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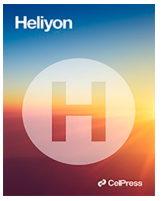

Research article

The impact of environmental protection tax on corporate performance: A new insight from multi angles analysis

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ABSTRACT

This study investigates the practical effects of adopting the environmental protection tax (EPT) policy on corporate performance in China. The analysis uses the Difference in Differences (DID) approach based on a quasi-natural experiment scenario. The findings indicate there is a negative impact of implementing the EPT policy on the financial performance of corporations, and the conclusion remains unchanged despite exhaustive robustness testing. The negative impact can be partly attributed to corporate technology innovation inputs. Meanwhile, enterprise property rights, pollution, and technical levels also substantially influence the implementation effect of the legislation. However, implementing this policy has improved corporations' environmental performance and established its efficacy in enhancing their sustainable capabilities. This study comprehensively explores the impact of environmental control legislation on business performance, spanning financial, environmental, and social dimensions. Corresponding findings offer valuable insights into how firms react to environmental legislation and adjust to the external environment. Meanwhile, it also provides an objective reference for the comprehensive green transformation.

1. Introduction

China has experienced exceptional economic expansion since implementing economic reforms and the opening-up policy began. Nevertheless, this upward trend has been accompanied by an upsurge in environmental apprehensions, predominantly attributable to the vast scale of development, which is consistent with the Environmental Kuznets Curve (EKC) hypothesis, that is, large-scale economic development will lead to the deterioration of environmental quality [1]. To decouple economic growth from the environment, numerous governments have implemented environmental regulations to address this pressing issue and the stressing climate problems, including climate change and the increasing occurrence of extreme weather phenomena linked to human activities. Among many environmental policies, the most prominent are environmental protection tax measures that have been deliberately formulated to internalize the expenses incurred by the environment externally [2] and restrict the release of pollutants [3,4]. The implementation of environmental taxation systems, including levies on energy, transportation, and carbon emissions, in OECD member states has exhibited encouraging outcomes in environmental governance. However, China, a significant consumer of conventional energy, released 34,344,006 kilotons of CO_2 into the atmosphere in2019,[1] highlighting China's urgent responsibility to curb greenhouse gas

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[1] Data source, the World Bank, https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?,2023-1-11.

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emissions and pollution actively. In this scenario, the Environmental Protection Tax (EPT) Law was inaugurated on January 1,2018.[2] Despite this achievement, doubts remain concerning the effectiveness of executing this legislation to achieve its desired goals, particularly regarding the governance implications of pollution reduction and the specific economic growth implications for China.

It has been found that implementing environmental protection taxes can lead to favorable environmental consequences, especially in heavy pollution sectors [5]. The enforcement of EPT increases regulatory pressures on enterprises, thereby impacting their environmental and economic practices. It, in turn, motivates them to conserve energy and reduce pollution [2]. Ultimately, this contributes to improving environmentally sustainable development abilities among corporations. Opposing perspectives suggest that implementing these levies could increase production expenses for businesses, impeding investment in environmentally friendly advancements and inadequately managing pollution [6]. According to Wang and Yu [7], environmental tax rates in different Chinese provinces now are below the optimal level needed to incorporate the external cost of environmental pollution into corporate expenses. This circumstance could hinder the effectiveness of green innovation. A critical debate arises on the value of applying environmental protection levies to micro-entities, such as corporations in China. An in-depth assessment will help make future adjustments and implement environmental regulation legislation. Further, evaluating the impact of emission reduction policies on enterprise emissions in China is vital to accomplishing mid- and long-term emission reduction goals and fully realizing the potential for reducing emissions. Therefore, this research intends to examine the influence of environmental protection levies on firm performance, specifically focusing on Chinese enterprises.

A limited number of studies have explored the broader micro-level implications of EPT implementation. Long et al. [2] and Zhao et al. [8] demonstrated a substantial negative impact on pollution-intensive enterprises, as indicated by negative correlations in the stock market. This paper differentiates itself from the preceding studies in several crucial areas. Firstly, it uses detailed micro-enterprise data to evaluate the significant impact of EPT enforcement on enterprise performance, expanding beyond a narrow emphasis on heavily polluting companies. Secondly, it explores how policy implementation can trigger the 'Porter Effect' in the Chinese innovation compensation setting. The study also investigates whether the government's focus on green construction amplifies or relieves the impact of the policy on business performance. Thirdly, it examines how the EPT legislation affects corporate performance differently based on corporation ownership structures, pollution levels, and technology improvements. Meanwhile, random forest regression analysis is applied to assess the reliability of the results and examine the partial dependence of significant factors, which offers a thorough grasp of the intricacies related to the influence of EPT on enterprise performance. Further, this paper examines how implementing EPT policy affects the corporation's environmental, social, and managerial performance, thus creating a more comprehensive research framework.

The rest of this paper is arranged as follows: Part 2 summarizes relevant research; part 3 is the theoretical analysis and the research hypothesis; part 4 introduces the theoretical model and related variables; part 5 shows the empirical results; part 6 further discusses the empirical results of this paper; part 7 further discusses and summarizes the conclusion of this paper and puts forward the policy enlightenment.

2. Literature review

The significance and immediacy of climate change and environmental concerns have been extensively addressed in existing literature. Several economic development literatures examine the interconnectedness of economic growth and environmental changes. There is widespread agreement that large-scale economic development will lead to the deterioration of environmental quality. As economic growth progresses and reaches a certain threshold, it exhibits an inflection point [1], beyond which further economic growth no longer leads to a decline in environmental quality, which is named by scholars as the Environmental Kuznets curve (EKC) [9,10]. However, a growing body of literature argues for a non-linear relationship, but the form does not align with the EKC [11]. While not all research fully supports the EKC hypothesis [12], numerous studies have verified the existence of a nonlinear relationship, and identified several elements that influence this relationship, including resource rent, corruption governance, and trade [11,13,14]. Further work also reveals the FDI and human capital influence on both economic and carbon emissions [15].

Although the relevant research on economic growth and the environment has not reached the same conclusion, the scale, structural, and technological effects have been widely recognized since the transformation from a high-energy-intensive industry to a service-oriented and technology based economy. Meanwhile, technological advancements have contributed to a reduction in pollution. Furthermore, the implementation of more stringent environmental rules has led to improvements in environmental quality and a decrease in emissions [1]. Given the worsening climate change situation, there is a growing importance of environmental regulations and policies in addressing this issue. Both statutory environmental laws and marketplace environmental policies play a key role in lowering pollutant emissions, mitigating climate change, and improving ecological sustainability. Meanwhile, the pollution paradise hypothesis suggests that developing nations, driven by the need for quick development, often implement less strict environmental regulations [13]. Therefore, it calls for more urgent research actions to measure the environmental regulations and policies in developing countries, particularly in heavily carbon-emitting countries such as China.

Many scholars have shown interest in environmental policy evaluation, leading to a growing body of work on the subject [16–18]. Studies have examined the influence of environmental policies on enterprise performance at the level of microenterprises [19]. While most research supports the impact of environmental legislation on reducing enterprise emissions, the findings regarding enterprise

[2] The details of EPT Law refer to Wu and Tal (2018).

performance are varied. Among these, the EPT policy is a crucial environmental policy tool with significant impact, and the micro- and macro-level implications of its implementation have been extensively debated.

Current research thoroughly examines the impacts of implementing the EPT. Studies on EPT implementation indicate that imposing fees on sulfur or nitrogen could help decrease carbon intensity and carbon emissions. Findings reveal a significant rise in corporate green innovation at the business level [20]. Nevertheless, it is essential not to overlook the potential decrease in welfare benefits due to environmental levies [3] and the increase in illicit emissions [21]. Besides, the bulk of works on EPT's effects on corporate development present conflicting views. Some literature believes that adopting the EPT policy significantly increases corporate environmental investments across several industries [22], encourages the development of green technology innovation, and enhances environmental performance. Nevertheless, it also incurs environmental expenses, harming many sectors' financial outcomes [23,24]. However, Lei et al. [25] discovered that implementing EPT policies can have a significant 'Porter effect,' enhancing long-term corporate performance. Zhao et al. [8] demonstrate that the EPT policy boosts innovation and provides economic advantages to innovative businesses. The policy is positively associated with corporate total factor productivity, according to He et al. [26]. The absence of agreement in current research highlights the significance of investigating the origins of disagreements, a primary motivation for this work.

Moreover, recent scholarly attention has been directed towards the impact mechanism of the EPT on corporate performance. Long et al. [2] identify an innovation effect of EPT, wherein companies are 'forced' to increase their research and development (R&D) investment, and inhibiting short-term corporate performance growth. He et al. [24] uncover a relationship between firms' political connections and fundamentals in the market's reactions to EPT policy implementation. Liu et al. [22] argue that implementing an environmental protection tax can influence corporate performance by altering environmental investment. Besides, Lei et al. [25] explore the connections between the EPT policy and corporate performance, focusing on innovation compensation, first-mover advantages, incentives for green transformation, and the relationship between technology and green transformation. Other studies have also shown that technological innovations and enhanced economic efficiency lead to green innovation and reductions in ecological footprints to improve green transformation [27,28]. Additionally, research focuses on the heterogeneity of the EPT policy's impact on corporate performance, primarily considering regional development levels, company size [2], and the nature of equity [23].

Despite the wealth of research, scholars have yet to reach a consensus on whether EPT policy implementation improves or reduces enterprise performance, with most studies concentrating on the micro-performance level. Few studies explore the enterprise value effects, and literature on the mechanism and heterogeneity of EPT policies on corporate performance is scarce. In comparison, this paper introduces several innovations: (1) It utilizes relatively comprehensive micro-enterprise data to test the significant impact of the EPT policy on enterprise performance; (2) The paper delves into the mechanism of its influence, examining whether policy implementation can yield a 'Porter effect' within the context of Chinese innovation compensation, and investigates whether the government's emphasis on green construction amplifies or relieves the impact of policies on enterprise performance. (3) The heterogeneity of the EPT policy on firm performance is further analyzed based on the property of firm ownership, the degree of firm pollution, and the level of firm technology. Additionally, random forest regression is applied to test the robustness of the results and discuss the partial dependence of relevant variables. (4) This article concurrently considers the EPT's impacts on corporations' financial, environmental, social, and governance performance.

3. Theoretical analysis and research hypothesis

As an environmental regulatory policy, the EPT inevitably amplifies the pressure on corporations' emissions reduction and environmental costs [1]. Operating on the 'polluter pays' principle, the essence of EPT is to internalize the costs of negative externalities [22], thereby inhibiting firm performance through the internalization of emissions costs [29]. In the long run, the pressures and costs associated with the green transition may drive enterprises to engage in green innovation, enhancing competitiveness and corporate efficiency [30], effectively avoiding negative environmental news, and reducing the risk of punishment [22]. In the short term, corporations with non-compliant pollution emissions and practices will experience a sharp increase in tax costs. Simultaneously, these companies will incur additional expenses to upgrade their equipment to meet environmental standards. Furthermore, the negative news from tax punishments will harm corporate reputation, resulting in severe value losses for corporate development. Therefore, this paper contends that the imposition of EPT underscores the environmental responsibility companies must bear in their development. Additionally, it significantly elevates their costs related to emission and pollution disposition in the short term, impacting cash flow, decreasing production efficiency, and ultimately leading to a substantial reduction in performance. Consequently, we propose hypothesis H1.

H1. EPT policy implementation will significantly reduce corporate performance.

Furthermore, the transmission mechanism of the EPT policy on corporate performance is widely discussed, primarily through the lens of innovation. These analyses often center on 'Porter's hypothesis,' asserting that environmental regulation increases enterprise costs. Simultaneously, environmental regulations may yield two positive impacts for enterprises: the 'innovation compensation effect' and 'first-mover advantage.' These positive effects empower enterprises to attain excess returns and enhance overall enterprise value [25,30].

However, enterprises must invest significant resources in scientific research funds for technological innovation activities in the short term. The corresponding technological implementation necessitates updates to production equipment and extensive personnel training in knowledge and skills. All these activities entail high costs for enterprises. Therefore, improving the technological innovation level of enterprises may result in a significant decline in performance in the short term. Consequently, hypothesis H2 is proposed in this

paper.

H2. The EPT policy will damage enterprise performance in the short term by improving innovation.

In addition, as local governments intensify their focus on green construction, the auxiliary and supervisory role of market construction and regulation becomes more crucial in the policy implementation process. Consequently, in administrative regions under the jurisdiction of local governments, there is a higher emphasis on green construction, enhancing the motivation of enterprises to engage in green construction and bringing potential performance enhancement. Based on this argument, Hypothesis H3 is proposed.

H3. The government's increased emphasis on green initiatives will relieve the negative effect of EPT policies on enterprise performance.

4. Methodology

4.1. Data

A-share listed companies from 2011 to 2019 were selected as the sample, primarily considering research years and data availability.[3] Enterprises with abnormal financial conditions, such as ST and *ST, were excluded during the sample period. Additionally, companies delisted during the sample period and those with substantial missing data on their performance were excluded. After the preliminary screening of samples, tools were used to further clean and process the data, resulting in a total of 20,615 retained sample data. The data were primarily sourced from China Stock Market & Accounting Research (CSMAR) and the Wind Economic Database, China's most popular, authoritative, and widely used financial and academic databases. The key variables and their specific explanations are outlined as follows.

(1) Explained variable

Proposed by Nobel Prize winner Tobin, this index is an authoritative measure of corporate performance. It reflects investors' expectations of future profits by predicting the comprehensive ability of enterprises' operations and profit in the future. Tobin Q encompasses past performance and anticipates future performance and value, making it an adequate measure of overall enterprise performance.

(2) Explanatory variables

This paper defines Post as a dummy variable. The EPT policy became effective in 2018; therefore, that equals 1 for observations from 2018 to 2019 and 0 for 2011 to 2017. Treat is a dummy variable that equals 1 if the company belongs to a province with a higher tax rate than the minimum tax rate and 0 otherwise. Post*Treat (PT) is the interaction of Treat and Post. For the experimental group, PT is 0 before the policy implementation and 1 afterward; for the control group, PT is always equal to 0 before or after the policy implementation.

(3) Controls

The size, revenue capacity of the business, and other aspects are company-level features that might influence company performance, as discussed in several studies [31,32]. Some variables are controlled in this paper: (i) Company size (Siz); the more significant scale of the company, the greater its ability to make profits and obtain cash flow, and the smaller the restrictions on its operation. Furthermore, the scale effect gives it a more vital ability to obtain profits; thus, its market performance will be better. (ii) Asset-liability ratio (Lev): Corporations with a high debt burden may be constrained by financial stress, reducing their performance. (iii) Revenue capacity (Gr): Enterprises with strong revenue capacity can provide stable capital supply and security for enterprise operations, improve the resilience of enterprises, increase the impetus for innovation in enterprises, and improve their performance. (iv) The proportion of independent directors (Id): Independent directors have the objective advantage of supervising and acting as agents and can bring indirectly related resource support and strategic suggestions. The introduction of independent directors can improve the efficiency of the board of directors and enhance the performance of enterprises [33]. (v) The percentage ownership of the largest shareholder (TOP1): The increase in the proportion of shareholders will increase the inefficiency of enterprise investment and then affect the performance of the corporation [34]. (vi) Dual identity (Dual) is also controlled in this paper to reduce the potential impact of executive characteristics. See Tables 1 and 2 for the main variable types, names, calculation methods, and descriptive statistics.

[3] In 2011, China began implementing the 12th Five-Year Plan, which led to a growing focus on environmental and ecological development after that. The study concluded in 2019 because of the significant impact of the COVID-19 epidemic in 2020 on enterprise production behavior. Therefore, this article selects 2011–2019 as the research timeframe.

Table 1
Research variables.

Variable type	Variable name	Calculation method	Data Source
Explained variable	Enterprise value (Q)	Ratio of the total market value of equity to the total book value of equity at the end of each year	CSMAR
Explanatory variables	Treat	Treat indicates whether the company is located in an area where the EPT rate is higher than minimum tax rate, where 1 indicates a positive response and 0 indicates a negative response	Created by corresponding policy areas
	Post	The post indicates whether the data correspond to 2018 or afterward, with 1 for positive and 0 for negative	Created by this paper
Mediator variable	Enterprise technology innovation level (Lnc)	The total application number of patents applied by enterprises. Considering that the number of patent applications of some enterprises is 0, the total number of patent applications of all enterprises during the sample period is added by 1 to take logarithmic processing	CSMAR
Moderator variable	Government green attention (EF)	The text mining and analysis of the annual government work reports of 31 provinces from 2011 to 2019 were carried out, and the word frequency of each province's annual reports referring to green construction was counted and summarized. For the construction of the dummy variable, the median of each year is used as the critical value and compared with it for each province. The provinces greater than or equal to the median of each year are assigned a value of 1; otherwise, 0	Created by text mining methods
Controls	Company size (Sc)	Take the logarithm of the total assets of the company	CSMAR
	Asset-liability ratio (Lev)	Total liabilities divided by total assets	CSMAR
	Revenue capacity (Gr)	Sales revenue growth rate	
	Proportion of independent directors (Id)	Current liabilities minus current assets and divided by total assets	CSMAR
	(TOP 1)	The percentage ownership of the largest shareholder	CSMAR
	Dual identity (Dual)	Whether there is a concurrent chairman and general manager	CSMAR

Table 2
Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Q	20167	2.002	1.286	0.815	17.676
Sc	20615	22.124	1.288	19.525	26.395
Id	20608	0.375	0.054	0.308	0.600
TOP1	20615	34.841	14.935	0.290	89.090
Lev	20615	0.408	0.203	0.031	0.925
Gr	19491	7.300	964.264	−0.952	134607.060
Dual	20406	0.289	0.453	0.000	1.000
Lnc	20615	4.427	1.625	0.000	11.067
EF	20615	0.520	0.5000	0.000	1.000

4.2. Empirical model

4.2.1. Benchmark regression

In order to verify the hypothesis proposed above, it is necessary to analyze further impact of the implementation of the EPT policy on enterprise performance. The DID method is a technique used to assess causal effects. The fundamental concept in this paper is to

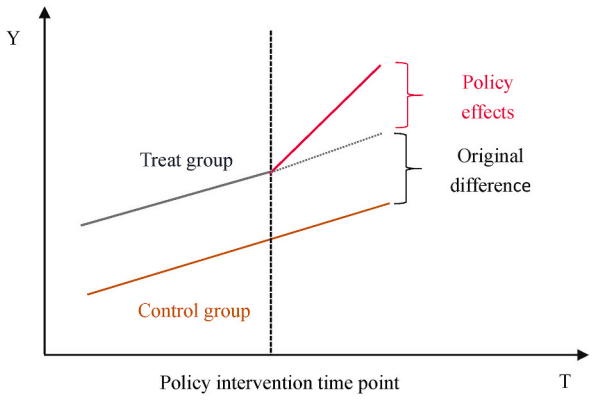

Fig. 1. The DID method schematic diagram.

consider the EPT policy as a natural experiment. To assess the overall effect of the policy implementation, the sample data is splited into two groups: the processing group, which is influenced by the policy, and the control group, which is unaffected by the policy. Enterprise performance indicators were chosen, and the first difference was calculated based on the time before and after policy implementation to get two group changes. After the initial difference, the consistent diversity among individuals was removed, followed by a further difference to eliminate the cumulative effect over time, resulting in the final result of the policy implementation (see Fig. 1). Due to its ability to provide thorough policy evaluation, the DID model has become a widely utilized approach for quantitatively assessing policy impacts [35,36].

Meanwhile, implementing the EPT policy provides an ideal quasi-natural experimental scenario to overcome potential endogeneity problems, and the parallel result also satisfied the application premise of the DID model. Therefore, this model is chosen as the basic model in this paper. The DID method based on individual and time-fixed effects is established in this paper to test the specific effects of policy implementation. The specific model form in this paper is as follows:

$$Q_{it} = \delta_0 + \beta_1(Treat_{it} \times Post_{it}) + \beta_X X_{it} + \vartheta_t + \mu_i + \varepsilon_{it} \quad (1)$$

Where, Q_{it} is i-th enterprise performance in year t, β_1 is the policy effect variable, β_X is control variables influence coefficient, ϑ_t and μ_i is time fixed effects and individual fixed effects respectively.

4.2.2. Mechanism test

(1) Technology innovation

In order to verify the hypothesis that the EPT policy will further decrease enterprise performance by improving the enterprise technology innovation level, this paper explores the role of the enterprise technology innovation level in the influence of the policy on enterprise performance. The specific model is as follows:

$$Q_{it} = \delta_0 + \beta_1(Treat_{it} \times Post_{it}) + \beta_2 \mathrm{Ln}c_{it} + \beta_X X_{it} + \vartheta_t + \mu_i + \varepsilon_{it} \quad (2)$$

Where, $Ln\ c_{it}$ represents the enterprise technology innovation level, β_2 is the regression coefficient of this variable, and other variables are the same as above.

(2) Government green attention

Table 3
Benchmark regression results.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.3830***	−0.3472***	−0.0676**	−0.0815***
	(-17.35)	(-16.31)	(-2.22)	(-2.61)
Sc		−0.3297***		−0.6540***
		(-39.32)		(-34.35)
Id		1.2798***		0.6070***
		(7.76)		(3.00)
TOP1		−0.0034***		−0.0091***
		(-5.60)		(-7.49)
Lev		−0.5437***		0.5930***
		(-10.59)		(8.13)
Gr		0.0000		0.0000
		(-0.66)		(0.20)
Dual		−0.0195		−0.0285
		(-0.97)		(-1.20)
Constant	2.082***	9.276***	2.016***	16.39***
	(205.79)	(50.73)	(231.89)	(38.61)
N	20167	18848	20103	18735
Time fixed effects	NO	NO	YES	YES
Individual fixed effects	NO	NO	YES	YES
R^2	0.0147	0.1634	0.6348	0.6721
adj. R^2	0.0147	0.1631	0.5700	0.6105
Mean VIF	1.0000	1.1500	1.0000	1.15000

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$. The mean VIF values of OLS regressions in columns (1) and (2) are 1.0000 and 1.1500, respectively, which means there are no potential multicollinearity problems, and both the p-values for White tests in columns (1) and (2) are 0.0000, which indicates there are no heteroscedasticity problems in this paper. Compared with the OLS model without controls, both the R^2 and adjusted R^2 have a more considerable value in OLS regression in Column (2) and the fixed effect model in Column (4) than in Column (1), which hints that missing variables will greatly reduce the interpretability of the results, while adding control variables will significantly improve the interpretability of the paper. Meanwhile, compared with the OLS model, the fixed effect model has more brilliant performance on R^2 and adjusts R^2, which validates the applicability of the model used in this paper.

From the hypothesis, the government's attention to green construction will further increase the intensity of pollution control policies in this region and the stricter supervision level of the existing policies. Therefore, enterprises in this region will face more significant pressure of green transformation and further strengthen the effect of the policies. The moderate effect model will be used to verify this hypothesis. The model detail is as follows:

$$Q_{it} = \delta_0 + \beta_1(Treat_{it} \times Post_{it}) + \beta_3 EF_{it} + \beta_4(Treat_{it} \times Post_{it} \times EF_{it}) + \beta_5(Treat_{it} \times EF_{it}) + \beta_6(Post_{it} \times EF_{it}) + \beta_X X_{it} + \vartheta_t + \mu_i + \varepsilon_{it} \quad (3)$$

Where, EF_{it} represents the government green attention level, β_4 is the regression coefficient of this variable, and other variables are consisted with Eq. (1).

5. Empirical results

5.1. Benchmark results

The analysis utilizes data from 2948 listed companies from 2011 to 2019 for the benchmark regression. Given the panel nature of the research data, panel data analysis involves considering fixed effect and random effect models. The Hausman test was initially employed to determine the optimal model to ensure the robustness of the results. The test results indicated a p-value of $0.0000 < 0.05$, signifying that the panel fixed effect model regression produced superior results compared to the random effects model. Consequently, the panel fixed effect model was selected for regression.

The regression results (see Table 3) demonstrate that, regardless of the inclusion of control variables or the consideration of fixed effects at the individual and time levels, the regression coefficients of Post*Treat are all negative, indicating that implementing EPT policy will reduce firm performance. This policy is still significant after controlling for time and individual effects. This finding further illustrates that changes in firm performance effectively respond to policy implementation even after other potential change factors are excluded. From a statistical perspective, the coefficients are significant at the 5 % confidence level. The p-values for Post*Treat in columns (1)–(4) are 0.000, 0.000, 0.026, and 0.009, respectively, which also suggests that while the policy effectively regulates enterprise behavior, reduces pollution, and accelerates the green transformation of enterprises, it concurrently hurts enterprise performance. Furthermore, this outcome aligns with and validates the hypothesis H1 proposed in this paper. Although the findings also align with the results in heavy pollution corporations by Long et al. [2] and Zhao et al. [8], this paper is based on more comprehensive sample data, so the conclusions are more generalized.

5.2. Robustness tests

The DID model may be susceptible to the influence of preexisting time trends, alterations in variables and samples, adjustments to pollution discharge fees, and concurrent policy changes, potentially introducing estimation bias. Consequently, this paper undertakes a series of robustness checks to substantiate the accuracy of the presented conclusions.

5.2.1. Parallel trend test

The fundamental prerequisite for applying the DID model is fulfilling the parallel trend test hypothesis. It necessitates consistency in the time trend between the experimental and control groups before and after policy implementation, thereby mitigating the impact of time trends and ensuring the validity of regression results. The results of the parallel trend test (depicted in Fig. 2) for the overall data before and after policy implementation (with the current variable set in 2018, marking the initiation of the EPT policy in China) reveal that the dynamic effect of the policy remains relatively stable around 0 both before and after policy implementation. It is only

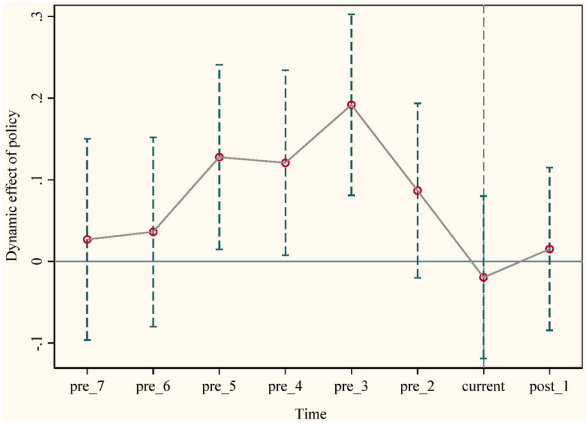

Fig. 2. The parallel test result.

after the policy takes effect that a significant shift in the dynamic effect is observed. This adherence to the parallel trend test indicates the suitability of employing the DID model in this context.

5.2.2. PSM-DID test

Inevitably, missing data in specific samples prompts consideration of potential sample selection bias, given that this paper confines its analysis to data from 2948 listed companies. The PSM-DID method mitigates this concern, effectively addressing sample selection bias. Following the matching of data and differential processing for regression, akin to benchmark regression (see Table 4), including industry-fixed and time-fixed effects for control variables, reveals that implementing the EPT policy significantly diminishes enterprise performance at the 10 % significance level (the p-values for Post*Treat in columns (1)–(3) are 0.009, 0.011, and 0.096, respectively). This finding suggests the absence of sample selection bias in the benchmark regression, affirming the robustness of the overall result.

5.2.3. Adjusted sample

Given the incremental year-on-year growth in the tax amounts of Inner Mongolia, Shanghai, Chongqing, and Yunnan, and to preempt potential errors, the data from these four regions is omitted for a reanalysis in this paper. The outcomes, as illustrated in the (1) and (2) columns of Table 5, persistently reveal that the EPT policy continues to exert a significant negative (p-values are 0.000 and 0.017) impact on corporate performance.

5.2.4. Concurrent policy test

The adverse impact of the EPT policy on corporate performance might be influenced by other concurrent policies, notably the pilot carbon emission trading policy. To account for potential effects, this paper omits sample data from 2011 to 2014, coinciding with the initiation of China's carbon emission trading launch. Columns (3) and (4) in Table 5 reveal that the coefficient for policy effects remains significantly negative (where p-values are 0.000 and 0.014), aligning with our benchmark results. It indicates that the pilot of the carbon emission trading policy does not alter the estimated outcomes.

5.2.5. Adjusted model

In addition to the OLS model, this paper reconsidered using a machine learning model—random forest regression—for robustness. The partial dependence plot of the policy variable (provided in Fig. 3) reveals the consistent negative impacts of the EPT policy on corporate performance. Furthermore, unlike previous analysis only reflect the line relations, this model provides nonlinear relationships for control variables. Corporate size negatively impacts performance, with relations stabilizing as firms expand. The increasing number of independent directors positively influences corporate operations and performance simultaneously. However, the asset-liability ratio and the percentage ownership of the largest shareholder (TOP1) exert financial and operational pressure on corporations, negatively impacting corporate performance.

5.2.6. Exclude major events

Recent works suggest that economic and climate uncertainty significantly influence business strategy and strategic planning of

Table 4
PSM-DID regression results.

Variables	(1)	(2)	(3)
Post*Treat	−0.0815***	−0.0776**	−0.0575*
	(-2.61)	(-2.53)	(-1.66)
Sc	−0.6540***	−0.6510***	−0.6000***
	(-34.35)	(-34.83)	(-26.43)
Id	0.6070***	0.4590**	0.7030***
	(3.00)	(2.31)	(2.75)
TOP1	−0.0091***	−0.0092***	−0.0085***
	(-7.49)	(-7.67)	(-5.81)
Lev	0.5930***	0.5970***	0.5040***
	(8.13)	(8.36)	(5.75)
Gr	0.0000	−0.0004	−0.0015
	(0.20)	(-1.02)	(-0.95)
Dual	−0.0285	−0.0267	−0.0109
	(-1.20)	(-1.15)	(-0.38)
Constant	16.3900***	16.3700***	15.1000***
	(38.61)	(39.29)	(29.73)
N	18735	18728	11768
Time fixed effects	YES	YES	YES
Individual fixed effects	YES	YES	YES
R^2	0.6721	0.6749	0.6918
adj. R^2	0.6105	0.6138	0.6056

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$. In regression (1), all matched samples are used. Regression (2) and (3) are regression results of samples with non-empty usage weights and samples satisfying the common supporting hypothesis, respectively.

Table 5
Robust results of adjusted sample and concurrent policy test.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.3330***	−0.0759**	−0.6044***	−0.0889**
	(-14.64)	(-2.38)	(-24.64)	(-2.46)
Sc	−0.3370***	−0.6470***	−0.4200***	−0.8590***
	(-37.78)	(-32.35)	(-38.00)	(-24.74)
Id	1.2390***	0.5776***	1.3532***	0.6277**
	(7.12)	(2.71)	(6.23)	(2.02)
TOP1	−0.0030***	−0.0085***	−0.0009	−0.0059***
	(-4.76)	(-6.65)	(-1.13)	(-2.58)
Lev	−0.5250***	0.5750***	−0.6066***	0.0079
	(-9.72)	(7.53)	(-8.64)	(0.06)
Gr	−0.0000	0.0000	0.0003	−0.0009*
	(-0.67)	(0.22)	(0.52)	(-1.75)
Dual	−0.0361*	−0.0140	−0.0257	−0.0837**
	(-1.71)	(-0.56)	(-0.98)	(-2.34)
Constant	9.4210***	16.2000***	11.4600***	21.2900***
	(48.41)	(36.36)	(46.96)	(27.37)
N	17090	16985	12264	12141
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
R^2	0.1602	0.6722	0.2207	0.7366
adj. R^2	0.1598	0.6106	0.2202	0.6523

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

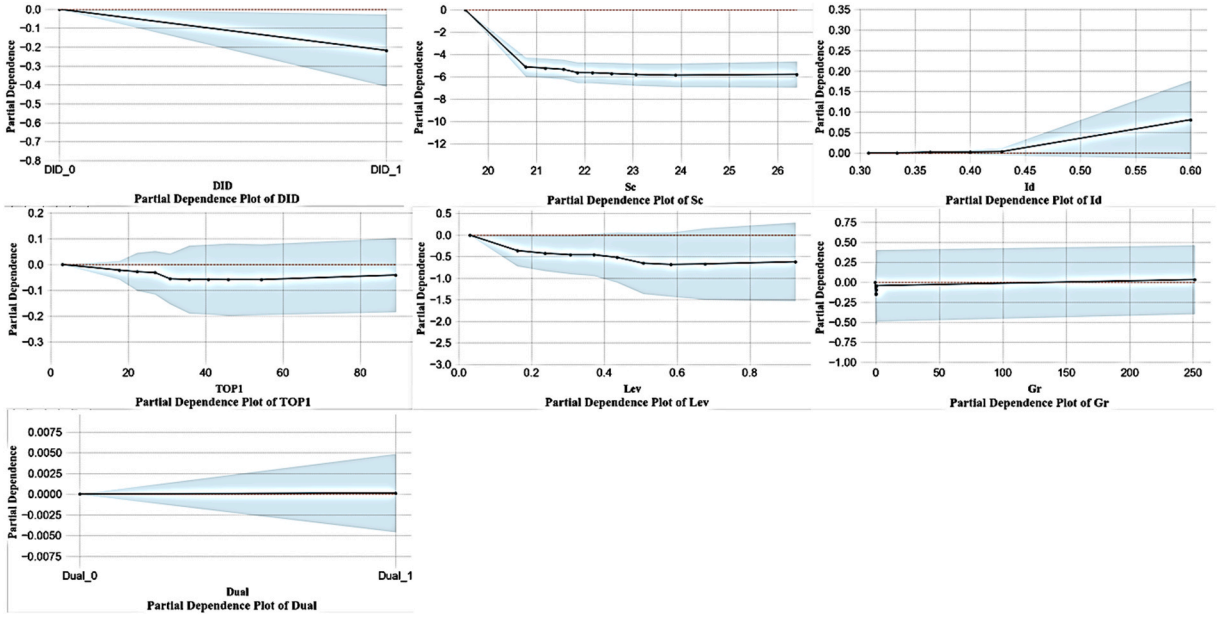

Fig. 3. The partial dependence plot for variables.

corporate performance, which undoubtedly impacts corporate performance. The entry into force of the Paris Agreement in 2016 and the two shocks in the Chinese stock market have caused a surge in the uncertainty of the living environment faced by enterprises, which may have a particular impact on the results. Keep this in mind: the samples from 2016 are also removed from this paper. The results are depicted in columns (1)–(2) in Table 6. The results are consistent with prior basic regressions; the EPT policy notably influences corporate performance at a 5 % significant level.

5.2.7. Further date processing

Further possible outliers and potential undetected heteroscedasticity problems could lead to bias in the results, so all continuous variables were winsorized at the 1st and 99th percentiles while clustering at the province level, and the results were consistent with the basic results (Table 6, columns (3)–(5)).

Table 6
Robust results of excluded major events and further data processing.

Variables	(1)	(2)	(3)	(4)	(5)
Post*Treat	−0.2691***	−0.0712**	−0.2926***	−0.0796***	−0.0796**
	(-12.23)	(-2.11)	(-17.02)	(-3.13)	(-2.65)
Sc	−0.2797***	−0.5604***	−0.2336***	−0.5054***	−0.5054***
	(-30.05)	(-25.95)	(-32.41)	(-30.14)	(-14.51)
Id	1.2167***	0.6639***	0.6736***	0.2548	0.2548
	(6.63)	(2.86)	(4.97)	(1.50)	(1.37)
TOP1	−0.0034***	−0.0079***	−0.0022***	−0.0082***	−0.0082***
	(-5.06)	(-5.86)	(-4.26)	(-7.82)	(-5.16)
Lev	−0.5833***	0.5915***	−0.8613***	0.4033***	0.4033***
	(-10.17)	(7.10)	(-19.85)	(6.54)	(3.75)
Gr	−0.0000	0.0000	0.1430***	0.1407***	0.1407***
	(-0.55)	(0.12)	(6.15)	(7.67)	(5.92)
Dual	−0.0077	−0.0559**	−0.0277*	−0.0493**	−0.0493**
	(-0.34)	(-2.03)	(-1.72)	(-2.57)	(-2.61)
Constant	8.1181***	14.1797***	7.3432***	13.1694***	13.1694***
	(40.04)	(29.51)	(46.74)	(35.21)	(17.13)
N	14946	14827	17129	16981	16981
Time fixed effects	NO	YES	NO	YES	YES
Individual fixed effects	NO	YES	NO	YES	YES
R^2	0.1350	0.6553	0.1718	0.6847	0.6847
adj. R^2	0.1346	0.5696	0.1714	0.6203	0.6203

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

5.2.8. *Change the explained variable*

For the discussion of firm performance, in addition to using Tobin Q as a proxy for this variable, many studies also use ROA, a variable of firm profitability, as a proxy variable, so this paper will replace the explanatory variable with ROA. The results (in Table 7) show that EPT policy hurts firm performance, consistent with the basic results.

5.3. *Mechanism tests*

This section aims to explore two key aspects: first, this paper discussed whether the implementation of the EPT policy can mitigate the adverse effects on corporate performance by fostering technological innovation with Eq. (2); and second, it considered whether the proactive environmental focus of an authoritarian government could amplify or relieve the negative impact on corporate performance under the EPT policy by applying Eq. (3).

Table 7
Robust results of replace explained variable.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.0014	−0.0045*	−0.0029*	−0.0047**
	(-0.83)	(-1.92)	(-1.93)	(-2.13)
Sc			0.0093***	0.0091***
			(15.08)	(4.93)
Id			−0.0178	0.0009
			(-1.55)	(0.06)
TOP1			0.0002***	0.0005***
			(5.83)	(4.63)
Lev			−0.1538***	−0.1779***
			(-39.76)	(-24.40)
Gr			0.0015***	0.0019***
			(4.96)	(7.40)
Dual			0.0091***	0.0016
			(5.68)	(0.76)
Constant	0.0451***	0.0458***	−0.1010***	−0.1012**
	(55.87)	(63.15)	(-7.57)	(-2.40)
N	5458	5444	5346	5327
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
R^2	0.0001	0.6105	0.2466	0.6607
adj. R^2	−0.0001	0.5312	0.2456	0.5900

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

Table 8
Mechanism test results.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.3598***	−0.0800**	−0.2390***	−0.0743*
	(-16.73)	(-2.56)	(-6.21)	(-1.69)
Lnc	0.0228***	0.0345**		
	(4.03)	(2.37)		
Post*Treat*EF			0.1200	0.0113
			(1.44)	(0.15)
Post*EF			−0.3200***	−0.0340
			(-4.82)	(-0.56)
Treat*EF			0.0877***	0.0130
			(4.26)	(0.53)
Constant	9.3860***	16.4728***	9.2200***	16.3800***
	(50.78)	(38.68)	(50.44)	(38.55)
Controls	YES	YES	YES	YES
N	18848	18735	18848	18735
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
R^2	0.1641	0.6722	0.1658	0.6721
adj. R^2	0.1638	0.6106	0.1654	0.6105

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

5.3.1. Technology innovation

Many existing studies attribute the impact of the EPT policy on enterprises to technological innovation, yet whether innovation takes a leading role remains a subject for further validation. Consequently, this paper delves into the role of enterprise innovation in shaping the policy's influence on enterprise performance. As evident in Table 8 (columns (1) and (2)), both the policy variable Post*Treat and the Lnc regression coefficient remain significant (p-values are 0.000 and 0.010). However, compared to the benchmark regression, the coefficient of the policy variable has decreased. It suggests that while the enhancement of technological innovation partially explains the negative impact of EPT policy implementation on enterprise performance, it does not provide a complete explanation. In other words, the results only partially support hypothesis H2.

5.3.2. Government green attention

This section examines the moderating effect of government green attention on corporate performance in the context of EPT policy implementation. According to Table 8 (columns (3) and (4)), the coefficient of Post*Treat*EF is positive but not significant. This result is in contrast to the findings of Long et al. [2] which suggest that environmental protection policies increase the amount of 'pain' in firms. However, our finding hints that with increasing government green attention, the negative impacts of EPT policy on corporate performance will be reduced. In other words, if the regional government pays more attention to green construction, it will promote the construction of local green infrastructure and accelerate the green transformation. At the same time, it also provides suitable conditions for the green development of enterprises so that enterprises can enjoy the basic public facilities, preferential policies, and tilted capital level provided by the government, thus improving their performance. However, this effect is not statistically significant, so hypothesis H3 does not hold. It implies that, despite local governments prioritizing green transformation, the corresponding supportive policies may not fully satisfy the government's intention for green development. Therefore, under EPT policy implementation, there is a need for the government to enhance efforts to disseminate awareness of low-carbon environmental protection to producers and to pressure enterprises to transition towards more sustainable practices.

6. Further analysis

Given the dynamic nature of external environments and the inherent diversity among companies, the effects of EPT exhibit heterogeneity across different firms. This section delves deeply into the analysis of the heterogeneous impact of EPT on corporate performance. Besides financial performance, environmental, social, and governance (ESG) performance have also recently been profoundly focused on by investors and customers. In the second part of this section, this paper discusses the influence of EPT policy on corporate ESG performance, which is helpful for a comprehensive understanding of EPT implementation's environmental, social, and economic benefits.

6.1. Heterogeneity

6.1.1. Equity heterogeneity

The disparity in property rights among enterprises can result in heterogeneous policy impacts. In China, state-owned enterprises possess unique resource advantages [37], with relatively stable capital sources and adherence to stringent regulations, leading to higher enterprise value. The EPT policy may exert minimal influence on state-owned enterprises. Conversely, non-state-owned enterprises contend with heightened market competition and financing constraints, potentially fostering greater motivation to undertake

Table 9
Equity heterogeneity results.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.2376***	−0.0030	−0.3970***	−0.1162***
	(-7.32)	(-0.07)	(-14.46)	(-2.88)
Constant	10.0100***	15.2500***	9.2750***	17.8791***
	(43.59)	(24.75)	(32.72)	(31.20)
Controls	YES	YES	YES	YES
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
N	6467	6402	12381	12279
R^2	0.2580	0.7279	0.1124	0.6669
adj. R^2	0.2572	0.6822	0.1119	0.5963

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$. Columns (1)–(2) and (3)–(4) are the state-owned and non-state-owned enterprises' results, respectively.

green transformation and maintain enterprise value. To investigate the impact of the EPT policy, regression analysis is performed on these two enterprise types, and the results are presented in columns (1)–(4) of Table 9.

The regression outcomes reveal that while policy implementation has decreased the value of state-owned enterprises, this decline is not statistically significant. The decisions and activities of state-owned enterprises are often long-term and subject to government intervention, making them less susceptible to significant alterations due to individual policy impacts. However, the policy variable is negatively significant for non-state-owned enterprises at the 1 % significance level (p-values are 0.000 and 0.004), which signifies that non-state-owned enterprises exhibit heightened sensitivity to changes in market policies, enabling them to promptly adjust production activities in response to policy dynamics, mitigate losses incurred by policy changes, and consequently enhance overall enterprise performance.

6.1.2. Pollution heterogeneity

The efficacy of EPT policy implementation in shaping enterprise behavior hinges on the demand for pollution disposition. When demand is substantial, enterprises bear proportionately high costs. The severity of the impact on enterprise performance is particularly pronounced for heavy-polluting enterprises with elevated pollution discharge requirements. Notably, the variance in existing research conclusions is often attributed to sample heterogeneity, with some studies encompassing the entire A-share listed company sample. In contrast, others focus on heavily polluting industries. To address this, the study classifies 58 industries into heavy-polluting and light-polluting categories based on pollution levels, using industry classification standards adopted by other scholars [38] and the industry code classification of the 2012 edition of the China Securities Regulatory Commission.

The regression results demonstrate that EPT policies negatively affect enterprise performance, evident in both heavy-polluting industries (columns (1)–(2) of Table 10) and light-polluting industries (columns (3)–(4) of Table 10). Moreover, the adverse impact on performance is more pronounced for heavy-polluting industries, with results being statistically significant (both p-values are 0.000). It implies that enterprises classified as heavy polluters experience the most substantial repercussions from EPT policy implementation. To mitigate these impacts, enterprises in this category must intensify efforts to reduce emissions, incurring higher compliance and environmental investment costs, ultimately reducing overall enterprise performance.

6.1.3. Technology gap heterogeneity

Low-tech industries typically exhibit a greater reliance on resources. Consequently, in the context of EPT policy implementation, these industries often grapple with more substantial transformation pressures, leading to a decline in enterprise performance. To explore whether this difference in technological intensity influences the effects of policy implementation, this paper conducts a heterogeneity analysis by dividing the samples into high-tech and low-tech industries, following the industry division standard referenced in Wei et al. [39].

Table 10
Pollution heterogeneity results.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.3781***	−0.1661***	−0.3389***	−0.0293
	(-10.49)	(-3.57)	(-12.85)	(-0.72)
Constant	8.4399***	13.7261***	9.7298***	18.0260***
	(28.61)	(19.01)	(41.70)	(32.22)
Controls	YES	YES	YES	YES
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
N	6346	6285	12502	12379
R^2	0.1784	0.7273	0.1582	0.6613
adj. R^2	0.1775	0.6761	0.1577	0.5940

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

Table 11
Technology gap heterogeneity results.

Variables	(1)	(2)	(3)	(4)
Post*Treat	−0.4380***	−0.1087	−0.3195***	−0.0570*
	(-9.53)	(-1.52)	(-14.03)	(-1.74)
Constant	10.3543***	18.5991***	8.5987***	15.7087***
	(23.61)	(20.28)	(45.48)	(34.18)
Controls	YES	YES	YES	YES
Time fixed effects	NO	YES	NO	YES
Individual fixed effects	NO	YES	NO	YES
N	5560	5521	13288	13214
R^2	0.1192	0.6784	0.1733	0.6646
adj. R^2	0.1181	0.6154	0.1729	0.6022

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$.

Table 12
The EPT policy's impact on ESG performance.

Variables	ESG	E	S	G
Post*Treat	0.4643**	0.7171**	0.1107	0.0937
	(2.32)	(2.51)	(0.39)	(0.73)
Sc	1.0182***	1.0431***	1.1152***	0.5075***
	(6.04)	(4.34)	(4.64)	(4.70)
Id	2.1227	0.1966	2.1691	1.8093**
	(1.48)	(0.10)	(1.06)	(1.96)
TOP1	0.0224**	0.0271*	0.0140	0.0210***
	(2.30)	(1.95)	(1.00)	(3.36)
Lev	−0.8677	−0.2925	−1.1097	−1.7433***
	(-1.31)	(-0.31)	(-1.17)	(-4.10)
Gr	−0.0335	−0.0562*	−0.0248	−0.0011
	(-1.47)	(-1.72)	(-0.76)	(-0.08)
Dual	−0.0853	−0.4964*	0.4522*	0.1407
	(-0.44)	(-1.81)	(1.65)	(1.14)
Constant	−2.0706	−13.1967**	−1.0715	33.0962***
	(-0.54)	(-2.41)	(-0.20)	(13.42)
N	5327	5327	5327	5327
R^2	0.8437	0.7938	0.8324	0.8887
adj. R^2	0.8112	0.7508	0.7975	0.8655

Note: t statistics in parentheses are show in the table under the regression coefficient, and * stands that $p < 0.1$, ** stands $p < 0.05$, and *** stands $p < 0.01$. Besides, E, S, and G in upper table stand environmental, social responsibility and corporate governance dimensions.

The results reveal that, in comparison with high-tech industries (columns (1) and (2) of Table 11), the impact coefficient of policies in low-tech industries (columns (3) and (4) of Table 11) is negatively significant at the 10 % significance level. It signifies that the variance in technological levels does indeed affect the outcomes of policy implementation. For low-tech industries, the negative impact of policy implementation on enterprise performance is more pronounced.

6.2. ESG effects

In the context of climate change, corporate environmental and social responsibility performance and corporate financial performance have become the focus of investors and consumers. Different from traditional financial rating systems, ESG focuses on corporate risks in environmental, social responsibility, and corporate governance dimensions and has become a vital decision-making factor affecting market participants [40]. Therefore, the influence of EPT on corporate ESG performance is also considered in this paper. The basic results (in Table 12) show that the launch of the EPT policy has significantly improved corporate ESG performance. Implementing the EPT policy can effectively enhance enterprises' environmental protection awareness and accelerate enterprises' green transformation, thus establishing a good corporate reputation and helping enterprises enhance their value.

Meanwhile, the results also reflect that EPT policy mainly improves enterprises' ESG performance by improving their environmental performance. However, they do not have a significant impact on corporate social responsibility and corporate governance, indicating that the impact of the policy is still insufficient and that it needs to be combined with other practical policy tools to stimulate enterprises further to carry out green, high-quality transformation and improve their market performance. These findings complement studies by many people, which are often based on heavily polluting industry samples and, therefore, have some limitations [41].

7. Conclusions, policy implications, and limitations

This paper presents the implementation of the EPT in China in 2018 as a quasi-natural experiment scenario. The evaluation of the

impact of EPT enforcement on enterprise performance goes beyond focusing solely on significantly polluting companies by utilizing specific micro-enterprise data. Additionally, this article presents a comprehensive analytical framework for assessing the implications of EPT on firms, encompassing not only financial repercussions but also considerations for the environment, social responsibility and governance. These endeavors will not only enhance research on policies related to the environment but also offer valuable perspectives on future practices in climate policy. Simultaneously, this study can offer valuable insights into the analysis of the nonlinear correlation between economic and environmental performance. It also confirms the impact of environmental regulations on environmental performance along the course of economic advancement. The specific conclusions are as follows.

(1) The results obtained from the DID method indicate that the EPT policy significantly and adversely affects the financial performance of firms. This effect persists even after excluding potential issues of endogeneity and questions about the robustness of the results. It adheres to the 'polluter pays' principle and emphasizes the environmental obligations that corporations should assume.
(2) This study discusses the negative consequences of policy implementation and how technical developments contribute to these repercussions, namely through the 'innovation compensating effect'. In addition, the adverse effects of policies are reduced due to the government's emphasis on sustainable construction.
(3) Policy's heterogeneity effects exist in different ownership, pollution, and technology conditions. It illustrates that state-owned firms are more resistant to the impact of the policy compared to non-state-owned enterprises. The degree of industrial pollution is recognized as a critical factor, and companies with high pollution levels face more significant challenges and costs as a result of the regulation. However, technical progress mitigates the negative effects of the policy, particularly in the high-tech industry. In addition, there is also encouraging news: the successful application of EPT policy improves the environmental performance of firms and elevates their overall ESG level. It helps organizations increase their reputation and reduce the long-term impact of regulations on corporate performance.

Drawing on these findings, these insights carry notable policy implications for policymakers to enhance the effectiveness of the EPT policy in China.

(1) Revise tax policies for environmental protection: Enhance the EPT system by introducing varied tax rates and preferential policies and encourage enterprises to adopt green production practices by providing deductions and discounts for eco-friendly activities, thereby promoting improved performance.
(2) Provide long-term policy signals: The government should release clear and long-term policy signals on environmental regulation. Strengthen publicity efforts and commend exemplary enterprises to heighten awareness of environmental responsibility among managers and market investors, fostering innovation within enterprises.
(3) Deepen production elements market reform: Advance reforms in the production elements by eliminating barriers such as local protectionism and information opacity. This reform will synergize with environmental regulations, enable the market to play a decisive role in resource allocation, and promote green reforms within enterprises from the supply side.

This study presents a comprehensive analysis framework for examining the effect of EPT on corporations. It also uses several strategies to provide a comprehensive understanding of the impacts of implementing environmental policies on corporations. Overall, this research makes a substantial contribution to the existing literature in this field. Nevertheless, it is necessary to recognize its limitations and delineate prospective areas for further research. Firstly, an investigation is necessary to determine potential nonlinear links between the EPT policy and the various environmental conditions of firms because of the growing public focus on green reputation and the diverse emission requirements. Secondly, given the significant impact of COVID-19 and the available data, this paper focuses on the time period from 2011 to 2019. To address these constraints, future studies could enhance the dataset by increasing its size, extending the research period, and boosting the sample size. This would allow for more comprehensive and detailed findings. Last, although the current study uses a suitable method, future research could gain advantages by employing more sophisticated econometric methodologies.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publish

Not applicable.

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Data availability statement

Data and materials are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Simin Shen: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Liang Wang:** Writing – review & editing, Validation, Software, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Q. Wang, F. Ren, R. Li, Exploring the impact of geopolitics on the environmental Kuznets curve research, Sustain. Dev. (2023) 1–23, https://doi.org/10.1002/sd.2743.
[2] F. Long, F. Lin, C. Ge, Impact of China's environmental protection tax on corporate performance: empirical data from heavily polluting industries, Environ. Impact Assess. Rev. 97 (2022) 106892, https://doi.org/10.1016/j.eiar.2022.106892.
[3] M. Khastar, A. Aslani, M. Nejati, How does carbon tax affect social welfare and emission reduction in Finland? Energy Rep. 6 (2020) 736–744, https://doi.org/10.1016/j.egyr.2020.03.001.
[4] X. Gao, N. Liu, Y. Hua, Environmental Protection Tax Law on the synergy of pollution reduction and carbon reduction in China: evidence from a panel data of 107 cities, Sustain. Prod. Consum. 33 (2022) 425–437, https://doi.org/10.1016/j.spc.2022.07.006.
[5] A.M. Pereira, R.M. Pereira, P.G. Rodrigues, A new carbon tax in Portugal: a missed opportunity to achieve the triple dividend? Energy Pol. 93 (2016) 110–118, https://doi.org/10.1016/j.enpol.2016.03.002.
[6] E. Lyubich, J.S. Shapiro, R. Walker, Regulating mismeasured pollution: implications of firm heterogeneity for environmental policy, AEA Papers and Proceedings 108 (2018, May) 136–142, https://doi.org/10.1257/pandp.20181089, 2014 Broadway, Suite 305, Nashville, TN 37203: American Economic Association.
[7] Y. Wang, L. Yu, Can the current environmental tax rate promote green technology innovation?-Evidence from China's resource-based industries, J. Clean. Prod. 278 (2021) 123443, https://doi.org/10.1016/j.jclepro.2020.123443.
[8] A. Zhao, J. Wang, Z. Sun, H. Guan, Environmental taxes, technology innovation quality and firm performance in China—a test of effects based on the Porter hypothesis, Econ. Anal. Pol. 74 (2022) 309–325, https://doi.org/10.1016/j.eap.2022.02.009.
[9] M.M. Alam, M.W. Murad, A.H.M. Noman, I. Ozturk, Relationships among carbon emissions, economic growth, energy consumption and population growth: testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia, Ecol. Indicat. 70 (2016) 466–479, https://doi.org/10.1016/j.ecolind.2016.06.043.
[10] D. Tenaw, A.D. Beyene, Environmental sustainability and economic development in sub-Saharan Africa: a modified EKC hypothesis, Renew. Sustain. Energy Rev. 143 (2021) 110897, https://doi.org/10.1016/j.rser.2021.110897.
[11] R. Li, Q. Wang, L. Li, S. Hu, Do natural resource rent and corruption governance reshape the environmental Kuznets curve for ecological footprint? Evidence from 158 countries, Resour. Pol. 85 (2023) 103890, https://doi.org/10.1016/j.resourpol.2023.103890.
[12] S. Özokcu, Ö. Özdemir, Economic growth, energy, and environmental Kuznets curve, Renew. Sustain. Energy Rev. 72 (2017) 639–647, https://doi.org/10.1016/j.rser.2017.01.059.
[13] Q. Wang, X. Wang, R. Li, X. Jiang, Reinvestigating the environmental Kuznets curve (EKC) of carbon emissions and ecological footprint in 147 countries: a matter of trade protectionism, Humanities and Social Sciences Communications 11 (1) (2024) 1–17, https://doi.org/10.1057/s41599-024-02639-9.
[14] Q. Wang, S. Hu, R. Li, Could information and communication technology (ICT) reduce carbon emissions? The role of trade openness and financial development, Telecommun. Pol. 102699 (2023), https://doi.org/10.1016/j.telpol.2023.102699.
[15] Q. Wang, L. Wang, R. Li, Trade openness helps move towards carbon neutrality—insight from 114 countries, Sustain. Dev. 32 (1) (2024) 1081–1095, https://doi.org/10.1002/sd.2720.
[16] Y. Shang, N. Schneider, J. Cifuentes-Faura, X. Zhao, Porter in China: a quasi-experimental view of market-based environmental regulation effects on firm performance, Energy Econ. 126 (2023) 106966, https://doi.org/10.1016/j.eneco.2023.106966.
[17] Y. Steinebach, Instrument choice, implementation structures, and the effectiveness of environmental policies: a cross-national analysis, Regulation & Governance 16 (1) (2022) 225–242, https://doi.org/10.1111/rego.12297.
[18] J. Sun, N. Zhai, J. Miao, H. Mu, W. Li, How do heterogeneous environmental regulations affect the sustainable development of marine green economy? Empirical evidence from China's coastal areas, Ocean Coast Manag. 232 (2023) 106448, https://doi.org/10.1016/j.ocecoaman.2022.106448.
[19] W. Zhang, Q. Luo, S. Liu, Is government regulation a push for corporate environmental performance? Evidence from China, Econ. Anal. Pol. 74 (2022) 105–121, https://doi.org/10.1016/j.eap.2022.01.018.
[20] S. Huang, H. Lin, Y. Zhou, H. Ji, N. Zhu, The influence of the policy of replacing environmental protection fees with taxes on enterprise green innovation—evidence from China's heavily polluting industries, Sustainability 14 (11) (2022) 6850, https://doi.org/10.3390/su14116850.
[21] J. Lu, Can environmental protection tax aggravate illegal pollution discharge of heavy polluting enterprises? Environ. Sci. Pollut. Control Ser. 29 (22) (2022) 33796–33808, https://doi.org/10.1007/s11356-021-18002-3.
[22] G. Liu, Z. Yang, F. Zhang, N. Zhang, Environmental tax reform and environmental investment: a quasi-natural experiment based on China's Environmental Protection Tax Law, Energy Econ. 109 (2022) 106000, https://doi.org/10.1016/j.eneco.2022.106000.
[23] H. Zheng, Y. He, How do the China pollution discharge fee policy and the environmental protection tax law affect firm performance during the transitional period? Environ. Sci. Pollut. Control Ser. 29 (29) (2022) 44541–44557, https://doi.org/10.1007/s11356-022-19050-z.
[24] Y. He, C. Wen, J. He, The influence of China Environmental Protection Tax Law on firm performance–evidence from stock markets, Appl. Econ. Lett. 27 (13) (2020) 1044–1047, https://doi.org/10.1080/13504851.2019.1659488.
[25] Z. Lei, L. Huang, Y. Cai, Can environmental tax bring strong porter effect? Evidence from Chinese Listed Companies, Environ. Sci. Pollut. Control Ser. (2022) 1–15, https://doi.org/10.1007/s11356-021-17119-9.

[26] Y. He, X. Zhu, H. Zheng, The influence of environmental protection tax law on total factor productivity: evidence from listed firms in China, Energy Econ. 113 (2022) 106248, https://doi.org/10.1016/j.eneco.2022.106248.
[27] Q. Wang, Y. Ge, R. Li, Does improving economic efficiency reduce ecological footprint? The role of financial development, renewable energy, and industrialization, Energy Environ. (2023) 0958305X231183914, https://doi.org/10.1177/0958305X231183914.
[28] Q. Wang, T. Sun, R. Li, Does artificial intelligence promote green innovation? An assessment based on direct, indirect, spillover, and heterogeneity effects, Energy Environ. (2024) 0958305X231220520, https://doi.org/10.1177/0958305X231220520.
[29] S.S. Bravo, V.H.G. Estrada, Oligopolistic competition, asymmetric trade and pollution taxes, Journal of Economics, Management and Trade 22 (1) (2018) 1–12, https://doi.org/10.9734/JEMT/2019/45763.
[30] M. Porter, America's green strategy, Bus. Environ.: A Reader 33 (1996) 1072.
[31] C. Dang, Z.F. Li, C. Yang, Measuring firm size in empirical corpor-ate finance, J. Bank. Finance 86 (2018) 159–176, https://doi.org/10.1016/j.jbankfin.2017.09.006.
[32] Q. Huang, Y. Li, M. Lin, G.A. McBrayer, Natural disasters, risk salience, and corporate ESG disclosure, J. Corp. Finance 72 (2022) 102152, https://doi.org/10.1016/j.jcorpfin.2021.102152.
[33] Y. Wang, Z. Zhao, X. Wei, Does board independence affect corporate performance? Econ. Res. 5 (2006) 62–73. CNKI:SUN:JJYJ.0.2006-05-006.
[34] G. Zhao, W. Yu, The Corporate Governance Effect of Major Shareholders' Equity Balance: Evidence from Private Listed Companies, vol. 11, Foreign Economic and Management, 2018, pp. 60–72, https://doi.org/10.16538/j.carol.carroll.nki.fem.2018.11.005.
[35] R. Watanabe, T. Watanabe, Effects of environmental policy on public risk perceptions of haze in Tianjin City: a difference-in-differences analysis, Renew. Sustain. Energy Rev. 109 (2019) 199–212, https://doi.org/10.1016/j.rser.2019.04.017.
[36] H. Wang, Y. Li, W. Lin, W. Wei, How does digital technology promote carbon emission reduction? Empirical evidence based on e-commerce pilot city policy in China, J. Environ. Manag. 325 (2023) 116524, https://doi.org/10.1016/j.jenvman.2022.116524.
[37] C. Zhang, G. Liu, The existence, dynamic characteristics and economic growth effect of optimal financial structure, Manag. World 268 (1) (2016) 66–77, https://doi.org/10.19744/j.cnki.11-1235/f.2016.01.007.
[38] Q. Li, Z. Xiao, Heterogeneous environmental regulation tools and corporate green innovation incentives: evidence from green patents of listed companies, Econ. Res. J. 55 (9) (2020) 192–208.
[39] L. Wei, & L. Ren, Whether carbon emission trading can promote enterprises' green technology innovation: from the perspective of carbon price, Lanzhou Academic Journal 334 (7) (2021) 91–110. https://kns.cnki.net/kcms2/article/abstract?v=kMpVSI0yL5dVv3JJzElwrh08jXboCNk5FbDA0QvfeazzjtGrQqg2wXKL7FaycDlc_RTsY8DlhBfVLjcNysjl8EEpRvG9_YOcRmemKkDxBs72D7xIzH42qDphFH9TUogep83-Kwk5OJM=&uniplatform=NZKPT&language=CHS.
[40] L.H. Pedersen, S. Fitzgibbons, L. Pomorski, Responsible investing: the ESG-efficient frontier, J. Financ. Econ. 142 (2) (2021) 572–597, https://doi.org/10.1016/j.jfineco.2020.11.001.
[41] X. He, Q. Jing, H. Chen, The impact of environmental tax laws on heavy-polluting enterprise ESG performance: a stakeholder behavior perspective, J. Environ. Manag. 344 (2023) 118578, https://doi.org/10.1016/j.jenvman.2023.118578.