Pol. J. Environ. Stud. Vol. 34, No. 6 (2025), 6625-6636
DOI: *10.15244/pjoes/192584* ONLINE PUBLICATION DATE: 2024-10-28

Original Research

Environmental Regulation, Cost Shifting, and Firms' Environmental Investment Choice: Evidence from China

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Received: 4 March 2024
Accepted: 23 August 2024

Abstract

As rational economic entities, firms may behave myopically if the cost of environmental investment outweighs the benefits. Moreover, in emerging economies with imperfect institutional environments, such as China, firms may shift the cost of environmental investment to customers, for example, by increasing product prices. Therefore, it is crucial to examine firms' environmental investment decisions and cost-shifting strategies under environmental regulation. This study examines the impact of environmental regulation on firms' environmental investment choices and whether this impact varies due to differences in cost-shifting ability. Using a sample of heavily polluting listed firms in China from 2012 to 2021, we find that when faced with environmental regulation, firms are more likely to choose expense environmental investment rather than capital environmental investment. This phenomenon is particularly pronounced for firms with stronger cost-shifting ability. Our further research shows that firms with stronger cost-shifting ability can shift the costs of environmental investment to customers by increasing product prices. This study suggests that in emerging markets such as China with an unfavorable institutional environment, firms' environmental investment may only be aimed at meeting regulatory requirements in the short term. It is possible that the costs of environmental investment are borne by the firm's customers.

Keywords: environmental regulation, cost shifting, environmental investment, price markups

Introduction

Since the beginning of the 21st century, the industrialization of human society has accelerated, leading to global pollution problems. To address the deteriorating natural environment, the Chinese government has implemented a series of environmental regulatory policies [1]. In China, the government can intervene strongly in the market to increase environmental costs for firms, especially those in heavily polluting industries [2]. When faced with environmental regulation, firms in China will incur significant environmental costs, and even their survival may be at risk [3]. Under policy pressure, firms will increase their environmental investment to meet government and public demands, thereby preserving their reputation and avoiding penalties for non-compliance [4]. Environmental investment can be categorized

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into capital environmental investment and expense environmental investment [5]. Capital environmental investment is the investment a firm makes to prevent potential future pollution. Expense environmental investment, on the other hand, is the cost to companies of cleaning up existing pollution. Capital environmental investment is more costly but can increase a firm's market value. However, in emerging markets such as China, where the institutional environment is not yet sound [6], the costs of environmental investment often exceed the benefits. Environmental investment by firms in China may only be aimed at short-term compliance with government environmental regulations. Under policy pressure, firms have increased their environmental investment. However, in pursuit of marginal profit margins, firms may shift the costs of environmental investment to consumers, for example, by increasing the price of products [7].

In this context, the purpose of this study is to examine the impact of environmental regulation on the investment choice of heavily polluting listed firms in China and whether these firms shift the costs of environmental investment to customers through price markups. There are two reasons why we chose heavily polluting listed firms in China as our sample. On the one hand, unlike developed countries, China, as the world's largest developing country, has an imperfect institutional environment and relies mainly on "command control" for government environmental regulation [8]. This lack of flexibility, together with government and public concerns, exerts significant market pressure on firms, which may influence their environmental investment choice. On the other hand, the heavy pollution industries face the greatest pressure from environmental regulation, and both the government and the public pay more attention to the environmental governance practices within the industries. Therefore, samples from heavy pollution industries are the most representative. We select the panel data of China's heavily polluting listed firms from 2012-2021 and construct a panel fixed effects model for regression analysis. We use the relative number of environmental protection investments by each local government in China to measure environmental regulatory intensity and firms' dependence on large customers to measure cost-shifting ability. We utilized panel ordinary least squares (OLS) for regression analysis and incorporated control variables that might potentially distort our research findings, with the objective of more precisely estimating the influence of environmental regulation on firms' environmental investment. Our study aims to determine whether heavily polluting listed firms in China engage in short-sighted environmental investment choices and cost-shifting behaviors in the context of extensive environmental regulation by the Chinese government [9].

Our research makes three marginal contributions: First, the Porter hypothesis suggests that environmental regulation drives firms to invest in technological innovation [10]. However, our study shows that in China, the largest emerging market, the institutional environment is less developed than in developed countries. The costs of environmental investment for firms are outweighed by the benefits. Faced with environmental regulation, firms tend to make short-term environmental investment decisions in response to government oversight. This suggests that the validity of the Porter hypothesis depends on a country's institutional environment. Second, we are the first to integrate environmental regulation, cost-shifting ability, and environmental investment into a single research framework and to identify firms' motivations for cost-shifting. While cost-shifting behavior is unobservable, cost-shifting ability can be measured. We measure cost-shifting ability using a firm's bargaining power with its customers and find that firms with stronger cost-shifting ability can more easily adapt to environmental regulation. Third, we find that firms with stronger cost-shifting ability tend to increase product prices when faced with environmental regulation. This helps, to some extent, to identify firms' cost-shifting behavior.

The remainder of this study is structured as follows: Section 2 reviews the relevant literature and develops hypotheses. Section 3 introduces the data and models. Section 4 presents and analyzes the empirical results. Section 5 provides conclusions.

Literature Review and Hypothesis Development

In this section, we conducted a literature review on environmental regulation, cost shifting, and firms' environmental investment and developed two hypotheses. The first hypothesis examined the relationship between environmental regulation and firms' environmental investment choices. The second hypothesis examined the relationship between the ability to shift costs and firms' environmental investment. To explain the relationship between environmental regulation, cost-shifting ability, and firms' environmental investment, we provided two arguments: the policy responsiveness argument and the customer dependency argument.

The Relationship between Environmental Regulation and Firms' Environmental Investment

The existing literature on the relationship between environmental regulation and firms' environmental investment has taken two main viewpoints: (i) Environmental regulation increases firms' environmental compliance costs, which may squeeze out funds that could have been used for research and development. Firms may have to allocate more funds more quickly to meet government and public expectations, thus reducing capital environmental investment and increasing expense environmental investment [7, 11-13], (ii) Environmental regulatory pressure motivates firms to improve the efficiency of resource allocation and promote

technological innovation. Technological innovation could bring economic benefits to firms, offsetting the costs of environmental investment. Therefore, firms were more inclined to choose capital environmental investment [10, 14, 15]. Some scholars found that the relationship between environmental regulation and firms' environmental investment is influenced by other factors. For instance, Sen (2015) reported that there was a negative correlation between environmental regulation and capital environmental investment, but when there was a significant principal-agent conflict within the firm, the relationship between environmental regulation and capital environmental investment became positive [16]. Liu et al. (2021) pointed out that the level of the legal system could affect the effectiveness of environmental regulation. If the legal system in a region was weak, environmental regulation would not affect firms' environmental investment [17].

The Relationship between Cost-Shifting Ability and Firms' Environmental Investment

Many scholars have noted the phenomenon of cost-shifting behavior in firms [7, 18-21]. For instance, De Miguel and Pazó (2017) found that while environmental regulation promoted product innovation in firms, this innovation didn't necessarily increase the market value of the firms. Instead, it often became an excuse for firms to increase product prices. Anand and Giraud-Carrier (2020) found that firms responded to environmental regulation by reducing output and increasing product prices and recommended that governments should primarily consider the impact on consumers rather than producers. Deng et al. (2022) examined the relationship between China's environmental regulation and the operating profits of steel firms and found that environmental regulation increased the cost-profit margin for firms.

Keynote in the Review

In summary, on the one hand, previous research has examined the impact of environmental regulation on firms' environmental investment without distinguishing between the types of environmental investment that firms make. On the other hand, previous studies have discussed firms' cost-shifting behavior but have neglected the fact that not all firms are able to shift the cost of their environmental investment to their customers. We distinguish between categories of environmental investment by firms (capital environmental investment and expense environmental investment) and use a variety of methods to measure firms' ability to shift cost (customer concentration and customer volatility). We have more precisely identified the firm's environmental investment motivations and cost-shifting behavior.

Hypotheses Development

Building upon the aforementioned literature and taking into account the unique institutional environment in China, we proposed the following two arguments, both of which contributed to the development of the two hypotheses in this study.

Policy Responsive Argument

The environmental regulation policies implemented by the Chinese government are 'command and control' in nature [5]. The central government exerted considerable political pressure on local governments, forcing them to implement environmental governance and fulfill political tasks. In this context, local governments often established a series of environmental protection standards to showcase their achievements and imposed severe penalties on firms that violated environmental regulations. When firms face environmental penalties, they often lose government policy incentives, receive more negative media coverage, face negative consumer evaluations, and experience a rapid loss of market share, possibly even facing bankruptcy and liquidation [22]. Therefore, even though investing in environmental protection significantly increased firms' operating costs, they continued to invest in energy conservation and pollution reduction to avoid local government environmental penalties [23]. The Chinese government placed more emphasis on the environmental performance of firms in each operating year than on the specific types of environmental investment chosen by firms [24]. In addition, China's environmental regulation policies were characterized by considerable uncertainty [25], making it difficult for firms to predict future trends in environmental standards. Firms need to adapt their environmental investment strategies as environmental regulation policies change to meet government policy requirements in the short term.

Customer Dependency Argument

As China's environmental regulation focused primarily on the environmental performance of firms rather than other aspects, firms were able to covertly shift the costs of environmental investment to customers by increasing product prices. However, not all firms have the ability to shift these costs to customers, especially those that rely heavily on large customers [26]. Increasing product prices could be a significant challenge for them, as it could lead to a loss of business from these large customers. In contrast to developed countries, having stable, large customers in China is seen as a positive signal for firms [27]. It means that they could achieve consistent operating profits and gain access to low-interest bank loans. Outside investors were also more likely to purchase stocks of these firms. To maintain relationships with large customers, firms were more reluctant to increase product prices and

found it more difficult to shift the costs of environmental investment to these customers. Conversely, firms with lower customer concentrations have greater bargaining power and a lesser need to maintain customer relationships, making it easier for them to shift the burden of environmental investment costs to customers.

Hypotheses

Based on these two arguments regarding China's unique institutional environment and its impact on firms' environmental investment choices and price markups, we develop the following two hypotheses:

H1: In the face of environmental regulation, firms are more likely to choose expense environmental investment rather than capital environmental investment.

H2: Firms with lower dependence on large customers can more easily increase environmental investment because they can shift the costs of environmental investment to customers through price markups.

Data and Models

This section consists of two parts. First, we introduce the sample selection process, provide definitions for the variables used in this study, and conduct a descriptive statistical analysis. Second, we construct two models and explain how these models address the two hypotheses we have developed.

Data and Variables

Given the redefinition of industry classification for listed firms by the China Securities Regulatory Commission (CSRC) in 2012 and taking into account the availability and completeness of data, this study focuses on listed firms in China's heavily polluting industries from 2012 to 2021. We obtained initial observations for 5,045 firm-year periods. The variables related to environmental regulation are derived from the Statistical Yearbook of Chinese Provinces, while other variables are derived from the China Stock Market & Accounting Research Database (CSMAR).

Sample Selection Process

As reported in Table 1, we conducted the following selection steps: (i) exclude firms marked with 'ST' or 'PT' as their operating status is likely to be abnormal and their financial data unreliable; (ii) exclude firms without financial information. In the end, we obtained 4,689 firm-year observations, accounting for 92.94% of the initial sample.

Measurement of Environmental Investment

Capital environmental investment can generate long-term assets and provide future benefits to firms, while expense environmental investment is merely a short-term response to government policies. Drawing on the research of Su and Liu (2023), we measure capital environmental investment by summing the amounts related to environmental investment in construction projects on the balance sheet (CAPI). Similarly, we measure expense environmental investment by summing the amounts related to environmental investment in management expenses on the income statement (EXPE). In order to mitigate the effects of size differences between firms, the above variables are logarithmically transformed.

Measurement of Environmental Regulation

Since 2012, the central and local governments in China have implemented a large number of environmental regulatory policies, with significant differences in the intensity of enforcement across regions. Drawing on the study by Liu et al. (2023) [28], we measure environmental regulation intensity (REGU) by the proportion of investment in air and water pollution treatment at the firm's location to the value of industrial output in that year. The advantage of using this measurement is that it is exogenous to the firm, reduces endogeneity concerns, and fully accounts for differences in the enforcement intensity of environmental regulation across regions.

Measurement of Cost-Shifting Ability

In this study, we primarily examine the ability to shift costs to customers. According to the study by [29], we measure the ability of firms to shift costs (SHIFT) using customer concentration (the proportion of sales from the top five customers to total sales). We divide the sample based on the median customer concentration: if a firm's customer concentration is higher than the median, the variable "SHIFT" is valued at 1, otherwise, it is valued at 0.

Measurement of Price Markups

According to the study by Su et al. (2023) [30], we measure price markups using the ratio of operating profit to operating revenue, as shown in the model (1). In this model, MARKUP is the price markup, PROFIT is the operating profit, DEPR is the depreciation amount, and REVE is the operating revenue. There are two advantages to using the model (1) to measure price markups. First, operating profit does not include interest and taxes, so it can capture all the information related to a firm's product sales activity. Second, by using operating revenue instead of operating costs as the denominator, we can avoid the impact of other unobservable factors that may cause abnormal changes in a firm's sales revenue.

Table 1. Sample selection process.

Population	5045
Step1: exclude firms marked with "ST" or "PT"	110
Step2: exclude firms without financial information	246
Sample	4689
Sample/population (%)	92.94%

$$MARKUP_{i,t} = \frac{PROFIT_{i,t} + DEPR_{i,t}}{REVE_{i,t}} \quad (1)$$

Measurement of Control Variables

Due to the potential influence of other factors on a firm's environmental investment choice, to mitigate the omitted variable problem, we add eight control variables related to firms' financial position, governance characteristics, and institutional environment, as shown in Table 2.

Descriptive Statistical Analysis

Table 3 shows the descriptive statistics of the variables. In terms of environmental investment, the mean value of CAPI (3.191) is smaller than EXPE (3.510), indicating that the amount of expense environmental investment in China's heavily polluting listed firms is larger than the capital environmental investment. In terms of environmental regulation, REGU has a standard deviation of 0.188, with a minimum value of 0.010 and a maximum value of 0.980, indicating significant differences in the intensity of environmental regulation faced by different firms. As for the ability to shift costs, SHIFT has a mean value of 0.460, indicating that, based on our classification, approximately 46% of the firms in the sample are considered to have a strong ability to shift costs. For the control variables, ROA, LEV, SIZE, AGE, and TOP1 have similar mean and median values, indicating that the selected characteristics of the sample population conform to a normal distribution. The mean of DUAL is 0.258, indicating that 25.8% of the firms have the chairman as CEO. The mean value of BIG4 is 0.046, indicating that only 4.6% of the firms opt for the services of the "Big Four" international auditors. The standard deviation of INST is 1.836, with a minimum value of 1.836 and a maximum value of 12.39, illustrating significant differences in the institutional environment across regions.

Models

Ordinary Least Squares (OLS) provides estimates of linear correlation and is able to test the relationship between economic variables while controlling for the effects of other factors [31, 32]. Therefore, we use ordinary least squares to test H1 and H2. Specifically, we constructed three OLS regression models. In these models, the explanatory variables are on the left and the explanatory variables are on the right. We focus on the sign and significance of the regression coefficients for the core explanatory variable (REGU). To test H1, we construct models (2) and (3). In the models, i represents the firm and t represents the year. YEAR represents fixed effects to control for the influence of time variation, while IND represents fixed effects to control for industry differences. ε is the regression residual. We expect β_1 to be insignificant in model (2), while β_1 is significantly positive in model (3). Our expectations imply that when faced with stronger environmental regulation, firms are more inclined to increase expense environmental investment than capital investment.

$$\begin{aligned} CAPI_{i,t} &= \beta_0 + \beta_1 REGU_{i,t} + \beta_2 ROA_{i,t} + \beta_3 LEV_{i,t} \\ &+ \beta_4 SIZE_{i,t} + \beta_5 AGE_{i,t} + \beta_6 DUAL_{i,t} + \beta_7 BIG4_{i,t} \\ &+ \beta_8 TOP1_{i,t} + \beta_9 INST_{i,t} + YEAR + IND + \varepsilon_{i,t} \end{aligned} \quad (2)$$

$$\begin{aligned} EXPE_{i,t} &= \beta_0 + \beta_1 REGU_{i,t} + \beta_2 ROA_{i,t} + \beta_3 LEV_{i,t} \\ &+ \beta_4 SIZE_{i,t} + \beta_5 AGE_{i,t} + \beta_6 DUAL_{i,t} + \beta_7 BIG4_{i,t} \\ &+ \beta_8 TOP1_{i,t} + \beta_9 INST_{i,t} + YEAR + IND + \varepsilon_{i,t} \end{aligned} \quad (3)$$

Table 2. Definition of control variables.

Symbol	Definition
ROA	Return on Total Assets
LEV	The asset-liability ratio
SIZE	The natural logarithm of total assets.
AGE	The natural logarithm of [(observation year - listed year) + 1]
DUAL	When the chairman serves as CEO, the value is 1; otherwise, it is 0
BIG4	When a company is audited by one of the "Big Four" international auditors, the value is 1; otherwise, it is 0
TOP1	The ownership percentage of the largest shareholder
INST	The index is sourced from the China Market Index Database (CMID), which has long been used to measure the institutional environment in different regions of China.

Table 3. Summary statistics of variables.

Variables	N	Mean	S.D.	Min.	Median	Max.
CAPI	4689	3.191	6.530	0	0	22.01
EXPE	4689	3.510	6.360	0	0	19.58
REGU	4689	0.208	0.188	0.010	0.150	0.980
SHIFT	4689	0.460	0.498	0	0	1
ROA	4689	0.037	0.058	-0.214	0.036	0.213
LEV	4689	0.426	0.203	0.047	0.425	0.886
SIZE	4689	22.24	1.271	20.04	22.03	25.77
AGE	4689	2.129	0.872	0	2.303	3.296
DUAL	4689	0.258	0.437	0	0	1
BIG4	4689	0.046	0.210	0	0	1
TOP1	4689	0.342	0.146	0.093	0.316	0.738
INST	4689	9.209	1.836	2.813	9.477	12.39

We conduct a two-step test of H2. First, we divide the samples into two groups based on the value of SHIIT (0 or 1) and perform a regression on model (3) for each group. We expect that when the firm's ability to shift costs is weaker (SHIFT=0), β_1 will be positive but insignificant; when the firm's ability to shift costs is stronger (SHIFT=1), β_1 will be significantly positive. Second, we construct model (4) as a test. We expect α_1 to be significantly positive. Our expectations imply that when faced with more stringent environmental regulations, firms with stronger cost-shifting ability will increase product prices to shift the cost of environmental investment to their customers, while firms with weaker cost-shifting ability will find it difficult to shift the cost of their environmental investment to their customers by increasing product prices because they are more dependent on their customers.

$$MARKUP_{i,t} = \alpha_0 + \alpha_1 REGU_{i,t} + \alpha_2 ROA_{i,t} + \alpha_3 LEV_{i,t} + \alpha_4 SIZE_{i,t} + \alpha_5 AGE_{i,t} + \alpha_6 DUAL_{i,t} + \alpha_7 BIG4_{i,t} + \alpha_8 TOP1_{i,t} + \alpha_9 INST_{i,t} + YEAR + IND + \varepsilon_{i,t} \quad (3)$$

Results and Discussion

Two-Sample T-Test

Table 4 shows the results of two-sample t-tests. In Panel A, we divide the samples into two groups

Table 4. Two-sample t-test.

Panel A: Mean value of variables partitioned by environmental regulation intensity			
Variables	Environmental regulation intensity	Mean	Mean difference
CAPI	High Environmental Regulatory Intensity	3.327	0.242
	Low Environmental Regulatory Intensity	3.085	
EXPE	High Environmental Regulatory Intensity	4.274	1.363***
	Low Environmental Regulatory Intensity	2.912	
Panel B: Mean value of variables partitioned by cost-shifting ability			
Variables	Cost-shifting ability	Mean	Mean difference
CAPI	SHIFT=1	3.556	0.675***
	SHIFT=0	2.881	
EXPE	SHIFT=1	3.751	0.447***
	SHIFT=0	3.304	
REGU	SHIFT=1	0.201	-0.014
	SHIFT=0	0.214	

Table 5. Regression results on the impact of environmental regulation on environmental investment.

Panel A: Regression results without controlling for any factors		
	(1)	(2)
	CAPI	EXPE
REGU	0.455	5.730***
	(0.898)	(11.774)
_cons	3.097***	2.317***
	(21.772)	(16.973)
YEAR FE	NO	NO
IND FE	NO	NO
Number of obs.	4689	4689
Adjust-R^2	0.000	0.029
Panel B: Regression results without controlling for year and industry effects		
	(1)	(2)
	CAPI	EXPE
REGU	-0.452	2.620***
	(-0.768)	(4.708)
ROA	3.000	-0.796
	(1.589)	(-0.446)
LEV	0.698	1.704***
	(1.104)	(2.851)
SIZE	0.612***	0.747***
	(5.996)	(7.743)
AGE	0.563***	0.231*
	(4.317)	(1.869)
DUAL	-0.111	0.580***
	(-0.489)	(2.709)
BIG4	-1.646***	-1.049**
	(-3.524)	(-2.375)
TOP1	1.964***	2.040***
	(2.849)	(3.130)
INST	0.024	-0.424***
	(0.389)	(-7.184)
_cons	-12.723***	-11.735***
	(-5.967)	(-5.821)
YEAR FE	NO	NO
IND FE	NO	NO
Number of obs.	4689	4689
Adjust-R^2	0.033	0.088

based on the median of REGU to test the difference in means between the groups. We find that when faced with stringent environmental regulation, firms significantly increase their expense environmental investment (EXPE), but there is no significant increase in capital environmental investment (CAPI). In Panel B, we divide the samples into two groups based on the values of SHIFT to test the difference in means between the groups. The results indicate that firms with stronger cost-shifting ability (SHIFT=1) tend to engage in more environmental investment. Furthermore, the examination of environmental regulations (REGU) reveals no significant difference in the intensity of regulations faced by firms with different cost-shifting abilities. This provides a clean experimental condition to examine the relationship among environmental regulations, cost-shifting ability, and environmental investment choice.

Regression Analysis of Environmental Regulation and Environmental Investment Choice

The results in Table 5 provide regression results on the impact of environmental regulation on environmental investment. Column (1) presents the regression results for model (2), while column (2) presents the regression results for model (3). Panel A shows the results without controlling for other factors. In column (1), the coefficient for REGU is positive, but with a t-value of only 0.898, indicating no significant relationship. In column (2), however, the coefficient on REGU is 5.730, which is statistically significant at the 1% level. Panel B builds on Panel A by adding control variables, but does not control for year and industry effects. In column (1), the coefficient on REGU becomes negative but remains insignificant. On the other hand, in column (2), the coefficient on REGU is 2.620, which is statistically significant at the 1% level. Panel C includes the addition of year and industry effects based on panel B. In column (1), the coefficient on REGU is negative but insignificant. In column (2), however, the coefficient on REGU is 1.917, which is statistically significant at the 1% level. The above results suggest that stricter environmental regulation has promoted expense environmental investment by firms. However, it does not have a significant impact on capital environmental investment and may even reduce capital environmental investment (the regression coefficients of REGU on CAPI in Panel B and Panel C are both negative). Our test results are consistent with the policy-responsive argument and provide support for H1.

Regression Results are Partitioned by Different Cost-Shifting Abilities

In this section, we examine the effect of environmental regulation on the choice of environmental investment, taking into account different cost-shifting abilities, as shown in Table 6. The results in columns

Table 5. Table continued.

Panel C: Regression results of model (2) and (3)		
	(1)	(2)
	CAPI	EXPE
REGU	-0.108	1.917***
	(-0.165)	(2.807)
ROA	2.587	-0.322
	(1.374)	(-0.183)
LEV	1.250**	1.809***
	(2.027)	(2.940)
SIZE	0.649***	0.887***
	(6.103)	(8.098)
AGE	0.661***	0.358***
	(5.479)	(3.044)
DUAL	-0.292	0.535**
	(-1.367)	(2.561)
BIG4	-1.408***	-1.097**
	(-2.935)	(-2.321)
TOP1	2.939***	2.016***
	(4.053)	(2.933)
INST	0.006	-0.384***
	(0.096)	(-6.134)
_cons	-17.398***	-16.832***
	(-7.827)	(-7.295)
YEAR FE	YES	YES
IND FE	YES	YES
Number of obs.	4689	4689
Adjust-R^2	0.050	0.098

(1)-(2) indicate that regardless of a firm's cost-shifting ability, environmental regulation does not have a significant effect on capital environmental investment, which is consistent with the policy-responsive argument. However, the coefficient of REGU is positive in column (1) and negative in column (2), suggesting that firms with stronger cost-shifting ability may have a greater ability to engage in capital environmental investment. The regression coefficient of REGU in column (3) is 3.572, which is significant at the 1% level. In column (4), the regression coefficient of REGU is 0.985, but the t-value is only 1.157. This suggests that when environmental regulation is strengthened, firms with stronger cost-shifting ability engage in more expense-related environmental investment compared to firms with weaker cost-shifting ability.

Regression Results of the Impact of Environmental Regulation on Price Markups

Table 7 shows the regression results for model (4) partitioned by different cost-shifting abilities. In column (1), the regression coefficient of REGU is 0.043, which is significant at the 1% level. This indicates that when environmental regulation is strengthened, firms with stronger cost-shifting ability are less dependent on large customers. They tend to shift the costs of environmental investment to customers by increasing product prices. In column (2), the regression coefficient of REGU is -0.013, but the t-value is only -0.780. This suggests that the strengthened environmental regulation exerts external pressure on firms. Firms with weaker cost-shifting ability are more dependent on large customers. They do not increase product prices and may even prevent customer loss by offering discounts. Our test results are consistent with the customer dependency argument and provide support for H2.

Replace the Measurement Method of Cost-Shifting Ability

To enhance the robustness of our conclusions, we replace the measure of cost-shifting ability by drawing on the studies of Patatoukas (2012) and Bi et al. (2022) [33, 34]. We use customer volatility (VOLA) as a measure of cost-shifting ability, which is calculated as the standard deviation of sales from the top five customers over the last three years. We divide the sample based on the median of customer volatility, where if a firm's customer volatility is higher than the median, the variable 'VOLA' is valued at 1, otherwise it's valued at 0. As shown in Table 8, our test results are consistent with Tables 6 and 7 in terms of both the sign and the significance of the regression coefficients. This suggests that firms with more stable customers will shift the costs of environmental investment to customers by increasing product prices.

Theoretical Implications

On the one hand, this study reveals an additional condition for the validity of Porter's hypothesis. In emerging markets with imperfect institutional environments, like China, high-pressure environmental regulation does not induce firms to make long-term environmental investments; instead, firms opt for short-term, expense-based environmental investments in response to compliance pressures. We propose the 'policy responsive argument' to explain this phenomenon. This argument also suggests that in emerging markets with imperfect institutional environments, the validity of Porter's hypothesis depends on the regulatory mode of environmental policy and the cost-benefit ratio of firms' environmental investment [35]. On the other hand, this study is an extension of the Information Asymmetry Theory. Unlike developed countries, China's capital

Table 6. Regression results partitioned by different cost-shifting ability.

	(1)	(2)	(3)	(4)
	CAPI		EXPE	
	SHIFT=1	SHIFT=0	SHIFT=1	SHIFT=0
REGU	0.210	-0.375	3.572***	0.985
	(0.186)	(-0.460)	(3.053)	(1.157)
ROA	4.119	1.857	4.429	-3.714*
	(1.223)	(0.829)	(1.566)	(-1.657)
LEV	1.211	1.391*	2.536**	1.427*
	(1.169)	(1.782)	(2.565)	(1.804)
SIZE	0.539***	0.710***	1.018***	0.780***
	(3.126)	(4.949)	(6.000)	(5.245)
AGE	0.634***	0.632***	0.044	0.542***
	(2.903)	(4.211)	(0.220)	(3.651)
DUAL	-0.288	-0.299	0.713**	0.377
	(-0.841)	(-1.111)	(2.257)	(1.380)
BIG4	-1.399*	-1.808***	-1.327**	-0.848
	(-1.923)	(-3.116)	(-1.992)	(-1.239)
TOP1	3.576***	2.158**	-0.244	3.929***
	(3.004)	(2.337)	(-0.233)	(4.322)
INST	0.098	-0.064	-0.529***	-0.283***
	(0.872)	(-0.873)	(-4.860)	(-3.731)
_cons	-13.608***	-17.708***	-15.330***	-16.219***
	(-3.543)	(-5.887)	(-4.126)	(-5.130)
YEAR FE	Yes	Yes	Yes	Yes
IND FE	Yes	Yes	Yes	Yes
Number of obs.	2156	2533	2156	2533
Adjust-R^2	0.047	0.049	0.120	0.083

Table 7. Regression results of the impact of environmental regulation on price markup.

	(1)	(2)
	MARKUP	MARKUP
	SHIFT=1	SHIFT=0
REGU	0.043***	-0.013
	(2.945)	(-0.780)
ROA	1.475***	1.865***
	(27.284)	(31.473)
LEV	-0.021	-0.066***
	(-1.434)	(-3.752)
SIZE	0.012***	0.021***
	(5.301)	(7.238)

Table 7. Table continued.

AGE	0.002	-0.008***
	(0.890)	(-2.654)
DUAL	0.004	0.022***
	(0.993)	(4.415)
BIG4	0.011	-0.011
	(1.576)	(-0.652)
TOP1	-0.093***	-0.088***
	(-7.526)	(-5.137)
INST	-0.006***	-0.010***
	(-4.684)	(-5.903)
_cons	-0.078	-0.150**
	(-1.532)	(-2.400)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Number of obs.	2156	2533
Adjust-R^2	0.575	0.601

Table 8. Measuring cost-shifting ability using customer volatility.

	(1)	(2)	(3)	(4)	(5)	(6)
	CAPI		EXPE		MARKUP	
	VOLA=0	VOLA=1	VOLA=0	VOLA=1	VOLA=0	VOLA=1
REGU	0.465	-0.251	3.184***	1.327	0.032*	-0.005
	(0.406)	(-0.311)	(2.661)	(1.619)	(1.808)	(-0.334)
ROA	2.041	2.991	1.750	-2.029	1.648***	1.739***
	(0.582)	(1.362)	(0.560)	(-0.961)	(25.196)	(31.760)
LEV	1.352	1.355*	2.881***	1.146	-0.013	-0.070***
	(1.235)	(1.821)	(2.716)	(1.512)	(-0.744)	(-4.251)
SIZE	0.440**	0.766***	0.830***	0.842***	0.017***	0.018***
	(2.432)	(5.688)	(4.427)	(6.197)	(6.110)	(6.638)
AGE	0.898***	0.590***	0.199	0.350**	-0.007*	-0.004
	(3.331)	(4.124)	(0.743)	(2.484)	(-1.802)	(-1.427)
DUAL	-0.386	-0.218	0.819**	0.273	0.018***	0.009**
	(-1.040)	(-0.839)	(2.349)	(1.063)	(3.577)	(1.980)
BIG4	-1.777**	-0.873	-1.202	-0.877	0.010	-0.007
	(-2.530)	(-1.298)	(-1.596)	(-1.481)	(1.067)	(-0.505)
TOP1	1.792	3.508***	2.538**	1.576*	-0.073***	-0.075***
	(1.441)	(3.910)	(2.111)	(1.900)	(-4.113)	(-5.068)
INST	0.065	-0.022	-0.606***	-0.276***	-0.009***	-0.009***
	(0.593)	(-0.289)	(-5.271)	(-3.774)	(-4.665)	(-5.644)
_cons	13.887***	18.346***	13.718***	14.029***	-0.062	-0.114**

Table 8. Table continued.

	(-3.667)	(-6.194)	(-3.418)	(-4.809)	(-1.077)	(-1.968)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs.	1956	2733	1956	2733	1956	2733
Adjust-R^2	0.034	0.057	0.108	0.085	0.573	0.575

market is Weak-Form Market Efficient [36], thus a high concentration of large customers is considered "good news" by the capital market [37]. In order to continue to provide good news to the public, firms with large customers will try to maintain a high concentration of customers, which makes it more difficult for them to shift the cost of environmental investment to their customers. We propose the 'customer dependence argument' to explain this phenomenon. Overall, this study contributes to the improvement of capital market theory in emerging markets.

Conclusions

This study examines the relationship among environmental regulation, cost-shifting ability, and environmental investment choice based on a sample of heavily polluting Chinese listed firms from 2012 to 2021. The main conclusions are as follows: First, environmental regulation promotes firms' expense environmental investment, but does not affect capital environmental investment. Second, firms with less dependence on large customers and those with a more stable customer base have stronger cost-shifting ability, which allows them to shift the costs of environmental investment to customers through price markups.

In light of our findings, we suggest two policy recommendations. First, government environmental departments should extend the evaluation period for firms' environmental performance, with a focus on evaluating firms' capital environmental investment. Second, the Chinese government should place more emphasis on the effect of environmental regulation on consumers rather than only on producers.

Although this study uses various methods to measure firms' cost-shifting ability, it still lacks direct observation of firms' cost-shifting behavior, which may introduce certain errors in our research conclusions. In addition, we only consider cost shifting to customers, while firms may still shift environmental investment costs to other stakeholders. Subsequent studies can further complement these aspects.

Acknowledgments

This work was supported by National key research projects of accounting (2023KJA3-12); Guangxi science and technology development strategy research project (ZL23014022); Project of Tibet science and technology department (XZ202301ZY0004F). project of Education Accounting Society of China (JYKJ2022-001ZD); project of China association of higher education (22JJ0101); Beijing education science “14th five-year plan” 2022 annual key project (AGAA22053); Project of association of Chinese graduate education (2020ZAC4).

Conflicts of Interest

The authors declare no conflict of interest.

References

1. LUO Z., QI, B.C. The Effect of environmental regulation on industrial transfer and upgrading and banking synergetic development: evidence from water pollution control in the yangtze river basin. Economic Research Journal, **1** (02), **2021**.
2. YANG J., GUO H., LIU B., SHI R., ZHANG B., YE W. Environmental regulation and the pollution haven hypothesis: do environmental regulation measures matter? Journal of Cleaner Production, 202, **2018**.
3. CAI X., LU Y., WU M., YU L. Does environmental regulation drive away inbound foreign direct investment? Evidence from a quasi-natural experiment in China. Journal of Development Economics, 123, **2016**.
4. LIAO Z. Environmental policy instruments, environmental innovation and the reputation of enterprises. Journal of Cleaner Production, 171, **2018**.
5. PATTEN D.M. The accuracy of financial report projections of future environmental capital expenditures: A research note. Accounting, Organizations and Society, **30** (5), **2005**.
6. WANG Q., WONG T.J., XIA L. State ownership, the institutional environment, and auditor choice: Evidence from China. Journal of Accounting and Economics, **46** (1), **2008**.
7. ANAND K.S., GIRAUD-CARRIER F.C. Pollution regulation of competitive markets. Management Science, **66** (9), **2020**.
8. WANG C., YANG Y., ZHANG J. China's sectoral strategies in energy conservation and carbon mitigation. Climate policy, **15** (S1), **2015**.
9. YU Y., YIN L. The evolution of Chinese environmental regualtion policy and its economic effects: A summary and prospect. Reform, **1** (03), **2022**.
10. PORTER M.E., LINDE C.V.D. Toward a new conception of the environment-competitiveness relationship. Journal

of Economic Perspectives, **9** (4), **1995**.
11. KATSOULACOS Y., ULP A., ULPH D. The effects of environmental policy on the performance of environmental research joint ventures. M. Behavioral and distributional effects of environmental policy. University of Chicago Press, 309, **2001**.
12. GRAY W.B., SHADBEGIAN R.J. Plant vintage, technology, and environmental regulation. Journal of Environmental Economics and Management, **46** (3), **2003**.
13. KNELLER R., MANDERSON E. Environmental regulations and innovation activity in UK manufacturing industries. Resource and Energy Economics, **34** (2), **2012**.
14. TURKEN N., CARRILLO J., VERTER V. Strategic supply chain decisions under environmental regulations: When to invest in end-of-pipe and green technology. European Journal of Operational Research, **283** (2), **2020**.
15. CHEN J., WANG X., SHEN W., TAN Y., MATAC L.M., SAMAD S. Environmental uncertainty, environmental regulation and enterprises' green technological innovation. International Journal of Environmental Research and Public Health, **19** (16), 9781, **2022**.
16. SEN S. Corporate governance, environmental regulations, and technological change. European Economic Review, 80, **2015**.
17. LIU Y., HUANG Z., LIU X. Environmental regulation, management's compensation incentive and corporate environmental investment: evidence from the implementation of the environmental protection law in 2015. Accounting Research, **1** (05), **2021**.
18. MARION J., MUEHLEGGER E. Fuel tax incidence and supply conditions. Journal of Public Economics, **95** (9-10), **2011**.
19. KOPCZUK W., MUNROE D. Mansion tax: The effect of transfer taxes on the residential real estate market. American Economic Journal: Economic Policy, **7** (2), **2015**.
20. DE MIGUEL C., PAZÓ C. Environmental protection, innovation and price-setting behavior in Spanish manufacturing firms. Energy Economics, 68, **2017**.
21. DENG Z., GAO T., PANG R., YANG C. Enterprise passive collusion: welfare effect analysis of environmental regulation under goals of carbon peaking and carbon neutrality. China Industrial Economics, **1** (07), **2022**.
22. WU J., SONG Z., LIANG M. On the Chinese solution of market reputation punishment failure and its efficacy: Evidence based on the practice of environmental dishonest joint punishment system in China. Economic Theory and Business Management, **43** (01), **2023**.
23. CUI G., JIANG Y. Does government environmental penalties promote environmental protection investment of manufacturing enterprises. China Economic Studies. **1** (02), **2022**.
24. YU Y., YIN L. The evolution of Chinese environmental regualtion policy and its economic effects: A summary and prospect. Reform, **1** (03), **2022**.
25. LIU Y., ZHOU S. The coordination mechanism of formal and informal environmental regulation reducing pollution and carbon emission benefits. Collected Essays on Finance and Economics, **1** (08), **2023**.
26. DHALIWAL D., MICHAS P.N., NAIKER V., SHARMA D. Greater reliance on major customers and auditor going-concern opinions. Contemporary Accounting Research, **37** (1), **2020**.
27. WANG D., LI, D., LI, H. Customer concentration and corporate investment efficiency. Accounting Research, **1** (01), **2020**.
28. LIU C., PAN H., LI P., FENG Y. Impact and mechanism of digital transformation on the green innovation efficiency of manufacturing enterprises in China. China Soft Science, **1** (04), **2023**.
29. DHALIWAL D., JUDD J.S., SERFLING M., SHAIKH S. Customer concentration risk and the cost of equity capital. Journal of Accounting and Economics, **61** (1), **2016**.
30. SU R., LIU Y. The tax reduction effect of environmental protection investment in Chinese enterprises: from the perspective of environmental subsidies and lifecycle. The World of Survey and Research, **1** (10), **2023**.
31. ALI S., XIAOHONG Z., HASSAN S.T. The hidden drivers of human development: Assessing its role in shaping BRICS-T's economics complexity, and bioenergy transition. Renewable Energy, 221, **2024**.
32. ALI S., FAROOQ M., XIAOHONG Z., HEDVICAKOVA M., MURTAZA G. Board characteristics, institutional ownership, and investment efficiency: Evidence from an emerging market. PLoS One, **19** (2), **2024**.
33. PATATOUKAS P.N. Customer-base concentration: Implications for firm performance and capital markets: 2011 American accounting association competitive manuscript award winner. The Accounting Review, **87** (2), 363, **2012**.
34. BI X., XING X., JIANG B. Does the customer culture promote enterprise innovation? Evidence from Chinese manufacturing listed companies. Accounting Research, **1** (2), **2020**.
35. MEHMOOD K., TAUSEE H.S. Comparative analysis of CO2 emissions and economic performance in the United States and China: Navigating sustainable development in the climate change era. Geoscience Frontiers, **15** (5), **2024**.
36. AZEEM A., NASEEM M.A, ALI R., ALI S. How does environmental performance contribute to firm financial performance in a multi-country study? Mediating role of competitive advantage and moderating role of voluntary environmental initiatives. Journal of the Knowledge Economy, 1, **2024.**
37. MEHMOOD K., HASSAN S.T., QIU X., ALI S. Comparative analysis of CO2 emissions and economic performance in the United States and China: Navigating sustainable development in the climate change era. Geoscience Frontiers, **15** (5), **2024.**