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Research on the Impact of Environmental Protection Tax Incentives on Enterprises' Green and Low-Carbon Transformation

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Abstract. As a major tax-collecting nation and one of the key contributors to global environmental governance, China's tax policies have attracted worldwide attention, whilst its environmental governance efforts have also come under scrutiny. To date, in the process of promoting sustainable and green development, China has introduced a range of tax measures, including the replacement of pollution discharge fees with an environmental protection tax, the establishment of a systematic framework comprising 56 green tax incentives to support green development, and the passage of the 'Ecological and Environmental Code of the People's Republic of China' in 2026. The introduction of environmental tax incentive policies is intended to facilitate a comprehensive green and low-carbon transition in economic and social development and to implement a sustainable development strategy. This paper delves further into the relationship between these two aspects and examines the mechanisms through which environmental tax incentives directly or indirectly influence enterprises' green and low-carbon transition. The study employs empirical analysis using listed data on environmental tax incentives for companies from 2008 to 2024, alongside data on green patents applied for by these companies. The study found that environmental tax incentives significantly promote enterprises' green and low-carbon transition, while internal factors—including cash levels and operating costs—as well as macro-level external environmental factors such as local public debt levels, exert negative moderating effects.

Keywords: Environmental tax incentives; The transition to a green and low-carbon economy; Local government debt.

1. Introduction

As the world's largest developing country, China has been continuously promoting tax reduction reforms in multiple fields, especially in environmental protection, and has gradually built a systematic tax and tax incentive policy system to help enterprises reduce their environmental burden, stimulate green innovation, and promote the development of low-carbon industries and high-quality economic development.

In 2008, Article 38 of the "Enterprise Income Tax Law of the People's Republic of China" was amended to include corporate environmental protection investment as a pre-tax deduction item, providing certain tax incentives for enterprises. In 2016, the Environmental Protection Tax Law was officially promulgated and implemented, marking China's first law concerning environmental taxes. This law stipulates the taxpayers, tax base, and tax rates for environmental protection taxes, and clearly defines the scope of use of environmental protection tax revenue. Green tax incentives are reflected to some extent in the Environmental Protection Tax Law. From 2018 to the present, the Chinese government has further increased its support for green tax incentives. In 2022, the State Taxation Administration integrated and implemented 56 tax and fee incentive policies supporting green development, namely environmental protection tax incentive policies, covering four key areas: environmental protection, energy conservation and environmental protection, comprehensive resource utilization, and low-carbon industry development. This significantly enhanced the incentive and support role of taxation in guiding market entities towards green and low-carbon transformation. In 2026, the Fourth Session of the 14th National People's Congress passed the "Ecological

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Environment Code of the People's Republic of China," which will come into effect on August 15, 2026. This code also explicitly mentions relevant environmental protection tax incentive policies .

At the same time, the country actively advocates for a green and low-carbon transformation of society. This transformation is a systematic strategy for China to comprehensively shift its economic and social development towards resource conservation, environmental friendliness, and ecological balance, driven by "dual carbon" targets to achieve deep integration of high-quality development and ecological civilization construction. The State Council's 2024 opinion on accelerating the comprehensive green transformation of economic and social development pointed out the need to unswervingly follow a path of ecological priority, resource conservation and intensive use, and green, low-carbon, and high-quality development. For enterprises, green and low-carbon transformation refers to the strategic process of systematically shifting from the traditional development model of high energy consumption, high pollution, and high carbon emissions to a sustainable development model of resource conservation, environmental friendliness, and low-carbon circularity. The reason my country continues to introduce environmental protection tax incentive policies stems from a growing recognition at the national development strategy level of the profound significance of promoting green and low-carbon transformation in society and enterprises.

In conclusion, environmental tax incentive policies appear to play an indispensable role in motivating and guiding enterprises towards green transformation. Specifically, while these policies can reduce the tax burden on enterprises to some extent and increase their enthusiasm for using clean energy and environmentally friendly materials, thereby accelerating their green and low-carbon transformation , some unscrupulous individuals target these tax incentives, illegally enjoying policy benefits and seriously disrupting normal market order and undermining fair competition. According to publicly available information from the State Taxation Administration, since the beginning of 2025 alone, its platform has published more than 20 cases of enterprises fraudulently obtaining tax benefits and evading taxes. This demonstrates that various tax incentive policies formulated by the government cannot necessarily completely eliminate the risk of abuse; on the contrary, regulatory loopholes and differences in implementation may bring new challenges to tax compliance and fairness.

Furthermore, actively promoting the green and low-carbon transformation of society also faces some difficulties. Although national policies continuously advocate for green and low-carbon transformation, most enterprises still suffer from insufficient investment in green R&D and weak environmental awareness in practice, and have not yet formed a comprehensive green and low-carbon transformation system. Therefore, it is of significant research value to explore in depth whether environmental tax incentive policies can effectively impact the green and low-carbon transformation of enterprises .

The significance of this study is mainly reflected in the following aspects. First, theoretically, this paper clearly defines the connotation and extension of environmental tax incentives , extending the theoretical discussion of tax incentives to the context of green and low-carbon development, further subdividing and enriching the research system of tax incentives. In terms of research content, this paper systematically clarifies the internal mechanism by which green tax incentives affect enterprises' green and low-carbon transformation, providing theoretical support for how enterprises can efficiently utilize policy tools to achieve low-cost and high-efficiency transformation . Second, in terms of practical significance, the research conclusions can provide empirical evidence and decision-making references for government departments to optimize the green tax policy system, helping to improve the accuracy and incentive effect of policies, and further promoting the implementation of the national green development strategy and the achievement of "dual carbon" goals. At the enterprise level, this research helps guide enterprises to more actively understand and utilize green tax incentive policies, rationally plan green investment and financing strategies, effectively reduce transformation costs, enhance sustainable competitiveness, and achieve a dual improvement in economic and environmental benefits.

2. Literature Review

In recent years, in order to promote the comprehensive green transformation of economic and social development, China has continuously improved the green tax system and implemented green tax incentive policies, also known as environmental protection tax incentive policies. Domestic and foreign scholars have conducted extensive research and discussion on the impact of tax incentive policies on the performance of enterprise technological innovation. On the one hand, tax incentives reduce the tax burden of enterprises, thereby reducing the enterprises' precautionary and speculative demand for cash [1] , increasing cash flow, enabling enterprises to invest more resources in innovation activities, and thus improving the level of innovation output [2] . On the other hand, tax incentives can effectively alleviate the financing constraints of enterprises [3 , 4] , improve the efficiency of internal capital allocation and capital turnover capacity of enterprises, and promote the flow of funds to long-term investment projects such as R&D activities [5] , thereby promoting technological innovation [6] . In addition, tax incentives can affect the technological innovation of enterprises through the supply chain [7], and indirectly promote the development of innovation activities by increasing the willingness of enterprises to participate in social responsibility activities and by improving the reputation of enterprises [8] . In summary, by reducing the tax burden, such tax incentive measures can increase the disposable cash flow of enterprises and reduce the necessity and cost of external financing.

Environmental tax incentive policies are an important part of the tax incentive system. Therefore, based on relevant research on tax incentives, it can be seen that environmental tax incentive policies will also promote enterprises to increase green innovation research and development. Furthermore, some studies have directly shown that environmental tax incentive policies, as a type of green subsidy, are a key factor driving green process innovation in enterprises. They can effectively alleviate the financial constraints of enterprises, thereby promoting green process innovation and enhancing the long-term competitive advantage of enterprises [9]. In addition, Ahmad et al. [10] studied the incentive mechanism under carbon tax and the role of green investment in the supply chain by establishing an inventory model. The results showed that environmental tax incentive mechanisms can encourage manufacturers to increase emission reduction efforts through green technology investment, thereby having a positive impact on economic and environmental performance.

The literature on green and low-carbon transformation of enterprises is as follows. First, green and low-carbon transformation of enterprises is a complex strategic process, the core of which is the innovative investment in green technology and low-carbon research and development. Under the current development model, technological innovation has been widely regarded as the key driving force for promoting high-quality economic development, enhancing the core competitiveness of enterprises and leading industrial upgrading [11]. However, enterprises still face a series of practical constraints in the process of promoting green innovation, especially the inherent high risk of R&D activities, long investment cycle and serious shortage of funds, which together restrict the improvement of enterprise innovation capabilities and delay the pace of their green and low-carbon transformation.

Regarding the key factors influencing enterprises' green and low-carbon transformation, existing research has identified multiple driving mechanisms. At the policy level, tax incentives such as "accelerated depreciation of fixed assets" effectively incentivize green technology investment by alleviating enterprises' cash flow pressure [12] ; the "low-carbon city pilot" policy promotes the coordinated transformation of enterprises in the region by building a systematic low-carbon institutional environment [13 , 14] . In addition, factors such as enterprises' own digital transformation [15] , foreign direct investment behavior [16] , and environmental information disclosure [17] have also significantly promoted enterprises' green innovation and low-carbon development from the perspectives of technology empowerment, international knowledge spillover, and social supervision.

In summary, while tax incentives are an important policy tool for governments to promote technological innovation, most existing literature has affirmed their role in promoting green

innovation. However, a detailed discussion of the impact of " environmental tax incentives " specifically on enterprises at the enterprise level is still lacking. Recent research, relying on national tax survey data, analyzes the specific mechanisms by which tax incentives affect enterprises' green transformation, focusing on taxes such as value-added tax, income tax, and consumption tax. This indicates that research in this field is gradually moving towards micro-level empirical studies and policy refinement. Although the aforementioned research provides solid empirical support for policy evaluation, there is still room for further expansion. Specifically, most literature focuses on the positive impacts of tax incentive policies, but pays less attention to the substantive effects of environmental tax incentives, the cost pressures during enterprises' green and low-carbon transformation, the impact of technological substitution on traditional jobs, and the heterogeneous outcomes for enterprises in different environments and industries .

Research on the relationship between environmental tax incentives and enterprises' green and low-carbon transformation is also limited. Based on the above analysis, it can be concluded that environmental tax incentives mainly reduce enterprises' cost and cash flow burdens through green tax breaks, thereby guiding enterprises to increase investment in green technology research and development and cleaner production, and promoting their green and low-carbon transformation. Current views generally believe that green tax incentive policies can effectively drive enterprises to carry out green process innovation, prompting them to actively seek more environmentally friendly and energy-saving production methods, thus promoting enterprises' transformation towards green sustainability. Furthermore, it can macroscopically promote industrial upgrading and the green and low-carbon development of technological structures, achieving a win-win situation for both economic and environmental benefits.

3. Theoretical Analysis and Research Hypotheses

3.1. The impact of environmental tax incentives on enterprises' green and low-carbon transformation

From a cost-effectiveness perspective, environmental tax incentives reduce a company's tax burden, increase cash flow, and indirectly lower the costs associated with green innovation and green, low-carbon transformation. The green transformation process inevitably increases a company's overall costs , and environmental tax incentives are a typical example of measures to guide companies towards this transformation. By reducing the tax burden, decreasing cash outflows, and encouraging energy conservation, environmental protection, and green innovation, environmental tax incentives help companies better transform. This is because the prerequisite for companies to enjoy environmental tax incentives is the continuous pursuit of more environmentally friendly, energy-efficient, and clean production methods and technologies—that is, engaging in green and low-carbon research and innovation to drive the company towards a greener and lower-carbon development direction.

In addition, according to the theory of information asymmetry and stakeholder theory, enterprises can convey their green and environmental protection signals to the outside world by obtaining environmental protection tax incentives , so that potential investors can better understand the specific situation of the enterprise, alleviate information asymmetry , and the green innovation and production technology transformation carried out by them to obtain tax incentives can not only improve resource utilization efficiency and reduce production materials and energy consumption, but also bring good external reputation to the enterprise, and ultimately bring positive economic performance to the enterprise [18] . In addition, as beneficiaries of environmental protection tax incentives and one of the main participants in environmental governance, the behavior of enterprises has attracted much attention from all sectors of society. This is because the fact that enterprises have received environmental protection tax incentives indicates that they have met the national green development requirements in terms of environmental protection, energy conservation and environmental protection,

comprehensive utilization of resources and development of low-carbon industries, which can effectively improve the competitiveness of enterprises.

Plays a positive role in the green and low-carbon transformation of enterprises . This paper proposes hypothesis H1:

Hypothesis H1: Environmental tax incentives promote the green and low-carbon transformation of enterprises.

3.2. Moderating effect of corporate cash flow and cost pressure

"lifeblood" of operations , directly impacting their survival, development, and financial stability. Furthermore, businesses aim to make a profit, thus they have greater concerns about costs, especially cost-intensive companies. When making strategic decisions, these companies may allocate resources more towards projects that reduce costs.

As mentioned earlier, environmental tax incentives promote green and low-carbon transformation by adjusting corporate cash flow and reducing the costs of green innovation. Therefore, it can be argued that when a company's cash flow is low, the increased cash flow from environmental tax incentives will have a greater effect on promoting green and low-carbon transformation than on companies with higher cash flow. Regarding cost pressure, although environmental tax incentives can reduce costs associated with green and low-carbon transformation to some extent, companies typically face high costs when choosing to undertake such transformations. This may lead companies already facing high cost pressures to postpone or abandon strategic investments in green and low-carbon transformation. Thus, the greater the cost pressure on a company, the less effective environmental tax incentives may be in promoting green and low-carbon transformation, this paper proposes hypothesis H2 .

Hypothesis H2: The cash flow level and cost pressure of enterprises play a negative moderating role in the environmental tax incentives that promote the green and low-carbon transformation of enterprises.

3.3. The Moderating Effect of Local Public Debt

In recent years, local government debt has been rising continuously, and the State Council executive meeting has also made arrangements to further prevent and resolve local debt risks. The continued rise in local government debt has had a significant impact on the domestic economic development situation, and its impact on enterprises is also deepening.

First, the expansion of local government debt, especially explicit debt, will crowd out credit resources in the market [19] , thereby intensifying the financing competition among private enterprises. In order to obtain a more favorable financing position, enterprises will be forced to implement corresponding measures to cope with financing pressure . As local public debt continues to increase, it continues to crowd out the financing resources of enterprises, and the financing of enterprises is significantly constrained, and the financing cost is also increasing [20]. Moreover, under the contemporary financing framework, private enterprises face huge challenges in obtaining credit from traditional financial institutions such as banks. And the green technology innovation and upgrading of enterprises require a lot of funds. The expansion of local government debt may restrict the green and low-carbon transformation of enterprises. Robin Döttling and Rola-Janicka Magdalena [21] pointed out that when regulators set emission taxes to incentivize borrowers to reduce emissions through costly emission reduction activities, borrowers need to borrow to finance emission reduction expenditures. However, since project revenue cannot be fully mortgaged to external investors, borrowing is subject to financial constraints. Such financial constraints will lead to a decline in the willingness of enterprises to carry out green and low-carbon transformation . Even with preferential policies such as environmental protection tax incentives, the enthusiasm of enterprises will be affected to a certain extent. Based on this, this paper proposes the following hypothesis:

Hypothesis H3: Local public debt will play a reverse regulatory role in the incentive of environmental protection taxes to promote the green and low-carbon transformation of enterprises

4. Sample selection and research design

4.1. Sample Selection and Data Sources

This paper selects A-share listed companies (excluding ST companies and those in the financial industry) from 2008 to 2024 as its research sample to study the impact of environmental protection tax incentive policies on enterprises' green and low-carbon transformation . The study covers 5237 A-share listed companies, of which 698 companies have benefited from environmental protection tax incentive policies. Classifying the industries into 47 major categories, this paper studies the distribution of industries among the companies receiving environmental protection tax incentives. The analysis shows that the companies receiving environmental protection tax incentives cover 41 different industries, almost achieving full industry coverage. Therefore, this paper selects a sample from all industries except the financial industry.

Data sources for this study include: information on whether enterprises received environmental tax incentives was obtained through textual analysis of enterprise annual reports; green patent data for enterprises came from the China Research Data Service Platform (CNRDS); and some data on local finance and environmental protection came from statistical databases such as the State Council Research Office website, CNRDS, and Peking University Legal Database. Other financial data came from the CSMAR database.

The data processing procedure for this study was as follows : First, companies marked with ST and ST*, as well as companies in the financial industry, were removed. Second, records with missing main and control variables were removed, retaining only those with complete data to facilitate subsequent regression analysis. Third, to address potential data anomalies, other abnormal data were also removed. Finally, considering the development history of environmental protection tax incentive policies and to enhance the value of this study, the research period was chosen to be 2008-2024. To avoid the influence of extreme values on the empirical analysis results, all continuous variables were shortened by 1% (both upper and lower). EXCEL and Stata 18 software were used for data processing.

4.2. Variable Definition

4.2.1. Explained Variable : The degree of green and low-carbon transformation of enterprises

(1) Number of green and low-carbon patent applications filed by the enterprise in the current year (*Gld*)

Enterprise green and low-carbon transformation refers to the combination of green transformation and low-carbon transformation. This involves replacing energy-saving, low-carbon, and clean production technologies and equipment, promoting the upgrading of processes, and innovating green and low-carbon technologies and coordinating the industrial chain. This process aims to shift the enterprise's development mode from high energy consumption and high emissions to low energy consumption and low carbon emissions, and achieve a dynamic process of coordinated and unified economic, environmental, and social benefits.

Numerous studies have shown that green innovation is one of the main channels for enterprises to achieve green and low-carbon transformation [22] . In order to ensure the accuracy of empirical data, this paper chooses to use the number of green and low-carbon patent applications of listed companies in the current year as the definition, and uses variables such as corporate environmental protection investment as the dependent variables in the robustness test. The data on corporate green and low-carbon patent applications comes from the green and low-carbon patent applications and authorization data of listed companies in the CNRS database.

4.2.2. Explanatory Variables : Whether the enterprise receives environmental protection tax incentives

The data on whether enterprises are subject to environmental tax incentives comes from text mining analysis of the annual reports of all A-share listed companies. Enterprises whose annual reports contain the explicit keyword "comprehensive utilization of resources" for environmental tax incentives are considered to have been affected by environmental tax incentive policies.

This study selects resource comprehensive utilization tax incentives as a proxy variable for environmental tax incentives because resource comprehensive utilization tax incentive policies are relatively independent, more representative, and can reduce the interference of other tax incentive policies on environmental tax incentive policies, resulting in more independent data. To this end, this paper constructs a variable indicating whether a company receives environmental tax incentives (*RTY*), assigning a value of 1 if the company receives green tax incentives, and 0 otherwise.

4.2.3. Mechanism Variables

The paper examines a company's cash flow (*CASH*) , cost pressure (*CB*), and the level of government debt (*Rdebt*) in its region. To further explore the regulatory mechanism of environmental tax incentives on the green and low-carbon transformation of enterprises, this paper, based on the theoretical analysis and referencing the selection methods of Sun Weizeng, Zhang Qi , and Wu Fei [23 , 24 , 25] , uses the cash-to-asset ratio to represent the company's cash flow level (*CASH*), calculated as: ending cash and cash equivalents balance / total assets. The company's cost pressure (*CB*) is represented by the operating cost ratio, calculated as: operating costs / operating revenue. The level of government debt (*Rdebt*) in the region where the company is located is calculated as : total amount of local government bonds issued in the province in the current year (RMB 100 million) / provincial GDP (RMB 100 million).

4.2.4. Control Variables

Drawing on relevant literature, this paper selects to control for the following variables that may affect corporate environmental investment performance. First, the control variables at the firm level include: firm size (*SIZE*); debt-to-equity ratio (*LEV*); overall leverage (*IL*); total asset growth rate (*GROWTH*); net profit margin on total assets (*ROA); return on equity (ROE*); ownership structure (*STATE*); dual-role ownership (*DUAL*); board size (*BDS*); percentage of independent directors (*IDR*); capital structure (*AS*); capital intensity (*CI*); shareholding ratio of the largest shareholder (*TOP1*); and shareholding ratio of the top ten shareholders (*TOP10*).

There are governance indicators for the region (province) where the enterprise is located, mainly including the provincial GDP level (*Gdp*) and *the* per capita GDP growth rate (*Gdp_s) :* controlling the GDP growth rate and per capita GDP growth rate of the region where the enterprise is located; and the local fiscal tax revenue level (*LTR*) . Controlling these is helpful in mitigating the impact of large differences in regional economic levels .

Table 1 for a detailed description of the relevant variables .

Table 1. Variable Definition Table.

type	symbol	name	illustrate
Explained variable	*Gld*	Enterprise green and low-carbon transformation degree	Number of green patents applied by the company that year
	EPII	Corporate environmental protection investment	For details, please refer to Chapter 4.2.1. The environmental protection investment amount of enterprises was compiled with reference to the method of Zhang Qi et al. (2019), and the natural logarithm was taken.
Explanatory variables	*RTY*	Are enterprises affected by Environmental Protection Tax Incentives?	1 - Received green tax benefits, 0 - Not received green tax benefits

Mechanism variables	*CASH*	Corporate cash flow level	The company's ending cash and cash equivalents balance / total assets;
	CB	Business cost pressure	The cost of goods sold ratio is used, and the calculation formula is Cost of goods sold / Revenue.
	Rdebt	Local government debt	Total amount of local government bonds issued in the province where the company is located in the current year (100 million yuan) / Provincial GDP (100 million yuan)
control variables	*SIZE*	Enterprise size	Total assets at year-end (natural logarithm)
	LEV	Debt-to-asset ratio	Total liabilities at year-end / Total assets at year-end
	IL	Comprehensive leverage	Financial leverage × Operating leverage
	GROWTH	Total asset growth rate	Year-to-date increase in total assets / Total assets at the beginning of the year
	ROA	Net profit margin on total assets	Net profit at year-end / Total assets at year-end
	ROE	Return on equity	Net profit at year-end / Shareholders' equity at year-end
	STATE	Property rights	State-owned enterprises take 1, non-state-owned enterprises take 0.
	DUAL	Two jobs combined	If the chairman and general manager are both held by the same person, the score is 1; otherwise, it is 0.
	BDS	Board size	Number of directors on the board
	IDR	Independent Directors Percentage	Number of independent directors / size of the board
	AS	Capital Structure	Fixed assets / Total assets
	CI	Capital intensity	Total assets/Operating revenue
	TOP1	The largest shareholder's shareholding percentage	Number of shares held by the largest shareholder / total number of shares, rounded down.
	TOP10	Shareholding ratio of the top ten shareholders	Number of shares held by the top ten shareholders / total number of shares, rounded down.
	LTR	Local fiscal revenue level	Local fiscal revenue (in 100 million yuan) of the region (province) where the enterprise is located (take the natural logarithm)
	Gdp	Local GDP level	GDP level of the province (autonomous region, municipality) where the enterprise is located
	Gdp _s	Local GDP per capita	GDP per capita in the province (autonomous region, municipality) where the enterprise is located
	Area	Province	The province where the listed company is located is a dummy variable.
	Industry	industry	Industry dummy variables
	Year	years	Annual dummy variables

4.3. Model Setting

First, to verify the main hypothesis H1 of this paper , we construct model (1) for testing:

$$Gld_{i,t} = \beta_0 + \beta_1 RTY_{i,t} + \sum Ctrls_{i,t} + \sum Industry + \sum Year + \sum Area + \varepsilon_{i,t} \quad (1)$$

In Equation (1) $\sum Industry$, $\sum Year$ refer to dummy variables for industry, year, where i represents the enterprise, t represents the year, and $Ctrls_{i,t}$represent the control variables, i.e., the various data of enterprise i in year t, and $\varepsilon_{i,t}$is the random error term. In the regression analysis, all models are estimated using the OLS method, and the dummy variables for year, region, and industry are considered as control variables.

Secondly, to verify the hypotheses H2 and H3 in this paper, a unified interaction term model (2) was constructed.

$$Gld_{i,t} = \beta_0 + \beta_1 RTY_{i,t} + \beta_2 RTY_{i,t} \times Moderating\text{-}variable_{i,t} + \sum Ctrls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (2)$$

5. Empirical results

5.1. Benchmark Regression Results

Table 2 presents the results of the baseline regression. Column (1) shows the simple OLS regression results of Equation (1) without the addition of control variables and regional fixed effects. Column (2) shows the regression results after adding control variables. Column (3) shows the regression results after controlling for the regional fixed effect of the province where the enterprise is located, based on Column (2). It is worth noting that the coefficients of the explanatory variables in Columns (1), (2), and (3) are all significantly positive. Since this paper has added regionally related variables to the control variables, and considering the feasibility of subsequent empirical research, this paper ultimately chooses the results in Column (2) as a more accurate estimate of the baseline model. The results show that after enterprises received environmental protection tax incentives, the number of green and low-carbon transformation invention patent applications of enterprises increased significantly, that is, environmental protection tax incentives significantly promoted the green and low-carbon transformation of enterprises.

Table 2. Benchmark Regression Results.

	(1) *Gld*	(2) *Gld*	(3) *Gld*
RTY	7.342***	4.004***	3.859***
	(0.361)	(0.327)	(0.326)
SIZE		6.207***	6.151***
		(0.074)	(0.074)
LEV		-5.066***	-4.849***
		(0.730)	(0.729)
AS		-3.861***	-3.648***
		(0.594)	(0.595)
ROA		-45.654***	-45.871***
		(6.003)	(5.985)
ROE		22.309***	23.081***
		(3.625)	(3.612)
IL		-0.042	-0.041
		(0.031)	(0.031)
GROWTH		-0.633***	-0.660***
		(0.204)	(0.204)
CI		-0.333***	-0.317***
		(0.046)	(0.046)
STATE		0.904***	0.690***
		(0.189)	(0.191)
TOP1		-0.010	-0.005
		(0.006)	(0.006)
TOP10		0.016**	0.011*
		(0.006)	(0.006)
IDR		0.087***	0.087***
		(0.013)	(0.013)
BDS		0.107	0.124
		(0.082)	(0.082)
DUAL		0.768***	0.750***
		(0.163)	(0.163)
GDP		-0.063	2.136
		(0.287)	(1.969)
GDP_s		1.952***	-0.628
		(0.304)	(1.855)
LTR		0.262	-1.501*
		(0.320)	(0.906)

Constant	-2.334***	-155.144***	-130.542***
	(0.852)	(3.710)	(9.365)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Area	No	No	Yea
r2_adjust	0.096	0.271	0.278
N	44115	44115	44115

5.2. Moderating effect of corporate cash flow and cost pressure

The theoretical analysis section of this paper points out that when a company's cash flow level is low, the effect of environmental tax incentives on increasing cash flow and thus promoting the company's green and low-carbon transformation is better than that on companies with higher cash flow levels. However, when a company's cost pressure is high, the effect of environmental tax incentives on increasing cash flow and thus promoting the company's green and low-carbon transformation will decrease. To address this, this paper constructs two variables, corporate cash flow level (*CASH*) and cost pressure (*CB*), and interacts with the explanatory variables, and puts them into the interaction term model —Equation (2)—to test hypothesis H2. The results are shown in Table 3. The results show that corporate cash flow level and cost pressure level play a negative moderating role in the process of environmental tax incentives promoting the company's green and low-carbon transformation.

Table 3. Empirical Results of the Moderating Effect of Corporate Cash Flow and Cost Pressure.

	(1)	(2)
	Gld	*Gld*
RTY	6.411***	-3.350**
	(0.496)	(1.691)
*RTY*CASH*	-19.387***	
	(3.016)	
CASH	2.830***	
	(0.643)	
*RTY*CB*		9.715***
		(2.188)
CB		-1.236*
		(0.633)
SIZE	6.214***	6.203***
	(0.074)	(0.074)
LEV	-4.596***	-4.927***
	(0.746)	(0.731)
AS	-3.423***	-3.912***
	(0.609)	(0.594)
ROA	-46.334***	-47.098***
	(6.001)	(6.111)
ROE	22.376***	22.440***
	(3.623)	(3.627)
IL	-0.044	-0.045
	(0.031)	(0.031)
GROWTH	-0.805***	-0.659***
	(0.208)	(0.204)
CI	-0.326***	-0.357***
	(0.046)	(0.052)
STATE	0.855***	0.928***
	(0.190)	(0.190)
TOP1	-0.010	-0.009

	(0.006)	(0.006)
TOP10	0.014**	0.016**
	(0.006)	(0.006)
IDR	0.088***	0.087***
	(0.013)	(0.013)
BDS	0.099	0.094
	(0.082)	(0.082)
DUAL	0.750***	0.764***
	(0.163)	(0.163)
GDP	0.008	-0.033
	(0.287)	(0.287)
GDP_s	1.964***	1.976***
	(0.304)	(0.304)
LTR	0.194	0.243
	(0.320)	(0.320)
Constant	-156.204***	-154.372***
	(3.732)	(3.730)
Year	Yes	Yes
Industry	Yes	Yes
r2_adjust	0.272	0.272
N	44115	44113

5.3. The Regulatory Effect of Local Government Debt

The prevailing view is that increasing local government debt will inhibit the flow of valuable financial resources to support innovation and the development of new productive forces in the real economy. This is because local government debt is generally issued by provincial governments and is subject to strict regulation, with funds tending to flow more towards infrastructure and state-owned enterprises, directly crowding out financial resources for private enterprises. Since enterprises require substantial financial support for green and low-carbon transformation, the increase in local government debt may suppress the effectiveness of environmental tax incentives in promoting green and low-carbon transformation, thus playing a negative regulatory role.

This paper uses the local government debt data of prefecture-level cities (*Rdebt1) from Xie Shenxiang, Chu Hong and Liu Jindong* [19] and the data of provincial-level local government debt from CNRS database from 2009 to 2024. However, the data for 2010 is missing because the government debt in that year was not subdivided into each province. The local government debt (*Rdebt2*) variable was generated and interacted with the explanatory variables. It was substituted into the model (2) to perform the regression of the moderating effect. It should be noted that the local debt data for 2010 was not specific to the corresponding province, so the data for 2010 is missing. The research results are shown in Table 4. It can be seen that the coefficients of the interaction term variables in the regression results are opposite to the coefficients of the main explanatory variables, but both are significant at the 5% test level. This proves the validity of the hypothesis H3 in this paper , that is, local government debt plays a negative moderating effect in the process of environmental protection tax incentives promoting the green and low-carbon transformation of enterprises.

Table 4. Moderating Effects of Local Government Debt.

	(1) *Gld*	(2) *Gld*
RTY	-6.601***	4.758***
	(1.486)	(0.798)
RTYRdebt1	1.520***	
	(0.229)	
Rdebt1	0.034	
	(0.055)	
RTYRdebt2		-7.889*
		(4.104)
Rdebt2		0.976
		(2.045)
SIZE	3.248***	6.790***
	(0.087)	(0.085)
LEV	-1.335*	-6.116***
	(0.784)	(0.856)
AS	-3.623***	-4.687***
	(0.637)	(0.700)
ROA	-26.446***	-62.580***
	(6.279)	(7.138)
ROE	20.172***	33.911***
	(3.688)	(4.362)
IL	-0.011	0.006
	(0.032)	(0.038)
GROWTH	-0.281	-0.643***
	(0.215)	(0.246)
CI	-0.117**	-0.382***
	(0.052)	(0.053)
STATE	-0.321	1.371***
	(0.207)	(0.223)
TOP1	-0.023***	-0.010
	(0.007)	(0.007)
TOP10	-0.031***	0.023***
	(0.007)	(0.007)
IDR	-0.019	0.088***
	(0.015)	(0.016)
BDS	-0.113	0.243**
	(0.084)	(0.100)
DUAL	0.553***	0.975***
	(0.185)	(0.185)
GDP	1.173***	0.519
	(0.452)	(0.347)
GDP_s	-1.005***	2.559***
	(0.370)	(0.382)
LTR	-0.279	-0.244
	(0.437)	(0.378)
Constant	-63.571***	-178.238***
	(4.088)	(4.944)
Year	Yes	Yes
Industry	Yes	Yes
r2_adjust	0.181	0.288
N	18462	36500

5.4. Robustness Analysis

5.4.1. Changing the explained variable

Considering that the number of green and low-carbon patent applications filed by enterprises in a given year cannot be fully used as a proxy variable for their green and low-carbon transformation,

this paper will replace the dependent variable with the enterprise's environmental protection investment (*EPII*) for robustness analysis to verify whether the empirical results of the main hypothesis are robust. Following the research methods of Zhang Qi et al ., Xie Dongming, and Wang Ping and Wang Yun et al. [23 , 26 , 27] , relevant information was collected from four tables in the notes to the enterprise's financial statements: the table of significant changes in construction in progress, management expenses, sales expenses, and R&D expenses. The investment amounts were then summarized to obtain the enterprise's environmental protection investment amount, and the natural logarithm of this amount was taken to obtain the dependent variable (*EPII*) . This variable can effectively compensate for the insufficient investment in green innovation alone in the enterprise's green and low-carbon transformation. The empirical results are shown in Table 5. The estimated coefficients of the core explanatory variable are still positive and significant at the 1% level, indicating that the main hypothesis is robust.

Table 5. Regression results with different explained variables.

	(1)
	EPI1
	Corporate environmental protection investment
RTY	0.453***
	(0.047)
SIZE	0.035***
	(0.011)
LEV	0.842***
	(0.104)
AS	0.448***
	(0.085)
ROA	2.335***
	(0.855)
ROE	-1.452***
	(0.517)
IL	-0.006
	(0.004)
GROWTH	0.085***
	(0.029)
CI	0.071***
	(0.007)
STATE	-0.162***
	(0.027)
TOP1	-0.000
	(0.001)
TOP10	0.002**
	(0.001)
IDR	-0.004**
	(0.002)
BDS	-0.020*
	(0.012)
DUAL	0.015
	(0.023)
GDP	0.032
	(0.041)
GDP_s	-0.021
	(0.043)
LTR	-0.020
	(0.046)
Constant	-1.239**
	(0.529)
Year	Yes
Industry	Yes
r2_adjust	0.043
N	44115

5.4.2. Endogeneity test of lagged explanatory variables

The endogeneity issues in this study may stem from reverse causality and omitted variables. This study argues that companies receive environmental tax incentives, which accelerate their green and low-carbon transformation. However, companies that have already undergone green and low-carbon transformation are also more likely to benefit from these incentives. This can be interpreted as companies with a higher degree of green and low-carbon transformation potentially enjoying greater environmental tax benefits under tax reduction and fee reduction policies , leading to a reverse causal relationship between corporate green and low-carbon transformation and environmental tax incentives. On the other hand , there may be unobserved corporate characteristics or external factors that simultaneously influence the effectiveness of both corporate green and low-carbon transformation and environmental tax incentive policies.

Considering that enterprises need time to undergo green and low-carbon transformation after receiving environmental tax incentives, this study, drawing on relevant literature, postponed the explained variable by one period and conducted a new empirical analysis. The empirical results are shown in Table 6 .

Table 6. Empirical analysis results of explanatory variables after a one-year extension.

	(1)	(2)	(3)
	Gld	*Gld*	*Gld*
L.RTY	8.162***	4.803***	4.659***
	(0.443)	(0.398)	(0.398)
SIZE		6.623***	6.558***
		(0.087)	(0.087)
LEV		-5.885***	-5.629***
		(0.874)	(0.873)
AS		-4.046***	-3.893***
		(0.687)	(0.688)
ROA		-53.836***	-54.354***
		(7.198)	(7.176)
ROE		27.396***	28.267***
		(4.379)	(4.362)
IL		-0.022	-0.023
		(0.040)	(0.040)
GROWTH		-1.984***	-2.099***
		(0.343)	(0.342)
CI		-0.347***	-0.328***
		(0.054)	(0.054)
STATE		0.996***	0.760***
		(0.217)	(0.219)
TOP1		-0.005	0.000
		(0.007)	(0.007)
TOP10		0.012	0.006
		(0.007)	(0.007)
IDR		0.083***	0.083***
		(0.016)	(0.016)
BDS		0.131	0.152
		(0.094)	(0.095)
DUAL		0.871***	0.855***
		(0.189)	(0.189)
GDP		-0.059	1.206
		(0.331)	(2.370)
GDP_s		2.171***	0.044
		(0.352)	(2.264)
LTR		0.284	-0.806
		(0.369)	(1.076)

Constant	-2.194**	-166.554***	-142.436***
	(1.009)	(4.325)	(11.581)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Area	No	No	Yea
r2_adjust	0.100	0.281	0.289
N	35637	35637	35637

5.4.3. Endogeneity test using instrumental variable method

To overcome endogeneity issues such as omitted variables and sample selection bias, this study selects a variable related to environmental protection tax incentives— local fiscal resource management expenditure (*GDL*) of the province where the enterprise is located. Specifically, the measurement method uses the proportion of local fiscal expenditures on resource exploration, electricity, information, and other affairs, and local fiscal expenditures on land resources, meteorology, and other affairs in the province where the enterprise is located, as instrumental variables , with units of 100 million yuan , for endogeneity testing. Regional resource management expenditure reflects the level of resource management and utilization in a region . The core explanatory variable in this paper is whether enterprises have engaged in comprehensive resource utilization, which is also closely related to resource utilization. When a region is rich in resources and has high management expenditures, enterprises have more flexible access to and control over resources, and their comprehensive resource utilization may decrease accordingly. This, in turn, affects enterprises' enthusiasm for comprehensive resource utilization, and consequently, reduces environmental protection tax incentives. Therefore, it can be argued that selecting this variable as an instrumental variable is justified.

This study tested the appropriateness of the instrumental variables. The regression results of the first stage showed that all selected instrumental variables were correlated with endogenous variables. In addition, the instrumental variables also passed the strong instrumental variable test. The study used the selected instrumental variables for two-stage least squares regression to correct the endogeneity problem in the model. The regression results of the instrumental variable method are shown in column (2) of Table 7. After alleviating the endogeneity problem, the regression coefficients of the explanatory variables were still positive at the 1% test level, and the conclusions of the baseline regression remained robust.

Table 7. Results of the instrumental variable method test.

	(1) *RTY*	(2) *Gld*
DGL	-0.376 ***	
	(0.058)	
RTY		98.222 ***
		(17.823)
SIZE	0.017 ***	4.568 ***
	(0.001)	(0.334)
LEV	0.026 **	-7.442 ***
	(0.011)	(1.320)
AS	-0.004	-3.518 ***
	(0.009)	(1.012)
ROA	0.070	-52.272 ***
	(0.088)	(10.281)
ROE	-0.074	29.283 ***
	(0.053)	(6.302)
IL	-0.002 ***	0.108 *
	(0.000)	(0.060)
GROWTH	-0.001	-0.505

	(0.003)	(0.348)
CI	0.001	-0.394 ***
	(0.001)	(0.079)
STATE	0.008 ***	0.176
	(0.003)	(0.350)
TOP1	0.000	-0.020 *
	(0.000)	(0.011)
TOP10	-0.000 ***	0.042 ***
	(0.000)	(0.012)
IDR	0.000	0.077 ***
	(0.000)	(0.023)
BDS	0.003 ***	-0.184
	(0.001)	(0.150)
DUAL	-0.009 ***	1.636 ***
	(0.002)	(0.322)
GDP	0.018 ***	-2.701 ***
	(0.004)	(0.697)
GDP_s	0.003	2.204 ***
	(0.004)	(0.518)
LTR	-0.016 ***	2.398 ***
	(0.005)	(0.677)
Obs	44115	44115
R2		-1.307
F	42.773	212.443
CD Wald F	42.773	
SW S stat.	87.619	

5.5. Heterogeneity Analysis

To further explore the potential heterogeneity of the impact of environmental protection tax incentive policies on enterprises' green and low-carbon transformation, this paper categorizes enterprises according to their industry and the environmental governance situation in their respective regions, and then conducts analysis based on these criteria.

This paper refers to the classification standard of heavily polluting enterprises in the 2012 revised "Guidelines for Industry Classification of Listed Companies" adopted by Ni Juan and Kong Lingwen [28] in their research, and divides the research sample into two samples: heavily polluting enterprises and non-heavily polluting enterprises, and conducts a grouped heterogeneity study. In order to further examine whether there are differences in the effect of environmental protection tax incentive policies on promoting the green and low-carbon transformation of enterprises under different environmental protection expenditures in the region where the enterprise is located, this paper adopts the method of taking the natural logarithm (*LEPE*) of local fiscal environmental protection expenditure, that is, the environmental protection expenditure of the province where the enterprise is located, and performs ternary processing, taking the upper and lower groups for grouped regression.

The heterogeneous grouping regression results are shown in the table below. Columns (1), (2), (3), and (4) in Table 8 show the effects of environmental tax incentives on the green and low-carbon transformation of enterprises in heavily polluting industries and non-heavily polluting industries, as well as enterprises located in areas with lower and higher environmental protection expenditures. The final empirical results show that environmental tax incentives significantly promote green and low-carbon transformation in the non-heavily polluting industry sample, while this effect is not significant in the heavily polluting industry sample . Furthermore, the effect of environmental tax incentives on promoting green and low-carbon transformation is more pronounced in enterprises located in areas with lower environmental protection expenditures.

This is because , generally speaking, heavily polluting industries face stricter environmental constraints and higher compliance costs due to their significant environmental impact and regulatory pressure. Enterprises undertaking green and low-carbon transformation typically face higher upfront investments, especially in heavily polluting industries where even simple upgrades can incur substantial initial costs. This may affect the effectiveness of tax incentive policies. Conversely, non-heavily polluting industries, with less environmental compliance pressure and lower environmental costs, may experience a relatively stronger marginal effect of environmental tax incentives on their green and low-carbon transformation.

The heterogeneity in environmental governance investment in the regions where enterprises are located may stem from the fact that China's environmental governance model is primarily based on government-mandated management, relying excessively on the government's dominant role while neglecting the roles of other environmental governance stakeholders such as enterprises and social organizations. This has led to enterprises and other stakeholders being relegated to a dispensable position for a long time. Therefore, when local government investment in environmental protection increases, enterprises may become overly reliant on environmental governance, thereby affecting the effectiveness of environmental tax incentives in promoting green and low-carbon transformation among enterprises.

Table 8. Results of Heterogeneity Analysis.

	(1)	(2)	(3)	(4)
	Gld	*Gld*	*Gld*	*Gld*
	Is it a heavily polluting industry?		Local government expenditure on environmental protection	
	yes	no	Low	high
RTY	2.121***	6.342***	5.042***	1.492**
	(0.276)	(0.465)	(0.467)	(0.630)
SIZE	2.651***	7.139***	3.535***	7.997***
	(0.085)	(0.092)	(0.095)	(0.144)
LEV	-3.447***	-5.942***	-2.681***	-9.275***
	(0.812)	(0.914)	(0.875)	(1.468)
AS	0.072	-3.240***	0.230	-5.846***
	(0.633)	(0.760)	(0.682)	(1.240)
ROA	-35.894***	-45.877***	-25.205***	-80.979***
	(6.634)	(7.567)	(7.054)	(12.326)
ROE	24.313***	20.500***	10.897***	45.061***
	(4.195)	(4.488)	(4.109)	(7.580)
IL	-0.072**	-0.019	-0.122***	0.041
	(0.030)	(0.042)	(0.035)	(0.065)
GROWTH	-0.060	-0.716***	-0.216	-0.802*
	(0.240)	(0.251)	(0.244)	(0.413)
CI	-0.219***	-0.352***	-0.143***	-0.562***
	(0.068)	(0.054)	(0.053)	(0.094)
STATE	0.288	1.005***	-0.482**	1.739***
	(0.201)	(0.240)	(0.219)	(0.394)
TOP1	-0.002	-0.013	-0.016**	-0.007
	(0.007)	(0.008)	(0.008)	(0.013)
TOP10	0.014**	0.014*	0.009	0.017
	(0.007)	(0.008)	(0.008)	(0.012)
IDR	0.048***	0.094***	0.087***	0.040
	(0.015)	(0.017)	(0.017)	(0.026)
BDS	0.198**	0.163	0.073	0.903***
	(0.084)	(0.105)	(0.088)	(0.186)
DUAL	-0.328*	1.068***	-0.339	1.896***
	(0.173)	(0.206)	(0.221)	(0.302)
GDP	-0.149	-0.212	-0.663**	-2.343***

	(0.312)	(0.363)	(0.307)	(0.677)
GDP_s	0.366	2.067***	0.995***	1.036*
	(0.322)	(0.386)	(0.344)	(0.607)
LTR	0.366	0.471	0.991***	2.550***
	(0.348)	(0.402)	(0.361)	(0.770)
Constant	-62.534***	-176.661***	-87.507***	-187.205***
	(3.911)	(4.713)	(4.001)	(8.854)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Chi-square value (P-value) for intergroup difference test	28.04 (0.0000)		45.03 (0.0000)	

There were calculated based on the results of the Suest test after grouped regression .

6. Summary and Outlook

6.1. Research Conclusions

This paper, based on the background of encouraging green and low-carbon development in society, analyzes the annual reports and panel data of Chinese listed companies from 2008 to 2024 to construct a variable on whether enterprises are incentivized by environmental protection taxes. It also considers the impact of regional economies and further empirically examines the impact and mechanism of environmental protection tax incentive policies on enterprises' green and low-carbon transformation.

The study found that, firstly, environmental tax incentives do significantly promote enterprises' green and low-carbon transformation, but this impact exhibits significant internal differentiation, especially after considering internal factors such as cash levels and operating costs. Secondly, when considering the impact of macroeconomic factors, this paper mainly examines the roles of local public debt levels and the local green business environment, finding that these macroeconomic factors play a significant negative moderating role. Further analysis reveals that differences in internal and external environments, such as whether an enterprise belongs to a heavily polluting industry and local government fiscal expenditure on environmental protection, will have varying effects on the promotion of green and low-carbon transformation by environmental tax incentives.

The final results indicate that enterprises' green and low-carbon transformation is inseparable from their own factors as well as the environmental impact of local governments. To maximize the benefits of environmental protection tax incentive policies, reasonable coordination and promotion from all sectors of society and local policies are needed.

6.2. Lessons Learned from Practice

First, at the government level: the government needs to optimize local government debt management , establish and improve the local government debt management system, clarify the upper limit of debt scale and risk warning mechanism; strengthen the supervision of debt funds to ensure the compliance and effectiveness of fund use; promote the optimization of debt structure, and rationally arrange debt maturity and interest rate structure; and encourage local governments to raise funds through market-oriented means to improve financing efficiency and transparency.

Secondly, increase fiscal budgetary investment in environmental protection, establish special environmental protection funds to support environmental protection project construction and technology research and development; and establish an environmental protection investment guidance fund to guide social capital into the environmental protection field. In optimizing local government debt management and increasing environmental protection investment, the government can learn from measures taken by enterprises to increase environmental protection investment and strengthen their environmental awareness. At the same time, it can draw on the experience of local

state-owned enterprise debt risk management, paying attention to balancing the relationships between medium- and long-term institutional reforms and short-term debt security, economic growth regulation and optimal debt and risk control, coordinating the government's short-term and long-term goals in the use of special bonds and their investment areas, and balancing sustainable debt development with fiscal budget preparation considerations.

Finally, at the enterprise level, companies should fully recognize the importance of green development, actively respond to government policies, and proactively assume environmental responsibility. Furthermore, companies should closely monitor local government debt and understand the impact of local government debt policies on the environmental field. When undertaking green and low-carbon transformation, they should rationally plan the sources and use of funds, avoiding over-reliance on local government support. Diversified financing channels can be used to ensure the smooth progress of green and low-carbon transformation projects.

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