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The Carbon Reduction Effect of Heterogeneous Environmental Regulation Tools

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Abstract

Against the backdrop of the "double carbon" goals, reducing the carbon intensity of heavy-polluting enterprises with high energy consumption and carbon emis-sions has become crucial. As an important policy tool to guide green and low-carbon development, environmental regulation policies are indispensable for governing enterprise carbon intensity. This study focuses on two heteroge-neous environmental regulation tools—environmental subsidies and pollution discharge fees—and selects 8,258 sample observations of Chinese listed compa-nies from 2011 to 2021 as the research object. The findings show that: Environ-mental subsidy policies can significantly reduce the carbon intensity of heavy-polluting enterprises, while pollution discharge fees exacerbate enterprise carbon intensity to a certain extent.The research conclusions are of great signif-icance for improving environmental regulation policies and guiding heavy-polluting enterprises to save energy and reduce emissions, providing a realization path for achieving the carbon neutrality goal by 2060.

Keywords

Heterogeneous environmental regulation tools; Pollution discharge fees; Environmental subsidies; Carbon intensity

1. Introduction

Global warming is a complex and urgent issue, primarily caused by increased emissions of greenhouse gases such as carbon dioxide (CO_2) from human activities. With the increase in CO_2 emissions, governments around the world have formulated emission reduction targets and environmental regulation policies. Environmental regulation has become an important means to solve environmental problems and has been widely applied in the economic activities of global countries.

Its strong negative externality forces the government to take measures for regulation. Enterprises participating in environmental governance face an asymmetry between costs and benefits. On the one hand, the benefits of enterprise environmental governance are shared by all economic agents, while the costs are borne alone; on the other hand, enterprises do not pay costs for their behavior of seizing

natural resources. Therefore, the key to incentivizing enterprises to participate in environmental governance is to internalize externalities, including charging enterprises for polluting the environment and subsidizing enterprises for reducing pollution (Harford, 1978). In recent years, do China's implementation of pollution discharge fees and environmental subsidies for enterprises truly guide enterprises to reduce carbon emissions? And for enterprises in different regions, will the effect of environmental regulation on enterprise carbon emission reduction differ significantly? The study of these issues helps academic circles and policy makers further clarify the policy effect of environmental regulation and the driving factors of enterprise carbon emission reduction.

Based on this, this paper selects relevant data of Chinese A-share heavy-polluting industry enterprises from 2011 to 2021, and through a fixed-effects model, takes enterprise pollution discharge fees and environmental subsidies as the main research variables of environmental regulation to deeply explore the impact of pollution discharge fees and environmental subsidies on enterprise carbon emission reduction.

2. Literature Review

Government support and regulatory policies play a key role in carbon emission reduction of heavy-polluting enterprises. For example, environmental regulation policies affect enterprise carbon emission intensity through cost effects and technological innovation, and domestic and foreign scholars have carried out research on carbon intensity governance in various aspects. On the one hand, environmental regulation is crucial for carbon emission governance. Li & Qi (2011) studied the actual development situation in China and showed that environmental regulation can curb carbon emissions, meeting the development requirements of energy conservation, emission reduction, and low-carbon economy, which is mainly due to the spillover effect of economic agglomeration (Wang et al., 2018). Zhang & Wei (2014) and Bin Li et al. (2017) believed that the direct impact of environmental regulation on carbon emissions is an inverted "U" -shaped curve. When environmental regulation is continuously strengthened, the impact transforms from the "green paradox" to "reverse emission reduction". With the optimization of economic structure and industrial structure, the efficiency of resource utilization improves in the direction of clean transformation (Asici&Acar, 2018). Meanwhile, the impact of environmental regulation on carbon emissions has significant regional heterogeneity. Berman & Bui (2001) found that when facing large-scale enterprise agglomeration, the technological spillover effect is significant. High environmental regulation intensity can improve production efficiency and reduce CO_2 emissions (Lanoie et al., 2008; Pan et al., 2018a, 2018b, 2018c). In regions with high industrial agglomeration, increasing the intensity of environmental regulation can achieve the inflection point of CO_2 for large-scale industrial agglomeration (Wang et al., 2018) and improve carbon

productivity. For how environmental regulation affects micro-enterprise behavior, existing research mostly focuses on how to make enterprises take the initiative to assume social responsibility for environmental protection and governance (Fan Ziying & Zhao Renjie, 2019; Zhang Qi et al., 2019) , and there are few literatures exploring how to achieve the "win-win" of enterprise competitiveness and environmental protection.

On the other hand, government governance is crucial for reducing carbon intensity. Environmental subsidy policies can promote enterprise environmental protection investment and technological innovation to a certain extent, thereby affecting their carbon intensity. For example, Wang Fangjun et al. (2019) believed that the government gives credit preferential support to enterprises in high-carbon emission industries to urge them to reduce carbon emissions, and government environmental subsidies can urge heavy-polluting enterprises to increase environmental protection investment. These policies encourage enterprises to carry out R&D and application of environmental protection technologies by providing financial support or preferential conditions, thereby helping to reduce their carbon emission levels. However, environmental subsidies may also have certain negative impacts. Cai Dongliang et al. (2019) found that environmental subsidies may crowd out the original environmental governance expenditure, deteriorating the environmental quality. In addition, Hu Zongyi et al. (2022) believed that environmental subsidies hinder the improvement of enterprise environmental responsibility performance, producing a "crowding out" effect through rent-seeking behavior and speculative behavior. This indicates that without appropriate supervision, environmental subsidies may be used by enterprises as a means to obtain short-term benefits rather than truly used to improve environmental performance.

3. Theoretical Analysis and Research Hypotheses

3.1. Environmental Subsidies and Enterprise Carbon Intensity

The market is the decisive force for resource allocation, but it also has its own limitations. Market resource allocation is difficult to take effect in environmental protection, and environmental problems with negative externalities such as the greenhouse effect are difficult to be solved efficiently only by the market. From the perspective of carbon intensity governance externality, reducing carbon intensity inevitably requires a large investment of manpower, material resources, and financial resources, while enterprises can only obtain indirect benefits such as green reputation and good government-enterprise relations in the short term when reducing carbon intensity. The environmental benefits generated by enterprises reducing carbon intensity under market conditions belong to public goods, with strong externality . Therefore, realizing "carbon neutrality" requires giving play to the role of the government.

As an ex-ante incentive policy, government subsidies provide financial support to

enterprises, which can directly alleviate the urgent need of enterprise fund shortage in the process of reducing carbon intensity, and attract investors to follow government investment by playing a signal transmission effect, relieving enterprise fund pressure. Environmental subsidies bring abundant cash flow to enterprises, creating conditions for enterprises to reduce carbon intensity. Operators face increased "moral hazard" constraints in the principal-agent problem in an environment of tight enterprise funds and difficult operations, so they pay more attention to short-term profits and survival of enterprises. Even if operators have the ideal of low-carbon transformation, they still place short-term profits and survival in the first place of decision-making and are difficult to consider carbon intensity governance. Government subsidies help improve enterprises' resource acquisition ability and internal cash flow level, create an environment of loose financing and abundant funds for enterprises, reduce the moral hazard faced by enterprise operators in the principal-agent problem, incentivize enterprises to consider long-term development, pay attention to energy consumption costs, government-enterprise relations, and social reputation, exchange short-term low-carbon transformation investment for long-term energy consumption cost savings, and promote enterprises to reduce carbon intensity. Based on the above analysis, the research hypothesis is put forward:

Hypothesis1: Environmental subsidies can incentivize heavy-polluting enterprises to reduce carbon intensity.

3.2. Pollution Discharge Fees and Enterprise Carbon Intensity

As a market-incentive policy, pollution discharge fees urge enterprises to reduce pollutant emissions through economic means. Studies have shown that increasing the standard for collecting pollution discharge fees can significantly reduce the emission of pollutants per unit of industrial output, thereby contributing to carbon emission reduction. As a market-type environmental regulation, pollution discharge fees have undoubtedly become an important tool for China's ecological environment governance.

However, some studies have also pointed out that the collection of pollution discharge fees has not reduced industrial "three wastes" emissions, and even sometimes caused an increase in industrial "three wastes" emissions . The collection of pollution discharge fees may also lead some enterprises to reduce production scale to reduce emissions, thereby having a negative impact on output . Some scholars believe that environmental regulation policies may not effectively reduce pollutant emissions due to imperfect systems, high costs (Li Jianjun & Liu Yuansheng, 2015) , tax and fee transfer (Lu Hongyou & Zhu Yunchan, 2017) , etc., but will aggravate pollutant emissions, and put forward the "green paradox".

If the tax amount of the environmental protection tax is far lower than the price of enterprise pollution prevention or the cost of green technological innovation, then enterprises may choose to continue polluting the environment from the perspective

of profit maximization, and at this time, the effect of carbon emission reduction will become very small or even insignificant . With the proposal of the "green paradox", many studies have found that strict environmental policies may lead enterprises to increase the development and use of energy under the "compliance cost effect", and deteriorate the ecological environment and aggravate pollutant emissions in the case of imperfect systems . Based on this, the research hypothesis is put forward:

Hypothesis2: Pollution discharge fees will increase the emission reduction costs of heavy-polluting enterprises, inhibit enterprise pollution prevention, and instead increase their carbon intensity.

4. Research Design

4.1. Sample Selection and Data Source

This paper takes the data of China's A-share heavy-polluting industry listed enterprises from 2011 to 2021 as samples to empirically test the impact of heterogeneous environmental regulation tools on the carbon intensity of heavy-polluting enterprises.

The data sources of this paper are as follows: (1) The data of pollution discharge fees and environmental subsidies come from the annual report notes of listed enterprises and the annual environmental reports that heavy-polluting industry listed enterprises are required to issue in accordance with the Guidelines for Environmental Information Disclosure of Listed Companies. (2) The explained variable carbon intensity (INTENSITY) is measured by the ratio of enterprise carbon dioxide emissions to main business income with reference to relevant research. Enterprise carbon dioxide is approximately estimated according to industry energy consumption. The industry standard coal consumption data come from the China Energy Statistical Yearbook.(3) The data of other variables come from the Guotai'an (CSMSR) database, Wande (WIND) database, and China Problem Research (CNRDS) database.

4.2. Variable Definition

Pollution Discharge Fees and Environmental Subsidies: This paper manually collects and sorts out the amounts of pollution discharge fees and environmental subsidies from the annual environmental reports and financial statement notes prepared by heavy-polluting industry listed enterprises in accordance with the Guidelines for Environmental Information Disclosure of Listed Companies.

INTENSITY (Carbon Intensity): With reference to Shen Hongtao et al. (2019), it is measured by dividing enterprise carbon dioxide emissions by main business income. Among them, enterprise carbon dioxide emissions are approximately estimated according to industry energy consumption, and the specific calculation method is shown in formula (1). The data of industry main business costs and industry total energy consumption come from the China Industrial Economic Statistical Yearbook

and China Energy Statistical Yearbook respectively. Referring to the carbon dioxide calculation standard of Xiamen Energy Conservation Center, the carbon dioxide conversion coefficient of 1 ton of standard coal is 2.493.

Carbon Dioxide Emissions=Industry Main Business CostsEnterprise Main Business Costs×Industry Total Energy Consumption×Carbon Dioxide Conversion Coefficient (1)

Table 1. Definition of Main Variables

Variable Type	Variable Name	Variable Symbol	Variable Definition
Explained Variable	Carbon Intensity	INTENSITY	CO2 Emissions / Operating Revenue × 1,000,000
Explanatory Variable	Environmental Subsidy	Subsidy	Environmental Subsidy / Total Assets
	Pollution Discharge Fee	Charge	Pollution Discharge Fees / Total Assets
Control Variables	Asset-Liability Ratio	Lev	Total Liabilities / Total Assets
	Firm Size	Size	Natural Logarithm of Total Assets
	Asset Growth Rate	AssetGrowth	(Total Assets at Year-End - Total Assets at Year-Begin) / Total Assets at Year-Begin
	Net Profit Growth Rate	NetProfitGrowth	(Current Net Profit - Prior Period Net Profit) / Prior Period Net Profit
	Nature of Ownership	SOE	State-Owned Enterprise = 1, Non-State-Owned = 0
	Tobin's Q	TobinQ	Market Value / Total Assets

4.3. Model Construction

$$INTENSITYi,t=\alpha 0+\alpha 1SUBi,t+\alpha nControls+\sum Area+\sum Year+\xi \quad (2)$$

$$INTENSITYi,t=\beta 0+\beta 1Chargei,t+\beta nControls+\sum Area+\sum Year+\xi \quad (3)$$

In models (2) and (3), Area and Year are province and year dummy variables. The coefficients we mainly focus on are α_1 and β_1. If pollution discharge fees and environmental subsidies have a promoting effect on enterprise carbon emission reduction activities, then α_1 and β_1 should be significantly negative; otherwise, α_1 and β_1 should be significantly positive. In addition, pollution discharge fees and environmental subsidies will also be placed in the same model for regression testing during the research process.

5. Empirical Test Results Analysis

5.1. Descriptive Statistics of Variables

The descriptive statistics for the variables are shown in Table 2.

Table 2. Descriptive statistics of variables

Variable	Obs	Mean	Std.Dev.	Min	Max
INTENSITY	8258	0.873	0.658	0	3.454
Subsidy	8258	0.036	0.109	0	0.668
Charge	8258	0.08	0.065	0	0.355
SOE	8258	0.342	0.475	0	1
Size	8258	22.236	1.247	19.59	26.452

Lev	8258	0.397	0.197	.032	0.908
TobinQ	8258	2.007	1.311	.802	15.607
AssetGrowth	8258	0.164	0.33	-.383	5.116
NetProfitGrowth	8258	-0.277	4.012	-36.533	15.501

5.2. Baseline Regression Results

To deeply explore the role of environmental regulation based on pollution discharge fees and environmental subsidies in enterprise carbon emission reduction, this part uses the software Stata for analysis. In the baseline regression, the enterprise carbon intensity is first used as the indicator of enterprise carbon emissions. Table 3 reports the baseline regression results of this paper. The regression coefficient of pollution discharge fee Charge is significantly positive at least at the 1% level, indicating that pollution discharge fees have played a hindering role in enterprise carbon emission reduction, which is because the current pollution discharge fee standard is on the low side, far lower than the pollution treatment cost, and many enterprises prefer to pay pollution discharge fees rather than treat pollution. The coefficient of government environmental subsidy is negative and significant at the 1% level. Government environmental subsidies can significantly reduce the carbon intensity of enterprises. Government environmental subsidies can effectively alleviate the "externality" problem of environmental governance, solve the problems of tight funds and high risks in the process of energy conservation and emission reduction of enterprises, enhance the confidence of enterprise managers, and incentivize enterprises to perform the responsibility of improving energy utilization efficiency and reducing carbon intensity advocated by the government.

Table 3. Baseline Regression Results

	(1)	(2)
Variable	INTENSITY	INTENSITY
Subsidy		-0.228***
Charge		(-3.972) 0.209*** (3.210)
Size	0.025***	0.022***
	(4.208)	(3.755)
Lev	0.138***	0.141***
	(5.119)	(5.228)
TobinQ	-0.031***	-0.031***
	(-10.804)	(-10.797)
AssetGrowth	-0.045***	-0.045***
	(-5.500)	(-5.536)
NetProfitGrowth	-0.006***	-0.006***
	(-8.936)	(-8.967)
SOE	0.042**	0.044**
	(1.990)	(2.085)
_cons	0.318**	0.378***
	(2.454)	(2.899)
N	8258	8258
R2	0.045	0.047
F	55.158	49.632
***p<0.01"，"**p<0.05"，"*p<0.10		

6. Conclusions and Implications

6.1. Research Conclusions

This paper takes Chinese heavy-polluting enterprise A-share listed companies from 2011 to 2021 as research samples to analyze the mechanism of the relationship between government subsidies and pollution discharge fees affecting enterprise carbon intensity. The empirical research results show that: First, government subsidies can significantly reduce enterprise carbon intensity, and produce a carbon intensity governance effect by incentivizing enterprise green technological innovation. Government subsidies help enhance enterprises' resource acquisition ability, correct the externality problems of carbon intensity governance and green technological innovation, promote enterprises to carry out green technological innovation, accelerate the pace of green production transformation, and improve production processes to enhance energy efficiency, so as to realize technological carbon reduction.

6.2. Policy Recommendations

The research conclusions show that under the "double carbon" goal, the collection of environmental protection taxes has significantly promoted the carbon emission reduction effect of enterprises, but this effect has different impacts on different industries. Therefore, the following two countermeasures and suggestions are put forward.

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