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Environmental Regulation Policies and Their Impact on the Performance of Heavily Polluting Enterprises—Evidence from China's A-share Listed Companies

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Abstract: *As the importance of synergizing environmental protection and corporate performance becomes increasingly prominent, the impact of environmental regulation policies on corporate performance has become a hot topic in academic research. Taking the 2015 implementation of the revised "Environmental Protection Law" as a starting point, this study selects 828 heavily polluting enterprises listed on China's A-share market from 2010 to 2022 as a research sample. Using a Difference-in-Differences (DID) model, it explores the effects of environmental regulation policies on corporate performance and their underlying mechanisms. The findings reveal that stricter environmental regulations, following the implementation of the new law, have not adversely impacted corporate performance. Instead, these policies have facilitated performance improvements through mechanisms such as technological innovation. Further analysis highlights the critical mediating roles of green technological innovation and R&D investment. Heterogeneity analysis indicates that the policies' effects are more pronounced for non-multinational and non-state-owned enterprises, while the impact on multinational corporations is relatively weaker. Based on these findings, it is recommended to strengthen policy support for non-state-owned enterprises to drive their transformation and upgrading while leveraging the successful practices of multinational corporations to achieve a win-win outcome between environmental protection and corporate performance.*

Keywords: *New "Environmental Protection Law"; Difference-in-Differences (DID); Green Technological Innovation; R&D Investment; Environmental Regulation*

1. Introduction

Since the initiation of the reform and opening-up policy, China's economy has achieved remarkable success over four decades of rapid growth, becoming the world's second-largest economy. However, this extensive growth model, which relies heavily on resource consumption and inefficient utilization, has led to diminishing growth potential and severe environmental issues, such as air pollution, water scarcity, and land desertification (Yang Rudai, 2015; Jin Laiqun et al., 2015) [1-2]. Consequently, there is an urgent need to transition to a new economic development model that prioritizes the enhancement of overall development quality.

The report of the 20th National Congress of the Communist Party of China explicitly emphasized that high-quality development is the primary task in building a modern socialist country. Environmental protection, energy conservation, low-carbon development, and emission reduction are central components of this strategy (Pei Chao, 2023) [3]. As society advances toward high-quality development, environmental protection has become a focal point of public attention, and the impact of environmental regulation policies has grown increasingly evident.

To balance economic growth with environmental protection, China adopted the revised "Environmental Protection Law" in 2014, which was implemented in 2015. This law strengthened environmental regulation policies, particularly targeting heavily polluting industries, compelling enterprises to adjust their production behaviors, thereby influencing their performance [4]. However, the specific impact of environmental regulations on corporate performance remains a subject of significant debate in the academic community. The traditional hypothesis posits that environmental regulations

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increase corporate costs and hinder performance (Wang Xiaoqi et al., 2020) [5]. In contrast, the Porter Hypothesis argues that stringent environmental regulations stimulate innovation, thereby enhancing performance (Wang Mingyue, Li Yingming, Wang Zitong et al., 2022) [6]. The Uncertainty Hypothesis suggests that the effects of environmental regulations are contingent upon the internal and external environments of enterprises (Fu Jingyan, Li Lisha, 2010) [7].

This study leverages the 2015 implementation of the new "Environmental Protection Law" as a natural experiment, selecting heavily polluting enterprises as the research sample and employing a Difference-in-Differences (DID) model to analyze the impact of environmental regulation policies on corporate performance and their underlying mechanisms. The contributions of this paper are threefold: first, it evaluates the implementation effects of the new "Environmental Protection Law" from a fresh perspective; second, it integrates DID with Propensity Score Matching Difference-in-Differences (PSM-DID) to address endogeneity issues; and third, it delves into the specific mechanisms through which the new "Environmental Protection Law" affects the performance of heavily polluting enterprises, providing practical insights for relevant policymaking.

2. Literature Review

2.1. Environmental Regulation Policies and Corporate Performance

The academic community has proposed three primary perspectives on the impact of environmental regulation policies on corporate performance. The traditional hypothesis suggests that environmental regulations increase production costs, such as those associated with pollution control, environmental technologies, and equipment investments, thereby suppressing corporate performance (Dean & Lovely, 2010) [8]. Additionally, higher costs related to management, monitoring, and energy consumption may reduce production efficiency (Harrington & Morgenstern, 2004) [9], leading to performance decline (Zhou Ruihui et al., 2023) [10].

In contrast, the Porter Hypothesis argues that environmental regulations incentivize enterprises to innovate, thereby improving productivity and long-term performance. Strict regulations encourage technological development, resource conservation, and waste reduction, which enhance corporate competitiveness (Porter, 1995) [11]. Furthermore, environmental regulations may create new business opportunities by fostering the development of clean technologies and renewable energy industries.

The Uncertainty Hypothesis posits that the impact of environmental regulations on corporate performance depends on a combination of factors, including industry characteristics, market competition, and government policies (Lanoie, 2002) [12]. Enterprises' strategies and performance in response to environmental regulations vary depending on their internal and external environments.

2.2. Environmental Regulation Policies and Green Technological Innovation

The relationship between environmental regulations and green technological innovation has received significant attention. Strict environmental regulations often compel enterprises to increase their investment in green technological innovation to meet environmental standards. Studies have shown that environmental regulations drive technological innovation, enabling enterprises to maintain their competitiveness (Liu Yingjun & Li Haifeng, 2023) [13]. However, environmental innovation typically requires additional R&D investment, which may increase costs and adversely affect short-term performance (Zhang Huihui & Sun Zhuohan, 2023) [14]

Moreover, green technological innovation improves corporate image, reduces environmental risks, and enhances social reputation, leading to a win-win scenario of economic growth and environmental sustainability.

2.3. Environmental Regulation Policies and Corporate R&D Investment

The impact of environmental regulations on corporate R&D investment has been a topic of divergent viewpoints in academia. The Porter Hypothesis posits that environmental regulations stimulate corporate innovation activities, thereby promoting technological progress and increasing R&D investment. Conversely, some scholars argue that environmental regulations elevate costs, potentially hindering R&D investment (Stavins, 1997) [15].

Additionally, some research indicates a nonlinear relationship between environmental regulations and

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technological progress, suggesting that regulations may suppress R&D investment in the short term but promote technological progress in the long term through the innovation compensation effect (Popp, 2002) [16]. Other studies contend that corporate R&D investment is influenced by multiple factors, including market demand and industrial competition, rather than being solely driven by environmental regulations (Jaffe et al., 1995) [17].

3. Research Design

3.1. Data Sources

This study selects China's A-share listed companies from 2010 to 2022 as the research sample, focusing on 16 categories of heavily polluting industries identified in the "Guidelines for Environmental Information Disclosure by Listed Companies" issued by the Ministry of Environmental Protection in 2010 (Wang Xu & Chu Xu, 2019) [18]. During the sample selection process, traditional financial industries, companies marked as ST (special treatment), and firms with severely incomplete financial data were excluded, resulting in a final sample of 828 heavily polluting enterprises. The primary data sources include the China Research Data Services Platform (CNRDS) for corporate data, the Wind database for multinational operation data, and the CSMAR database for financial data.

3.2. Variable SelectionData Sources

3.2.1. Dependent Variable

The dependent variable in this study is corporate performance, measured using return on equity (ROE). In previous studies, Tobin's Q or ROE has been commonly used to assess corporate performance. However, Tobin's Q may be significantly influenced by market volatility, and changes in book value tend to be minimal, potentially leading to biased empirical result.Therefore, ROE is chosen as the performance indicator in this study.

3.2.2. Independent Variable

The independent variable is the effect of the "Environmental Protection Law" on heavily polluting enterprises, analyzed using a Difference-in-Differences (DID) model. Specifically, the treatment group comprises heavily polluting enterprises affected by the new law, assigned a value of 1, while the control group consists of non-heavily polluting enterprises, assigned a value of 0. The post-policy implementation dummy variable (Post) takes a value of 1 for years from 2015 onwards and 0 for years prior to 2015. The interaction term (Treat × Post) is used to measure the impact of the "Environmental Protection Law (EL)" on heavily polluting enterprises(HP).

3.2.3. Mechanism Variables

•Green Technological Innovation (LNP): Following the methodology of Xu Jia and Cui Jingbo (2020) [19], green technological innovation is measured using the natural logarithm of the number of green invention patents and green utility model patents.

• R&D Investment (RD): As a mediating variable, R&D investment is measured by R&D intensity. Referring to Zhang Yilin (2023) [20], R&D intensity is calculated as the ratio of R&D expenditure to operating revenue and the ratio of R&D expenditure to total assets.

Control Variables.To account for other factors potentially affecting corporate performance, the following control variables are included:Leverage (Lev),Total Asset Turnover (ATO),Cash Flow Ratio (Cashflow),Proportion of Independent Directors (Indep),Dual Leadership Structure (Dual),Ownership Concentration (OC).Additionally, the model incorporates fixed effects for years and industries to control for potential temporal and industry-specific effects.

3.3. Model Construction

Based on the above theoretical analysis, it is inferred that the implementation of the new "Environmental Protection Law" significantly impacts the performance of heavily polluting enterprises. To better explore the effects of the law, a series of control variables are introduced into the model. The basic regression model is constructed as follows:

$$ROE_{i,t} = \beta 1 + \beta 2\, Postt \times Treati + \sum Controls_{i,t} + \sum year + \sum IND + \varepsilon_{i,t} \quad (1)$$

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Where i represents the firm, t represents the year, $ROE_{i,t}$ is the corporate performance of firm i in year t, $Treati$ is the treatment group dummy variable, $Postt$ is the post-policy dummy variable, $Postt \times Treati$ is the DID variable, $Controls$ represents the control variables, year indicates year fixed effects, IND denotes industry fixed effects, and ε represents the random error term.

To investigate the mediating role of R&D investment in the relationship between the new "Environmental Protection Law" and corporate performance, the variable for green technological innovation is incorporated into the regression, resulting in the following model:

$$LNP_{i,t} = \beta1 + \beta2\ Postt \times Treati + \sum Controls_{i,t} + \sum year + \sum IND + \varepsilon_{i,t} \quad (2)$$

Where $LNP_{i,t}$ represents the number of green technological innovation patents of firm i in year t.

Finally, the variable for green technological innovation is added to the original model, as follows:

$$ROE_{i,t} = \beta1 + \beta2\ Postt \times Treati + \beta3 LNP_{i,t} + \sum Controls_{i,t} + \sum year + \sum IND + \varepsilon_{i,t} \quad (3)$$

To further investigate whether R&D investment mediates the relationship between the law and corporate performance, the following regression model is constructed:

$$RD_{i,t} = \beta1 + \beta2\ Postt \times Treati + \sum Controls_{i,t} + \sum year + \sum IND + \varepsilon_{i,t} \quad (4)$$

Where $RD_{i,t}$ represents the R&D intensity of firm i in year t

Finally, the R&D investment variable is incorporated into the original model, as follows:

$$ROE_{i,t} = \beta1 + \beta2\ Postt \times Treati + \beta3 RD_{i,t} + \sum Controls_{i,t} + \sum year + \sum IND + \varepsilon_{i,t} \quad (5)$$

4. Empirical Analysis

4.1. Baseline Regression

The regression results are presented in Table 1. Columns (1) and (2) exclude control variables, while columns (3) and (4) include control variables and account for fixed effects for both years and industries. The coefficient of the key explanatory variable, DID, is significantly positive at the 1% level across all specifications. This indicates that the implementation of the Environmental Protection Law positively impacts the performance of heavily polluting enterprises.

Table 1: Baseline Regression Results

	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
HP	-0.008	-0.026***	-0.006	-0.020***
	(0.006)	(0.006)	(0.005)	(0.006)
EL	-0.052***	-0.117***	-0.018***	-0.047***
	(0.002)	(0.004)	(0.002)	(0.003)
DID	0.044***	0.042***	0.020***	0.019***
	(0.003)	(0.003)	(0.003)	(0.003)

Notes: Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.*(Same applies below)

4.2. Robustness Checks

4.2.1. Outlier Removal

To mitigate the influence of outliers and improve data stability, a Winsorization method (at the 1% and 99% levels) was applied to continuous variables. The results in Table 2 (Column 1) show that the DID coefficient remains significantly positive at the 1% level after outlier removal, consistent with the baseline regression.

4.2.2. Alternative Dependent Variable

To ensure accuracy, return on assets (ROA) was used as an alternative dependent variable. As shown in Table 2 (Column 2), the results are consistent with the baseline regression, further demonstrating robustness.

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4.2.3. Adjusted Research Period

To account for potential distortions caused by the COVID-19 pandemic, data from 2020 onwards were excluded. The results in Table 2 (Column 3) indicate that the positive impact of the law on corporate performance remains significant at the 1% level, regardless of the inclusion or exclusion of pandemic years.

4.2.4. PSM-DID Test

To address endogeneity and reduce systematic errors, the study employed a Propensity Score Matching Difference-in-Differences (PSM-DID) method with 1:1 nearest neighbor matching. As shown in Table 2 (Column 4), the DID coefficient remains significantly positive at the 1% level, further validating the robustness of the results.

Table 2: Robustness Checks Results

	(1)	(2)	(3)	(4)
	ROE	ROA	ROE	ROE
HP	-0.019***	-0.006**	-0.018***	-0.007
	(0.006)	(0.003)	(0.007)	(0.009)
EL	-0.047***	-0.025***	-0.051***	-0.041***
	(0.003)	(0.001)	(0.003)	(0.005)
DID	0.019***	0.010***	0.016***	0.012***
	(0.003)	(0.001)	(0.003)	(0.004)

5. Further Analysis

This study examines the mechanisms through which the Environmental Protection Law enhances the performance of heavily polluting enterprises, focusing on two dimensions: green technological innovation and R&D investment.

5.1. Mechanism Analysis

5.1.1. Green Technological Innovation

The regression results in Table 3 (Column 2) show that the coefficient of DID with respect to green technological innovation is 0.039, significantly positive at the 5% level. This indicates that the implementation of the Environmental Protection Law positively correlates with green technological innovation in heavily polluting enterprises, signifying a notable positive effect.

As shown in Table 3 (Column 3), the performance of heavily polluting enterprises improves under the influence of the Environmental Protection Law. The coefficient of DID with respect to corporate performance is 0.019, significantly positive at the 1% level, while green technological innovation also exerts a significant positive effect on performance. The coefficient of green technological innovation with respect to corporate performance is 0.007, also significant at the 1% level. Therefore, when green technological innovation is considered a mediating variable, it significantly and positively impacts corporate performance, demonstrating partial mediation.

Table 3: Green Technological Innovation

	(1)	(2)	(3)
	ROE	LNP	ROE
HP	-0.020***	-0.076**	-0.019***
	(0.006)	(0.035)	(0.006)
EL	-0.047***	0.638***	-0.051***
	(0.003)	(0.021)	(0.003)
DID	0.019***	0.039**	0.019***
	(0.003)	(0.019)	(0.003)
LNP			0.007***
			(0.001)

5.1.2. R&D Investment

As shown in Table 4 (Column 2), the coefficient of DID with respect to R&D investment is 2.366,

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significantly positive at the 1% level, indicating a positive correlation between the Environmental Protection Law and R&D investment in heavily polluting enterprises. This suggests that the law significantly fosters growth in R&D investment.

In Table 4 (Column 3), corporate performance improves under the influence of the Environmental Protection Law, with a DID coefficient of 0.019 (significant at the 1% level). R&D investment also positively affects performance, with a coefficient of 0.011 (significant at the 1% level). Thus, when R&D investment is used as a mediating variable, it significantly and positively impacts corporate performance, demonstrating partial mediation.

Table 4: R&D Investment

	(1)	(2)	(3)
	ROE	Rd	ROE
HP	-0.021***	-0.127***	-0.020***
	(0.007)	(0.047)	(0.007)
EL	-0.026***	2.366***	-0.053***
	(0.004)	(0.028)	(0.005)
DID	0.018***	-0.087***	0.019***
	(0.003)	(0.022)	(0.003)
RD			0.011***
			(0.001)

5.2. Heterogeneity Analysis

To examine the differential effects of the Environmental Protection Law on corporate performance and explore whether different types of enterprises experience heterogeneous impacts, firms are categorized by ownership type (state-owned vs. non-state-owned) and multinational status (multinational vs. non-multinational). This classification provides a more comprehensive understanding of the law's effects by accounting for external and internal factors.

5.2.1. Multinational vs. Non-Multinational Enterprises

Heterogeneity analysis was conducted in two steps: first, analyzing the sample of non-multinational enterprises, and second, analyzing multinational enterprises. As shown in Table 5, the DID coefficient is 0.022 for non-multinational enterprises (significant at the 1% level) and 0.012 for multinational enterprises (also significant at the 1% level). These findings indicate that the Environmental Protection Law has a more pronounced positive impact on the performance of non-multinational enterprises compared to multinational enterprises.

5.2.2. State-Owned vs. Non-State-Owned Enterprises

Similarly, heterogeneity analysis was conducted by categorizing enterprises as state-owned or non-state-owned. As shown in Table 5, the DID coefficient is 0.024 for non-state-owned enterprises (significant at the 1% level) and 0.012 for state-owned enterprises (also significant at the 1% level). These results demonstrate that the Environmental Protection Law has a stronger positive impact on the performance of non-state-owned enterprises.

Table 5: Heterogeneity Analysis: Multinational Enterprises

	(Non-Multinational)	(Multinational)	(State-Owned)	(Non-State-Owned Enterprises)
	ROE	ROE	ROE	ROE
HP	-0.021***	-0.001	-0.011	-0.025***
	(0.008)	(0.012)	(0.008)	(0.009)
EL	-0.049***	-0.014	-0.041***	-0.033***
	(0.004)	(0.010)	(0.005)	(0.005)
DID	0.022***	0.012**	0.024***	0.012***
	(0.004)	(0.006)	(0.004)	(0.004)

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6. Research Conclusions and Discussion

6.1. Research Conclusions

Based on an analysis of 828 heavily polluting A-share listed enterprises from 2010 to 2023 using the Difference-in-Differences (DID) model, this study examines the impact of the implementation of the new Environmental Protection Law on corporate performance. The findings reveal that the implementation of the law significantly enhances corporate performance. Specifically, the law promotes green technological innovation and increases R&D investment, thereby boosting corporate competitiveness and supporting the Porter Hypothesis, which asserts that environmental regulation policies positively impact corporate performance.

The mediation effect analysis demonstrates that green technological innovation and R&D investment play critical intermediary roles between the Environmental Protection Law and corporate performance. Faced with stricter environmental regulations, heavily polluting enterprises have leveraged technological innovation and increased R&D investment to successfully address environmental pressures, enhance performance, and advance sustainable development

Heterogeneity analysis indicates that the Environmental Protection Law has a more pronounced impact on non-multinational and non-state-owned enterprises. Multinational enterprises, which generally already comply with international environmental standards, are less affected. In contrast, non-multinational and non-state-owned enterprises exhibit greater management flexibility and decision-making efficiency, enabling them to adapt more effectively to new regulations and improve performance. By comparison, state-owned enterprises face multiple governmental pressures, resulting in slower performance improvement.

6.2. Discussion

Despite the in-depth analysis of the Environmental Protection Law's impact on corporate performance, this study has certain limitations.

First, the analysis is limited to A-share listed companies and does not include non-listed enterprises. Future research could expand the sample scope to consider the performance of small- and medium-sized enterprises (SMEs).

Second, the study primarily focuses on green technological innovation and R&D investment to explore the underlying mechanisms, while neglecting other potential factors, such as the environmental awareness of management and policy support. Future studies could incorporate additional variables to further enrich the mechanism analysis.

Finally, this study focuses on the implementation of the new Environmental Protection Law. Future research could compare the impacts of different policy stages to investigate long-term effects. Additionally, local government policy variations may also influence corporate performance, suggesting a need for further exploration of regional policy effects in subsequent studies.

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