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Environmental protection tax collection, financing constraints, and corporate green technology innovation

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Abstract

The article empirically examines the relationship between environmental protection tax levy and enterprises' green technology innovation and the moderating effect of financing constraints between the two with a sample of heavy polluters listed in A-share companies in Shanghai and Shenzhen from 2015 to 2021. It is found that the levy of environmental protection tax significantly promotes the green technology innovation investment of heavily polluting enterprises. It is further found that enterprise financing constraints have a negative moderating effect in the process of environmental protection tax stimulating enterprise innovation input. The article proposes to continue to strengthen the reform of environmental protection tax to form a collection model with both incentives and constraints and at the same time, to improve the financing efficiency of enterprises through green digital finance to alleviate the impact of financing constraints on enterprise technological innovation.

Keywords

environmental protection tax, financing constraints, green technology innovation, high-quality development

1. Introduction

In the past three decades, China's rapid economic development has brought about various problems such as environmental pollution and excessive carbon emissions, which have been

How to achieve a win-win situation between the economy and the environment has become an important task in the new era. The report of the 19th CPC National Congress made it clear that China's economy has shifted from the crude growth mode to the stage of high-quality development, and the report of the 20th CPC National Congress also proposed to accelerate the development of green and low-carbon industries; at the 75th United Nations General Assembly, China for the first time made a "dual-carbon" commitment to the world to "achieve carbon peak by 2030 and carbon neutrality by 2060". "Double carbon" commitment to the world for the first time in the 75th United Nations General Assembly. It can be seen that green innovation, transformation, and upgrading of enterprises is not only a need for sustainable development of enterprises, but also an objective requirement for the transformation and development of China's economy. Environmental protection tax (hereinafter referred to as environmental protection tax), as a kind of incentive-type

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environmental regulation policy, is an important tool to reduce the environmental "tragedy of the commons", and is one of the important means to stimulate energy conservation and emission reduction of enterprises and realize China's "double-carbon" goal, and also an economic induced institutional arrangement (hereinafter referred to as environmental protection tax) to promote the green transformation of enterprises. It is also an economically induced institutional arrangement to promote the green transformation of enterprises (Yu Lianchao et al., 2019). Since the implementation of the environmental protection tax in 2018, the Bulletin of China's Ecological and Environmental Conditions disclosed that China's wastewater discharge dropped from 71,782.5 million tons to 70,956.5 million tons in 2017~2019, and ammonia nitrogen emission in wastewater dropped from 1,395,100 tons to 533,100 tons, with a significant and continuous downward trend. There are also data showing that the environmental protection tax on the first levy period, the Beijing-Tianjin-Hebei region, sulfur dioxide fell by 22,000 tons year-on-year, or 22.7%; nitrogen oxides fell by 35,000 tons year-on-year, or 13.1%, effectively improving the city's comprehensive air quality. All these reflect the "environmental dividend" effect of environmental protection tax. For heavily polluting enterprises, green innovation to achieve sustainable development will be the inevitable choice for the future in the context of strengthening environmental regulations, and there is already evidence that the benefits of industrial green transformation will far outweigh the costs in the long run (Li Ping, 2011). However, innovation requires a large amount of financial support, under the constraints of enterprise financing, whether heavy polluting enterprises continue to increase investment in innovation or comply with the "production and cost theory" to invest more funds in profitable short-term projects is a topic of concern. This paper takes the listed companies in the heavy pollution industry in Shanghai and Shenzhen as the research object and uses the method of empirical test and theoretical analysis to explore whether the environmental protection tax affects the green technological innovation of the enterprises, and how the financing constraint affects the relationship between them.

2. Literature review and research hypothesis

2.1 Literature review

Environmental protection tax based on the hypothesis of a "double dividend" has been studied by scholars at home and abroad. Economist Pegu

The "polluter pays principle" holds that taxes internalize external costs so that environmental taxes can motivate firms to invest in preventive measures and changes in production technologies and processes to reduce pollutant emissions. Porter's hypothesis also suggests that environmental regulation can incentivize firms to engage in technological innovation because technological innovation can partially or even fully offset the costs of regulation. This view has been empirically tested by many subsequent scholars, such as Singh et al. (2017), who found that Japan's environmental regulations have effectively guided innovation in the country; and Qian Zhang et al. (2018), who concluded that environmental regulations bias firms' technological innovations towards green. However, at the same time, some studies have concluded that environmental regulation does not promote enterprise technological innovation, because environmental regulation forces enterprises to increase the automatic monitoring equipment of various emissions, change the process flow, and so on to increase the cost of enterprises (Kemp, 2005); and by raising the tax cost of polluting enterprises and occupying the funds of enterprises, it undoubtedly increases the production and operation costs of enterprises, which has a technological innovation of the enterprise "crowding out effect" (Zhang et al., 2016). Of course, some scholars concluded that the relationship between environmental regulation and enterprise technological

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innovation presents a "U" type relationship (Ramanathan et al., 2017), and there are even studies that suggest that there is no significant correlation between environmental regulation and enterprise technological innovation. As can be seen from these, domestic and foreign scholars have not reached a unified consensus on the relationship between environmental regulation and enterprise technological innovation.

China formally promulgated and implemented the Law of the People's Republic of China on Environmental Protection Tax (hereinafter referred to as Environmental Protection Tax) in 2018, which is an external market incentive-type tool to solve the resource and environmental problems faced by China's economic development, and does it play a role in promoting enterprises to realize the upgrade of green technology innovation? Does the environmental protection tax stimulate enterprises to realize green technological innovation in this path regulated by financing constraints? This paper tries to take the heavy pollution industry as the research sample to explore the impact of environmental protection tax on enterprises' green technological innovation and its influence mechanism, to provide the basis for further deepening the reform of environmental protection tax.

2.2 Theoretical analysis and research hypotheses

China introduced the environmental protection tax in 2018, to urge enterprises to reduce pollution, fulfill their social responsibility for environmental protection, and achieve ecological harmony and sustainable development for the whole society. Compared with the previous sewage charges and other forms of environmental regulation, environmental protection tax has the rigid characteristics of taxation, which not only restricts the behavior of enterprises but also regulates the government's collection behavior. On the one hand, under the tax collection and management mode, the emission behavior of enterprises has converged, and the declared emission data are more real and reliable; on the other hand, the strengthening of the collection and management has solved the problems of "negotiated charges" and "non-payment" that existed in the collection and management of sewage charges in the past (Xu Wen 2017). Both reasons are likely to make the introduction of an environmental protection tax increase the actual tax burden of enterprises to a certain extent. Lv Zhihua et al. (2012) use the panel data of 12 countries, including the Netherlands and Sweden, from 1980 to 2009, empirical tests to conclude that the introduction of environmental taxes will produce a significant tax burden on some energy-intensive industries, and the increase in the tax burden undoubtedly enhances the business risk of enterprises.

"According to Porter's hypothesis, under the pressure of the tax burden generated by the environmental protection tax, heavily polluting enterprises will have the incentive to reduce their tax compliance costs by finding technological revolutions for pollution control or by upgrading and transforming their enterprises. On the one hand, the various tax incentives based on environmental protection tax will stimulate enterprises to maximize tax benefits by adopting technological innovations; on the other hand, according to the theory of reputation mechanism and signaling theory, green technological innovations of enterprises will help enterprises to obtain the reputation of environmental protection, to signal to outsiders that enterprises pay attention to environmental protection and enhance the social value of enterprises, and therefore enterprises will increase their investment in green technological innovations to improve pollution treatment technology and increase the cost of tax compliance by upgrading and transforming their enterprises. Therefore, enterprises will increase green technology innovation to improve pollution treatment technology and reduce pollutant emissions from the source. The research of Deng Yuping et al. (2021) proves that the innovation compensation effect of

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energy-saving and low-carbon policies on enterprises is much larger than the compliance cost effect. Therefore, this paper proposes hypothesis 1.

H1: Environmental protection tax will stimulate enterprises to make green technology innovations

Innovation is a capital-intensive activity, which itself is characterized by high financing costs and high adjustment costs (Hall, 2002), and enterprises' green technological innovation is subject to environmental regulations that lead to the willingness to innovate, but also require enterprises to continuously invest a large amount of capital and labor costs, and the activities are affected by a variety of factors, such as enterprise research and development capabilities, internal control and other factors that lead to the possibility that the enterprise's payout and the return on investment are not proportional to each other. Enterprise innovation activities require stable funds resulting in higher cash flow requirements for enterprises. Xie Weimin (2019) found that bank loans, an external financing model, are still an important source of financing for most corporate innovations at present. If the enterprise has a serious shortage of funds and is subject to large financing constraints, the enterprise's innovation activities will lose their economic basis, which may lead to the enterprise choosing to "pay for emissions". It has been shown that enterprises' green technology innovation investment will be negatively affected by financing constraints (Ye Cuihong, 2021). Accordingly, this paper proposes hypothesis 2.

H2: Financing constraints play a moderating role in the relationship between environmental taxes affecting firms' green technology innovation.

3. Research design

3.1 Sample selection and data sources

This paper takes the listed companies in the heavy pollution industry in Shanghai and Shenzhen A-share as the research object from 2015-2021 and excludes the companies with abnormal trading status in this category such as ST, *ST, and PT, as well as the companies with missing financial data and not meeting the requirements, and finally gets 2709 observation samples. Among them, the heavy pollution industries are mainly recognized by the Guidelines for Industry Classification of Listed Companies (2012 Revision) and the Guidelines for Environmental Information Disclosure of Listed Companies (Draft for Public Comments), including 16 industries such as mining, coal, pharmaceutical manufacturing and paper making; the data of environmental protection tax comes from China Environmental Statistics Yearbook, and the other financial data comes from the database of Wanderlust (Wind) and the database of Cathay Pacific (CSMAR).

3.2 Definition and interpretation of variables

1. Explained variable, green technology innovation (GPSI). This paper refers to the calculation obtained by the following formula: (R&D expenditure + technology transformation cost)/operating income.

2, Explanatory variable, environmental protection tax (ET). Directly take the natural logarithm of the environmental tax data disclosed by firms,pre-2018 in rows of

Dirt fee data instead.

3. Moderating variable, financing constraint (FC). Drawing on the SA index designed by Hadlock & Pierce

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(2009) to measure financing constraints, the specific SA index is calculated as follows: SA = -0.737×Size +0.043×Size2 -0.04×Age. The larger the absolute value of the SA index, the more serious the financing constraints faced by the firms, and vice versa.

4. Control variables. The variables are all important variables affecting the technological innovation of enterprises, such as enterprise size (Size), intensity of government support (Gov), capital structure (Lev), equity concentration (Top1), intensity of competition in the market (comp), size of the board of directors (Brand), and the dummy variable year (Year). The specific descriptions are shown in Table 1.

Table 1 Description of main variables

Variable type	variable name	variable symbol	definition
Explained variable	Green Technology Innovation	GPSI	Percentage of green R&D costs = (R&D expenditure + technological transformation cost)/ operating income
Explanatory variable	green tax	ET	Natural logarithm of environmental tax data, replaced by sewage charges until 2018
moderator variable	Financing constraints	FC	SA =-0.737*×Size +0.043×Size^2 -0.04*×Age Size is the natural logarithm of the size of the firm and Age is the age of the firm, expressed as the length of time the firm has been in existence A smaller SA index represents a smaller financing constraint faced by the firm and vice versa.
control variable	Enterprise size	Size	Natural logarithm of total assets at the end of the period
	Intensity of government support	Gov	Government grants/operating income
	capital structure	Lev	Gearing ratio = total liabilities/total assets
	shareholding concentration	Top1	Shareholding of the largest shareholder
	degree of market competition	comp	Profit margin from main business = operating profit/revenue from main business
	Board size	Brand	Natural logarithm of the number of board members
	Year	Year	dependent variable

3.3 Modeling

To test hypothesis 1, model 1 is constructed. Taking green technology innovation as the explained variable and environmental protection tax as the explanatory variable, regression analysis was performed after adding various control variables.

Modle 1: GPSI=β0+β1×ET+β2×Size+β3×Gov+β4×Lev+β5×Top1+β6×Comp+β7×Brand+$\sum Id$+$\sum Year$ +ε1

To test Hypothesis 2, regression analysis was conducted with green innovation inputs as the explanatory variable, financing constraints as the explanatory variable, and the introduction of each control variable.

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Modle 2: GPSI=β0+β1×ET+β2×SA+β3×ET*SA+β4×Size+β5×Gov+β6×Lev+β7×Top1+β8×Comp+β9×Brand+$\sum Id$+$\sum Year$+ε2

$\sum Id$, $\sum Year$ denote individual and annual fixation, respectively, andε1 is the randomized perturbation term.

4. Empirical analysis

4.1 Descriptive statistics

As can be seen from the descriptive statistics table in Table 2, in the 2709 samples, the average GPSI of green technological innovation of enterprises is 1.6078, the maximum value is 7.3562, and the minimum value is 0, which indicates that the green innovation level of most of the enterprises has not yet reached the average level, and the most value aspect presents a high degree of dispersion, indicating that there are significant differences in the green technological innovation level of different sample enterprises, and it is a practical necessity to analyze whether the level of green technological innovation of different sample enterprises is because of the It is necessary to analyze whether it is due to the introduction of environmental protection tax. The minimum value of the explanatory variable environmental protection tax is 0, and the maximum value is 21.835, indicating that there are also significant differences in the environmental protection tax disclosed by different sample enterprises. All other control variables are within reasonable limits and will not be repeated.

Table 2 Descriptive statistics

Variables	N	average	median	variance	maximum value	Minimum value
GPSI	2709	1.6078	1.6094	1.2056	7.3562	0
ET	2709	15.1896	15.3498	2.6167	21.8353	0
FC	2709	−3.8486	−3.8666	0.2699	−2.1880	−4.8588
Size	2709	23.1797	23.0006	1.3706	28.6364	19.9159
Gov	2709	0.7421	0.4315	1.0660	19.1888	−0.2002
Lev	2709	0.4697	0.4718	0.2018	2.6809	0.0340
Top1	2709	0.3572	0.3308	0.1568	0.8999	0.0471
Comp	2709	0.0862	0.0715	0.2621	4.1623	−5.4050
Brand	2709	8.9734	9	1.8631	17	5

4.2 Correlation analysis

Before the regression analysis, the correlation analysis between the variables is examined, and the analysis is shown in Table 3, which shows that there is a positive correlation between the environmental protection tax and the green technology innovation of enterprises, indicating that the environmental protection tax can promote the green technology innovation of the heavy polluting enterprises, and hypothesis 1 has been preliminarily verified. The absolute value of the correlation coefficient between most of the variables is less than 0.5, indicating that there is no serious multicollinearity between the variables.

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Table 3 Correlation analysis

Variables	GPSI	ET	SA	Size	Gov	Lev	Top1	Comp	Brand
GPSI	1								
ET	0.1262***	1							
FC	0.3707***	−0.0172	1						
Size	0.5111***	0.3667***	0.4063***	1					
Gov	-0.1187***	-0.1729**	-0.0710***	-0.2307***	1				
Lev	0.1893***	0.2327***	0.0675***	0.4218***	−0.1301***	1			
Top1	0.2527***	0.1004***	0.2756***	0.4184***	-0.1346***	0.1522***	1		
Comp	0.0249	0.0305	-0.0286	0.0747***	-0.0228	-0.3669***	0.0468**	1	
Brand	0.1828***	0.1942***	0.1359***	0.3477***	-0.0469**	0.1498***	0.0923***	0.0592***	1

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively, as below.

4.3 Regression analysis

Regression analysis of environmental protection tax, financing constraints, and enterprise green technology innovation, the specific results are shown in Table 4.

First, the test of the relationship between environmental protection tax and enterprise green technology innovation. Using model 1 to test the relationship between environmental protection tax and enterprise green technology

The relationship between the environmental protection tax (ET) and green technology innovation (GPSI) regression coefficient is 0.0412, with a significance level of 1%, indicating that the environmental protection tax is significantly positively correlated with the green technology innovation of enterprises, i.e., the environmental protection tax plays a significant positive role in guiding the green technology innovation of enterprises, which verifies the hypothesis 1. The main reason is that under the cost pressure brought by the implementation of environmental protection tax, heavy polluting enterprises choose green technology innovation to reduce the pollutants generated in the production process, or update and upgrade old production equipment to optimize various production processes, to obtain the "innovation compensation effect". Another important reason is that the collection of environmental protection tax releases a signal to enterprises, that is, the quality of environmental protection may form a "green barrier" in the industry (Wang Xin et al., 2020) if the enterprise's excessive emission of pollutants resulting in environmental protection does not meet the standard, it will be limited outside the industry, thus promoting enterprises have to carry out technological innovation to apply this policy environment, which has a positive effect on corporate technological innovation.

Second, the test of the moderating effect of financing constraints on the relationship between environmental protection tax and corporate green technology innovation. Using Model 2 to check

The results of examining the moderating effect of financing constraints on the relationship between environmental protection tax and enterprise green technological innovation are shown in Table 4, and the coefficient of the cross-multiplier of environmental protection tax and financing constraints, ET*FC, is significantly negative at 5% level, which indicates that financing constraints play an inhibitory role in the positive correlation between environmental protection tax and green technological innovation, and Hypothesis 2 is established. Analyze the reason, mainly because the development of green finance led to the heavy pollution enterprise financing threshold is increasing, so enterprises have to avoid business risks and choose to reduce the investment in technological innovation.

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Table 4 Regression analysis

variable	Basic regression--Model 1	Financing constraints--Model 2
constant item	-8.1681***	4.0548
	（-4.99）	（1.15）
ET	0.0412***	-0.2538*
	（3.34）	（-1.96）
FC		2.9138***
		（3.83）
ET*FC		-0.0791**
		（-2.23）
Size	0.3940***	0.3350***
	（5.3）	（4.39）
Gov	0.0275	0.0205
	（1.37）	（0.99）
Lev	-0.4217*	-0.3487
	（-1.72）	（-1.46）
Top1	0.5241	0.4719
	（1.4）	（1.36）
Comp	-0.3632***	-0.3303***
	（-3.19）	（-2.89）
Brand	-0.0248	-0.0255
	（-1.02）	（-1.07）
F	34.39***	30.51***
R^2	0.1678	0.1772
N	2709	
Id	Control	
Year	Control	

Note: *, **, *** indicate significance levels of 10%, 5% and 1%.

5. Conclusions and insights

The active implementation of a green technology innovation strategy has become an inevitable choice for heavy-polluting industries to cope with environmental regulation. Article Selection

A total of 2,709 observation samples from the data of listed companies of heavily polluting enterprises in China from 2015 to 2021 were used to test the impact of levying environmental protection tax on enterprises' green technological innovation, and it was concluded that the levying of environmental protection tax has a positive incentive effect on the enterprises' green technological innovation, but this effect is moderated by financing constraints, and with the increase in the financing constraints, the smaller the impact of environmental protection tax on the enterprises' green technological innovation is.

Based on this, this paper puts forward the following suggestions: since environmental protection tax can effectively enhance the effectiveness of green technology innovation of enterprises, the government should actively

It should guide and increase the tax incentives for environmental protection tax, improve the level of enforcement of environmental protection tax, and form a mode of collection in which incentives and constraints coexist, to realize the harmonious development of environmental protection and economic development. For enterprises, they should reasonably utilize the cost pressure generated by the environmental protection tax,

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actively formulate green technology innovation strategies, abandon high-pollution and high-energy-consumption production modes, promote green changes in production methods and products, and promote their sustainable development, in line with the national trend of green development.

Given that financing constraints have weakened the transmission mechanism of environmental protection tax affecting enterprises' green innovation, for enterprises, effective measures should be taken to enhance their credit level and strive for more exogenous financing. The government, should actively build an environment for the application of green digital finance, guide financial institutions to develop green digital finance, provide green digital financial products, and popularize green credit. There is evidence that green digital finance can effectively reduce information asymmetry and alleviate the financing constraints of enterprises (Hotenrott, 2012). And, Wang Wenna et al. (2020) pointed out that financial institutions are fully capable of screening high-quality enterprises among heavy polluters with the support of new-generation information technology to improve the mismatch of financial resources. Through green digital finance to improve the financing efficiency of enterprises and reduce the impact of financing constraints on enterprises, to promote the green transformation and green upgrading development of heavily polluting enterprises.

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