BRICS JOURNAL OF ECONOMICS
DOI 10.3897/brics-econ.3.91590
2022 Volume 3 Number 4

The Relationship Between Environmental Taxes, Technological Innovation and Corporate Financial Performance: a Heterogeneous Analysis of Micro-Evidence from China

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Academic editor: M. Sheresheva | Received 12 August 2022 | Accepted 24 September 2022 | Published 23 December 2022

Citation: Ding, X., & Petrovskaya, M. (2022). The Relationship Between Environmental Taxes, Technological Innovation and Corporate Financial Performance: a Heterogeneous Analysis of Micro-Evidence from China. *BRICS Journal of Economics, 3*(4), 249–270. https://doi.org/10.3897/brics-econ.3.91590

Abstract

As a formal environmental regulation, environmental tax is important for the green upgrading of industrial structure. In order to explore the impact mechanism of environmental tax on corporate financial performance, this paper constructs a difference-difference (DID) model with two-way fixed effects based on financial data of Chinese A-share manufacturing listed companies from 2015 to 2019. We have found that environmental taxes contribute directly and significantly to the improvement of financial performance and that technological innovation, in some degree, produces mediating effect. Financing constraints not only negatively moderate the relationship between environmental taxes and technological innovation; they also inhibit the impact of technological innovation on financial performance and have a moderate mediating effect as part of the indirect influence. In the heterogeneity analysis, the direct effect is more significant among State-owned enterprises (SOEs) and eastern enterprises, and the moderating effect of financing constraints is more significant among non-SOEs and eastern enterprises. This paper advances the understanding of economic consequences of environmental tax levies from the perspective of property and regional heterogeneity.

It provides empirical evidence in support of the applicability of Porter's hypothesis in China and makes suggestions for the optimization of environmental policy and improvement of financial performance of enterprises.

Keywords
Environmental Taxes, Technological Innovation, Financial Performance, Difference in Difference, Heterogeneity Analysis.

JEL: G30, M48, O38, Q58.

1. Introduction

The upgrading of industrial structures through technological innovation is an urgent task for Chinese enterprises if they are to break through the bottleneck of inertial development to the new normal. China is passing a period of transition from the declining traditional growth to high-quality advancement, with significant macroeconomic spillovers resulting from the current economic slowdown and rising domestic imbalances (Sznajderska & Kapuściński, 2020). Meanwhile, the contradiction between environmental pollution and economic development is becoming more and more serious as there is a pressing need to promote the green and sustainable development of enterprises through technological innovation. To give full play to macro-control and market economy in resource allocation, the Chinese government vigorously implemented a green taxation reform, which exerted the binding effect on environmental pollutants (Lai et al., 2020; Han & Li, 2020). To further promote green economic development, the environmental tax was introduced in 2018. It became an integral part of the green tax system and now plays a key role in achieving the goals of "carbon peaking" and "carbon neutrality".

Using environmental taxes to guide companies in their efforts to engage in green innovation and thereby improve enterprise performance is an important topic of research for many scholars. The studies on the economic consequences of environmental taxes usually address either macro or micro aspect of the phenomena in question. According to the macro approach, the green tax system can be built through the implementation of environmental taxes, leading to the effect of "environmental and social dividends". While improving regional environmental quality, it also promotes regional tax revenue growth, redistributes income and increases employment (Andreoni, 2019). Tu et al. (2022) have recently carried out a study that analyses and the impact of the carbon tax on the environment and economic system after its implementation in China and predicts its possible effects in the future. The authors expect that the implementation of the carbon tax will result in a significant but not immediate increase in the level of environmental quality as it usually has an instantaneous effect on most variables, but at a reduced significance. Another research, carried out by Tu & Wang (2021) has shown that

the imposition of environmental taxes reduces pollutant emissions and improves ecological quality but at the same time it has a negative impact on economic growth, leading to a decline in consumption, output, wages and capital, generally slowing the pace of development in China.

At the enterprise level, there are different views about the impact of environmental taxes on enterprise performance. According to the Porter hypothesis, environmental taxes will stimulate companies to improve their ability to combat pollution and boost the technological capacity of their products, creating an "incentive effect" for investment in technological innovation. From the perspective of regional heterogeneity, the impact of environmental regulations on technological innovation is more significant for eastern enterprises than for those in central and western China (Wang et al., 2021). Technological innovation is the fundamental motivation for the development of green economy. Different levels of regional economic development and varying intensity of government-enterprise connection determine the obvious unevenness of technical efficiency in the Chinese companies, and this heterogeneity is significantly influenced by the institutional and policy environment (Wang et al., 2020). Some scholars have proposed the opposite view of the "weak" Porter hypothesis from the perspective of "production and cost" theory. The imposition of environmental tax could increase regulatory and financial costs for enterprises, which will inevitably create the crowding out effect and lead to technological innovation with reduced investment. (Zhou et al., 2020). Based on the panel data of heavily polluting Chinese listed enterprises, Zhao et al. (2022) validate the "strong version" of Porter's hypothesis. Environmental taxes promote innovation and bring economic and environmental benefits to companies. From the perspective of heterogeneity in property, Zheng & He (2022) find that environmental policies have a greater impact on the financial and environmental performance of non-SOEs than those of SOEs. However, based on signaling theory, the market reacts strongly and negatively to heavily polluting companies that are taxed, thus inhibiting their growth (Tu et al., 2020). The inappropriate degree of fiscal decentralization, high information asymmetry between the central and local levels, inadequate performance evaluation systems for officials, inadequate environmental regulation and insufficient innovation environment are the reasons for the failure of the strong version of the Porter hypothesis in China (Wu, 2020; He et al., 2020). In addition, the intensity of environmental regulation has a significant impact on the financial performance of firms. The low intensity of environmental regulation inhibits performance, but as the intensity of regulation increases, it contributes to higher levels of performance.

In conclusion, the findings of scholars concerning the relationship between environmental taxes, technological innovation and enterprise financial performance remain controversial; there still is a shortage of research from the perspective of heterogeneity. Referring to Wen et al. (2021), we regard the implementation of environmental taxes as a quasi-experiment, and construct a DID model with two-way fixed effects to analyse the intrinsic logical relationship between variables.

It provides references for the government to further deepen the environmental tax reform and complete the design of its green fiscal system. The present paper not only validates the applicability of a strong version of Porter's hypothesis in China but also analyses the direct effect and the moderating effect of financing constraints with regard to property and geographical heterogeneity. We also make practical suggestions for optimizing environmental policies and improving enterprises' financial performance from both government and enterprise perspectives.

2. Theoretical Analysis and Formulation of Hypothesis

2.1. Direct effect of environmental taxes and financial performance of enterprises

Green development and ecological civilization in China are the matters of broad social consensus. Therefore, the Chinese government not only requires that heavily polluting industries actively fulfil their corporate social responsibility (CSR) and promptly disclose environmental information but also takes the initiative to assume international social responsibility by proposing a "double carbon" target, which is in line with China's national conditions, and thus actively promotes domestic green tax reform through market mechanisms.

Businesses operate on the principle of profit maximization, while paying environmental taxes and technological innovation can require considerable capital. The innovation compensation effect has a lag but can fully cover the cost of compliance under environmental constraints (Wang et al., 2021). The imposition of environmental taxes should encourage enterprises to make more environmental investment and willingly accept responsibility for the environment, thereby improving financial and environmental performance of enterprises (Liu et al., 2022). Environmental performance disclosure and public scrutiny put enormous pressure on companies. A green corporate image enhances a company's environmental reputation, which in turn strengthens its business credibility and reduces transaction costs. The implementation of environmental taxes affirms the value and competitive advantage of environmental investments and effectively contributes to the output of corporate innovation performance by influencing management's perceptions of environmental governance, increasing green awareness and enhancing the internal drivers for companies to engage in green innovation (Yu & Cheng, 2021). The authors of the present paper support Porter's hypothesis theory that the implementation of environmental taxes obliges companies to engage in technological innovation, which not only expands the market share of their products but also helps to enhance their green image. Based on this, we propose the following hypothesis:

H1: Environmental taxes significantly improve enterprise financial performance.

2.2. The mediating effect of technological innovation

The implementation of the green economy development strategy imposes higher demands on production processes, energy saving and emission reduction of enterprises. Technological innovation helps to meet customers' needs for the products and their concepts of consumption; it also improves resource utilization and optimizes controls costs, thus enhancing profitability of businesses(Chege & Wang, 2020). Environmental taxes can stimulate companies to reduce harmful emissions, boost their capability to control pollution and raise the technological level of green products by modifying production processes and increasing investments in green innovation thereby expanding the market share of their products (Lei, 2022). Furthermore, environmental taxes are levied on the principle of "more emissions, more taxes". To internalise the environmental costs and alleviate the tax pressure, apart from strengthening internal management, enterprises can take the initiative to increase the amount of investment in green technology innovation to promote corporate transformation and upgrading, which will eventually improve their performance through innovation compensation and first-mover advantage (Lei et al., 2022).

As concerns the reduction of tax burden and protecting reputation, we believe that the implementation of environmental taxes will stimulate companies to proactively invest in technological innovation and reduce pollution. As a result, the amount of tax paid will be reduced too, and the green reputation and resource utilization of companies will be improved. Technological innovation is undoubtedly the best approach for enterprises to promote green development and safeguard public interests, helping them achieve a win-win situation for both environmental protection and enterprise development. Based on the above, this paper proposes the following hypothesis.

H2: Technological innovation has a mediating effect on the relationship between environmental taxes and financial performance of an enterprise.

2.3. The moderating effect of financing constraints

The implementation of environmental taxes reduces the cash flow of enterprises, while the long-term and high-risk technological innovation activities usually involve serious financing and adjustment costs. Large external financing requires companies to have sufficient and available internal capital, while higher adjustment costs mean that they need to ensure the continuity of investment to avoid losing the valuable R&D staff. The cyclical character of technological innovation implies that the direct benefits from R&D do not compensate for the initial R&D investment (He et al., 2021). Technological innovation activities make high demands on the financing sources and continuity of enterprises. Therefore, when enterprises face tighter financing constraints, the stimulating effect of environmental taxes on technological innovation is diminished. The lower financing constraints could better support the innovation compensation effect and mitigate the crowding out effect of environmental taxes, thus

stimulating companies to willingly engage in technological innovation (Zhang et al., 2022). Based on the above analysis, the following research hypothesis is proposed:

H3: Financing constraints not only negatively moderate the relationship between environmental taxes and technological innovation but also lessen the impact of technological innovation on enterprise financial performance

Based on this hypothesis, we developed a research model (Figure 1).

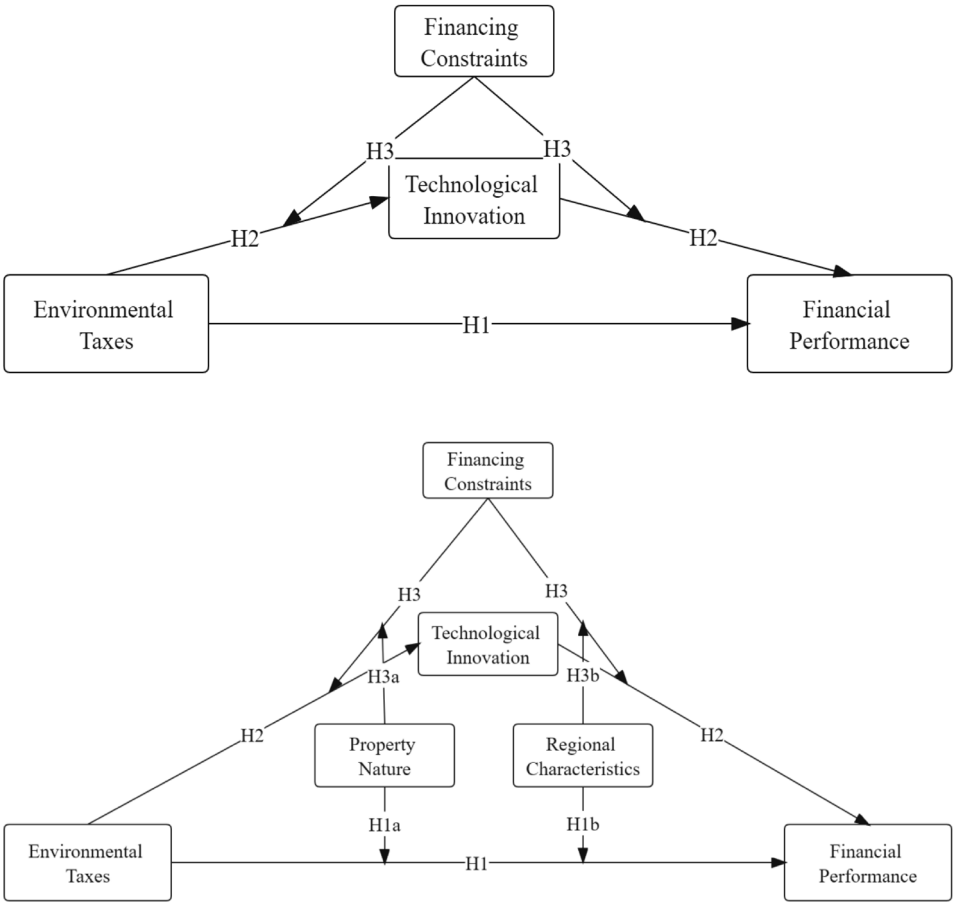

Figure 1. Conceptual model

3. Descriptive Data and Model Specifications

3.1. Sample selection and data sources

In this paper, we use data about listed companies in the manufacturing industry in China A-share from 2015-2019. According to the industry classification methods

of the China Securities Regulatory Commission (2012Version) and the Guidelines for Disclosure of Environmental Information of Listed Companies published by the Ministry of Environmental Protection of the PRC, 10 sub-industries are classified as heavily polluting industries; in the present research they make up experimental group: these include textiles, petroleum processing, coking and nuclear fuel processing, pharmaceutical manufacturing, metal products, and chemical raw materials and chemical products.,–The remaining 16 sub-industries, including food, furniture, cultural, educational, industrial, aesthetic, sporting and recreational goods, instrumentation, transportation equipment, and comprehensive utilization of waste resources, are classified as non-heavily polluting industries; here they constitute a comparison group. In the sample screening process, we exclude companies marked with ST and *ST, unsound data and extreme values. Of these, ST refers to "special treatment" stocks, which operate at a loss for two consecutive years; *ST refers to delisting warning stocks, which operate at a loss for three consecutive years. Finally, we obtained 730 valid observations for the experimental group and 1595 valid observations for the control group. The data in this paper are taken from the China Stock Market & Accounting Research (CSMAR) and Wind databases. Python 3.8 is used for data processing and analysis.

3.2. Variable identification and sample description

3.2.1. Explained variables

In this paper, Tobin's Q is adopted to measure enterprise financial performance. This indicator not only predicts the ability of company to develop but also evaluates the trend of company value growth (Butt et al., 2021).

3.2.2. Explanatory variables

The interaction term of policy implementation is used to represent the net effect of the exogenous factor known as environmental tax on firm performance. $Treated_i$ is the policy object, $Treated_i = 1$ means heavily polluting enterprises, $Treated_i = 0$ means non-heavily polluting enterprises, and $Post_t$ is the policy implementation time effect. As China formally introduced environmental taxes on 1 January 2018, $Post_t = 1$ is the period after 2018 (including 2018) when environmental taxes are formally levied, and $Post_t = 0$ is the period when environmental taxes are not formally levied.

3.2.3. Mediating variables and moderating variables

Technological innovation is an important measure for enterprises to solve environmental pollution problems at the source and achieve balanced environmental and economic development. Using technological innovation as a mediating variable, we further explore

its transmission mechanism between environmental taxes and enterprise financial performance. Financing constraints are an important factor for enterprises to engage in technological innovation. To analyze the moderating effect of financing constraints on the relationship between environmental taxes and enterprise financial performance, we use the natural logarithm of the SA index, with higher values indicating a higher intensity of financing constraints.

3.2.4. Control variables

Enterprise scale, growth, nature of ownership, concentration of shareholding, ratio of independent directors, CEO duality and employee intensity are selected as control variables (Lee, 2022; Martín-de Castro et al., 2019). The specific variables involved in this paper are defined in Table 1.

Table 1. Variable definitions and measurements

Variable Category	Specific Indicators	Signs	Variables description
Explained variables	Short-term performance	*TobinQ*	Ratio of market value to replacement cost of assets
Explanatory variables	Policy Target	*Treated*	High polluters as 1, otherwise as 0
	Time of policy implementation	*Post*	After policy implementation as 1, otherwise as 0
	Interaction term	*Treated*Post*	Policy Target*Time of policy implementation
Mediator	Technological innovation	*Rd*	Ratio of R&D investment to operating revenue
Moderator	Financing constraint strengths	*Fcs*	Ln(SA index)
Control variables	Enterprise scale	*Size*	Logarithm of total assets
	Enterprise growth	*Growth*	Operating revenue growth rate
	Type of shareholding	*State*	State-owned enterprises as 1, otherwise as 0
	Concentration of shareholding	*Cos*	Shareholding ratio of the largest shareholder
	Ratio of independent directors	*Idr*	Ratio of independent directors to total board members
	Dual role	*Isd*	Serve as both chairman and general manager as 1, otherwise as 0
	Employee Intensity	*Sin*	Ratio of employees to millions of RMB

3.3. Empirical model construction

In this paper, we consider the imposition of environmental taxes as a quasi-natural experiment and analyze the intrinsic logical relationship between the variables by constructing a DID model with two-way fixed effects. To validate ***H1, H1a and H1b,*** the regression model of environmental tax and enterprise performance is constructed as follows:

$$TobinQ_{it} = \beta_0 + \beta_1 Treated_{it} \times Post_{it} + \beta_2 Controls_i^t + Fixedeffects + \varepsilon_i^t \quad (1)$$

To validate ***H2***, technological innovation is introduced as a mediating variable in the DID model, and the following models are constructed based on model (1) to test the transmission effect of technological innovation between environmental taxes and financial performance.

$$\begin{cases} TobinQ_{it} = \beta_0 + \beta_1 Treated_{it} * Post_{it} + \beta_2 Rd_{it} + \beta_3 Controls_i^t + Fixedeffects + \varepsilon_i^t \\ Rd_{it} = \beta_0 + \beta_1 Treated_{it} * Post_{it} + \beta_2 Controls_i^t + Fixedeffects + \varepsilon_i^t \end{cases} \quad (2)$$

To validate ***H3, H3a and H3b***, we introduce the financing constraint as a moderating variable into the DID model and construct the following model:

$$\begin{cases} Rd_{it} = \beta_0 + \beta_1 Treated_{it} * Post_{it} + \beta_2 Fcs_{it} + \beta_3 Treated_{it} * Post_{it} * Fcs_{it} + \\ +\beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t \\ TobinQ_{it} = \beta_0 + \beta_1 Rd_{it} + \beta_2 Fcs_{it} + \beta_3 Rd_{it} * Fcs_{it} + \beta_4 Controls_i^t + Fixedeffects + \varepsilon_i^t \end{cases} \quad (3)$$

Where, i is the nth firm, t is the t^{th} year, β is the coefficient, *Controls* is the set of control variables, *Fixedeffects* is the two-way fixed effects, and ε_i^t is the residual.

4. Empirical Examination and Result Analysis

4.1. Descriptive analysis of variables

The results in Table 2 show that the mean value of financial performance is 2.228, which is greater than the median, with a maximum value of 14.086 and a minimum value of 0.771. This indicates that the majority of companies are operating relatively well, but the polarization of performance levels is very pronounced, and there is a high degree of individual heterogeneity. The minimum and maximum values for technological innovation are 0.000 and 0.886, respectively, which indicate that there is a large difference in the amount of R&D investment and environmental awareness among manufacturing companies and that the innovation capacity needs to be improved urgently. The mean financing constraint is 1.335, which is higher than the median, which indicates that most companies are under greater financing pressure.

Table 2. Descriptive Analysis of Variables

Variables	Mean	Std	Min	25%	50%	75%	Max
TobinQ	2,228	1,366	0,771	1,342	1,807	2,667	14,086
RD	0,048	0,044	0,000	0,027	0,039	0,056	0,886
Fcs	1,335	0,058	1,016	1,300	1,334	1,372	1,656
Size	17,664	6,517	6,100	9,422	21,355	22,332	26,673
Growth	0,293	0,946	-2,215	-0,003	0,138	0,372	32,964
State	0,284	0,451	0,000	0,000	0,000	1,000	1,000
Cos	0,332	0,138	0,030	0,230	0,317	0,417	0,891
Idr	0,377	0,059	0,200	0,333	0,333	0,429	0,800
Isd	0,292	0,455	0,000	0,000	0,000	1,000	1,000
Sin	1,316	0,825	0,060	0,710	1,159	1,714	7,476

In terms of enterprise scale and growth, the mean value of company size (Size) is 17.664, which indicates that the overall size of the sample companies is large and that they are all asset-heavy enterprises. The minimum and maximum values of growth are -221,5% and 3296,4%, respectively, which show that there is a wide range of revenue growth rates in the sample companies.

From the perspective of corporate governance, SOEs account for 27.3% of the total number of manufacturing enterprises, indicating a higher number of non-SOEs. The mean value of the concentration of shareholding is 0.332, with a large difference between the maximum and minimum values, indicating that there are significant differences between companies in terms of the level of the first largest shareholder's control over the company and the lack of relevant regulatory mechanisms. According to the relevant regulations of the Chinese Company Law, the percentage of independent directors should not be less than 33.3%, while the minimum value among the sample companies is only 20%, indicating that the number of independent directors set in some companies does not comply with the relevant regulations and is less independent. The ratio of companies with CEO duality is 29.2%, indicating that most companies can ensure independent oversight of their board of directors, thus reducing their agency costs such as ethical costs and adverse selection. The mean value of employee intensity is 1.316, which is greater than the median, indicating that employee intensity is not very high in most manufacturing companies.

4.2. Analysis of the relationship between environmental taxes, technological innovation and financial performance

In this paper, we use stepwise regression to analyze the relationship between environmental protection tax, technological innovation and enterprise performance

separately. As shown in Table 3, after introducing the interaction term, the goodness of fit of model (2) is significantly greater than that of model (1). Environmental taxes have a significant positive correlation with the financial performance of heavily polluting listed manufacturing companies at the 1% level, indicating that environmental taxes significantly improve enterprise financial performance. ***H1*** is fully supported. Furthermore, enterprise scale and ownership both significantly inhibit enterprise financial performance.

Table 3. Regression Results of Environmental Tax, Technological Innovation and Enterprise Performance

Dep. Variable	Model(1)	Model(2)	Model(3)	Model(4)
	TobinQ	TobinQ	TobinQ	Rd
*Treated*Post18*		0.141***	0.138***	-0.001
		(2.68)	(2.63)	(-0.80)
Rd			-2.771**	
			(-2.44)	
Size	-0.610***	-0.605***	-0.616***	-0.004
	(-4.59)	(-4.57)	(-4.67)	(-1.02)
Growth	-0.010	-0.010	-0.012	-0.001
	(-0.79)	(-0.76)	(-0.86)	(-1.12)
State	-0.369**	-0.366**	-0.353**	0.005*
	(-2.22)	(-2.19)	(-2.12)	(1.87)
Cos	-0.046	-0.043	-0.090	-0.017
	(-0.07)	(-0.06)	(-0.13)	(-0.99)
Idr	0.760	0.727	0.804	0.028
	(1.43)	(1.37)	(1.52)	(1.53)
Isd	-0.204***	-0.204***	-0.208***	-0.001
	(-2.90)	(-2.90)	(-2.96)	(-0.93)
Sin	0.030	0.029	0.093	0.023***
	(0.53)	(0.51)	(1.54)	(3.54)
Intercept	12.866***	12.764***	12.997***	0.084
	(5.18)	(5.16)	(5.27)	(1.26)
Effects	Entity	Entity	Entity	Entity
	Time	Time	Time	Time
No. Observations	3200	3200	3200	3200
R-Squared	0.039	0.041	0.046	0.149

Note: *, **, *** Significant at 10%, 5% and 1% confidence levels, respectively, with T-stats in parentheses. Same as below.

The results of model (3) show that environmental taxes have a significant positive correlation with enterprise financial performance at the 1% level and a significant negative correlation with technological innovation at the 5% level. However, there is no significant correlation between environmental taxes and technological innovation in model (4). Therefore, we use the bootstrap method to conduct a mediation test. The test results show that the 95% confidence interval [-0.0652, -0.0192] does not contain 0, which means that technological innovation plays a partially mediating effect in the relationship between environmental taxes and enterprise financial performance. This finding fully supports ***H2***. In summary, when environmental taxes are imposed, companies can significantly improve their financial performance by increasing investment in technological innovation. Environmental taxes reduce pollutant emissions through technological innovation, thereby increasing resource utilization, optimizing resource allocation, and improving productivity and general efficiency. Eventually, environmental performance improves together with financial performance (Chege et al., 2020; Callegari & Nybakk, 2022).

4.3. Robustness tests

The imposition of the environmental tax significantly boosted enterprise financial performance. To avoid inaccurate results due to omitted variables, this paper uses methods such as fictitious policy implementation time and replacement of explanatory variables for robustness testing. Table 4 shows that using 2017 as a fictitious time for the implementation of environmental taxes, the impact of environmental taxes on enterprise financial performance is significantly positively correlated at the 1% level in model (1), indicating that there is an expected effect of the implementation of environmental taxes. The main reason for this is that after the implementation of the harshest new environmental protection law by the Chinese government in 2015, heavy polluters significantly adjusted their industrial structure and business targets. Then, the environmental tax was implemented in 2018. Due to the short interval between the implementation of the environmental protection law and environmental taxes, it has increased the sensitivity of business managers to environmental policies, which created the expected effect. When we use 2019 as a fictitious time for the implementation of environmental taxes, we observe no significant influence of environmental taxes on financial performance in model (3). This finding indicates that there is no lagged effect in the implementation of environmental taxes.

The impact of environmental taxes on enterprise financial performance is retested using the price-to-book ratio instead of Tobin's Q. Model (2) shows that environmental taxes have a significant positive relationship with enterprise financial performance at the 1% level. The test results are generally consistent with the findings of the above study, indicating that the findings of this paper are more reliable.

Table 4. Regression Results for Robustness Tests

Dep. Variable	Model(1)	Model(2)	Model(3)
	TobinQ	Bp	TobinQ
*Treated*Post17*	0.213***		
	(3.53)		
Treated*Post18		0.514***	
		(3.61)	
Treated*Post19			0.078
			(1.06)
Control variables	Yes	Yes	Yes
Intercept	12.649***	30.227***	12.841***
	(10.00)	(10.15)	(10.14)
Effects	Entity	Entity	Entity
	Time	Time	Time
Observations	3200	3200	3200
R-squared	0.044	0.042	0.039

4.4. Heterogeneity test for direct effect

This paper tests the heterogeneity of the direct effect of environmental taxes on financial performance in terms of the nature of ownership and regional characteristics. In table 5, the property grouping test shows that the impacts of environmental taxes on the financial performance of both SOEs and non-SOEs have significant positive correlations at the 5% level. However, the direct effect is stronger for SOEs than for non-SOEs.

Table 5. Results of the Heterogeneity Test

Classifications	Property Rights Nature		Regional	
	State Owned	Non-State-owned	East	Non-East
*Treated*Post18*	0.204**	0.127**	0.159**	0.101
	(2.20)	(2.03)	(2.37)	(1.20)
Control variables	Yes	Yes	Yes	Yes
Intercept	6.070*	13.928***	19.434***	3.166***
	(1.71)	(4.25)	(4.77)	(2.59)
Effects	Entity	Entity	Entity	Entity
	Time	Time	Time	Time
Observations	875	2325	2130	1070
R-squared	0.024	0.041	0.062	0.011

Regional grouping tests show that enterprises in the eastern regions have a significant positive correlation at the 5% level in the relationship between environmental taxes and financial performance. Enterprises in non-eastern regions (central, western and north-eastern regions) have a positive and non-significant relationship between environmental taxes and financial performance. To summarize the above findings, from the perspective of heterogeneity, the impact of environmental taxes on financial performance is more significant for SOEs and enterprises in non-eastern regions.

4.5. Moderating effect of financing constraints

The results of the test for the moderating effect of financing constraints are shown in Table 6. The interaction term between environmental taxes and financing constraints in model (1) is significantly negatively correlated with technological innovation at the 5% level. The interaction term between technological innovation and financing constraints in model (2) is significantly and negatively related to financial performance at the 10% level. Financing constraints negatively moderate the relationship between environmental taxes and technological innovation and inhibit the impact of technological innovation on financial performance. Capital is an important factor for technological innovation. Only with steady financial support is it possible to develop new environmental technologies and improve production processes (Karmaker et al., 2021). Therefore, enterprises should open up various financing channels, maintain a reasonable debt-to-assets ratio, and improve their financial flexibility and level of resistance against financial risks.

Table 6: Moderating Effect of Financing Constraints

Dep. Variable	*Rd*	*TobinQ*
	Model(1)	**Model(2)**
*Treated*Post18*	0.046**	
	(2.25)	
Fcs	0.273*	-24.060***
	(1.81)	(-7.09)
*Treated*Post18*Fcs*	-0.035**	
	(-2.30)	
Rd		51.466*
		(1.85)
*Rd*Fcs*		-39.021*
		(-1.87)

Table 6. Continued

Dep. Variable	*Rd*	*TobinQ*
	Model(1)	**Model(2)**
Size	-0.006	-0.497***
	(-1.21)	(-3.90)
Growth	-0.001	0.003
	(-1.30)	(0.15)
State	0.005**	-0.402***
	(2.13)	(-2.59)
Isd	-0.001	-0.190***
	(-0.94)	(-2.77)
Cos	-0.009	-0.765
	(-0.61)	(-1.15)
Idr	0.028	0.781
	(1.53)	(1.51)
Sin	0.024***	0.039
	(3.58)	(0.69)
Intercept	-0.258*	43.236***
	(-1.66)	(8.12)
Effects	Entity	Entity
	Time	Time
No. Observations	3200	3200
R-Squared	0.158	0.115

Technological innovation plays a mediating effect, and financing constraints play a negative moderating effect in the relationship between environmental taxes and enterprise financial performance. Therefore, in this paper, we test the moderated mediation effect of financing constraints using the bootstrap method, with the algorithm following Model No. 58 in the Process procedure developed by Igartua & Hayes (2021). The results of the test are shown in Table 7. When financing constraints are at the average level (Fcs=1.3350), the bootstrap 95% confidence interval excludes 0, indicating that there is a mediating effect. When financing constraints are at a low level (Fcs=1.2775), the bootstrap 95% confidence interval includes 0, indicating that

there is no mediating effect. When financing constraints are high (Fcs=1.3926), the bootstrap 95% confidence interval excludes 0, indicating that there is a mediating effect. In summary, financing constraints negatively moderate the mediating effect of technological innovation in the relationship between environmental taxes and enterprise financial performance.

Table 7. The Results of Tests for Moderated Mediation

Route	Mediator	*Fcs*	Effect	Boot SE	BootLLCI	BootULCI
		1.2775	-0.0314	0.0282	-0.0886	0.0257
Treated*Post18 to TobinQ	*RD*	1.3350	-0.0328	0.0118	-0.0575	-0.0114
		1.3926	-0.0197	0.0133	-0.0516	-0.0002

Note: BootLLCI is the 95% lower confidence limit, BootULCI is the 95% upper confidence limit.

4.6. Heterogeneity of the moderating effect of financing constraints

This paper analyses the moderating effect of financing constraints from the perspective of heterogeneity. In table 8, regional grouping tests show that the interaction term between environmental taxes and financing constraints is negatively and insignificantly correlated with technological innovation by SOEs. The interaction term between technological innovation and financing constraints is negatively and insignificantly correlated with the financial performance of SOEs. The interaction term between environmental taxes and financing constraints is significantly negatively correlated with technological innovation by non-SOEs at the 5% level. The interaction term between technological innovation and financing constraints is significantly negatively correlated with the financial performance of non-SOEs at the 1% level. Thus, the moderating effect of financing constraints is stronger for non-SOEs than for SOEs.

The interaction term between environmental taxes and financing constraints is significantly and negatively correlated with technological innovation by enterprises in the eastern regions at the 1% level. The interaction term between technological innovation and financing constraints is negatively and significantly correlated with the financial performance of enterprises in the eastern regions at the 1% level. The interaction term between environmental taxes and financing constraints is negatively and insignificantly correlated with technological innovation by enterprises in the non-eastern regions. The interaction term between technological innovation and financing constraints is negatively and insignificantly correlated with the financial performance of enterprises in the non-eastern regions. Thus, the moderating effect of financing constraints is stronger for enterprises in the eastern regions than for enterprises in the non-eastern regions.

Table 8. Heterogeneity Analysis of Moderating Effect

Classifications	Property Rights Nature				Regional			
	State Owned		Non-State-owned		East		Non-East	
Dep. Variable	*RD*	*TobinQ*	*RD*	*TobinQ*	*RD*	*TobinQ*	*RD*	*TobinQ*
*Treated*Post18*	0.032		0.060**		0.078***		-0.004	
	(0.82)		(2.27)		(3.06)		(-0.09)	
Fcs	0.439	-34.456***	0.025	-20.984***	0.063	-21.131***	0.458	-23.123***
	(1.44)	(-5.37)	(0.47)	(-6.28)	(1.11)	(-4.98)	(1.57)	(-4.87)
*Treated*Post18*Fcs*	-0.026		-0.045**		-0.058***		-0.001	
	(-0.89)		(-2.34)		(-3.13)		(-0.02)	
RD		40.873		117.715***		121.733***		8.276
		(0.84)		(2.81)		(2.68)		(0.26)
*RD*Fcs*		-30.304		-90.594***		-93.708***		-6.636
		(-0.87)		(-2.83)		(-2.68)		(-0.29)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-0.327	63.631***	-0.048	36.689***	-0.132	42.992***	-0.455	34.921***
	(-0.77)	(6.69)	(-0.55)	(6.45)	(-1.37)	(6.56)	(-1.33)	(5.39)
Effects	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time
No. Observations	875	875	2325	2325	2130	2130	1070	1070
R-Squared	0.320	0.140	0.106	0.110	0.082	0.137	0.336	0.075

5. Discussion and Conclusion

In this paper, we take China A-share listed manufacturing companies in 2015-2019 as the research object. To effectively control for endogeneity, we combine two-way fixed effects with the DID model to validate the applicability of the "strong Porter hypothesis" in China. Environment taxes not only significantly improve the financial performance of heavily polluting enterprises in the manufacturing industry but also have a partially mediating effect on technological innovation (Lee, 2020). By adjusting the timing of policy implementation and replacing the explanatory variables in the robustness test, we demonstrate the reliability of the paper's findings. In 2015, the Chinese government enacted the new Environmental Protection Law, and in 2018, it implemented the environmental protection tax. The continuity of the two environmental policies increases the sensitivity of enterprises, thereby creating the expected effect of the impact of environmental taxes on enterprise financial performance. Replacing the explained variable, environmental taxes still significantly improve enterprise

financial performance. In the heterogeneity analysis, we find that the direct effect is more significant among SOEs and eastern enterprises; the moderating effect of financing constraints is more significant among non-SOEs and eastern enterprises. Our novelty finding is that financing constraints negatively moderate the mediating effect of technological innovation in the relationship between environmental taxes and enterprise financial performance.

This paper makes a substantial contribution to the study of the economic consequences of implementing environmental policies for enterprises; its findings are illuminating and instructive for business operators and government departments.

First, enterprises should strengthen their technological innovation when faced with environmental constraints from the government. It reduces the pressure of environmental policies on the development of enterprises and also enhances their core competitiveness through technological innovation, thus achieving a "win-win" situation of pollution control and performance improvement. For optimum performance, companies need to maintain a stable capital structure and generate sufficient cash flow for technological innovation investments.

Second, government departments should improve the incentive mechanism for environmental protection tax. To create a properly functioning green tax system, they will need to gradually adjust the tax structure, enhance tax transparency and keep refining the whole system of taxation.

Third, the government should build an open and cooperative innovation mechanism, increase R&D support for heavy polluters, and provide more financial support, such as tax rebates, increased environmental subsidies, and increased tax reduction brackets. Establishing a low-carbon financing system to guide enterprises to enhance their environmental responsibility, stimulate their technological innovation potential and form an effective incentive mechanism for innovation (Huang et al., 2022).

Fourth, the government should adjust the environmental protection tax system in accordance with the nature of ownership and region and coordinate the relationship between tax types to achieve the optimization of the environmental protection tax system. At the same time, more attention should be given to the green innovation enthusiasm of non-SOEs to prevent excessive tax burdens. The upgrading of environmental technology in the central and western regions should be accelerated, and tax incentives, financial subsidies and other financial support policies should be appropriately increased.

There are certain limitations to this paper' research. Although equity financing, debt financing and government subsidies (Liu et al., 2019) are very important sources of external financing for enterprises, we only analyze the moderating effect of financing constraints from the perspective of heterogeneity and do not explore in depth the impact of different financing channels in the relationship between environmental taxes and enterprise financial performance. Corporate governance and board diversity characteristics are significant factors that influence corporate financial performance and they also require careful consideration (Lagasio & Cucari, 2019; Cosma et al., 2021: Zhu et al., 2022). These are the directions in which we plan to continue our research.

Funding

This research was funded by China Scholarship Council (Grant No. 202008090357), Russian Government Scholarships (Grant No. CHN-10039/20), RUDN Strategic Academic Leadership Program "Priority-2030" (Project No. P08582-p).

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Acknowledgments

The authors want to thank our Editor and reviewers, for their valuable comments and advises.

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