Green Finance Policy and Corporate Green Innovation: Evidence from China's Green Finance Reform and Innovation Pilot Zones

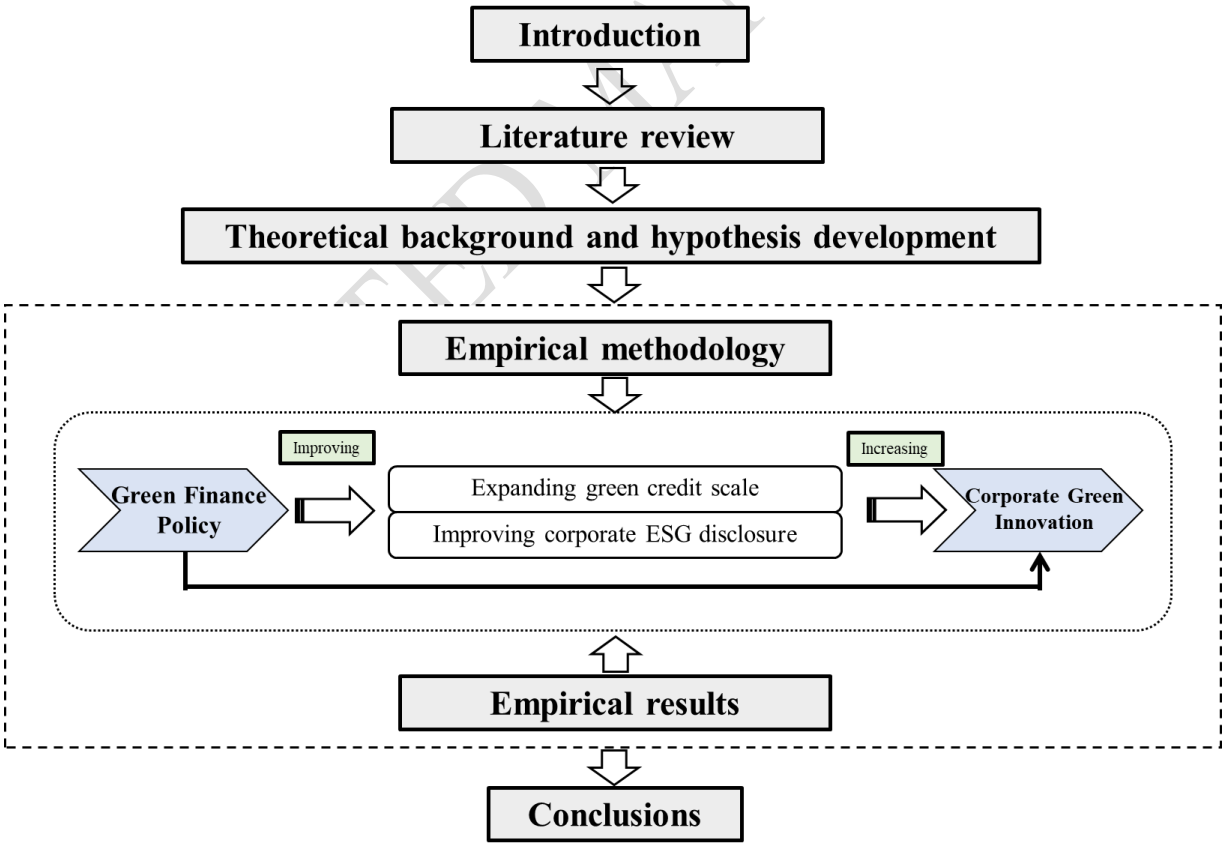
Huanyan Liu [1], Bao Feng[2*]

[1] School of Business, Beijing Information Science & Technology University, Beijing, China
[2] School of Finance, Shanghai University of Finance and Economics, Shanghai, China

* to whom all correspondence should be addressed: e-mail: fengbao@mail.shufe.edu.cn

Received: 16 July 2026

Graphical abstract:



PEER REVIEW MANUSCRIPT

Abstract:

Against the backdrop of China's continued pursuit of high-quality economic development and the accelerated implementation of its "dual carbon" goals, examining whether green finance policies can stimulate corporate green innovation is of considerable theoretical and practical significance. Using data on China's A-share listed companies from 2010 to 2022, this study empirically investigates the effects of the Green Finance Reform and Innovation Pilot Zone policy on corporate green innovation and explores the underlying mechanisms. The main findings are as follows. First, the policy significantly promotes corporate green innovation, and this result remains robust after parallel-trends tests, placebo tests, and a series of additional robustness checks. Second, the policy operates through two main channels: financial support and information governance. On the one hand, it expands the availability of green credit and alleviates the financing constraints faced by firms in undertaking green R&D and project investment. On the other hand, it improves the quality of corporate ESG disclosure, enhances market transparency, and strengthens external monitoring, thereby encouraging corporate green innovation. Third, the heterogeneity analysis shows that the positive effect is more pronounced among state-owned enterprises, larger firms, and firms operating in heavily polluting industries.

Keywords: Green finance policy; Corporate green innovation; Green credit; ESG disclosure; China

1. Introduction

Amid the sustained advancement of global economic and social development, the contradiction between environmental protection and economic growth has become increasingly prominent, and global climate change has emerged as a major non-traditional security challenge. Following the signing of the Paris Agreement, the global low-carbon transition has been accelerated, and advancing green development to achieve sustainable growth has become a shared priority of the international community. Against such a backdrop, green innovation, as the core driving force to mitigate environmental constraints and fuel low-carbon transformation, is growing in strategic importance. Aimed at alleviating environmental burdens and optimizing resource utilization, green innovation covers multi-dimensional innovations spanning technology, products, institutions and beyond. It acts as a vital bridge linking environmental goals with economic activities. Not only does it constitute a core contributor to global carbon emission reduction, but it also serves as a strategic lever for all countries to compete in the global green market.

Recent research also examines the coordination of carbon and conventional pollution reduction. Cai et al. (2026) document spatial and temporal differences in such coordination and study the role of data element marketization and environmental regulation. Their findings

ACCEPTED MANUSCRIPT

highlight the role of information and regulation in environmental governance, providing related context for evaluating the innovation outcomes of green finance.

As a major carbon emitter, China is confronted with immense pressure to cut emissions amid the global low-carbon transition, which nevertheless creates vital opportunities for the green restructuring of its economy. At the 75th Session of the United Nations General Assembly, China put forward the goal of peaking carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060, fueling the continuous improvement of its green financial system. China's green financial policies have evolved through three distinct stages. The initial stage began in 2007, when environmental factors were incorporated into credit policy frameworks. During the nationwide rollout period starting in 2012, commercial banks vigorously expanded green credit services. The sector entered a phase of rapid development in 2015, when the state issued the Overall Plan for the Reform of the Ecological Civilization System and proposed establishing a green financial system. The launch of the Green Finance Reform and Innovation Pilot Zone policy (hereafter, the GFPZ policy) in 2017 marked the substantive integration of finance and green industries. Nevertheless, the fading demographic dividend and declining returns on capital have exerted downward pressure on economic growth, compelling enterprises to shift toward an innovation-driven development model, with green innovation evolving into a core corporate philosophy. A pure market-oriented mechanism alone cannot deliver a full-scale green transition; accordingly, green financial policies are indispensable to advancing the green transformation and sustainable growth of the economy.

An extensive literature examines green finance and green innovation. Early scholars focused on the correlation between financial development and environmental quality, before extending their research to the incentive effect of green finance on green innovation. They explored how financial development and environmental regulation shape green investment, providing a basis for research on financing constraints and innovation (Li et al., 2015; Falcone, 2020). Domestic Chinese studies center on the evolution of China's green financial policies and the nexus between green finance and green innovation. Some literature verifies that green financial policies boost corporate green innovation, while other scholars argue that green finance may crowd out traditional R&D resources, giving rise to disputes over its inhibitory effect. Studies of the GFPZ policy also examine corporate innovation and regional outcomes. Further evidence on its financial and informational pathways and on differences across firms can help clarify how the policy operates.

Against the backdrop of the "Dual Carbon" goals, the GFPZ policy represents a pioneering attempt to leverage finance for green transformation, and its effectiveness can influence the coordinated advancement of ecological environmental protection and high-quality economic development. At present, corporate green innovation is generally plagued by financing constraints and high-risk aversion. By innovating financial instruments and optimizing resource allocation, the GFPZ policy provides an institutional pilot program to address the aforementioned dilemmas. By exploring the nexus between the pilot zone policies and corporate green innovation, this paper evaluates the practical enabling effects of such

ACCEPTED MANUSCRIPT

policies on enterprises' green technology R&D and the implementation of environmental protection projects, identifies areas for optimization in policy enforcement, and furnishes practical evidence for the nationwide rollout and refinement of relevant policies in China. Accordingly, this paper carries out the following core research work: First, based on panel data of China's A-share listed companies from 2010 to 2022, it empirically tests the overall impact of the GFPZ policy on corporate green innovation. Second, it dissects the underlying transmission mechanisms linking the two variables. Third, it tests whether the policy effects differ across firms by ownership, size, and industry pollution intensity.

This paper makes the following marginal contributions. First, from a theoretical perspective, it analyzes the impact mechanism of the GFPZ policy on green innovation. By comparing the gaps between pilot zones and non-pilot zones, this study adds firm-level evidence on the relationship between green finance and green innovation and informs policy formulation. Moreover, formal interaction tests clarify how the estimated effects vary across firm characteristics, complementing the analysis of potential transmission channels. Second, in practical terms, this research bears twofold practical value. For one thing, it offers guidance for corporate operations, helping enterprises comply with policy requirements under the Dual Carbon targets, boost their performance in green technological innovation, and facilitate the deep integration of economic growth and ecological civilization construction. For another, it delivers actionable policy recommendations for local governments to advance the development of the GFPZ policy, enabling green finance to progress from local experimentation toward wider implementation.

2. Literature review

2.1. Green finance and green financial policy

Green finance refers to financial activities through which the financial sector integrates socio-economic sustainable development into financial policies during investment, financing decisions and related financial operations. It directs capital toward environmental protection, energy conservation, clean energy and other sectors via financial instruments, so as to conserve and efficiently allocate resources and advance sustainable economic and social development. Encompassing specific financial products and services, policy frameworks, market mechanisms and shifts in social philosophies, green finance acts as a core driving force for global low-carbon transition and ecological civilization construction. The formation and evolution of this concept have been a gradual process. At the end of the 1990s, academia began to explore the link between environmental protection and the financial system, incorporating ecological sustainability into financial research. White (1996) put forward the concept of environmental finance. Based on this foundation, scholars proposed the definition of green finance as financial activities that channel capital to energy-saving and environmental protection sectors and advance sustainable development goals through optimized allocation of financial resources, which was later widely recognized by academic circles (Cowan, 1998; Labatt & White, 2002).

ACCEPTED MANUSCRIPT

Subsequently, researchers expanded and deepened the connotation of green finance from diverse perspectives, clarifying its core function: precisely supporting the development of energy conservation and environmental protection industries with financial tools, coordinating the allocation of economic resources with ecological protection, and simultaneously fostering the green transformation of the financial industry itself. As an essential financial service tool, green finance plays a vital role in sustainable economic growth and low-carbon transition. In response, the Chinese government launched GFPZ experiments in designated areas of five provinces. By coordinating fiscal, monetary and other policy tools, the state safeguards the steady development of green finance, guides the efficient green upgrading of industries, and injects new momentum into sustainable economic growth.

Driven by the global demand for sustainable development, China has gradually established a multi-layered system of green financial policies, whose evolutionary path and implementation effects have become a focal point of academic research. During the initial exploratory stage, policies centered on the pilot application of single financial instruments. The issuance of the Green Credit Guidelines in 2012 marked the preliminary formation of the policy framework. Criscuolo & Menon (2015) examined how environmental policies affect risk finance in green sectors, offering theoretical support for policy design in this stage.

In the top-level design stage, the proposal of a green financial system in 2015 and the release of the guiding document by seven central ministries and commissions in 2016 elevated relevant policies to a national strategy. The G20 Green Finance Study Group (2016) emphasized the vital role of top-level design in advancing the standardized and systematic development of green finance, which echoes China's policy orientation during this period. The launch and nationwide scaling-up of pilot projects constitute the core link in policy implementation. Following the launch of the first batch of the GFPZ policy in 2017, the scope of pilots has been gradually expanded. Labatt & White (2002) discuss environmental financial products and risk assessment, providing a general basis for understanding financial innovation in this setting. After 2020, relevant policies entered a refinement phase, and the central bank's framework of "Three Core Functions and Five Pillars" further optimized the green finance system. Nordhaus (2021), in *The Spirit of Green*, emphasizes the economic importance of environmental externalities, providing a broader rationale for incorporating environmental considerations into financial decisions. It also highlighted the significance of policy effectiveness evaluation, driving China's green finance to shift from fragmented local innovations to comprehensive systemic progress.

A separate strand of financial research highlights cross-market risk transmission. Zhang et al. (2026) analyze global systemic financial risk using time-varying quantile methods, showing why risk propagation and financial stability deserve attention in the institutional context of financial reform. This perspective highlights the relevance of financial stability when designing and implementing green financial reforms.

ACCEPTED MANUSCRIPT

2.2. Green innovation

As environmental problems have become increasingly prominent in recent years and the concept of sustainable development has gained widespread recognition among the public, scholars have integrated energy conservation and environmental protection into innovation theories and continuously enriched such theories. The theory of green innovation originated from the environmental movements at the end of the 20th century. Rennings (2000) developed the concept of "eco-innovation", which refers to new or improved products, processes, markets, organizations or institutions designed to mitigate environmental pressures and optimize resource utilization. The proposal of this concept overcomes the limitation of traditional innovation theories that prioritize economic growth while ignoring environmental impacts, shifts innovation research toward the coordinated development of economy and environment, and lays a core framework for the systematic advancement of green innovation theories in subsequent studies.

Serving as a bridge linking environmental goals and economic activities, green innovation encompasses both breakthroughs in tangible technological strengths and improvements in the intangible institutional environment. It can generate knowledge spillovers while delivering environmental benefits simultaneously (Aldieri et al., 2019). In terms of driving mechanisms, green innovation is driven by the "reverse forcing effect" of environmental regulations and supported by the "incentive effect" of green finance. The synergistic mechanism formed by these two factors acts as a critical lever to stimulate enterprises' vitality in green innovation. Oriented toward sustainable development, green innovation mitigates the adverse environmental impacts of economic activities through innovations in technology, products and business models. Boasting dual advantages of economic development and environmental protection, it constitutes a core pillar for achieving the Dual Carbon goals.

Green innovation supports carbon reduction through cleaner technologies and more efficient resource use. The connotation of green innovation covers green technological innovation and green institutional innovation. As a comprehensive form of innovation, it not only serves as the core pathway to accomplish the Dual Carbon goals, but also represents a strategic option for advancing high-quality development and participating in global green competition (Xu et al., 2024). From a practical perspective, green innovation has become the core track of global industrial upgrading. Developed countries have gradually built green competitive advantages by deploying cutting-edge green technologies such as new energy and carbon capture. Meanwhile, developing countries are accelerating the transformation and application of green innovation achievements through policy guidance and market cultivation (Liu & Liang, 2024a).

Supporting green innovation requires coordination among policies, market incentives, and technology diffusion. This highlights that green innovation is far more than one-dimensional technological breakthroughs; instead, it represents a systematic project requiring the linkage of multiple elements including policy, market, technology and capital. Its

ACCEPTED MANUSCRIPT

development level directly determines the progress of achieving global sustainable development goals.

2.3. The impact of green finance on green innovation

As an innovative financial model integrating environmental protection with economic benefits, green finance pursues both economic and ecological effects simultaneously. Within the GFPZ policy, green financial products and services launched by financial institutions can provide financial backing for major initiatives including local environmental governance and black and odorous water body remediation. Such support fosters economic growth, incubates emerging industries, and drives high-efficiency local economic development. The majority of existing studies confirm that green finance exerts a facilitating effect on corporate green technological innovation. Encompassing diversified instruments such as green credit and green bonds, these green financial products deliver differentiated financial support tailored to the heterogeneous innovation demands of enterprises. In particular, they resolve the initial predicaments of "difficult and costly financing" for small and medium-sized enterprises (SMEs) conducting green technology R&D, thereby amplifying the enabling effect of relevant policies on green innovation.

Li et al. (2024b) examine the roles of green finance and green technology in achieving climate objectives. Li et al. (2024a) provide evidence on regional heterogeneity in green innovation, while Huang et al. (2022) emphasize spatial and nonlinear relationships. Wang & Wang (2021) also find that green credit policies promote corporate green innovation. Using a quasi-natural experiment, Hu et al. (2021) further demonstrate that the green credit policy significantly stimulates green patent output in heavily polluting enterprises, particularly those facing stronger financing constraints. Innovation theory highlights technological innovation as the linchpin of sustainable transition, yet this process requires substantial capital investment. Given limited fiscal funds from government authorities, green projects struggle to attract capital from private investors and traditional financial sectors due to modest capital appreciation potential and substantial latent risks. Accordingly, capital shortage has become a prominent bottleneck restraining corporate green innovation. Green financial policies are designed to fill such financing gaps. They ease financing constraints faced by firms engaging in green innovation through preferential credit terms, low-cost financing and risk-sharing mechanisms. Beyond that, green finance generates a signaling effect, through which high-quality green innovators gain market recognition and draw increased social capital inflows.

Tang & Zhang (2020) examine shareholder benefits from green bond issuance, while Li et al. (2024c) study green finance policy, ESG ratings, and debt costs. These financial outcomes provide related evidence on how green finance may support corporate investment. Integrating local economic conditions and resource endowment advantages, the GFPZ policy steers the allocation of green capital via innovative policy instruments to foster green innovation. Each pilot zone explores differentiated development paths based on regional characteristics: resource-dependent regions prioritize capital provision for the green transformation of traditional industries, while ecologically sensitive zones focus on supporting

ACCEPTED MANUSCRIPT

innovative ecological restoration projects. Multiple replicable practical experiences have been accumulated, further verifying that the promotional effect of green finance on innovation is context-dependent. Nevertheless, Jiang & Yuan (2025) find that green credit expands the scale of the real economy while reducing its efficiency, highlighting the distinction between financing expansion and effective resource allocation.

Meanwhile, some scholars hold opposing views and argue that green finance may crowd out R&D resources of traditional industries and curb substantial innovation. Relatedly, a growing strand of literature cautions that policy-induced improvements in corporate environmental disclosure may partly reflect strategic information disclosure—namely, "greenwashing"—rather than substantive green innovation (Marquis et al., 2016), and overlooking such behavior could overstate innovation effects inferred from disclosure-based measures. Huang et al. (2025) report that the GFPZ policy increases greenwashing, whereas Tong et al. (2024) find that it reduces ESG greenwashing. Huang et al. (2022) cast doubts on the nexus between green finance and green technological innovation, documenting that green finance exerts a distinct nonlinear impact on green technological innovation. At the early stage of development, constrained by immature development and low resource allocation efficiency, green finance fails to fully deliver its innovation incentives and may even generate certain inhibitory effects on green technological innovation in the short run. In addition, other scholars suggest that multilateral development banks incorporate environmental performance into financing assessment criteria when providing financial support. As a result, entities with poor environmental performance receive less credit backing, and capital constraints may hinder their progress in green technological innovation (Buntaine, 2016). Such enterprises generally lack accumulated upfront funds for green transition. Tighter credit restricts their capital input for technological upgrading, creating a vicious cycle that constitutes a practical contradiction to be resolved during the implementation of green financial policies.

Green finance empowers green innovation through multiple mechanisms, whose core channels can be summarized into three dimensions: resource allocation, cost mitigation, and incentive guidance (Liu et al., 2025). In terms of resource allocation, green finance leverages diversified instruments including green credit and green bonds to channel social capital away from high-pollution and high-energy-consumption sectors toward green technology R&D and environmental project construction in a well-organized manner. It provides steady and long-term financial support for green innovation activities and effectively addresses the widespread capital shortage dilemma faced by green innovation projects (Wang et al., 2023a; Wang et al., 2023b; Yuan et al., 2024). From the perspective of cost mitigation, institutional designs such as differentiated pricing strategies and risk-sharing mechanisms under green finance substantially cut financing costs and R&D risks of green innovation projects. Such measures alleviate firms' financing constraints and fully stimulate their enthusiasm to engage in green innovation (Wang et al., 2023b; Liu et al., 2025). As for incentive guidance, green financial policies convey clear policy orientations and market signals to strengthen firms' awareness of environmental responsibility, which in turn forces enterprises to voluntarily scale up green R&D investment. Meanwhile, green finance facilitates industry-university-research

ACCEPTED MANUSCRIPT

collaborative innovation, accelerates the commercialization and application of green technological achievements, and bridges the gap between theoretical R&D and practical industrial deployment of green innovation (Li et al., 2024a; Liu et al., 2025).

2.4. Summary

Existing studies have conducted comprehensive explorations of green finance and green innovation. Scholars have clarified that green finance originates from early research on environmental finance and has gradually formed a mature conceptual connotation. Specifically, green finance guides capital flows toward environmental protection, energy conservation, and other green sectors through financial instruments, thereby facilitating the coordinated development of economic growth and ecological sustainability. The evolution of the green financial policy system relies on top-level institutional design and regional pilot practice, and relevant theoretical findings have laid solid foundations for policy formulation. In parallel, green innovation is derived from the concept of eco-innovation and encompasses multi-dimensional progress in technological upgrading and institutional optimization. With dual economic and environmental benefits, green innovation serves as a critical driver for achieving the dual-carbon goals and advancing global green transition, and has become a core competition track for global industrial upgrading. Regarding the nexus between green finance and green innovation, most studies confirm that green finance effectively alleviates corporate financing constraints and reduces R&D costs through resource allocation optimization and cost mitigation mechanisms, thereby promoting green innovation performance. Nevertheless, several studies raise contradictory arguments, suggesting that green finance may crowd out traditional R&D resources or inhibit corporate green innovation due to tightened credit screening and capital rationing.

Against this backdrop, this paper provides two contributions to the existing literature. First, this study systematically analyzes the influence mechanism of the GFPZ policy on green innovation. By comparing the differences in green innovation performance between pilot zones and non-pilot zones, this paper adds evidence on the relationship between green finance and green innovation, informing future policy formulation. Second, this paper examines differences across ownership, size, and industry pollution groups using formal interaction tests, enriching the evidence on heterogeneous responses to green finance policies.

3. Theoretical background and hypothesis development

3.1. The impact of green finance policy on corporate green innovation

Compared with conventional technological innovation, green technological innovation is characterized by large-scale R&D investment, long return cycles, and high operational risks, which can create financing frictions and underinvestment. Such inherent drawbacks drive enterprises to pursue sustained and stable financial support, while green financial policies provide essential capital guarantees for corporate green innovation by broadening external financing channels. The establishment of the GFPZ policy constructs a comprehensive and

ACCEPTED MANUSCRIPT

multi-dimensional support framework for green innovation. In terms of optimizing market-oriented financing mechanisms, the pilot zones improve the market financing system through diversified measures, including attracting domestic and foreign green capital investment, encouraging financial institutions to expand green business layouts, optimizing risk prevention and control systems, developing green insurance products, and facilitating corporate green bond issuance (Bhutta et al., 2022; Yan et al., 2022; Hong, 2025). In terms of local government policy support, the GFPZ policy forms a multi-level policy support network by integrating preferential fiscal and tax policies, land supply guarantees, and talent introduction incentives, which effectively alleviates the financing constraints restricting the development of green technological innovation.

Beyond providing capital guarantees for corporate green innovation through market-oriented mechanisms and policy incentives, green financial policies can also foster a favorable institutional environment for green technological innovation from the perspective of industrial regulation by guiding financial institutions to optimize credit structures. By integrating environmental governance principles into credit policies and formulating stringent environmental lending standards, financial institutions constrain the unregulated expansion of high-energy-consuming and high-emission enterprises. This practice not only mitigates environmental degradation and promotes the low-carbon transformation of industrial sectors but also forces traditional enterprises to upgrade their technological paradigms, thereby generating endogenous demand for green technological innovation. Furthermore, the establishment of the GFPZ policy further strengthens such policy effects. By concentrating green financial resources, accelerating the circulation of green capital, and developing regionally tailored green financial instruments in line with local economic endowments, the GFPZ policy can mitigate firms' external financing frictions and provide strong support for corporate green innovation. Accordingly, this study proposes the following research hypothesis:

Hypothesis H1: The establishment of the GFPZ policy significantly promotes corporate green technological innovation.

3.2. The mechanism of green finance policy in influencing corporate green innovation

3.2.1 Green finance policy, green credit scale, and corporate green innovation

Guided by the dual-carbon goals, the GFPZ policy stands as a core practical initiative for the construction of China's green financial system. By guiding financial resources to prioritize green sectors, this policy provides crucial support for corporate green innovation. Corporate green innovation is characterized by large capital input, long investment cycles, and high operational risks, with financing constraints acting as the core bottleneck restricting its development. As the core instrument of green finance, green credit serves as a vital linkage connecting macro green financial policies and micro corporate innovative behaviors (Liu et al., 2024b). Empowered by targeted policy incentives, the GFPZ policy optimizes regional

ACCEPTED MANUSCRIPT

green credit allocation from the supply side and effectively expands the scale of local green credit supply. The GFPZ policy introduces a series of incentive measures such as green loan interest subsidies and risk compensation mechanisms, which reduce the risk exposure of financial institutions in issuing green loans and strengthen their willingness to expand green credit businesses. Furthermore, by clarifying green-oriented credit guidelines and improving corporate environmental information disclosure systems, the pilot policies redirect financial resources from high-pollution and high-energy-consumption industries toward green innovation projects, thereby directly expanding the overall scale of green credit supply (Huang & Zhang, 2021).

The expansion of green credit scale can effectively ease the capital constraints of corporate green innovation and stimulate firms' innovation motivation. Sufficient green credit funds provide stable financial support for enterprises' green technology research and development, environmental protection equipment upgrading, green product development, and other green practices, helping firms bear the R&D costs and operational risks throughout the innovation process. Existing studies have verified that green credit can significantly improve corporate green technological innovation by boosting firms' R&D investment (Hu et al., 2021; Mi et al., 2024). The improvement of environmental information disclosure systems effectively mitigates information asymmetry between financial institutions and enterprises, thereby enhancing the allocation efficiency of green credit (Zhang et al., 2025). Meanwhile, policy incentive measures further eliminate financial institutions' risk concerns regarding green credit issuance and promote the aggregation of credit resources toward green industries (Xu et al., 2023).

In summary, the GFPZ policy facilitates the expansion of regional green credit scale through policy guidance and incentive arrangements. The increased green credit supply alleviates capital constraints on corporate green innovation, provides robust financial backing for firms' green R&D activities, and ultimately improves corporate green innovation performance. Accordingly, this study proposes the following mediating hypothesis:

Hypothesis H2: The GFPZ policy enhances corporate green technological innovation by expanding the scale of green credit.

3.2.2 Green finance policy, ESG disclosure, and corporate green innovation

Guided by the dual-carbon goals, the GFPZ policy represents a pioneering exploration in the construction of China's green financial system. By establishing differentiated service systems and refining incentive and restraint mechanisms for environmental governance, the policy delivers vital support for the green transformation of enterprises. Corporate green innovation lies at the heart of low-carbon transition, and its advancement hinges on guaranteed information transparency. As a core medium for conveying firms' environmental, social and governance performance, ESG disclosure acts as a critical bridge linking green financial policies and corporate green innovation (Xue et al., 2023).

ACCEPTED MANUSCRIPT

The GFPZ policy motivates enterprises to strengthen their ESG information disclosure through multiple channels. Regulations introduced in the pilot zones standardize disclosure criteria and require financial institutions to incorporate corporate ESG performance into credit pricing and investment decisions, thereby forming a transmission mechanism of "disclosure quality – financing cost-development potential" that pushes enterprises to optimize their ESG disclosure practices. Sun et al. (2023) find that the pilot policy significantly improves corporate ESG performance, and standardized information disclosure stands out as a key channel that effectively cuts firms' institutional disclosure costs and mitigates information asymmetry. Meanwhile, the GFPZ policy can strengthen external supervision to curb ESG greenwashing. Tong et al. (2024) find that the reduction in ESG greenwashing is more pronounced among non-state-owned and heavily polluting firms. However, Huang et al. (2025) report increased greenwashing, indicating that the effectiveness of the information channel depends on credible disclosure and monitoring.

Improved corporate ESG information disclosure provides comprehensive support for green innovation. High-quality ESG disclosure alleviates financing constraints, enables enterprises to acquire low-cost capital such as green credit, and guarantees sustained investment in innovative R&D. Meanwhile, it conveys corporate green development concepts to attract green investors and cooperative partners, and facilitates the incorporation of green innovation into long-term corporate strategies by optimizing internal governance. Tong et al. (2024) highlight the role of monitoring in curbing ESG greenwashing, supporting the importance of credible information in the policy transmission process. Furthermore, ESG disclosure reduces information asymmetry, lowers the risks and uncertainties of innovation projects, and stimulates corporate innovation initiatives (Wang & Wang, 2025). Based on the above theoretical analysis and existing research findings, this study proposes the following hypothesis:

Hypothesis H3: The GFPZ policy promotes corporate green innovation by improving corporate ESG information disclosure.

4. Method and data

4.1. Data

This study uses panel data on Chinese A-share listed firms from 2010 to 2022. The data are primarily obtained from the Wind and CSMAR databases, the China Statistical Yearbook, the China Environment Yearbook, and listed firms' annual reports. Information on the GFPZ policy is compiled from relevant policy documents published on the official websites of provincial and municipal governments, while green patent data are obtained from the CNRDS Green Patent Research Database.

Referring to the research of Liew & Cao (2025), this paper screens the sample following the criteria below: (1) exclude listed firms receiving special treatment (ST, *ST and PT); (2) eliminate financial listed companies; (3) remove samples with severe missing values of key

ACCEPTED MANUSCRIPT

variables. After data matching and screening, a total of 15673 valid observations are finally obtained.

4.2. Variable selection

(1) Dependent variable: Corporate green innovation (*GreenInno*)

Drawing on Li et al. (2024a), this study measures corporate green innovation (*GreenInno*) as the natural logarithm of one plus the number of green invention patent applications filed by a firm in a given year. As a robustness check, the natural logarithm of one plus the annual total number of green patent grants (*GreenInno1*) is used as an alternative measure.

(2) Explanatory variable: the GFPZ policy shock (*DID*)

The GFPZ policy, established in 2017, represents a key policy initiative by the Chinese central government to promote the development of green finance. The pilot program initially covered five provinces—Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang—selected to reflect regional diversity and different levels of economic development. Within these provinces, the policy was implemented in selected prefecture-level cities or new districts, which constitute the treatment group in the empirical analysis. The pilot zones aim to promote green industrial development through financial innovation and institutional reforms. The policy introduced a set of mandatory and incentive-based measures in pilot regions, forming the core policy shock examined in this study.

(3) Mediating variables: Green credit scale (*GloanAmount*) and ESG disclosure (*ESG*).

Following the approach proposed by Li et al. (2022), the total amount of green credit is winsorized by quantiles to mitigate the bias of extreme values. The indicator of green credit scale is further constructed by taking the natural logarithm of one plus the processed green credit amount. Hexun ESG Rating is a comprehensive evaluation system covering corporate environmental, social and governance performance released by Hexun network. It highlights the completeness and transparency of corporate ESG information disclosure throughout the assessment. Given its adequate measurement of disclosure performance, this study adopts Hexun ESG Rating as the proxy variable for the level of corporate ESG information disclosure.

(4) Control Variables

Referring to Chu et al. (2021) and Xie et al. (2024), this study incorporates firm-level and city-level control variables. The control variables cover firm size (*Size*), asset-liability ratio (*Lev*), return on total assets (*ROA*), firm age (*FirmAge*), firm growth (*Growth*), cash flow ratio (*Cashflow*), board size (*Board*), and ownership nature (*Soe*). Detailed definitions of main variables are presented in Table 1.

ACCEPTED MANUSCRIPT

Table 1. Definition of main variables

Variable type	Variable name	Symbol	Declaration
Dependent Variable	Corporate green innovation	*GreenInno*	Natural logarithm of (1 + green invention patents)
Explanatory Variable	Green finance policy shock	*DID*	The GFPZ policy shock
Mediating Variables	Green credit scale	*GloanAmount*	The total green credit amount is winsorized, then the natural logarithm of one plus the processed value is taken
	ESG disclosure	*ESG*	Hexun ESG rating index
Control Variables	Firm size	*Size*	Natural logarithm of annual total assets
	Asset-liability ratio	*Lev*	Total year-end liabilities / Total year-end assets
	Return on total assets	*ROA*	Net profit / Average total assets balance
	Firm age	*FirmAge*	Current year − the firm's founding year
	Firm growth	*Growth*	Current year operating revenue / Last year operating revenue − 1
	Cash flow ratio	*Cashflow*	(Cash and cash equivalents + Marketable securities) / Current liabilities
	Board size	*Board*	Number of board directors
	Ownership nature	*Soe*	1 for state-controlled enterprises, otherwise 0

4.3. Model selection

Since 2017, China has established the GFPZ policy and issued a series of supporting policies within these zones, marking the substantive advancement of integration between the financial sector and green industries. This paper takes the launch of the GFPZ policy in 2017 as the research policy shock. Based on panel data spanning 2010 to 2022, the difference-in-differences (*DID*) method is adopted for empirical analysis. The econometric model is specified as follows:

$$GreenInno_{i,t} = \alpha_0 + \alpha_1 DID_{i,t} + \alpha_2 Controls_{i,c,t} + \eta_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

Where $GreenInno_{i,t}$ is the explained variable, representing corporate green innovation level; $DID_{i,t}$ is the core explanatory variable, satisfying $DID_{i,t}=treatment_i \times post_t$. $treatment_i=1$ if the prefecture-level city (autonomous prefecture, prefecture, league) where the firm locates is designated as a Green Finance Reform and Innovation Pilot Zone during the sample period, otherwise $treatment_i=0$; $post_t=1$ when $t \geq 2017$, otherwise $post_t=0$ Subscripts i, c and t denote firm individual, prefecture-level city (autonomous prefecture, prefecture, league) and year respectively; $Controls_{i,c,t}$ stands for control variables; η_i and γ_t represent firm fixed effects and year fixed effects separately; $\varepsilon_{i,t}$ is the random disturbance term, and α_0, α_1, α_2 are regression coefficients of variables. The estimated coefficient α_1 of the DID interaction term captures the policy effect. If the policy exerts a positive effect, α_1 will be significantly positive.

ACCEPTED MANUSCRIPT

Furthermore, this paper adopts a two-step approach to construct the following mediating effect model to explore the specific mechanism, as shown in Equation (2):

$$M_{i,t} = \beta_0 + \beta_1 DID_{i,t} + \beta_2 Controls_{i,c,t} + \mu_i + \gamma_t + \sigma_{i,t} \quad (2)$$

Where $M_{i,t}$ denotes two mediating variables: the scale of green credit and the level of corporate ESG information disclosure; $\sigma_{i,t}$ is *the* random disturbance term; β_0, β_1, *and* β_2 are parameters to be estimated.

5. Empirical Results

5.1. Descriptive Statistics

Table 2 presents the descriptive statistics of the main variables. The mean value of corporate green innovation (*GreenInno*) is 0.4176, the median is 0.2483, and the standard deviation is 0.5562. The minimum is zero and the maximum reaches 5.9723, indicating substantial variation in green patenting activity across the sample firms. The mean exceeding the median also suggests that relatively active innovators contribute to the upper part of the distribution. These differences may reflect firms' technological capabilities, resource endowments, and industry characteristics, which motivate the subsequent analysis of policy effects and firm heterogeneity.

The core explanatory variable *DID* has a mean of 0.1547, indicating that 15.47% of the firm-year observations correspond to treated firms in the post-policy period. Its standard deviation is 0.3616, with values ranging from zero to one. Table 2 also presents descriptive statistics for the mediating variables, green credit scale (*GLoanAmount*) and ESG performance (*ESG*), alongside control variables such as firm size (*Size*) and the asset-liability ratio (*Lev*). These statistics reveal variation in firms' financial and ESG characteristics, providing a basis for the subsequent empirical analysis.

Table 2. Descriptive Statistics

Variable	Obs	Mean	SD	Min	Median	Max
GreenInno	15673	0.4176	0.5562	0.0000	0.2483	5.9723
DID	15673	0.1547	0.3616	0.0000	0.0000	1.0000
GLoanAmount	15673	1.6771	0.6028	0.4238	1.8495	3.3003
ESG	12430	25.0931	16.3160	-14.1800	22.0800	90.8700
Size	15673	22.4278	1.3867	19.7421	22.2082	26.7621
Lev	15673	0.4289	0.2031	0.0313	0.4260	0.9347
ROA	15673	0.0406	0.0594	-0.4143	0.0389	0.2459
FirmAge	15673	10.2588	7.6821	0.0000	9.0000	29.0000
Growth	15673	1.9451	1.2005	0.7920	1.5589	10.4961
Cashflow	15673	0.1979	0.1392	0.0121	0.1588	0.7866
Board	15673	8.5726	1.6835	5.0000	9.0000	15.0000
Soe	15673	0.3781	0.4849	0.0000	0.0000	1.0000

ACCEPTED MANUSCRIPT

5.2. Parallel trends test

To examine the parallel-trends assumption of the difference-in-differences model, this paper estimates the dynamic effects of the GFPZ policy using an event-study specification. Figure 1 presents the results for 2010-2022, corresponding to event times -7 to +5. The policy was implemented in 2017 (t=0), and 2016 (t=-1) is the omitted reference year. The model includes the eight controls and firm and industry-by-year fixed effects, with standard errors clustered at the firm level. Table A1 in Appendix reports the detailed annual estimates and sample sizes.

As shown in Figure 1, the pre-policy coefficients fluctuate around zero and are individually insignificant. Their joint test gives F(6,1886)=1.329 and p=0.2408, supporting the parallel-trends assumption. Following policy implementation, the estimated coefficients are positive: the 2017 and 2018 estimates are significant at 10%, and those for 2019-2021 are significant at 5%. The 2022 estimate remains positive but is not significant. Overall, these findings support the parallel-trends assumption underlying the DID analysis and indicate improved corporate green innovation following policy implementation, with the clearest evidence in the middle of the post-policy period.

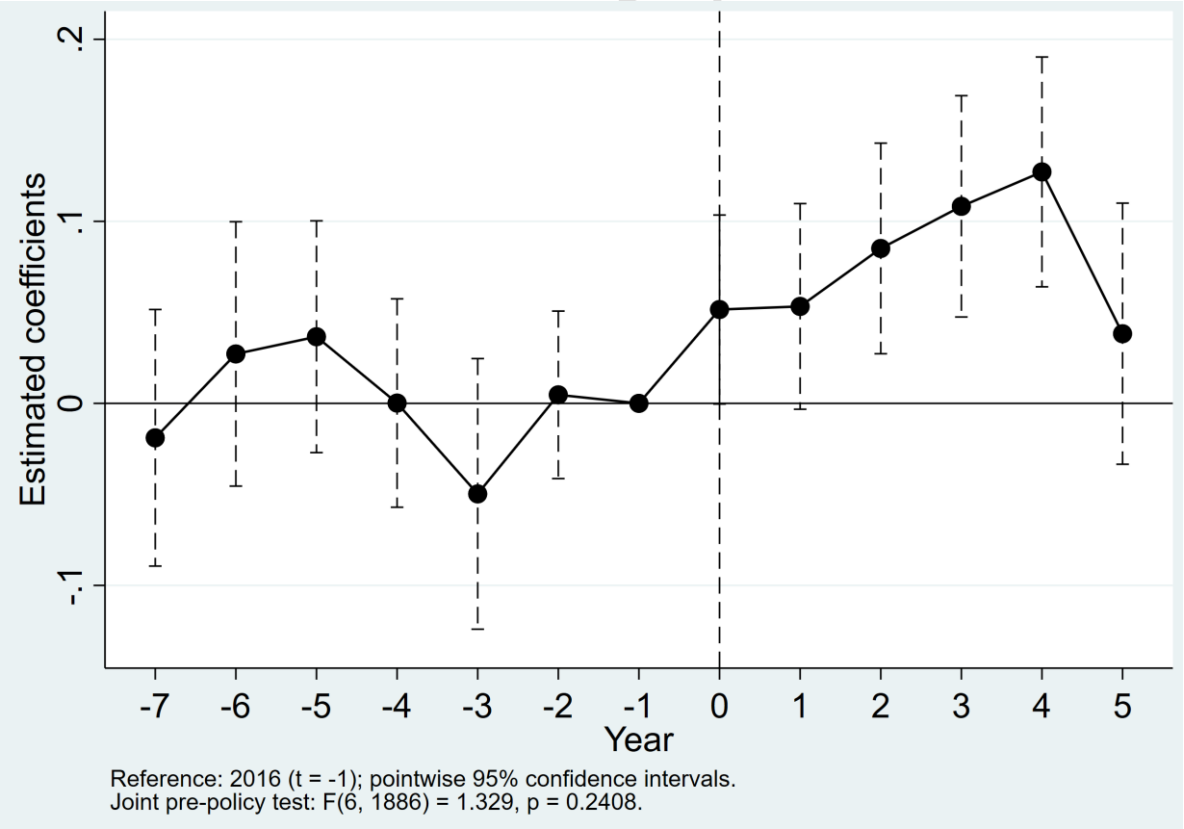


Figure 1. Parallel trend test

Notes: The omitted reference year is 2016 (t=-1); 2017 is the policy year (t=0). Error bars show 95% confidence intervals.

5.3. Baseline regression

The regression results of Equation (1) are reported in Table 3. Column (1) includes firm and year fixed effects without the additional firm-level controls. The coefficient of the core explanatory variable *DID* is 0.0580 and is statistically significant at the 1% level. This indicates that firms covered by the GFPZ policy experience a greater increase in green innovation after implementation relative to firms in the comparison group, providing preliminary evidence of a positive policy effect.

After incorporating the eight firm-level controls in column (2), the *DID* coefficient increases to 0.0650 and remains significant at the 1% level. Thus, accounting for differences in firm size, financial conditions, governance, and other observed characteristics does not alter the positive relationship. On the basis of column (2), column (3) uses firm-clustered standard errors to account for possible error correlation within firms over time. The coefficient remains 0.0650, with a standard error of 0.0249, and is still significant at the 1% level. The result therefore persists when inference allows for within-firm dependence.

Across the three specifications, the estimated policy coefficient is consistently positive. Together with the parallel-trends evidence, these results support Hypothesis H1 that the GFPZ policy promotes corporate green innovation.

Table 3. Baseline regression results

Variable	(1) *GreenInno*	(2) *GreenInno*	(3) *GreenInno*
DID	0.0580***	0.0650***	0.0650***
	(0.0159)	(0.0159)	(0.0249)
Size		0.0324***	0.0324
		(0.0089)	(0.0228)
Lev		-0.2204***	-0.2204***
		(0.0375)	(0.0777)
ROA		-0.4116***	-0.4116***
		(0.0743)	(0.1076)
FirmAge		0.1026	0.1026
		(0.0703)	(0.0724)
Growth		0.0208***	0.0208**
		(0.0041)	(0.0090)
Cashflow		0.2608***	0.2608***
		(0.0366)	(0.0685)
Board		-0.0043	-0.0043
		(0.0037)	(0.0059)
Soe		0.0699***	0.0699**
		(0.0233)	(0.0316)
_cons	0.4086***	-1.3414*	-1.3414
	(0.0039)	(0.7437)	(0.8479)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
R^2	0.6053	0.6093	0.6093
N	15673	15673	15673

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. The same notation applies to all subsequent tables.

ACCEPTED MANUSCRIPT

5.4. Placebo Test

To further examine whether the baseline relationship could arise from arbitrary treatment assignments, this paper conducts a placebo test with 1,000 random assignments, as illustrated in Figure 2. In each repetition, 40 of the 203 prefecture-level units are selected without replacement, preserving the number of treated units. All firms within a selected unit receive the same fictitious treatment, while the policy year remains 2017. The sample of 15673 observations, the eight controls, firm and year fixed effects, and the firm-clustered specification are held constant. Re-estimating the model under these assignments produces a distribution against which the actual policy coefficient can be compared.Table A2 in Appendix reports the full set of placebo coefficient quantiles and the additional simulation results.

The placebo coefficients are distributed around zero, with a median of 0.0055 and 2.5th and 97.5th percentiles of -0.0801 and 0.0732, respectively. The actual coefficient is 0.065026, consistent with the rounded baseline estimate in Table 3, and lies in the upper tail of this distribution. Fifty of the 1,000 placebo coefficients exceed the actual estimate, giving an empirical right-tail probability of 0.0500, or 0.05095 with the add-one correction. Thus, similarly large positive estimates occur relatively infrequently under the fictitious assignments, providing additional support for the baseline finding.

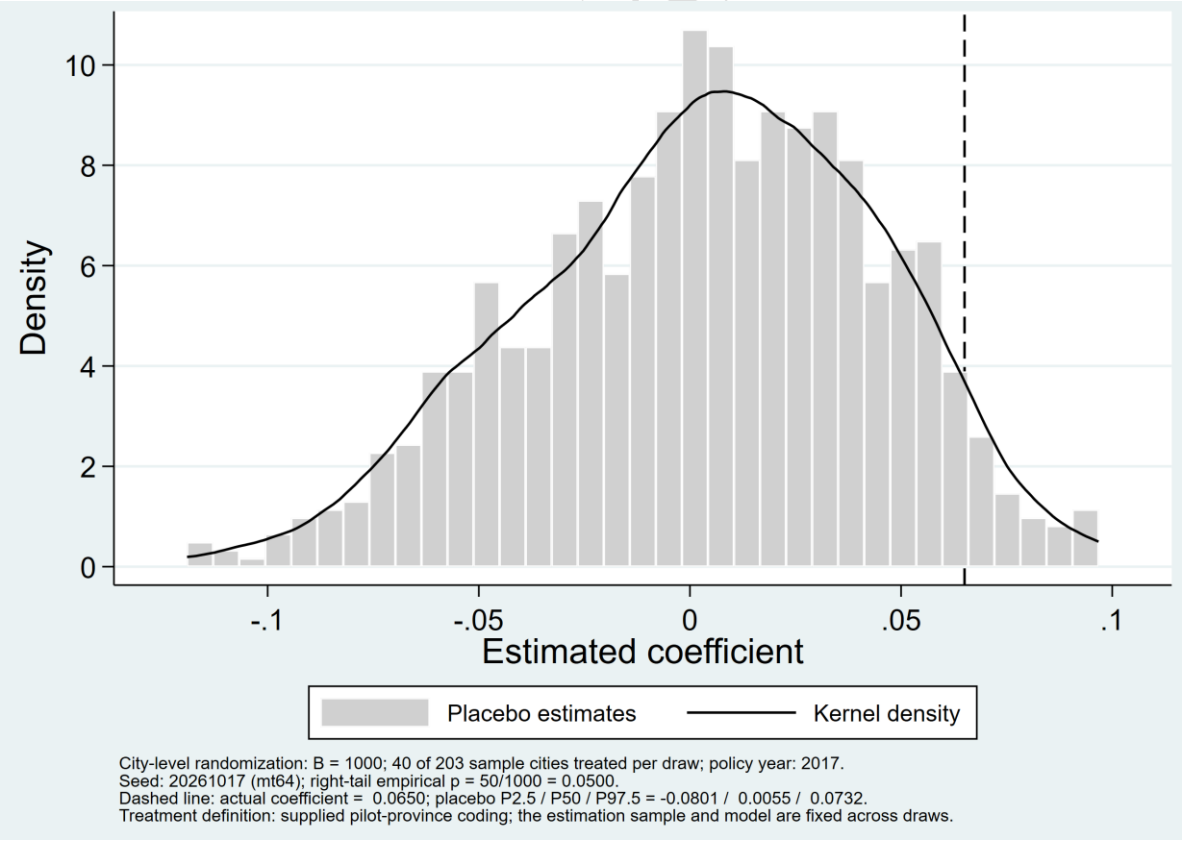


Figure 2. Placebo test

Notes: B=1,000 valid reassignments, with 40 of 203 prefecture-level units selected without replacement in each repetition. The dashed line marks the actual coefficient, 0.0650.

5.5. Robustness test

(1) Alternative measure of the dependent variable

To assess whether the baseline conclusion depends on the measurement of green innovation, this paper replaces *GreenInno* with *GreenInno1* in column (1) of Table 4. *GreenInno1* is defined as the natural logarithm of one plus the annual total number of green patents granted to the listed firm, including both green invention patents and green utility model patents. The data are obtained from CNRDS and assigned to the year of authorization. This measure captures granted innovative output and therefore complements the application-based indicator used in the baseline regression.

The *DID* coefficient is 0.0598, with a firm-clustered standard error of 0.0261, and is statistically significant at the 5% level. The positive effect is therefore maintained when green innovation is measured by total patent grants. Since applications and grants reflect different stages of the patenting process, the consistency of their coefficient signs provides evidence that the main conclusion is not confined to application activity alone.

(2) PPML count-model check

The baseline dependent variable is a logarithmic transformation of patent applications, whose underlying counts include many zeros. To examine the result under a specification suited to nonnegative outcomes, column (2) of Table 4 estimates a Poisson pseudo-maximum-likelihood (PPML) model using the raw number of green invention patent applications (Santos Silva & Tenreyro, 2006). The model includes firm and year fixed effects and the same set of controls, with firm-clustered sandwich standard errors. The effective sample contains 7905 observations from 900 firms, including 4876 zero-count observations. Firms with all-zero outcomes do not contribute to the fixed-effect PPML estimation, so its effective sample differs from that of the baseline regression.

The *DID* coefficient is 0.4153, with a standard error of 0.1688, and is statistically significant at the 5% level. Although the coefficient magnitude is not directly comparable with the log-transformed OLS estimates, its positive sign provides complementary evidence that the policy relationship is maintained when the outcome is modeled as a patent count. The result therefore supports the baseline conclusion under a different functional form.

(3) Lagging the control variables

Adopting one-period lagged control variables can mitigate potential bidirectional causality between the explained variable and control variables to some extent, alleviate endogeneity concerns in the model, and enhance the robustness of estimation results. Accordingly, this paper incorporates lagged one-period control variables into the regression model, with results reported in Column (3) of Table 4. The coefficient of the core explanatory variable *DID* is 0.0687 and statistically significant at the 5% level, which is basically consistent with the baseline regression outcome. In conclusion, lagging control variables by one period does not alter the primary findings of this paper, further verifying the robustness of baseline regression results.

ACCEPTED MANUSCRIPT

(4) Accounting for the COVID-19 shock

The COVID-19 pandemic exerted widespread impacts on corporate operation and innovation activities, which may trigger systematic bias in the correlations among research variables and distort the accuracy of empirical results. The sample period of this paper spans from 2010 to 2022, while the full-scale outbreak of COVID-19 started in 2020. To eliminate disturbances induced by the pandemic shock, we exclude observations from 2020 onwards for robustness testing, with regression results presented in Column (4) of Table 4. The coefficient of the core explanatory variable *DID* is 0.0495 and significant at the 5% level, consistent with the baseline regression. In short, the main conclusions remain valid after dropping pandemic-period samples, further verifying the strong robustness of baseline estimates.

Table 4. Robustness test results

Variable	(1) Alternative measure of the dependent variable	(2) PPML count-model check	(3) Lag controls	(4) Accounting for the COVID-19 Shock
	GreenInno1	*GreenInno*	*GreenInno*	*GreenInno*
DID	0.0598**	0.4153**	0.0687**	0.0495**
	(0.0261)	(0.1688)	(0.0278)	(0.0212)
_cons	-2.3623***	-33.7913***	-2.0689***	0.3590
	(0.4539)	(5.8869)	(0.8020)	(0.6021)
Controls	Yes	Yes	No	Yes
Lag Controls	No	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	0.7259	--	0.6489	0.6395
N	15673	7905	12889	10752

Notes: Columns (1), (3), and (4) use OLS with firm-clustered standard errors. Column (2) uses raw green invention application counts in PPML, with firm-clustered sandwich standard errors. OLS R-squared is not reported for PPML. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.6. Mechanism Analysis

5.6.1 Green credit scale channel

Based on the foregoing theoretical analysis, this paper further examines the green credit channel through which the GFPZ policy may promote corporate green innovation. Following Jiang (2022), the mechanism analysis uses Equation (2) to relate the policy indicator to green credit scale. In column (1) of Table 5, the *DID* coefficient is 0.0479 and is statistically significant at the 1% level, indicating that the GFPZ policy is positively associated with green credit supply.

A plausible explanation is that the GFPZ policy improves the institutional arrangements for green finance, strengthens financial institutions' incentives to support green activities, and facilitates the identification of eligible projects. These changes can direct more credit toward green technology R&D and environmental investment. Compared with conventional investment, green innovation often requires substantial initial expenditure and involves long development cycles and uncertain returns. Greater availability of green credit can help firms

ACCEPTED MANUSCRIPT

sustain such expenditure, accommodate the time needed for technological development, and reduce the pressure to abandon projects when internal funds are insufficient. Expanded green credit may consequently strengthen firms' willingness and capacity to engage in green innovation. The positive credit response is consistent with Hypothesis H2 and the financial-support mechanism.

5.6.2 ESG disclosure channel

This paper also examines the information-governance pathway through which the GFPZ policy may influence corporate green innovation. Column (2) of Table 5 reports the regression of the Hexun ESG score on the policy indicator using Equation (2). The *DID* coefficient is 1.5059 and is statistically significant at the 1% level, indicating an improvement in firms' ESG-related performance and information environment. The Hexun score is a composite proxy, so the result concerns the broader ESG information channel.

A plausible explanation is that the GFPZ policy strengthens the role of ESG information in project screening, credit allocation, and monitoring, encouraging firms to improve the transparency and completeness of their disclosure. On the one hand, more accessible and comparable ESG information helps financiers assess green projects' environmental benefits and commercial prospects, reducing information asymmetry and project-assessment costs. This can strengthen financiers' confidence and improve access to funding for green innovation. Such financing is particularly important for green R&D projects that require substantial initial investment and involve long development cycles and uncertain returns. On the other hand, greater transparency makes firms' environmental commitments and investment decisions more observable, strengthening external monitoring and encouraging substantive innovation activities. To maintain credibility and continued access to green financing, firms have stronger incentives to sustain green R&D and technological upgrading. The positive ESG response is therefore consistent with Hypothesis H3 and the proposed information-governance mechanism.

Table 5. Mechanism test

Variable	(1) Green credit scale channel	(2) ESG disclosure channel
	GLoanAmount	*ESG*
DID	0.0479***	1.5059***
	(0.0146)	(0.4012)
_cons	-3.2545***	-89.3321***
	(0.5117)	(7.5594)
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
R^2	0.8286	0.6175
N	15673	12430

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

ACCEPTED MANUSCRIPT

5.7. Heterogeneity Analysis

5.7.1 Ownership heterogeneity

Corporate ownership may influence firms' access to financial resources and their ability to respond to policy incentives. To formally examine ownership heterogeneity, this paper adds the interaction term *DID* × *Soe* to the baseline model. This term is constructed by multiplying the policy indicator *DID* by *Soe*, which equals one for state-owned firms and zero for non-state-owned firms. The coefficient on *DID* therefore captures the policy effect for non-state-owned firms, while the sum of the coefficients on *DID* and *DID* × *Soe* captures the effect for state-owned firms. The interaction coefficient directly measures the between-group difference. Columns (1) and (2) of Table 6 report an estimated effect of 0.1349 for state-owned firms, significant at the 1% level, and 0.0407 for non-state-owned firms, which is statistically insignificant. The interaction coefficient is 0.0942, with a Wald test yielding $F(1,1886)=4.3067$ and $p=0.0381$, indicating a significantly stronger policy effect among state-owned firms at the 5% level.

One possible explanation is that state-owned enterprises have more established relationships with financial institutions and greater capacity to coordinate green investment with policy objectives. Their organizational resources may also help them prepare eligible projects, meet green financing requirements, and maintain investment over lengthy development cycles. These conditions can make it easier to translate policy support into green patenting activity. Non-state-owned enterprises may face greater difficulty obtaining suitable finance or supplying the information required for project assessment, which can limit their ability to respond. The ownership comparison thus suggests that the effectiveness of green financial support depends partly on firms' capacity to obtain and deploy the resources made available by the policy.

5.7.2 Firm size heterogeneity

Firm size may influence resource endowments, project implementation capacity, and access to external finance. This paper classifies firms using the mean of their annual *Size* values over 2010–2022, where *Size* is the natural logarithm of total assets. Firms at or above the median of these firm-level means, 22.0181, are classified as large, and the remainder as small, yielding 944 large firms and 943 small firms. To test size heterogeneity, the interaction term *DID* × *Large* is added to the baseline model, where *Large* equals one for large firms and zero for small firms. The coefficient on *DID* captures the policy effect for small firms, while the sum of the *DID* and interaction coefficients gives the effect for large firms. Columns (3) and (4) of Table 6 report an estimated effect of 0.1752 for large firms, significant at the 1% level, and -0.0535 for small firms, which is statistically insignificant. The interaction coefficient is 0.2287, with a Wald test yielding $F(1,1886)=32.1441$ and $p<0.0001$, indicating a significantly stronger policy effect among large firms at the 1% level.

A plausible interpretation is that large enterprises possess more financial resources, specialized personnel, and experience in project management, enabling them to undertake the substantial initial investment required for green innovation. More developed governance and

ACCEPTED MANUSCRIPT

reporting arrangements may also help them satisfy lenders' assessment requirements and obtain green financial support. Smaller firms can face narrower financing channels and greater difficulty spreading the costs of technological development across multiple projects, which may constrain their response to the policy. The group indicator remains fixed throughout the sample, while annual continuous *Size* remains a control. Under this classification, the results show a clearer innovation response among large firms; the statistically insignificant small-firm estimate does not establish an adverse policy effect for that group.

5.7.3 Industrial pollution intensity heterogeneity

Industries differ in environmental regulatory pressures, technological conditions, and the investment required for green transformation. Following Pan et al. (2019) and the listed-company industry classification framework (China Securities Regulatory Commission, 2012), this paper classifies firms into heavily polluting and other industries using their annual industry codes. The complete names and codes of the 15 heavily polluting industries are reported in Table A3 in Appendix. To examine industry heterogeneity, the baseline model is augmented with an industry-group indicator (*Heavy*) and the interaction term *DID* × *Heavy*, where *Heavy* equals one for firms in heavily polluting industries and zero otherwise. The coefficient on *DID* captures the policy effect for firms in other industries, while the sum of the *DID* and interaction coefficients gives the effect for heavily polluting firms. The interaction coefficient directly measures the between-group difference. Columns (5) and (6) of Table 6 report an estimated effect of 0.1336 for heavily polluting firms, significant at the 1% level, and 0.0465 for firms in other industries, which is statistically insignificant. The interaction coefficient is 0.0871, with a Wald test yielding F(1,1886)=3.2541 and p=0.0714, indicating a significantly stronger policy effect among heavily polluting firms at the 10% level.

The stronger estimated response among heavily polluting firms may reflect their greater need for technological upgrading under environmental regulation. Replacing pollution-intensive processes and developing cleaner technologies can require substantial financing, making green financial support particularly relevant to these firms' investment decisions. The GFPZ policy may help connect their upgrading needs with financial resources and encourage innovation that supports compliance and longer-term transformation. Firms in other industries can also benefit, but their technological adjustment needs and reliance on policy-supported finance may differ. Since the interaction provides weaker evidence than the ownership and size comparisons, the industry result is interpreted as a qualified indication of heterogeneity rather than an equally strong pattern across all three dimensions.

Table 6. Heterogeneity analysis

Variable	(1) SOEs	(2) non-SOEs	(3) Large-scale	(4) Small-scale	(5) Heavily polluting	(6) Non-heavily polluting
DID	0.1349***	0.0407	0.1752***	-0.0535	0.1336***	0.0465
	(0.0424)	(0.0282)	(0.0318)	(0.0326)	(0.0448)	(0.0283)
Controls	Yes	Yes	Yes	Yes	Yes	Yes

ACCEPTED MANUSCRIPT

Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Difference p	0.0381		<0.0001		0.0714	
R^2	0.6096		0.6113		0.6096	
N	15673		15673		15673	

Notes: Each adjacent pair of columns reports group-specific effects from one pooled interaction model. R-squared, N, and the difference-test p-value are shared within each pair. The difference p-value comes from the Wald F test of the DID-by-group interaction. ***, **, and * denote two-sided significance at 1%, 5%, and 10%, respectively.

6. Conclusions and policy implications

6.1. Conclusions

Against the critical backdrop of advancing high-quality economic development and accelerating the implementation of the "Dual Carbon" goals in China, exploring how green financial policies can effectively stimulate corporate green innovation constitutes an important research topic with both theoretical value and practical implications. Based on panel data of Chinese A-share listed firms spanning 2010 to 2022, this paper systematically examines the impact and underlying mechanisms of the GFPZ policy on corporate green innovation, aiming to provide empirical evidence for green finance to empower corporate green innovation. The major findings are summarized as follows:

First, the GFPZ policy significantly promotes corporate green innovation. The positive relationship remains after accounting for firm characteristics and within-firm error correlation. The parallel-trends test supports the identifying assumption, while the placebo exercise provides additional evidence for the baseline finding. The conclusion is also maintained when innovation is measured using green patent grants, when raw patent counts are estimated using PPML, when control variables are lagged, and when the pandemic years are excluded. Together, these results support the role of green finance reform in encouraging corporate green technological development.

Second, the mechanism analysis suggests two complementary pathways: financial support and information governance. The policy is positively associated with green credit supply and firms' Hexun ESG scores. Expanded green credit can help firms sustain investment in green R&D and projects, while an improved ESG information environment can support project assessment, market transparency, and external monitoring. These findings are consistent with the proposed mechanisms and suggest that financial resources and information conditions jointly matter for firms' capacity to undertake green innovation.

Third, the policy effect varies across firms with different ownership, size, and industry characteristics. The interaction models indicate a more pronounced effect on corporate green innovation among state-owned enterprises, larger firms, and firms in heavily polluting industries. These findings suggest that institutional relationships, resource capacity, and technological upgrading needs shape firms' responses to green financial support and should be considered when designing policies for different groups of enterprises.

ACCEPTED MANUSCRIPT

6.2. Policy implications

Based on the research conclusions of this paper, the following targeted policy recommendations are put forward:

First, continuously advance the construction of the GFPZ policy and scale up green financial policy support. The findings suggest that the GFPZ policy can significantly boost corporate green innovation. Governments should further optimize institutional arrangements and policy implementation mechanisms within the GFPZ policy, improve a diversified green financial product system including green credit, green bonds and green funds, and expand the coverage of green finance to provide sustained policy support. In addition, stronger coordination among local governments, financial regulators and financial institutions should be established to improve the allocation efficiency of green financial resources, so as to improve the guiding and supporting effects of green finance on corporate green innovation.

Second, smooth financing channels for green innovation and improve information disclosure and supervision. The channel results are consistent with financial-support and information-governance pathways. Financial institutions ought to increase credit supply for green innovation projects, streamline the identification and approval procedures of green projects, and lower financing barriers for corporate green technology R&D and green investment. Meanwhile, authorities should standardize corporate ESG information disclosure rules to improve disclosure uniformity and transparency, tighten external supervision, and strengthen the capital market's capacity to identify and reward corporate green innovation activities. In this way, a dual-driving system integrating capital support and information governance can be formed.

Third, differentiated green financial services should accommodate firms' varying capacities and investment needs. The interaction results indicate stronger policy responses among state-owned enterprises, larger firms, and firms in heavily polluting industries. Accordingly, policymakers should improve access to green finance and project-assessment services for non-state-owned and smaller firms, while providing tailored financial support for technological upgrading and cleaner production in heavily polluting industries. Financial support should consider project viability and environmental benefits alongside firms' ownership, size, and industry characteristics, helping green financial resources reach projects with substantive innovation potential.

Conflict of Interest

The authors declare no conflicts of interest.

References

Aldieri, L., Carlucci, F., Vinci, C. P., & Yigitcanlar, T. (2019). Environmental innovation, knowledge spillovers and policy implications: A systematic review of the economic effects literature. *Journal of Cleaner Production*, *239*, 118051.

ACCEPTED MANUSCRIPT

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, *175*, 121378.

Buntaine, M. T. (2016). *Giving aid effectively: The politics of environmental performance and selectivity at multilateral development banks*. Oxford University Press.

Cai, Z., Ding, X., Yang, X., Chu, X., Jiang, X., & Jiang, P. (2026). Spatiotemporal evolution and driving mechanism of synergistic carbon and pollution reduction. *iScience*, 29(3), 115084.

China Securities Regulatory Commission. (2012). *Guidelines for the industry classification of listed companies (2012 revision)*.

Chu, Z., Cheng, M., & Yu, N. N. (2021). A smart city is a less polluted city. *Technological Forecasting and Social Change*, *172*, 121037.

Cowan, E. (1998). *Topical issues in environmental finance* (No. sp199801t2). Economy and Environment Program for Southeast Asia (EEPSEA).

Criscuolo, C., & Menon, C. (2015). Environmental policies and risk finance in the green sector: Cross-country evidence. *Energy Policy*, *83*, 38-56.

Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. *International Journal of Green Economics*, *14*(2), 159-173.

G20 Green Finance Study Group. (2016). G20 green finance synthesis report. *G20 Green Finance Study Group: Sanya, China.*

Hong, Z. (2025). Risks and prevention methods in green finance. *SHS Web of Conferences*, *218*, 03018.

Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, *98*, 105134.

Huang, H., & Zhang, J. (2021). Research on the environmental effect of green finance policy based on the analysis of pilot zones for green finance reform and innovations. *Sustainability*, *13*(7), 3754.

Huang, X., Li, R., & Chen, X. (2025). Does the green finance policy motivate firms to greenwash? A quasi-natural experiment based on the" Green finance reform innovation pilot zones". *The Quarterly Review of Economics and Finance*, *101*, 101980.

Huang, Y., Chen, C., Lei, L., & Zhang, Y. (2022). Impacts of green finance on green innovation: A spatial and nonlinear perspective. *Journal of Cleaner Production*, *365*, 132548.

Jiang, S., & Yuan, X. (2025). Does green credit promote real economic development? Dual empirical evidence of scale and efficiency. *PloS one*, *20*(8), e0326961.

Jiang, T. (2022). Mediating effects and moderating effects in causal inference. *China Industrial Economics*, (5), 100-120.

Labatt, S., & White, R. R. (2002). *Environmental finance: a guide to environmental risk assessment and financial products.* John Wiley & Sons.

Li, L., Ma, X., Ma, S., & Gao, F. (2024a). Role of green finance in regional

ACCEPTED MANUSCRIPT

heterogeneous green innovation: Evidence from China. *Humanities and Social Sciences Communications*, *11*, 1011.

Li, S., Zhang, J., & Ma, Y. (2015). Financial development, environmental quality and economic growth. *Sustainability*, *7*(7), 9395-9416.

Li, T., Yue, X. G., Qin, M., & Norena-Chavez, D. (2024b). Towards Paris Climate Agreement goals: The essential role of green finance and green technology. *Energy Economics*, *129*, 107273.

Li, W., Cui, G., & Zheng, M. (2022). Does green credit policy affect corporate debt financing? Evidence from China. *Environmental Science and Pollution Research*, *29*(4), 5162-5171.

Li, W., Hu, H., & Hong, Z. (2024c). Green finance policy, ESG rating, and cost of debt——Evidence from China. *International Review of Financial Analysis*, *92*, 103051.

Liew, M., & Cao, J. (2025). Accounting for carbon emissions through green supply chain management: A systematic literature review. *Business Strategy and the Environment*, *34*(7), 8281-8304.

Liu, G., & Liang, K. (2024a). The role of technological innovation in enhancing resource sustainability to achieve green recovery. *Resources Policy*, *89*, 104659.

Liu, M., Yaacob, M. H., Ma, Q., & Ding, S. (2025). Green Finance and Corporate Green Innovation: A Systematic Literature Review. *SAGE Open*, *15*(3), 21582440251370800.

Liu, W., Zhang, J., Ji, M., & Luo, Y. (2024b). Investigating the link between green finance, environmental orientation, and carbon neutrality: A panel study of the metal extraction sector. *Resources Policy*, *89*, 104550.

Marquis, C., Toffel, M. W., & Zhou, Y. (2016). Scrutiny, norms, and selective disclosure: A global study of greenwashing. *Organization science*, *27*(2), 483-504.

Mi, K., Cui, Z., Zhu, X., & Zhuang, R. (2024). Can green credit improve the innovation of enterprise green technology: Evidence from 271 cities in China. *Systems*, 12(2), 63.

Nordhaus, W. D. (2021). *The spirit of green: The economics of collisions and contagions in a crowded world. Princeton University Press.*

Pan, A., Liu, X., Qiu, J., & Shen, Y. (2019). Can green mergers and acquisitions under media pressure promote substantive transformation of heavily polluting enterprises? *China Industrial Economics*, (2), 174–192.

Rennings, K. (2000). Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological economics*, *32*(2), 319-332.

Santos Silva, J. M. C., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and Statistics*, 88(4), 641-658.

Sun, X., Zhou, C., & Gan, Z. (2023). Green finance policy and ESG performance: Evidence from Chinese manufacturing firms. *Sustainability*, *15*(8), 6781.

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds?. *Journal of Corporate Finance*, *61*, 101427.

Tong, Y., Lau, Y. W., & Binti Ngalim, S. M. (2024). Do pilot zones for green finance

ACCEPTED MANUSCRIPT

reform and innovation avoid ESG greenwashing? Evidence from China. *Heliyon*, *10*(13), e33710.

Wang, D., & Wang, T. (2025). Does ESG information disclosure improve green innovation in manufacturing enterprises?. *Sustainability*, *17*(6), 2413.

Wang, H., Du, D., Tang, X., & Tsui, S. (2023a). Green finance pilot reform and corporate green innovation. *Frontiers in Environmental Science*, *11*, 1273564.

Wang, X., & Wang, Y. (2021). Research on the green innovation promoted by green credit policies. *Management World*, 37(6), 173–188.

Wang, Y., Liu, J., Yang, X., Shi, M., & Ran, R. (2023b). The mechanism of green finance's impact on enterprises' sustainable green innovation. *Green Finance*, *5*(3), 452-478.

White, M. A. (1996). Environmental finance: Value and risk in an age of ecology. *Business Strategy and the Environment*, *5*(3), 198-206.

Xie, C., Ye, L., Zhong, N., & Wan, W. (2024). Impact of digital finance on corporate green innovation: Exploring role of land resource misallocation in China. *Resources Policy*, *91*, 104920.

Xu, P., Ye, P., Jahanger, A., Huang, S., & Zhao, F. (2023). Can green credit policy reduce corporate carbon emission intensity: Evidence from China's listed firms. *Corporate Social Responsibility and Environmental Management*, *30*(5), 2623-2638.

Xu, Q., Xie, Y., & Ying, H. (2024). Exploring the green patent system in China from the perspective of achieving the dual carbon goal: development, challenges and prospective enhancements. *Humanities and Social Sciences Communications*, *11*(1), 1738.

Xue, Q., Wang, H., & Bai, C. (2023). Local green finance policies and corporate ESG performance. *International Review of Finance*, *23*(4), 721-749.

Yan, C., Mao, Z., & Ho, K. C. (2022). Effect of green financial reform and innovation pilot zones on corporate investment efficiency. *Energy Economics*, *113*, 106185.

Yuan, X., Shang, L., & Xu, J. (2024). Green financial policy, resource allocation and corporate environmental responsibility. *Sustainability*, *16*(15), 6273.

Zhang, L., Ding, X., & Zhang, Z. (2026). Cross-market risk transmission and marginal contribution differentiation in global systemic financial risk: A study based on the TVP-QVAR model. *Emerging Markets Finance and Trade*, 62(14), 5511-5531.

Zhang, X., Xie, X., Xiao, J., & Wang, Y. (2025). Green credit and enterprises' carbon emission intensity: empirical data from Chinese microenterprises. *Scientific Reports*, *15*(1), 13338.

ACCEPTED MANUSCRIPT

Appendix. Supplementary definitions and diagnostics

Table A1. Event-study estimates and annual sample support

Year	t	Estimate (SE)	Pointwise 95% CI	p	N	Treated N
2010	-7	-0.0189 (0.0359)	[-0.0894, 0.0516]	0.5985	793	235
2011	-6	0.0272 (0.0370)	[-0.0455, 0.0998]	0.4633	916	278
2012	-5	0.0366 (0.0325)	[-0.0271, 0.1003]	0.2595	969	294
2013	-4	0.0002 (0.0292)	[-0.0571, 0.0574]	0.9956	962	286
2014	-3	-0.0497 (0.0379)	[-0.1241, 0.0246]	0.1895	959	292
2015	-2	0.0047 (0.0235)	[-0.0413, 0.0507]	0.8417	1080	334
2016	-1	0 (reference)	Not estimated	Not tested	1126	351
2017	0	0.0515 (0.0265)	[-0.0004, 0.1035]	0.0516	1236	402
2018	1	0.0533 (0.0288)	[-0.0032, 0.1098]	0.0646	1337	360
2019	2	0.0851 (0.0295)	[0.0273, 0.1430]	0.0040	1424	396
2020	3	0.1082 (0.0310)	[0.0474, 0.1690]	0.0005	1488	382
2021	4	0.1272 (0.0322)	[0.0640, 0.1903]	<0.0001	1665	433
2022	5	0.0383 (0.0366)	[-0.0335, 0.1100]	0.2955	1683	451

Table A2. Placebo coefficient quantiles

Percentile	Placebo coefficient
1.0	-0.095289
2.5	-0.080114
5.0	-0.067921
25.0	-0.024782
50.0	0.005476
75.0	0.032742
95.0	0.064883
97.5	0.073178
99.0	0.086544

ACCEPTED MANUSCRIPT

952 **Table A3.** Complete heavily polluting industry list

Code	Industry
B06	Mining and washing of coal
B07	Extraction of petroleum and natural gas
B08	Mining and processing of ferrous metal ores
B09	Mining and processing of non-ferrous metal ores
C17	Manufacture of textiles
C19	Manufacture of leather, fur, feather products and footwear
C22	Manufacture of paper and paper products
C25	Processing of petroleum, coking and nuclear fuel
C26	Manufacture of raw chemical materials and chemical products
C28	Manufacture of chemical fibers
C29	Manufacture of rubber and plastic products
C30	Manufacture of non-metallic mineral products
C31	Smelting and rolling of ferrous metals
C32	Smelting and rolling of non-ferrous metals
D44	Production and supply of electricity and heat

953

ACCEPTED MANUSCRIPT