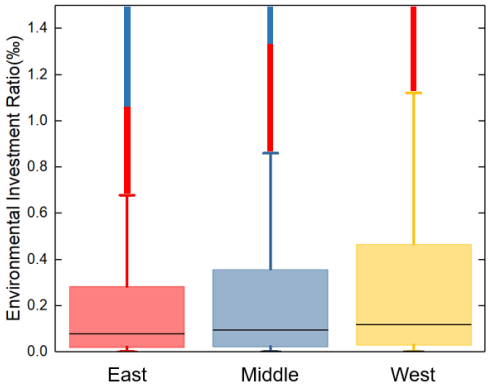

Fig. 4. Environmental investment ratios in three regions in China.

4. Results and Discussion

To analyze how financial constraints influence firms' investments to control pollution, we need to consider two perspectives: first, whether financial constraints prevent firms from investing and, second, if not, to what extent will financial constraints impede firms from investing. This is attributed to the fact that in our dataset, part of the observations did not allot fund to pollution control. Hence, we devised our main regression analyses based on these two aspects. In our first regression, we used the Probit model to test whether financial constraints prevented firms from investing in pollution control, where the dependent variable, expense of pollution control, was set as a dummy variable. In our second regression, we tested to what extent financial constraints influenced investment decisions by adopting three different methods: Tobit, OLS, and OLS with fixed effects controlled. The investment cannot be negative, which means the data were left-censored. Variations of the Tobit model can be produced by changing where and when censoring occurred (Amemiya 1985). Thus, Tobit, to some extent, was a better reflection of the nature of our dataset (Table 1).

Table 1. Baseline regressions results of financial constraints impacting on the investment of environmental protection

	Dep.Var.=Expense Dummy	Dep. Var.=Exhaust Gas Expense/Assets		
	Probit	Tobit	OLS	OLS with fixed effects
Variables	(1)	(2)	(3)	(4)
Financial Constraints	-0.468**	-0.174***	-0.698***	-0.372***
	(0.204)	(0.022)	(0.102)	(0.099)
Firm Size	-0.006	0.079***	0.233***	0.164***
	(0.094)	(0.010)	(0.041)	(0.038)
Firm Size^2	0.006	-0.008***	-0.023***	-0.016***
	(0.008)	(0.001)	(0.003)	(0.003)
Firm Age	-0.027*	-0.017***	-0.039***	-0.004
	(0.016)	(0.002)	(0.008)	(0.007)
Constant	1.715***	0.059*	-0.012	-0.309**
	(0.283)	(0.030)	(0.129)	(0.122)
Observations	34,235	34,235	34,235	34,235

R-squared			0.006	0.160
Log Pseudo-likelihood	-3353.8	-2834.4		
Industry Dummies	YES	YES	NO	YES
Region Dummies	YES	YES	NO	YES
Firm Effect	YES	YES	NO	YES

The first column in Table 1 shows that for the entry behavior, firms with financial constraints were less likely to participate in pollution control activities. A one unit increase in investment-cash flow sensitivity led to a 46% slump in participation. Columns 2-4 in Table 1 explicate how the proportion of expenditure on air pollution control was influenced by financial constraints. Whether tested by the Tobit or OLS model, the signs of financial constraints were significantly negative. This means that financially constrained firms encountered more resistance to enlarge their expenditure to combat emissions. Another noticeable finding was that firm size showed a reverse U-shape effect on expenditure. As the firm became larger, the ratio a firm invested in air pollution control first increased, then it declined gradually. Meanwhile, in out Tobit model, the younger a firm was, the more willing it was to invest in controlling air pollution.

We also considered the ownership structure of firms (Table 2). We classified firms into three categories: State-owned (SOE), Privately-owned (POE), and Foreign-owned (FOE).

Table 2.
Regressions results of financial constraints impacting on the investment of environmental protection considering ownership

	OLS with fixed effects		
	Dep. Var.=Exhaust Gas Expense/Assets		
Variables	(1)	(2)	(3)
Financial Constraints	-0.579***	0.001	-0.339***
	(0.101)	(0.137)	(0.104)
Financial Constraints*State	2.293***		
	(0.291)		
Financial Constraints*Private		-0.484***	
		(0.138)	
Financial Constraints*Foreign			-0.257*
			(0.133)
Firm Size	0.180***	0.171***	0.162***
	(0.038)	(0.038)	(0.038)

Firm Size^2	-0.018***	-0.017***	-0.016***
	(0.003)	(0.003)	(0.003)
Firm Age	-0.006	-0.005	-0.004
	(0.007)	(0.007)	(0.007)
Constant	-0.362***	-0.323***	-0.305**
	(0.122)	(0.122)	(0.122)
Observations	34,235	34,235	34,235
R-squared	0.163	0.161	0.160
Log Pseudo-likelihood			
Industry Dummies	YES	YES	YES
Region Dummies	YES	YES	YES
Firm Effects	YES	YES	YES

Noticeably, SOEs did not suffer from financial constraints in decision-making about investments in pollution control. The interactions of Financial Constraints and State ownership dummy variable have a positive and significant impact on environmental investment. In fact, SOEs relieved financial constraints because state-owned banks very often display biases, which favor state-owned firms (Allen et al. 2005; Brandt and Li 2003). Thus, compared with non-SOEs, financial constraints were an advantage to SOEs, because financing choices for non-SOEs in China were very limited. Along these lines, signs of the interaction terms for non-SOEs were significantly negative. This effect was more observable for POEs, which were nearly twice as large as FOEs.

We further analyzed whether characteristics of industries have an impact on a firm's investment in pollution curbs. Thus, the polluting levels of industries were taken into account. We divided observations into two groups: heavily polluting and lightly polluting. Additionally, we analyzed how different ownership structures behaved differently considering these polluting levels (Table 3).

Table 3.
Regressions results of financial constraints impacting on the investment of environmental protection in different industries

	OLS with fixed effects	Dep. Var.=Exhaust Gas Expense/Assets
	Heavily Polluting Industry	Lightly Polluting Industry

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Financial Constraints	-0.273	-0.778***	-0.936***	-0.795***	0.267	-0.731***
	(0.172)	(0.123)	(0.223)	(0.165)	(0.179)	(0.125)
Financial Constraints*State	3.946***			0.049		
	(0.464)			(0.165)		
Financial Constraints*Private		0.330			-0.401*	
		(0.328)			(0.211)	
Financial Constraints*Foreign			-1.014***			-0.211
			(0.231)			(0.171)
Firm Size	0.256***	0.130***	0.242***	0.127***	0.220***	0.126***
	(0.060)	(0.049)	(0.061)	(0.049)	(0.061)	(0.049)
Firm Size^2	-0.023***	-0.014***	-0.022***	-0.014***	-0.019***	-0.014***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
Firm Age	-0.016	-0.001	-0.014	-0.000	-0.011	-0.000
	(0.011)	(0.009)	(0.011)	(0.009)	(0.011)	(0.009)
Constant	-0.697***	-0.004	-0.644***	0.001	-0.577***	0.003
	(0.195)	(0.178)	(0.197)	(0.177)	(0.197)	(0.177)
Observations	13,521	20,714	13,521	20,714	13,521	20,714
R-squared	0.212	0.120	0.206	0.120	0.205	0.120
Industry Dummies	YES	YES	YES	YES	YES	YES
Region Dummies	YES	YES	YES	YES	YES	YES

For firms in heavily polluting industries, financial constraints had no effect on decision-making if they were primarily privately owned. In point of fact, one unit increase of the ICFS would lead to 4‰ increase in environmental investment ratio. SOEs still relieved their financial constraints, but FOEs were still profoundly deterred from making efforts on clean-ups because they faced financial constraints. 1‰ drop could be seen for every unit increment in the ICFS. Noticeably, financial constraints were not a factor that influenced SOEs and FOEs in less polluting industries. Nonetheless, POEs were affected negatively by financial constraints in the investment in pollution control, but the impact was comparatively small, which was only 1‰.

Because financial constraints had different impacts on different ownership structures, it is reasonable to explore further whether financing modes of firms influenced the investment in pollution control. We

considered internal financing and external financing, which were measured by the ratios of net income to total asset and interest expense to total asset, respectively. Hence, we introduced a new item in the interaction term, which was in the form of the product of Financial Constraint × the ownership structure × cash flow (CF) ratio or bank loan interest ratio (Table 4).

Table4. Regressions results of financial constraints impacting on the investment of environmental protection considering internal and external financing mechanisms

	OLS with fixed effects			Dep. Var.=Exhaust Gas Expense/Assets		
	Internal financing mechanism			Bank financing mechanism		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Financial Constraints	-0.564***	0.001	-0.342***	-0.476***	0.068	-0.220**
	(0.116)	(0.143)	(0.118)	(0.105)	(0.140)	(0.108)
Financial Constraints*State	1.369***			0.703*		
	(0.374)			(0.407)		
Financial Constraints*Private		-0.650***			-0.635*	
		(0.146)			(0.382)	
Financial Constraints*Foreign			-0.324*			-0.460***
			(0.166)			(0.166)
Financial Constraints*State*CF	4.671					
	(4.476)					
Financial Constraints*Private *CF		1.339***				
		(0.249)				
Financial Constraints*Foreign*CF			0.234			
			(0.925)			
Financial Constraints*State*Bank				84.771***		
				(19.628)		
Financial Constraints*Private *Bank					10.057	
					(10.631)	
Financial Constraints*Foreign*Bank						15.626
						(10.128)
Firm Size	0.182***	0.161***	0.160***	0.169***	0.160***	0.152***
	(0.038)	(0.038)	(0.038)	(0.039)	(0.035)	(0.040)
Firm Size^2	-0.018***	-0.016***	-0.016***	-0.016***	-0.016***	-0.015***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm Age	-0.009	-0.005	-0.006	-0.006	-0.006	-0.005
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	-0.198	-0.153	-0.159	-0.186	-0.163	-0.162
	(0.160)	(0.157)	(0.159)	(0.162)	(0.152)	(0.162)
Observations	32,944	32,944	32,944	31,195	31,195	31,195

R-squared	0.167	0.164	0.163	0.170	0.167	0.167
Industry Dummies	YES	YES	YES	YES	YES	YES
Region Dummies	YES	YES	YES	YES	YES	YES

As we mentioned before, SOEs primarily relied on bank loans for financing. Thus, the bank loan interest interaction term had a significantly positive sign, but the cash flow ratio interaction term was not significant. In addition, SOEs were very efficient in obtaining bank loans, where one unit increase in the bank loan interest ratio while smoothing the financial constraints could lead to 84‰ increase in environmental investment ratio.

On the contrary, for POEs that financed themselves by internal methods, financial constraints were not an obstacle to increase efforts on environmental clean-ups, though the internal method was not efficient whose was a 1‰ positive effect. Nevertheless, what is noteworthy in our results for FOEs was that internal or external financing methods did not change their decision-making to reduce pollution emissions.

Conclusion

This study explored the relationship between Chinese manufacturing firms' financial constraints and their investment in environmental protection. Based on the assumptions of investment cash flow sensitivity (FHP) theory, we extended the previous literature on the determinants of a firm's investment in environmental protection by introducing three different types of ownerships: state, private, and foreign. We further exploited the mechanisms that determined the environmental investment when firms were constrained financially.

Our main findings suggested that financial constraints had a strong negative, significant impact on environmental investment. Furthermore, SOEs overcame financial constraints better, however, private and foreign firms suffered dramatically from financial constraints, and their environmental investments were constrained by their financial resources. Our study also described the mechanisms by which different ownership structures solved their financial constraints and investment in environmental problems. SOEs

accessed bank loans more easily and benefited from the soft budget, and external financing supported their investment in environmental protection significantly. On the contrary, we discovered that POEs and FOEs mainly used internal cash flow to smooth their environmental investment to alleviate effects of financial constraints. Our study provides new evidence that is related to financial constraints and investment behavior regarding environmental protection, and it considered the different financing modes that exist due to ownership structure.

Our study had limitations, which provide possibilities for future research. The first problem was related to the cross-sectional data. We used a large cross-sectional dataset rather than panel data, which may have limited our analysis of the dynamic relationship between financial constraints and investment in environmental protection. In addition, recognizing the environmental protection efficiency and investigating the linkages between environmental input and firm performance are important for understanding the possible drivers of a firm's growth.

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