

DOES ENVIRONMENTAL TAX PROMOTE GREEN INVESTMENT OF MANUFACTURING FIRMS? EVIDENCE FROM CHINESE HEAVY-POLLUTING LISTED COMPANIES

REN, G. F.* – LU, Y. X.

*School of Management, Jiujiang University, No.551, Qianjin East Road, Jiujiang 332005, Jiangxi Province, China
(phone/fax: +86-0792-833-4037)*

**Corresponding author
e-mail: gaofei_ren@163.com*

(Received 12th Jan 2023; accepted 10th Mar 2023)

Abstract. The green investment of manufacturing firms is not only the key measure to implement the China intelligent manufacturing development plan in the 14th five-year plan, but also an important technical path to achieve the national carbon peaking and carbon neutrality goals on schedule. Does environmental tax promote green investment of manufacturing firms? Taking the Chinese heavy-polluting listed companies from 2015 to 2019 as a sample, this study analyses the impact of environmental tax on green investment in manufacturing firms. The results show that environmental tax can significantly promote green investment of manufacturing firms. Further research shows that the nature of property rights and the degree of regional marketization moderate the relationship between environmental tax and green investment; in non-state-owned firms and areas with high degree of marketization, environmental tax plays a more significant role in promoting manufacturing firms' green investment.

Keywords: *manufacturing firms, heavy pollution, environmental tax, green investment, carbon emission reduction*

Introduction

The manufacturing industry is an important cornerstone of China's industrial development and the main support for economic development. However, the development mode characterized by high consumption, high pollution, and high emission is still dominant in China's manufacturing industry at present (Sun et al., 2020). Environmental pollution and energy consumption have become the main bottlenecks in the high-quality development, transformation, and upgrading of the manufacturing industry. Reviewing the existing relevant literatures, it is found that although there are many studies on the impact of environmental tax on firms' green investment, the research conclusions are not the same based on the different sample selection and model construction (Lei et al., 2022; Liu et al., 2022; Shen et al., 2021; Tchórzewska et al., 2022; Yasmeen et al., 2023). The effect and mechanism of environmental tax on firms' green investment need to be further clarified. China's environmental protection tax was levied late, and more scholars focused on the rationality of the environmental protection tax policy and the impact of the environmental tax.

Although the impact of the environmental tax on firms' green investment was analyzed theoretically (Carfora et al., 2021; Fan et al., 2019; Rustico and Dimitrov, 2022), there was a lack of empirical investigation based on empirical analysis. At the level of research objects, existing studies mostly analyze the double dividend of

environmental tax, economic effect, and its relationship with economic growth and green transformation of firms from the level of the whole industry, and rarely study the impact of environmental tax on green investment of heavy-polluting manufacturing firms from the micro level. Based on the microscopic perspective of manufacturing firms, this paper selects Chinese heavy-polluting listed companies in the manufacturing industry as observation samples to empirically test the impact of environmental taxation on green investment of manufacturing firms and analyzes the heterogeneous impact of environmental taxation on green investment of manufacturing firms under two dimensions of property right nature and regional marketization degree. This study makes up for the research deficiency of environmental tax and green investment; our findings provide new empirical evidence and policy implications for the government's environmental tax regulation and emission reduction governance.

The rest of the paper is organized as follows: Section 2 is the literature review, providing the theoretical analysis of environmental tax and firm investment and theoretical hypotheses. Section 3 provides the research design. Section 4 gives the empirical results and robustness tests. Section 5 concludes and provides policy implications.

Literature review and theoretical hypothesis

Environmental tax and firms' green investment

The introduction of the environmental tax will inevitably produce environmental costs, which, as the production cost of firms, will lead to an increase in the overall cost of firms, and an increase in the stickiness of enterprise costs will accelerate the allocation effect of idle resources of firms, and urge firms to allocate idle resources to green transformation activities, to alleviate the negative impact of environmental tax on enterprise value creation (Bi and Yu, 2016). When the environmental tax exceeds a certain critical value, the increase of environmental tax will encourage firms to make the investment in emission reduction, and the compliance cost brought by the increase of tax burden will also make firms make more investments to reduce pollution emissions (Farzin and Kort, 2000). Therefore, reasonable environmental taxation can promote firms' investment in pollution control and increase the value of products (Porter and Van der Linde, 1995). Moreover, the stricter the government environmental tax is, the more adequate firms' green investment will be (Olson, 1999). In particular, manufacturing firms, due to the characteristics of heavy pollution and high emission, will be able to improve the quality of their products. Under the strong constraint of environmental taxation, if the business strategy remains unchanged, it needs to bear high transaction costs but also needs to bear environmental costs internalized by environmental taxation. Therefore, environmental taxation, as one of the important means of government environmental regulation, has a significant positive correlation between industry attributes and the scale of enterprise environmental protection investment. Heavy-polluting industries will invest more environmental protection funds than non-heavy-polluting industries to reduce the adverse impact of environmental taxation on firms (Cheng et al., 2022; Tang et al., 2013).

When environmental taxation reaches a certain intensity, its impact on firms' environmental costs may be manifested as promotion and inhibition. Tang et al. (2013)

found that there is a U-shaped relationship between the intensity of government environmental regulation and the scale of enterprise environmental investment, and environmental regulation has a significant threshold effect on enterprise environmental investment behavior (Dai et al., 2021; Li et al., 2022a). Before environmental regulation reaches the critical value, the low intensity of government environmental regulation has an inhibitory effect on enterprise environmental investment, and after the critical value, with the gradual increase of environmental regulation intensity, the scale of firms' investment in environmental protection will be larger. Environmental regulation plays a promoting role in firms' investment in environmental protection, and this dual role is more obvious in heavy-polluting industries. Based on this, this study proposes hypotheses 1:

H1: *Environmental tax can significantly promote green investment in manufacturing firms.*

The heterogeneity of environmental tax on firms' green investment

There are great differences between state-owned firms and non-state-owned firms in the nature, internal management, and operation mode (Khalid et al., 2021; Shahab et al., 2019). In terms of the nature of firms, as state-owned firms are owned by the state, funded and controlled by the state as the manager, they have a natural blood relationship with the government, their operation and management will be more affected by government policies and administrative orders. On the other hand, non-state-owned firms have a relatively clear property right structure, a clear relationship between rights, responsibilities, and interests, and less relationship between principal-agent levels (Li et al., 2022b; Yu et al., 2022). To pursue long-term competitiveness and sustainable development of firms, the market mechanism will encourage enterprise managers to actively make the green investments. Meanwhile, compared with state-owned firms, the management, and operation of non-state-owned firms are more flexible and independent (Cao et al., 2022b; Sun et al., 2022). Therefore, environmental taxes may have a greater impact on green investment by non-state-owned firms than by state-owned firms, hypothesis 2 is proposed:

H2: *Compared with state-owned firms, environmental taxation has a more significant impact on green investment of non-state-owned manufacturing firms.*

At present, there are great differences in the degree of marketization among different regions in China. The marketization process in different regions has an impact on environmental quality and environmental investment efficiency through different resource allocation mechanisms (Cui et al., 2019), and the effect of manufacturing firms' green investment may show certain heterogeneity. When an enterprise is located in an area with a strong degree of marketization, on the one hand, environmental policies are stricter and stronger in implementation; on the other hand, market competition is more full and resource allocation is more perfect, which is more conducive to the play of the green effect of environmental taxation and promote the sustainable development of firms by improving the capacity utilization rate (Cao et al., 2022a; Fang et al., 2022). Therefore, compared with regions with a lower degree of marketization, heavy-polluting firms in regions with a higher degree of marketization are more inclined to green transformation and cleaner production due to the economic cost of pollution discharge, the performance evaluation of local officials and the environmental protection market (Pan et al., 2019). Based on this, this study puts forward hypothesis 3:

H3: *Compared with regions with a lower degree of marketization, environmental taxation has a more significant impact on manufacturing firms' green investment in regions with a higher degree of marketization.*

Research design

Model

To test the research hypothesis, this study adopts panel data for empirical analysis. Considering the lag of the environmental tax policy and other major control variables, the basic regression model is set as follows:

$$GI_{i,t} = \beta_0 + \beta_1 ET_{i,t-1} + \Sigma Control_{i,t-1} + \mu_i + \gamma_t + \varepsilon \quad (\text{Eq.1})$$

Here, i represents the firm, t represents the year, $GI_{i,t}$ is the firms' green investment, $ET_{i,t-1}$ is the environmental tax burden of the firms, $\Sigma Control_{i,t-1}$ is all the control variables, μ_i is the industry effect, γ_t is the time effect, and ε is the random disturbance term.

Fixed-effect panel quantile regression is to estimate the influence of the explanatory variable on the whole conditional distribution, that is, under different quantiles of the explained variable, estimate the influence of the explanatory variable on the explained variable. The advantage is that it is not only not susceptible to extreme values, but also can provide comprehensive information about conditional distribution. As shown in *Equation 2*.

$$QGI_{i,t}(\tau|ET_{i,t}) = \beta_i + ET_{i,t}^T \gamma(\tau) \quad i = 1, \dots, n, t = 1, \dots, m_i \quad (\text{Eq.2})$$

Definition of variables

Firms' green investment (GI)

At present, there is no unified environmental disclosure standard and caliber for corporate responsibility reports. This study draws on the research of Zhao et al. (2022) and combines with the actual situation disclosed in financial statements to measure the green investment of manufacturing firms by using the relevant investment project expenditures of pollution prevention, pollution control, and ecological environment restoration in the production and construction process of manufacturing firms.

Environmental tax (ET)

Before the introduction of the environmental protection tax, this study uses the consumption tax, urban land utilization tax, tax on the occupancy of cultivated land, pollutant discharge fee and so on that firms bear the environmental tax; After the introduction of the environmental protection tax, it is measured by environmental protection tax, and some missing data come from the notes to the annual financial statements of firms. To avoid the effect of the coefficient index, the environmental tax is treated logarithmically.

Control variables

Based on relevant studies (Bi and Yu, 2016; Cheng et al., 2018; Hu et al., 2017; Zhang et al., 2019), Select enterprise Size (Size), financial leverage (Lev), profitability (ROA), cash holdings (Cash), operating benefit (Profit), growth capacity (Growth),

board of supervisors size (Board), proportion of independent directors (Indep), profit and loss nature (Loss) as a control variable. Variables' detailed definitions are given in *Table 1*.

Table 1. *Definitions of variables*

Variables	Definitions
GI	Green investments, enterprise investments for environmental protection: the ratio of environmental capital expenditure to total assets in the same year
ET	Environmental tax, enterprise environmental taxes, and pollution charges
Size	Enterprise size, the natural log of total assets at the end of the period
Lev	Financial leverage, the ratio of total liabilities to total assets
ROA	Profitability, the ratio of net profit to total assets
Cash	Cash holding, the number of cash items in the balance sheet of an enterprise
Profit	Operating benefit, the ratio of operating profit to total business income
Growth	Growth rate, the growth rate of operating income
Board	Board of supervisors size, the number of supervisors
Indep	Proportion of independent directors, the ratio of the number of independent directors to the total number of directors
Loss	Profit and loss nature, if the net profit of the current year is positive, take 1, otherwise, take 0

Sample selection and data sources

According to Zhu et al. (2011), based on the measurement of industrial wastewater discharge, solid waste production, and SO₂ discharge of firms, this study selects 12 manufacturing industries (*Table 2*) as heavy-polluting industries using unit output value and standardization. Since the disclosure of green investment data of firms after 2015 is relatively complete, some characteristic variables in the model, such as the latest data of the marketization index, are up to 2019. Therefore, the heavy-polluting manufacturing companies listed in China's A-share market during 2015-2019 are taken as data samples, and the following screening is done: Listed companies with Special Treatment (ST) and *ST in the sample period, fail to disclose their social responsibility reports, missing some control variables. 123 listed companies (including 54 state-owned enterprises) were selected and 615 sample data were obtained. The data mainly came from China Stock Market & Accounting Research (CSMAR) database. To avoid the influence of outliers on the analysis results, all continuous variables were winsorized at the 1% and 99% fractile.

Empirical results and discussion

Descriptive statistics analysis

Through descriptive statistical analysis of the sample data, the results are shown in *Table 3*. It can be seen that, as the explained variable, the difference between the minimum value and the maximum value of corporate green investment (GI) is 0.320 units, and the standard deviation is 0.065, indicating that the scale of green investment of different sample firms presents great differences. As an explanatory variable, the difference between the minimum value and the maximum value of environmental tax

(ET) is 9.72, and the standard deviation is 2.007, indicating that the environmental tax burden of different firms is also significantly different, and other control variables are consistent with the normal distribution and the actual situation of firms.

Table 2. Description of heavy-polluting industries

Industry code	Description
B06	Coal mining and washing industry
B07	Oil and gas extraction industry
B08	Black metal mining industry
B09	Nonferrous metal mining industry
C25	Petroleum processing, coking, and nuclear fuel processing industries
C26	Manufacturing of chemical raw materials and chemical products
C28	Chemical fiber manufacturing
C30	Non-metallic mineral products industry
C31	Ferrous metal smelting and rolling industry
C32	Nonferrous metal smelting and rolling processing industry
C33	Metal products industry
D44	Electricity and heat production and supply industry

Table 3. Descriptive statistics of the variables

Variable	Observation	Mean	Min	Median	Max	Standard deviation
GI	615	0.139	0.042	0.123	0.362	0.065
ET	615	16.680	11.570	16.780	21.290	2.007
Size	615	22.810	20.620	22.670	25.630	1.124
Lev	615	0.437	0.061	0.447	0.826	0.171
ROA	615	0.047	-0.134	0.041	0.222	0.056
Cash	615	20.980	16.640	20.900	24.330	1.295
Profit	615	0.067	-0.686	0.059	0.477	0.103
Growth	615	0.136	-0.448	0.090	2.783	0.305
Board	615	8.787	5	9	15	1.736
Indep	615	0.370	0.333	0.333	0.571	0.051
Loss	615	0.914	0	1	1	0.281

The unit of environmental tax (ET) and Cash is 10,000 yuan, and the unit of board size is the number of people

Correlation analysis

Table 4 presents the Pearson correlation coefficients of the variables. Most of the absolute values of the relevant coefficients of the variables in the model are smaller than 0.30. Furthermore, to test whether there is collinearity, a variance inflation factor (VIF) of each variable is calculated. The maximum value of variable VIF is 3.52, and the mean value of variable VIF is 1.93, both of which are smaller than 5, indicating that there is no serious collinearity problem among the variables in the research model. According to the test results of the correlation coefficient matrix, it is preliminarily confirmed that the positive correlation between environmental taxation (ET) and enterprise green investment (GI) conforms to hypothesis H1.

Table 4. Pearson correlation of the variables

Variable	GI	ET	Size	Lev	ROA	Cash	Profit	Growth	Board	Indep	Loss
GI	1										
ET	0.38***	1									
Size	0.34***	0.54***	1								
Lev	0.22***	0.22***	0.45***	1							
ROA	0.04	0.08*	0.07*	-0.37***	1						
Cash	0.18***	0.23***	0.34***	0.10**	0.08*	1					
profit	-0.03	-0.01	0.03	-0.36***	0.81***	0.03	1				
Growth	0.01	-0.01	0.02	-0.03	0.33***	0.11***	0.24***	1			
Board	0.18***	0.24***	0.33***	0.16***	0.03	0.13***	-0.03	0.02	1		
Indep	0.04	-0.06	0.08**	0.00	-0.00	0.02	0.00	-0.05	-0.51***	1	
Loss	0.05	0.09**	0.07*	-0.16***	0.56***	0.08*	0.56***	0.21***	0.03	0.00	1

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

Basic regression

Hausman test results show that the Prob value is 0.018 (<0.05), indicating that the null hypothesis that the fixed effect is not significant can be rejected, that is, the fixed effect model is selected for regression analysis. The regression results are shown in columns (1) and (2) of *Table 5*. Among them, column (1) only controls the fixed effects of industry and year. The results show that the regression coefficient of environmental tax (ET) is 0.531 and significant at the 1% level. To eliminate the interference of other factors on the regression results, other control variables are added to column (2). The results show that the regression coefficient of environmental tax (ET) is 0.414, which is significant at the 1% level, indicating that environmental tax has a significant positive effect on the green investment of firms, which means that every unit increase of environmental tax burden of firms, manufacturing firms will increase the green investment by 0.414 units, which has significant economic significance. Accordingly, environmental taxation can significantly promote manufacturing firms' green investment, which supports H1.

Heterogeneity analysis

The influence of property nature

In this study, the sample firms are divided into state-owned firms and non-state-owned firms according to the nature of ownership. The fixed effect model regression is carried out on the samples of the two groups of firms respectively. The influence results of the property's right nature are shown in *Table 6*. According to the regression results, in the group of state-owned firms, the regression coefficient between environmental tax revenue and corporate green investment is 0.314, and is significant at the 10% level; while in the group of non-state-owned firms, the regression coefficient between environmental tax revenue and firms' green investment is 0.468, and is significant at the 1% level, which indicates that compared with state-owned firms, the promotion effect of environmental tax on green investment of non-state-owned manufacturing firms is more significant, which supports H2.

Table 5. *The results of baseline regression*

Variable	GI	
	(1)	(2)
ET	0.531*** (8.86)	0.414*** (5.93)
Size		0.218 (1.27)
Lev		2.266** (2.61)
ROA		4.051 (1.03)
Cash		0.060 (0.57)
profit		-2.459 (-1.21)
Growth		-0.045 (-0.10)
Board		0.197* (2.29)
Indep		6.084* (2.19)
Loss		0.387 (0.78)
Constant	-5.097*** (-4.80)	-14.720*** (-4.09)
Industry	YES	YES
Year	YES	YES
N	615	615
Adj_R ²	0.148	0.190

The t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 6. *Grouping regression based on property rights*

Variable	GI	
	State-owned firms	Non-state-owned firms
ET	0.314* (2.47)	0.468*** (5.46)
Control	YES	YES
Industry	YES	YES
Year	YES	YES
N	270	345
Adj_R ²	0.218	0.158

The t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

The influence of regional marketization degree

This study refers to the research of Xie and Zou (2021), uses the Marketization Index of China's Provinces: NERI Report 2021 by Wang et al. (2021) to group the marketization degree in the region where the province where the enterprise is registered with the average marketization index. Regions with higher than the average marketization index are classified as strong marketization and marked as 1 (Market = 1); regions with lower than the average marketization index are classified as weak marketization degree and marked as 0 (Market = 0). According to the results in *Table 7*, the regression coefficient between environmental tax revenue and firms' green investment in regions with a strong marketization degree is 0.599, and is significantly positive at the 1% level. However, in the regions with weak marketization degree, the regression coefficient of firms is 0.307, and it is significantly positive at the 5% level. This indicates that, compared with manufacturing firms in areas with a weak degree of marketization, environmental taxation has a more significant promoting effect on green investment of manufacturing firms in areas with a higher degree of marketization, which supports H3.

Table 7. Grouping regression based on marketization degree

Variable	GI	
	Market = 1	Market = 0
ET	0.599*** (6.15)	0.307** (3.10)
Control	YES	YES
Industry	YES	YES
Year	YES	YES
N	285	330
Adj_R ²	0.318	0.160

The t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Robustness tests

Added control variables

To ensure the credibility of the research conclusions, two new control variables were added to this study: Research and Development (R&D) investment (Invest) and Government subsidy (Gov). In order to avoid the influence of the coefficient index, the data on R&D investment and government subsidy are processed logarithmically, and the regression results are shown in *Table 8*. It can be seen from the analysis results that environmental tax still has a significant promoting effect on manufacturing firms' green investment. Non-state-owned manufacturing firms have a more significant impact than state-owned firms, and regions with a higher degree of marketization have a more significant impact than regions with a lower degree of marketization, thus further verifying the robustness of the original conclusion.

Control the provincial level

Since individual factors that do not change over time may have an important impact on firms' green investment, to further eliminate the endogenous impact, the

regression results after controlling the provincial fixed effect are shown in *Table 9*. It can be found from the analysis results that after controlling the fixed effect at the provincial level, the full-sample regression results are consistent with the basic regression results, which indicates that the original analysis results are robust. In terms of property rights nature, the environmental tax of non-state-owned manufacturing firms still plays a more significant role in promoting the green investment of firms than that of state-owned firms, and the manufacturing firms in regions with higher marketization degree are more significant than those in regions with lower marketization degree.

Table 8. Robustness test results of added control variables

Variable	GI				
	Full sample	State-owned firms	Non-state-owned firms	Market = 1	Market = 0
ET	0.407*** (5.78)	0.309* (2.43)	0.471*** (5.39)	0.603*** (6.05)	0.265* (2.62)
Size	0.197 (1.13)	0.206 (0.74)	0.252 (1.01)	0.207 (0.70)	0.100 (0.47)
Lev	1.852* (2.12)	2.429 (1.65)	1.329 (1.14)	2.120 (1.61)	2.398* (1.97)
ROA	7.754 (1.80)	18.920* (2.47)	4.185 (0.72)	14.480* (2.16)	11.820* (2.04)
Cash	0.047 (0.44)	0.210 (1.35)	-0.158 (-1.00)	-0.033 (-0.19)	0.150 (1.11)
Profit	-5.787* (-2.25)	-18.380** (-3.17)	-1.883 (-0.61)	-11.970** (-2.68)	-8.031* (-2.38)
Growth	-0.022 (-0.04)	0.468 (0.55)	0.380 (0.57)	0.221 (0.29)	-0.282 (-0.41)
Board	0.138 (1.55)	-0.094 (-0.69)	0.206 (1.55)	0.415** (2.83)	-0.139 (-1.23)
Indep	5.104 (1.81)	0.045 (0.01)	8.067 (1.94)	3.337 (0.80)	8.177* (2.14)
Loss	0.329 (0.63)	1.822* (2.28)	-0.342 (-0.48)	-0.184 (-0.20)	1.121 (1.84)
Invest	0.085*** (3.34)	0.088* (2.41)	0.088* (2.21)	0.041 (0.86)	0.117*** (3.78)
Gov	0.015 (0.45)	0.071 (1.45)	-0.059 (-1.30)	0.007 (0.16)	0.046 (0.91)
Constant	-14.401*** (-3.98)	-14.362* (-2.57)	-12.685* (-2.26)	-16.774** (-2.96)	-12.311** (-2.62)
Adj_R ²	0.212	0.243	0.175	0.329	0.209
Industry	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
N	615	270	345	285	330

The t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Table 9. Robustness test results at the control provincial level

Variable	GI				
	Full sample	State-owned firms	Non-state-owned firms	Market = 1	Market = 0
ET	0.345*** (4.75)	0.233 (1.79)	0.406*** (4.28)	0.465*** (4.64)	0.316** (2.89)
Size	0.421* (2.23)	0.353 (1.18)	0.437 (1.44)	0.598* (2.01)	0.147 (0.59)
Lev	2.109* (2.35)	2.958 (1.70)	2.279 (1.85)	1.354 (1.05)	3.675** (2.87)
ROA	9.556* (2.03)	15.342 (1.80)	18.071** (2.95)	12.196 (1.70)	11.993 (1.89)
Cash	0.055 (0.53)	0.205 (1.39)	-0.195 (-1.27)	-0.001 (-0.00)	0.096 (0.72)
Profit	-7.344* (-2.50)	-16.723** (-2.65)	-11.467** (-3.23)	-10.835* (-2.25)	-7.322 (-1.90)
Growth	0.053 (0.10)	0.674 (0.81)	0.755 (1.17)	0.074 (0.10)	0.027 (0.04)
Board	0.214* (2.26)	0.206 (1.21)	0.096 (0.62)	0.454** (3.15)	0.018 (0.14)
Indep	8.462** (2.86)	5.585 (1.17)	7.419 (1.72)	5.011 (1.25)	15.212** (3.23)
Loss	0.724 (1.44)	2.353** (3.06)	0.582 (0.82)	0.096 (0.11)	1.134 (1.86)
Constant	-17.901*** (-4.09)	-17.995** (-2.81)	-12.394 (-1.66)	-24.293*** (-3.76)	-14.050** (-2.64)
Adj_R ²	0.316	0.425	0.326	0.398	0.304
Industry	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Province	YES	YES	YES	YES	YES
N	615	270	345	285	330

The t-statistics are in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01

Conclusions

Based on the panel data of Chinese heavy-polluting listed companies for the 2015–2019 period, this study empirically analyzes the impact of environmental tax on green investment of manufacturing firms, as well as the heterogeneity based on the property rights of firms and the regional marketization degree. The results show that environmental tax has a significant promoting effect on the green investment of manufacturing firms. The nature of property rights and the degree of marketization have a moderating effect on the relationship between environmental tax and green investment of manufacturing firms. Compared with state-owned manufacturing firms, green investment of non-state-owned manufacturing firms is more significantly affected by the environmental tax. Compared with manufacturing firms in areas with weak

marketization degree, environmental tax has a stronger promoting effect on green investment of manufacturing firms in areas with strong marketization degree. It is also found that, compared with the external factor of environmental tax, internal factors such as firms' financial leverage and board size also play a certain role in promoting green investment.

The findings of this study provide a piece of new empirical evidence for the environmental tax system to promote manufacturing firms' green investment. Under the background of China's strategic goals of carbon peaking and carbon neutrality, these findings have important policy implications for heavy-polluting manufacturing firms to formulate economic incentive environmental regulation policies to promote carbon reduction.

First, strengthen the collection and administration of environmental tax and improve the external conditions for the implementation of environmental tax. Since the manufacturing industry, especially the heavy-polluting industry consumes more resources and causes more environmental pollution, the fiscal and taxation departments should strengthen the collection and administration, constantly improve the environmental tax supervision system, and encourage manufacturing firms to make green investments and green technology innovations through tax means.

Second, the property rights of firms should be fully considered in the implementation process of environmental tax policies. State-owned firms should strengthen the internal control guidance of green investment and improve the internal control system of firms to promote the green transformation and upgrading of state-owned manufacturing firms. Non-state-owned firms should strengthen the guidance and publicity of environmental tax policies, provide a sound green financing environment, and stimulate firms' green investment through policy drives.

Third, in the process of policy design and supervision, government should adapt to local conditions and constantly optimize the allocation of regional market resources. In the formulation of environmental tax policies, especially tax rates and preferential policies, full consideration should be given to the economic development level and marketization degree of each region, further adjustment of the range and rate of environmental protection tax, allowing different tax rates to be implemented within a certain range. China should vigorously develop the inner circle economy, further promote market development in economically disadvantaged areas through transfer payments and other means of resource allocation, stimulate manufacturing firms' green innovations through environmental tax as a market incentive, and promote green investment, transformation, and upgrading of manufacturing firms to help achieve the dual-carbon goal on schedule.

Author Contributions. Methodology, Gaofei Ren; Data, Yuxin Lu; Writing—original draft, Gaofei Ren and Yuxin Lu; Writing—review and editing, Gaofei Ren. Both authors have read and agreed to the published version of the manuscript.

Funding. This research was funded by the Planned Project of Culture and Art Science in Jiangxi Province (No.YG2021166), and the Science and Technology Research Project of Jiangxi Education Department (No.GJJ2201908).

Acknowledgments. The authors thank the anonymous reviewers and editors, whose comments notably contributed to the improvement of this manuscript.

Conflicts of Interests. No potential conflict of interests was reported by the authors.

REFERENCES

- [1] Bi, Q., Yu, L. C. (2016): Relationship between environmental taxes and enterprise green investment behavior: a panel quantile regression approach. – *China Population, Resources and Environment* 26: 76-82.
- [2] Cao, Q., Wang, H., Cao, L. (2022a): Business tax to value-added tax and enterprise innovation output: evidence from listed companies in China. – *Emerging Markets Finance and Trade* 58: 301-310.
- [3] Cao, Z., Chen, Y., Zeng, J., Zhang, Q. (2022b): Political connection, family involvement, and IPO underpricing: evidence from the listed non-state-owned enterprises of China. – *Pacific Economic Review* 27: 105-130.
- [4] Carfora, A., Pansini, R. V., Scandurra, G. (2021): The role of environmental taxes and public policies in supporting RES investments in EU countries: barriers and mimicking effects. – *Energy Policy* 149: 112044. <https://doi.org/10.1016/j.enpol.2020.112044>.
- [5] Cheng, B., Xu, Y., Li, X. (2018): Public pressure, firm globalization and environmental governance. – *Statistical Research* 9: 54-66. <https://www.cnki.net/kcms/doi/10.19343/j.cnki.11-1302/c.2018.09.005.html>.
- [6] Cheng, B., Qiu, B., Chan, K. C., Zhang, H. (2022): Does a green tax impact a heavy-polluting firm's green investments? – *Applied Economics* 54: 189-205. <https://doi.org/10.1080/00036846.2021.1963663>.
- [7] Cui, X. S., Han, M., Fang, Z. (2019): Inverted U-shape of EKC with dynamic evolution trend. *China Population, Resources and Environment* 29: 74-82.
- [8] Dai, L., Mu, X., Lee, C. C., Liu, W. (2021): The impact of outward foreign direct investment on green innovation: the threshold effect of environmental regulation. – *Environmental Science and Pollution Research* 28: 34868-34884.
- [9] Fan, X., Li, X., Yin, J. (2019): Impact of environmental tax on green development: a nonlinear dynamical system analysis. – *Plos One* 14: e0221264. <https://doi.org/10.1371/journal.pone.0221264>.
- [10] Fang, H., Zhang, X., Guo, L. (2022): Productivity effects of corporate income tax: evidence from China. – *The World Economy*. <https://doi.org/10.1111/twec.13328>.
- [11] Farzin, Y. H., Kort, P. M. (2000): Pollution abatement investment when environmental regulation is uncertain. – *Journal of Public Economic Theory* 2: 183-212. <https://doi.org/10.1111/1097-3923.00036>.
- [12] Hu, J., Song, X., Wang, H. (2017): Informal institution, hometown identity and corporate environmental governance. – *Management World* 3: 76-94. <https://www.cnki.net/kcms/doi/10.19744/j.cnki.11-1235/f.2017.03.006>.
- [13] Khalid, F., Sun, J., Huang, G., Su, C. Y. (2021): Environmental, social and governance performance of Chinese multinationals: a comparison of state-and non-state-owned enterprises. – *Sustainability* 13: 4020. <https://doi.org/10.3390/su13074020>.
- [14] Lei, Z., Huang, L., Cai, Y. (2022): Can environmental tax bring strong porter effect? Evidence from Chinese Listed Companies. – *Environmental Science and Pollution Research* 29: 32246-32260. <https://doi.org/10.1007/s11356-021-17119-9>.
- [15] Li, G., Gao, D., Li, Y. (2022a): Dynamic environmental regulation threshold effect of technical progress on green total factor energy efficiency: evidence from China. – *Environmental Science and Pollution Research* 29: 8804-8815. <https://doi.org/10.1007/s11356-021-16292-1>.
- [16] Li, W., Yang, X., Yin, X. (2022b): Non-state shareholders entering of state-owned enterprises and equity mispricing: evidence from China. – *International Review of Financial Analysis* 102362. <https://doi.org/10.1016/j.irfa.2022.102362>.
- [17] Liu, G., Yang, Z., Zhang, F., Zhang, N. (2022): Environmental tax reform and environmental investment: a quasi-natural experiment based on China's environmental protection tax law. – *Energy Economics* 109: 106000. <https://doi.org/10.1016/j.eneco.2022.106000>.

- [18] Olson, M. K. (1999): Agency rulemaking, political influences, regulation, and industry compliance. – *Journal of Law, Economics, and Organization* 15: 573-601. <https://doi.org/10.1093/jleo/15.3.573>.
- [19] Pan, A. L., Liu, X., Qiu, J. L., Shen, Y. (2019): Can green M&A of heavy polluting enterprises achieve substantial transformation under the pressure of media? – *China Industrial Economics*: 174-192. <https://www.cnki.net/kcms/doi/10.19581/j.cnki.ciejournal.20190131.005>.
- [20] Porter, M. E., Van der Linde, C. (1995): Green and competitive: ending the stalemate. – *Harvard Business Review* 73: 120-134.
- [21] Rustico, E., Dimitrov, S. (2022): Environmental taxation: the impact of carbon tax policy commitment on technology choice and social welfare. – *International Journal of Production Economics* 243: 108328. <https://doi.org/10.1016/j.ijpe.2021.108328>.
- [22] Shahab, Y., Ntim, C. G., Ullah, F. (2019): The brighter side of being socially responsible: CSR ratings and financial distress among Chinese state and non-state-owned firms. – *Applied Economics Letters* 26: 180-186. <https://doi.org/10.1080/13504851.2018.1450480>.
- [23] Shen, B., Zhu, C., Li, Q., Wang, X. (2021): Green technology adoption in textiles and apparel supply chains with environmental taxes. – *International Journal of Production Research* 59: 4157-4174. <https://doi.org/10.1080/00207543.2020.1758354>.
- [24] Sun, Y., Li, L., Shi, H., Chong, D. (2020): The transformation and upgrade of China's manufacturing industry in Industry 4.0 era. – *Systems Research and Behavioral Science* 37: 734-740. <https://doi.org/10.1002/sres.2714>.
- [25] Sun, L., Liu, S., Chen, P. (2022): Does the paternalism of founder-managers improve firm innovation? Evidence from Chinese non-state-owned listed firms. – *Finance Research Letters* 49: 103146. <https://doi.org/10.1016/j.frl.2022.103146>.
- [26] Tang, G. P., Li, L. H., Wu, D. J. (2013): Environmental regulation, industry attributes and corporate environmental investment. – *Accounting Research*: 83-89 + 96.
- [27] Tchórzewska, K. B., Garcia Quevedo, J., Martinez Ros, E. (2022): The heterogeneous effects of environmental taxation on green technologies. – *Research Policy* 51: 104541. <https://doi.org/10.1016/j.respol.2022.104541>.
- [28] Wang, X. L., Fan, G., Hu, L. P. (2021): Marketization Index of China's Provinces: NERI Report 2021. – Social Science Press, Beijing.
- [29] Xie, Y. Z., Zou, D. (2021): The impact of the market incentive environmental regulation on enterprises' green investment: an empirical study of high-polluting listed companies of a shares market. – *Journal of Yunnan Normal University (Humanities and Social Sciences Edition)* 53: 75-83.
- [30] Yasmeen, R., Zhang, X., Tao, R., Shah, W. U. H. (2023): The impact of green technology, environmental tax and natural resources on energy efficiency and productivity: perspective of OECD Rule of Law. – *Energy Reports* 9: 1308-1319. <https://doi.org/10.1016/j.egy.2022.12.067>.
- [31] Yu, Z., Shen, Y., Jiang, S. (2022): The effects of corporate governance uncertainty on state-owned enterprises' green innovation in China: perspective from the participation of non-state-owned shareholders. – *Energy Economics* 115: 106402. <https://doi.org/10.1016/j.eneco.2022.106402>.
- [32] Zhang, Q., Yu, Z., Kong, D. (2019): The real effect of legal institutions: environmental courts and firm environmental protection expenditure. – *Journal of Environmental Economics and Management* 98: 102254. <https://doi.org/10.1016/j.jeem.2019.102254>.
- [33] Zhao, L. D., Wang, X. F., Xu, L. (2022): Does corporate green investment reduce stock price volatility? – *China Population, Resources and Environment* 32: 85-95.
- [34] Zhu, P. F., Zhang, Z. Y., Jiang, G. L. (2011): Empirical study of the relationship between FDI and environmental regulation: an intergovernmental competition perspective. – *Economic Research Journal* 46: 133-145.