From Regulatory Pressure to Green Innovation: A Cognitive Perspective from China's Plastic Industry

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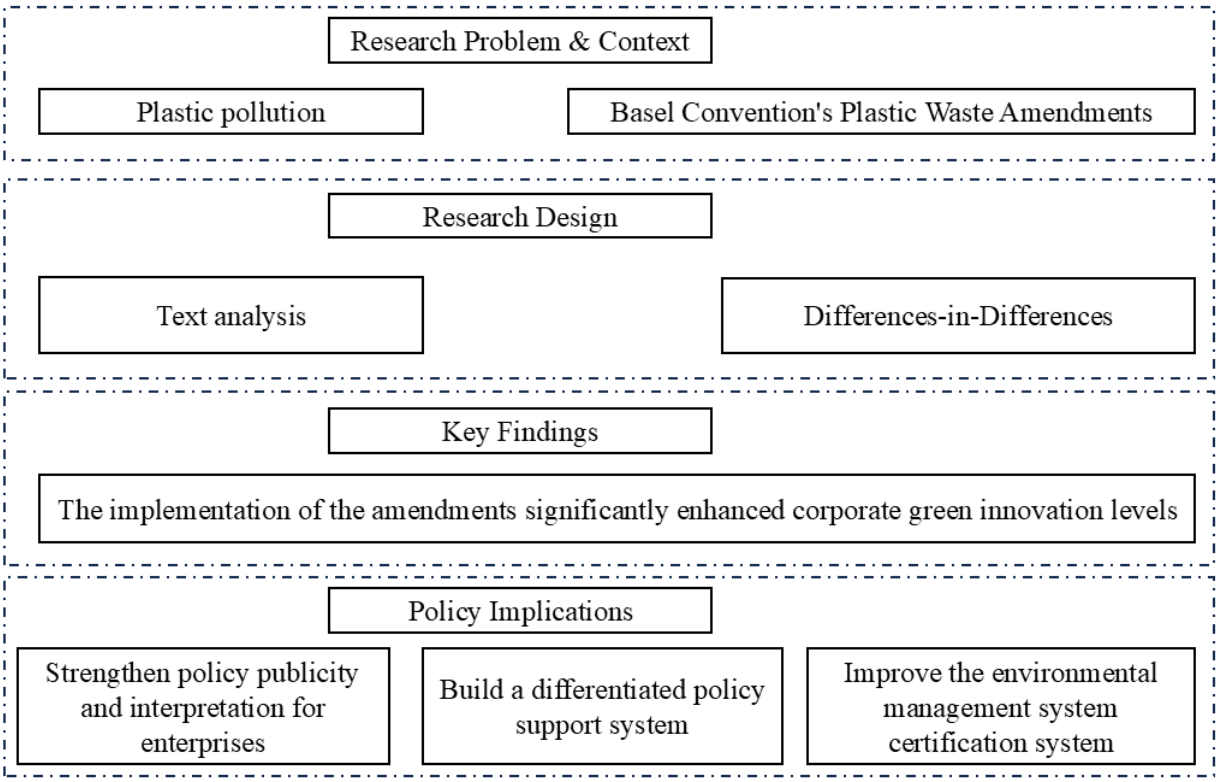
Graphical abstract



ABSTRACT

Environmental regulations aim to stimulate green innovation, yet the cognitive mechanisms through which policies influence corporate decisions remain poorly understood. This study investigates how environmental regulations transform corporate behavior through management cognition pathways using China's plastic industry as a case study. Analyzing panel data from Chinese plastic-related listed companies (2014-2024), we find that new regulatory frameworks enhanced corporate green innovation by 12.8%. This effect operates through dual cognitive channels: reshaping executives' perception of regulatory pressure while heightening awareness of technological change imperatives. Larger enterprises and those with mature environmental management systems demonstrated significantly stronger innovative responses. Our findings advance environmental planning literature by revealing the psychological dimensions through which regulations catalyze innovation and offer practical insights for policy design that accounts for enterprise heterogeneity. This research provides empirical evidence for understanding how sustainability regulations drive industry transformation through cognitive pathways.

Keywords: Environmental Management; Environmental Planning; Green Innovation; Management Perception; Plastic Pollution Management

1. Introduction

Plastic pollution has become a major challenge in global environmental governance, second only to climate change in severity (MacLeod et al., 2021). Recent research shows that uncollected waste, accounting for 68% of global plastic emissions (MacLeod, 2024), is currently the main source of global plastic pollution, a problem particularly acute in low and middle-income countries. Due to limited funding, these countries often resort to uncontrolled landfills and open burning for disposal, which not only causes plastic fragment emissions but also produces microplastic pollution and releases carbon dioxide and other harmful pollutants into the atmosphere. Studies indicate that waste management alone can no longer effectively address plastic pollution; it is necessary to restrict the production and consumption of virgin plastics derived from fossil fuels at the source (Kibria et al., 2023).

To address this global challenge, the international community is actively advancing relevant governance mechanisms. At the fifth session of the United Nations Environment Assembly resumed meeting in March 2022, a historic resolution was adopted to "End Plastic Pollution: Towards an International Legally Binding Instrument." An Intergovernmental Negotiating Committee (INC) was established to develop an international legally binding instrument on plastic pollution by the end of 2024, with the final negotiations (INC-5) scheduled to take place in Busan, South Korea, from November 25 to December 1, 2024. Meanwhile, multiple countries have formed a "High Ambition Coalition," advocating for expanding governance scope to cover the entire plastic lifecycle, including design, production, use, and disposal phases (Arora et al., 2024). In this context, the implementation of the Basel Convention's Plastic Waste Amendments represents a crucial milestone in global plastic governance, reshaping industry development patterns through restrictions on transboundary movements of plastic waste (Kang & Lee, 2021; Li et al., 2024).

Existing research has paid extensive attention to the policy effects of environmental regulations. Some scholars argue that environmental regulations can produce innovation offset effects, achieving coordinated economic and environmental development by compelling corporate technological

innovation. The Porter Hypothesis suggests that appropriate environmental regulations can stimulate corporate innovation drive, improving environmental quality while enhancing corporate competitiveness (Porter & van der Linde, 1995). However, new institutional economics emphasizes that institutional constraints raise corporate transaction costs and crowd out innovation resources, a view supported by some empirical studies (Jacobsen, 2006). In recent years, some scholars have begun to focus on the differential effects of various types of environmental regulations. Research has shown that market-oriented environmental regulations are more effective at promoting corporate environmental innovation than command-and-control regulations (Wang et al., 2019; Zhang et al., 2020).

Research on corporate green innovation has also attracted considerable scholarly attention. Existing studies mainly discuss innovation motivations, pathway selection, and performance impacts. Some scholars have found that external pressure and internal motivation are important factors driving corporate green innovation (Cao & Chen, 2019; Chen & Liang, 2023; Lei & Xu, 2025; Zhao & Lei, 2024). Other research indicates that internal characteristics such as technical capabilities, organizational inertia, and management cognition influence corporate green innovation behavior (Huang & Li, 2017; Shi & Zhang, 2018). Scholars have also discovered that corporate green innovation can improve environmental performance and enhance economic benefits, achieving win-win outcomes for economy and environment (Martinez-Zarzoso et al., 2019).

However, existing research lacks systematic understanding of the micro-level mechanisms through which environmental regulations influence corporate green innovation. Particularly in the important policy context of the Basel Convention's Plastic Waste Amendments, the question of how companies respond to environmental regulatory pressure and advance green innovation transformation requires in-depth exploration. First, existing research has paid insufficient attention to the internal mechanisms through which environmental regulations influence corporate innovation via management cognition and other pathways. Second, research on the policy effects of the Basel Convention's Plastic Waste Amendments is relatively scarce, especially lacking empirical testing of how these amendments

influence corporate green innovation through environmental regulatory pressure perception and technological change awareness.

Based on this, this research focuses on several key questions: What impact has the implementation of the Basel Convention's Plastic Waste Amendments had on corporate green innovation? Through what micro-mechanisms is this impact achieved? How do corporate characteristics moderate policy effects? Exploring these questions helps understand the innovation effects of environmental regulations and provides important implications for improving environmental policy design.

This research achieves theoretical innovation and practical value in the following aspects: First, it reveals the micro-mechanisms through which environmental regulations influence corporate green innovation from a management cognition perspective, enriching the theoretical implications of the Porter Hypothesis; Second, based on the quasi-natural experiment of the Basel Convention's Plastic Waste Amendments, it provides new empirical evidence for the innovation effects of environmental regulations; Third, it examines the moderating effects of corporate size and environmental management systems on policy outcomes, providing new theoretical perspectives for understanding the heterogeneous effects of environmental regulations.

The structure of this paper is as follows: Section 2 constructs the theoretical analysis framework and proposes research hypotheses; Section 3 introduces the research design and variable measurements; Section 4 conducts empirical analysis and discusses research findings; Section 5 carries on the in-depth discussion; Section 5 summarizes the research conclusion and puts forward the policy suggestion.

2. Theoretical Analysis and Research Hypotheses

The impact of environmental regulation policies on corporate innovation is a complex research topic. The Basel Convention's Plastic Waste Amendments fundamentally changed the global flow patterns of plastic waste by restricting transboundary movements (Yang, 2020). Current academic debate remains divided on the innovation effects of these policy constraints, mainly due to divergent theoretical perspectives. The Porter Hypothesis suggests that environmental regulations can stimulate

corporate innovation drive and achieve economic-environmental synergy, providing a theoretical foundation for regulation promoting innovation (Ambec et al., 2013). However, new institutional economics emphasizes that institutional constraints raise corporate transaction costs and thereby crowd out innovation resources, a view also supported by some empirical studies. Regarding the specific policy of the Basel Convention's Plastic Waste Amendments, how effectively it forces plastic enterprises to transform by restricting waste exports still requires rigorous empirical testing. Based on this, this research proposes:

H1: The implementation of the Basel Convention's Plastic Waste Amendments may affect corporate green innovation levels.

From a micro-mechanism perspective, cognitive psychology provides an important perspective for explaining how environmental regulations influence corporate innovation. This theory indicates that external stimuli must be processed through individual cognition to influence behavioral decisions, fundamentally explaining how policy effects can only be realized through managers' cognitive processes (Cristofaro, 2020). In the plastics industry context, the amendments changed corporate decision-making environments by raising compliance costs, and managers' perception and interpretation of this pressure directly influences their innovation decision orientation. Prospect theory further suggests that stronger pressure perception may prompt companies to adopt innovative strategies to escape disadvantageous situations, revealing possible pathways for regulatory pressure to transform into innovation drive (Galvin & Hacker, 2020). Accordingly, this research proposes:

H2: The implementation of the Basel Convention's Plastic Waste Amendments may influence corporate green innovation levels through environmental regulatory pressure perception.

Within the organizational change theoretical framework, dramatic external environmental changes often trigger organizational members to reflect on existing technological systems (Greenwood & Hinings, 2006). Organizational learning theory suggests that environmental changes can activate organizations' "non-inertial thinking," prompting them to break path dependencies (Barrett, 2017), revealing how policy shocks may bring about innovation breakthroughs by enhancing technological

change awareness. However, organizational inertia theory also points out that technological path switching faces enormous conversion costs and uncertainties, especially in the plastics industry where technological change often requires systemic transformation (Hofmann & Jaeger‐Erben, 2020). This theoretical tension prompts us to deeply explore whether the policy signals of the Basel Convention's Plastic Waste Amendments can effectively enhance corporate technological change awareness and thereby bring about substantial innovation investment. Based on this, this research proposes:

H3: The implementation of the Basel Convention's Plastic Waste Amendments may influence corporate green innovation levels through technological change awareness.

The conceptual model of this paper is shown in Figure 1. Through systematic empirical testing, this research will reveal the transmission mechanisms through which the Basel Convention's Plastic Waste Amendments influence corporate green innovation via the dual pathways of environmental regulatory pressure perception and technological change awareness, aiming to provide new theoretical insights for understanding the micro-level mechanisms of environmental regulation policies.

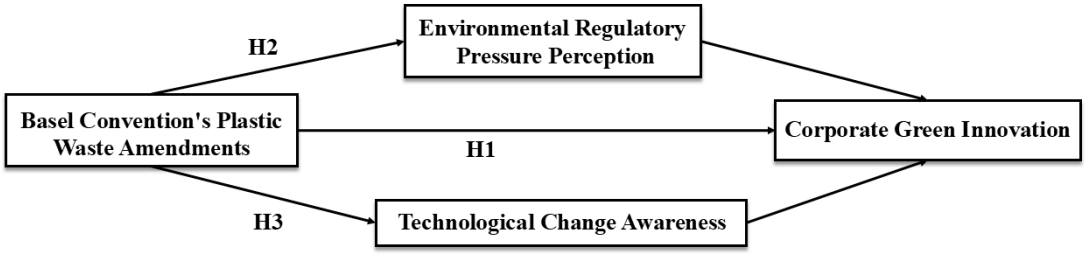


Figure 1. Research Framework

3. Research Design

3.1 Data Sources

This study selects listed companies from China's A-share market between 2014-2024 that are closely related to plastic production and usage, including plastic products manufacturing and packaging printing industries. Based on the China Securities Regulatory Commission's "Guidelines for Industry Classification of Listed Companies," the sample specifically includes: C29 Rubber and Plastic

Products, C22 Paper and Paper Products, C23 Printing and Recording Media Reproduction, C26 Chemical Raw Materials and Chemical Products Manufacturing, and other plastic-related industries. Corporate financial data is primarily sourced from the Wind database. Environmental information is extracted from the environmental information disclosure sections of listed companies' annual reports and separately published environmental responsibility reports. Patent data is obtained from the China National Intellectual Property Administration's patent search platform, which provides detailed patent application and grant information. ISO14001 environmental management system certification information is collected through corporate official websites and environmental information disclosure reports. To ensure data quality, this study applied strict sample screening criteria: excluding ST and *ST companies due to their abnormal operations potentially affecting research reliability, and eliminating samples with severe missing data. The final balanced panel dataset comprises 1,246 firm-year observations.

3.2 Variable Definitions

The dependent variable in this study is corporate green innovation level (GRIN). This paper employs patent applications as a measure of innovation output, specifically using the natural logarithm of patent applications related to plastic recycling and biodegradable materials (Jin & Lei, 2024). Patent counts serve as an appropriate proxy for innovation as they represent tangible outcomes of R&D efforts that have undergone rigorous external validation through patent office examination. Additionally, patents provide detailed technological information and are directly linked to specific environmental domains, making them particularly suitable for measuring targeted environmental innovation activities.

The independent variable is the implementation status of the Basel Convention's Plastic Waste Amendments (Basel). This is operationalized as a dummy variable, taking the value of 0 for observations before 2021 and 1 for observations from 2021 onward, reflecting the enforcement timeline of this significant international environmental policy. This measurement approach allows us

to capture the regulatory shock effect and establish a clear temporal boundary for examining policy impact, consistent with methodologies employed in prior policy evaluation studies.

For mediating mechanisms, this study establishes two distinct measures to capture organizational cognitive responses. The first mediating variable is environmental regulatory pressure perception (Pressure), which we measure using computational text analysis methods based on established research by previous research (Qian et al., 2023).. Traditional approaches to measuring regulatory pressure perception have relied heavily on questionnaire surveys, which suffer from several limitations: restricted sample coverage, response bias, and inability to reconstruct historical perceptions. The emergence of sophisticated natural language processing techniques has enabled researchers to directly quantify management cognition through systematic analysis of corporate disclosures. Following this methodological innovation, we analyze environmental protection-related content in corporate annual reports, constructing a comprehensive environmental protection keyword dictionary through a semi-supervised approach that combines expert-identified seed words with word vector expansion techniques. The environmental regulatory pressure indicator is then derived by calculating the relative frequency ratio of negative to positive sentiment-laden terms within environmental discussions, building on the sentiment analysis framework developed by previous research (Buehlmaier & Whited, 2018).. This approach allows us to capture management's subjective assessment of regulatory constraints in a longitudinal and comparable manner.

The second mediating variable is technological change awareness (TAWARE), which we operationalize by measuring the frequency of technology innovation-related terminology in corporate disclosures. Specifically, we track the occurrence of terms such as "technological change," "technical upgrade," "process improvement," "technological innovation," and "R&D advancement" in annual reports and formal announcements. This indicator reflects the degree to which enterprises consciously recognize and emphasize the importance of technological adaptation and innovation in their strategic communications. The calculation methodology references established literature on management cognition measurement (Zhang & Li, 2024), which has validated the correlation between linguistic

emphasis and actual managerial attention allocation. By constructing this measure, we aim to capture the cognitive precedent to innovation activity that may be triggered by external policy pressures.

For moderating variables that may condition the relationship between regulatory pressures and innovation responses, we incorporate two firm-level characteristics. Enterprise size (Size) is represented by the natural logarithm of total assets, a widely accepted measure that accounts for the scale advantages and resource availability that larger firms possess when responding to regulatory changes. The logarithmic transformation addresses the skewed distribution of firm sizes in our sample and facilitates interpretation of marginal effects. The second moderator, environmental management system maturity (EMSM), is measured by the natural logarithm of ISO14001 certification years. This measure captures the accumulated experience and institutionalization of environmental management practices within the organization, reflecting both the depth and duration of formalized environmental governance. Prior research has demonstrated that organizations with more mature environmental management systems tend to exhibit different response patterns to regulatory pressures due to both enhanced capabilities and established routines.

To control for other factors that might affect corporate green innovation, this study includes a series of control variables. First are corporate financial characteristic variables: asset-liability ratio (Lev) reflects corporate financial risk level, profitability (ROA) is measured by return on total assets, and cash flow condition (CFO) is represented by net operating cash flow divided by total assets. Second are corporate governance variables: institutional investor shareholding ratio (INSTHOLD) reflects external supervision intensity, board size (Board) is represented by the natural logarithm of total board members, and independent director ratio (INDDIR) measures board independence. Additionally, this study controls for enterprise nature (State, taking 1 for state-owned enterprises and 0 otherwise) and industry competition level (HHI, measured by the Herfindahl-Hirschman Index). Moreover, considering that regional economic development level may affect corporate innovation behavior, the natural logarithm of per capita GDP (PGDP) of the province where the enterprise is located is included as a control variable.

3.3 Model Specification

To examine the impact of the Basel Convention's Plastic Waste Amendments on corporate green innovation, this study constructs the following baseline regression model:

$$GRIN_{i,t} = \alpha_0 + \alpha_1 Basel_{i,t} + \beta CONTROLS_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

where subscripts i and t represent enterprise and year respectively. The dependent variable $GRIN_{i,t}$ represents the green innovation level of enterprise i in year t, and the independent variable $Basel_{i,t}$ represents the implementation status of the Basel Convention's Plastic Waste Amendments. Controls represents a series of control variables, including enterprise size, asset-liability ratio, profitability, etc. μ_i represents firm fixed effects, controlling for unobserved firm-level characteristics that do not vary with time; γ_t represents year fixed effects, controlling for annual common shocks such as macroeconomic environment; $\varepsilon_{i,t}$ is the random disturbance term.

4. Empirical Analysis

4.1 Descriptive Analysis

Table 1 reports descriptive statistics for the main variables. For the dependent variable, the mean value of corporate green innovation level (GRIN) is 0.683, with a median of 0.562 and standard deviation of 0.427, indicating that the sample enterprises' green innovation patent applications are generally low with certain variations. For mediating variables, environmental regulatory pressure perception (Pressure) has a mean of 0.224, median of 0.215, and standard deviation of 0.116, suggesting that most enterprises experience moderate to low levels of environmental regulatory pressure; technological change awareness (TAWARE) has a mean of 0.156, median of 0.142, and standard deviation of 0.089, reflecting generally low levels of technological change awareness among enterprises. Among control variables, enterprise size (Size) has a mean of 21.836 with a standard deviation of 1.324, showing relatively concentrated distribution; asset-liability ratio (Lev) has a mean of 0.427 and median of 0.416, indicating moderate financial leverage among sample enterprises; institutional investor shareholding ratio (INSTHOLD) has a mean of 0.186, suggesting moderate institutional investor participation. Additionally, board size (Board) and independent director ratio

(INDDIR) have means of 2.234 and 0.372 respectively, reflecting that sample enterprises' corporate governance structures generally comply with regulatory requirements.

Table 1. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Median	Max
GRIN	1246	0.683	0.427	0.000	0.562	2.398
Basel	1246	0.273	0.446	0.000	0.000	1.000
Pressure	1246	0.224	0.116	0.032	0.215	0.583
TAWARE	1246	0.156	0.089	0.018	0.142	0.426
Size	1246	21.836	1.324	19.245	21.763	25.127
Lev	1246	0.427	0.198	0.086	0.416	0.824
ROA	1246	0.052	0.048	-0.086	0.047	0.186
INSTHOLD	1246	0.186	0.162	0.000	0.156	0.627
Board	1246	2.234	0.186	1.792	2.197	2.708
INDDIR	1246	0.372	0.053	0.333	0.364	0.556

4.2 Baseline Model Results

Table 2 reports the estimation results of the baseline regression. As shown in column (1), the coefficient of Basel is significantly positive at the 5% level (0.131), indicating that the implementation of the Basel Convention's Plastic Waste Amendments has a certain promoting effect on corporate green innovation levels. After adding control variables, column (2) shows that Basel's coefficient remains significantly positive at the 5% level (0.128), with moderate economic significance - the implementation of the amendments increased corporate green innovation levels by an average of 12.8%. This result provides preliminary support for hypothesis H1, suggesting that environmental regulations have to some extent driven corporate green innovation investment.

Table 2. Baseline Regression Results

Variable	(1) GRIN	(2) GRIN
Basel	0.131**	0.128**
	(2.192)	(2.143)
Size		0.086**
		(2.276)
Lev		-0.324*
		(-1.865)
ROA		0.562
		(1.428)
INSTHOLD		0.246*
		(1.914)
Board		0.182
		(1.536)
INDDIR		0.226
		(1.442)
Constant	0.624***	-1.246**
	(3.686)	(-2.165)
Year FE	YES	YES
Firm FE	YES	YES
N	1246	1246
R^2	0.186	0.246

Note[1]

4.3 Robustness Tests

[1] ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively; t-statistics in parentheses.

To ensure the reliability of baseline regression results, this study employs multiple methods for robustness testing. First, considering that patent application numbers mainly reflect innovation input rather than innovation quality (GQ), we use the natural logarithm of granted invention patents related to plastic recycling and biodegradable materials as an alternative dependent variable for re-estimation. Patent grants undergo substantive examination and better reflect the technical content and market value of innovations. As shown in column (1) of Table 3, Basel's coefficient is 0.113, significant at the 10% level, consistent with baseline regression results, indicating that research conclusions remain robust when using indicators that better reflect innovation quality.

Table 3. Robustness Test Results

Variable	(1) GQ	(2) Basel	(3) GRIN	(4) GRIN
Basel	0.113*		0.162*	0.142*
	(1.886)		(1.946)	(1.892)
Distance		-0.246***		
		(-3.124)		
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
N	1246	1246	1246	986
R^2	0.234	0.256	0.264	0.242
First-stage F		15.86		

Second, considering potential endogeneity issues between policy implementation and corporate innovation, this study employs instrumental variable methods for treatment. We select the geographic distance (logarithm) to the nearest solid waste treatment center as an instrumental variable. This indicator characterizes the intensity of environmental regulatory constraints faced by enterprises from a geographic spatial distribution perspective. Theoretically, enterprises located farther from waste

treatment centers face higher waste disposal costs, which affects the actual constraint intensity of the policy, but enterprise geographic location is historically formed and does not directly affect current innovation decisions through other channels, thus satisfying the relevance and exogeneity requirements for instrumental variables. Column (2) of Table 3 reports first-stage regression results, showing the instrumental variable Distance's coefficient as -0.246, significantly negative at the 1% level, consistent with theoretical expectations, indicating that more distant enterprises face stronger policy constraints; meanwhile, the F-statistic of 15.86 significantly exceeds the critical value of 10 for weak instrumental variables, supporting the relevance of the instrumental variable. Column (3) shows that after using the instrumental variable method, Basel's estimated coefficient remains significant at 0.162 at the 10% level, indicating that research conclusions hold after controlling for endogeneity.

To further control for sample selection bias, we employ Propensity Score Matching (PSM) to match treatment and control group enterprises. We calculate propensity scores based on characteristics such as enterprise size, asset-liability ratio, industry, and region, using nearest neighbor matching to select control group samples. Column (4) of Table 3 reports regression results after matching, showing Basel's coefficient as 0.142, still significantly positive at the 10% level, with coefficient magnitude similar to baseline results, indicating that our research conclusions remain robust after controlling for selection bias.

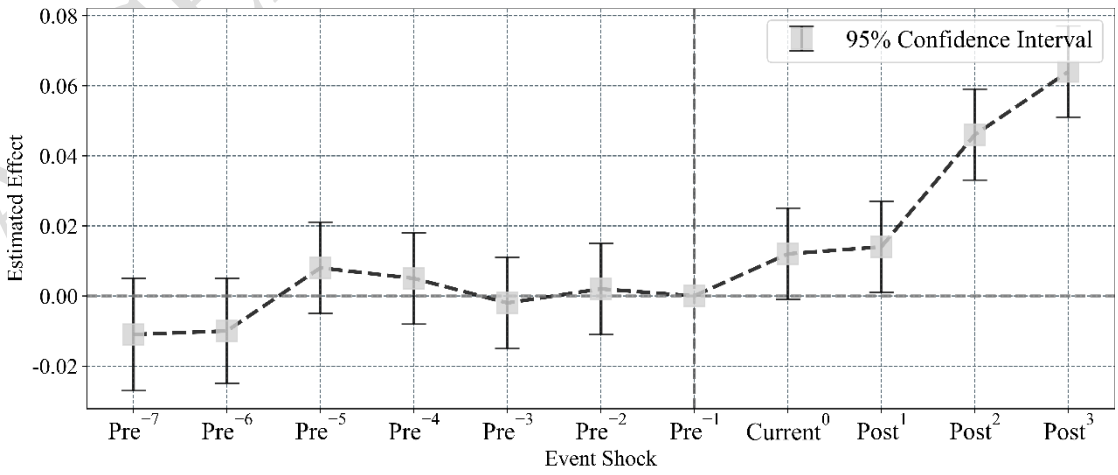


Figure 2. Parallel Trends Test

Finally, we examine the dynamic evolution of policy effects through event study methodology. As shown in Figure 2, we plot the green innovation level trends for treatment and control group enterprises before and after policy implementation. Before policy implementation, both groups exhibited similar change patterns, supporting the parallel trends assumption. After policy implementation, treatment group enterprises showed significant innovation level improvements while control groups remained relatively stable, intuitively demonstrating the policy's treatment effect.

To further verify result reliability, we conducted placebo tests through random assignment of treatment status. As shown in Figure 3, our results cannot be obtained randomly.

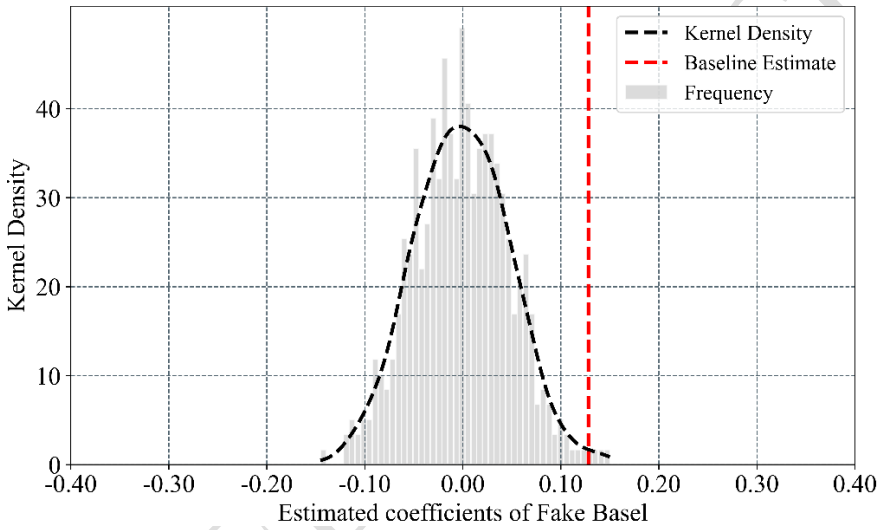


Figure 3. Placebo Test

4.4 Heterogeneity Analysis

Corporate green innovation policy responses may exhibit significant differences. This study conducts heterogeneity analysis from two dimensions: enterprise size and environmental management system maturity. First, we examine the moderating effect of enterprise size. Following existing literature's classification methods, we divide samples into large-scale and small-scale groups using the median of sample enterprise asset size as the boundary, constructing a size dummy variable (SIZE_H), where large-scale group is assigned 1 and small-scale group 0. Results in column (1) of Table 4 show that the interaction term coefficient between SIZE_H and Basel is 0.168, significantly positive at the 5% level, indicating that compared to small-scale enterprises, large-scale enterprises demonstrated stronger innovation drive after policy implementation. This finding aligns with theoretical

expectations that large enterprises possess stronger resource integration capabilities and risk-bearing capacity, also confirming the important role of economies of scale in environmental governance.

Second, we explore the influence of environmental management system maturity. Based on ISO14001 environmental management system certification status, we construct an environmental management system maturity indicator (EMSM). Specifically, enterprises with ISO14001 certification exceeding the industry median certification period are assigned 1, indicating relatively mature environmental management systems; those without certification or with shorter certification periods are assigned 0, indicating relatively immature environmental management systems. As shown in column (2) of Table 4, the interaction term coefficient between EMSM and Basel is 0.146, significantly positive at the 5% level, indicating that enterprises with more mature environmental management systems can better transform policy pressure into innovation drive. This may be because comprehensive environmental management systems provide enterprises with more systematic environmental risk identification and response mechanisms, enabling them to more quickly adjust innovation strategies to adapt to policy changes. Long-term operation of environmental management systems also helps enterprises accumulate rich environmental governance experience, forming systematic cognition and response capabilities for environmental issues. This finding emphasizes the importance of organizational capacity building in promoting environmental policy effects and provides valuable insights for enterprises on how to enhance environmental governance effectiveness. These heterogeneity analysis results indicate that policy effects largely depend on enterprises' own characteristics and capabilities, which has important implications for understanding and improving the implementation effects of environmental regulation policies.

Table 4. Heterogeneity Analysis Results

Variable	(1) GRIN	(2) GRIN
Basel	0.097	0.101*
	(1.624)	(1.697)
SIZE_H × Basel	0.168**	
	(2.286)	
EMSM × Basel		0.146**
		(2.234)
Controls	YES	YES
Year FE	YES	YES
Firm FE	YES	YES
N	1246	1246
R^2	0.256	0.262

4.5 Further Investigation

To gain a deeper understanding of the mechanisms through which the Basel Convention's Plastic Waste Amendments influence corporate green innovation, this study validates a "dual-channel" transmission pathway based on theoretical analysis. First, we examine the mediating path of environmental regulatory pressure perception. As shown in column (1) of Table 5, policy implementation significantly enhanced enterprises' environmental regulatory pressure perception, with a coefficient of 0.052, significant at the 5% level. Furthermore, column (2) of Table 5 shows that after controlling for environmental regulatory pressure perception, the direct effect of the policy variable on innovation level decreased (coefficient dropped from 0.128 to 0.113), while the pressure perception variable's coefficient was significantly positive (0.286), verifying that environmental regulatory pressure perception played a partial mediating role in how policy influences innovation.

Simultaneously, we examined the pathway of technological change awareness. Results in column (3) of Table 5 show that policy implementation significantly enhanced enterprises' technological change awareness, with a coefficient of 0.068, significant at the 5% level. After incorporating the technological change awareness variable, as shown in column (4) of Table 5, the direct effect of the policy variable weakened (coefficient decreased to 0.110), while technological change awareness had a significant positive impact on innovation level (coefficient of 0.264). This indicates that technological change awareness also constitutes an important transmission channel for policy influence on innovation. This finding reveals the micro-mechanism through which environmental regulations influence innovation behavior by changing enterprise managers' cognitive patterns and decision-making logic, providing new perspectives for understanding environmental policy's operational process. Notably, both pathways demonstrate partial mediation effects, suggesting that beyond the identified cognitive-level influences, policies may affect enterprise innovation through other channels, providing new directions for future research.

Table 5. Transmission Mechanism Tests

Variable	(1) Pressure	(2) GRIN	(3) TAWARE	(4) GRIN
Basel	0.052**	0.113*	0.068**	0.110*
	(2.268)	(1.895)	(2.186)	(1.842)
Pressure		0.286**		
		(2.324)		
TAWARE				0.264**
				(2.286)
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
N	1246	1246	1246	1246

R^2	0.236	0.268	0.242	0.274

5. Discussion

This study examines the impact of environmental regulations on corporate green innovation through the lens of the Basel Convention's Plastic Waste Amendments. Our findings support the Porter Hypothesis that appropriate environmental regulations can stimulate innovation while enhancing environmental quality. Specifically, we find that the implementation of these amendments increased corporate green innovation by 12.8%, operating through dual cognitive pathways: reshaping executives' perception of regulatory pressure and heightening awareness of technological change imperatives. This positive relationship between environmental policy and innovation aligns with previous research suggesting that environmental regulations can induce innovation offsets, achieving coordinated economic and environmental development by compelling corporate technological adaptation (Ambec et al., 2013; Porter & van der Linde, 1995). Unlike studies that found negative effects due to increased transaction costs (Jacobsen, 2006), our research identifies positive innovation outcomes in the context of international policy changes affecting global plastic waste flows.

The dual cognitive pathways we identify offer new insights into how environmental regulations translate into corporate action. The first pathway—environmental regulatory pressure perception—demonstrates how policy changes are internalized by management, creating innovation incentives rather than mere compliance burdens. This supports Cristofaro's (2020) assertion that external stimuli must be processed through individual cognition to influence behavioral decisions (Cristofaro, 2020). The second pathway—technological change awareness—reveals how policy signals reshape strategic orientation toward innovation, consistent with Barrett's (2017) organizational learning theory that environmental changes can activate "non-inertial thinking" and break path dependencies (Barrett, 2017). Our heterogeneity analysis further demonstrates that firm characteristics significantly moderate these effects. Larger enterprises exhibited stronger innovative responses, supporting the notion that resource availability provides advantages in addressing regulatory challenges (Gao et al., 2022). Similarly, firms with mature environmental management systems showed enhanced responses,

aligning with research on organizational transformation capacity and established environmental governance structures (Hofmann & Jaeger‐Erben, 2020).

Our study contributes to the growing literature examining the micro-level mechanisms through which environmental policies influence corporate innovation. While some researchers have emphasized the superiority of market-based instruments over command-and-control approaches (Wang et al., 2019; Zhang et al., 2020), our analysis shows that even command-oriented international agreements can stimulate significant innovation when they fundamentally alter market conditions and cognitive frameworks. The partial mediating effects observed in our model suggest that while cognitive factors are important, they represent only part of the complex relationship between regulation and innovation. This underscores the need for policymakers to consider multiple intervention points when designing environmental regulations, particularly in addressing challenges like plastic pollution where restrictions on production and consumption at the source are increasingly necessary (Kibria et al., 2023). Future research should continue exploring additional mediating mechanisms, examine longer-term innovation outcomes, and investigate how these effects vary across different policy contexts and industrial sectors.

6. Conclusions and Recommendations

Based on the significant environmental policy event of the Basel Convention's Plastic Waste Amendments, this study systematically examines the impact of environmental regulations on corporate green innovation and their operational mechanisms. The research finds that the implementation of the amendments significantly enhanced corporate green innovation levels, with an average increase of 12.8%, a conclusion that remains robust when using different measurement indicators and controlling for endogeneity and sample selection bias. Further research reveals a dual transmission mechanism of policy impact: on one hand, the policy promotes innovation investment by increasing enterprises' environmental regulatory pressure perception; on the other hand, policy implementation strengthens enterprises' technological change awareness, encouraging them to break through traditional technological path dependencies. Meanwhile, the research also finds significant

enterprise heterogeneity in policy effects, with large-scale enterprises and those with mature environmental management systems showing stronger innovative responses, reflecting the important role of enterprise resource endowments and organizational capabilities in environmental policy implementation.

Based on these research findings, this paper proposes the following policy recommendations: First, when formulating and implementing environmental regulation policies, governments should fully consider enterprises' subjective cognition and organizational capacity building, helping enterprises accurately understand policy intentions and enhance their environmental governance confidence through strengthened policy publicity, interpretation, and technical guidance. Second, considering differences in enterprise response capabilities, it is recommended to construct a differentiated policy support system, increasing technological transformation subsidies and financing support for small and medium-sized enterprises while encouraging large enterprises to play demonstration and leading roles in driving upstream and downstream enterprises in the industry chain to jointly improve environmental governance levels. Third, policymakers should design environmental regulations with both short-term compliance requirements and long-term innovation incentives, creating a policy environment that rewards continuous improvement rather than mere minimum compliance. Fourth, the environmental management system certification should be further integrated into regulatory frameworks, using it as an important reference basis for enterprises to enjoy relevant policy support, guiding more enterprises to establish and improve environmental management systems and form long-term environmental governance mechanisms. Finally, international coordination of plastic-related environmental regulations should be strengthened to prevent regulatory arbitrage and ensure consistent innovation incentives across global markets. Through these measures, it is hoped to achieve positive interaction between environmental regulations and enterprise innovation, promoting green transformation and sustainable development in the plastics industry.

Limitations and Future Research Directions

While this study provides important insights into the cognitive mechanisms linking environmental regulations and green innovation, several limitations should be acknowledged. First, our research focuses primarily on listed companies due to data availability constraints, potentially limiting the generalizability of findings to smaller, non-listed enterprises that may face different innovation challenges and resource constraints. Second, the relatively short post-policy implementation period (2021-2024) may not fully capture long-term innovation outcomes that require extended development cycles. Third, our measures of cognitive perceptions, while methodologically sound, cannot completely isolate the causal psychological processes within management teams. Future research could address these limitations by: employing mixed-methods approaches that combine quantitative analysis with qualitative interviews to better understand managerial cognitive processes; extending the temporal scope to examine longer-term innovation trajectories; exploring additional mediating mechanisms beyond the cognitive dimensions; examining cross-country variations in policy responses to identify contextual factors affecting innovation outcomes; and investigating the potential spillover effects to non-plastic industries within broader supply chains. Such extensions would further enrich our understanding of how environmental policies can effectively stimulate sustainable technological transitions while accounting for organizational heterogeneity.

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