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Can Green Finance Policies Slow Greenhouse Gas Emissions? Evidence from China's Manufacturing Sector

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Abstract

Reducing greenhouse gas emissions is not only an inevitable requirement for the construction of ecological civilization, but also a key step to enhance high-quality development. Based on the current research situation, this paper uses the DID (Difference- Difference) method to test and explore the influence mechanism of Green Finance Reform and Innovation Pilot zone (GFRI) policy on greenhouse gas emissions (GHG) of Chinese manufacturing enterprises in a multi-dimensional way, and further analyzes the industry and spatial variability of the influence of green finance policy, and puts forward corresponding policy recommendations based on the empirical results.

Keywords: *Greenhouse Gases, Green Finance Innovation and Reform Pilot zone (GFRI), Manufacturing, Green Finance Policy, SA Index, ESG.*

Introduction

Global climate change has become one of the most serious challenges facing society today, and GHG are a major factor contributing to global climate change. As the world's largest developing country and one of the highest emitters of greenhouse gases, China has an important responsibility in mitigating climate change. In recent years, the Chinese government has been actively promoting the development of green finance through a series of policy instruments to facilitate the green transformation of economic structure, especially in the manufacturing industry, which is a major carbon emitter and plays a key role. In this context, it is of great theoretical and practical significance to study the effects of green finance policies on GHG emissions, especially in the manufacturing sector (Mansoor et al., 2024).

In addition, green financial policies provide important support for the green transformation of the economy by guiding the flow of funds to environmental protection industries and low-carbon technological innovation. However, existing research lacks a systematic empirical analysis of the effects of green financial policies, especially their actual impact on corporate carbon emissions. In this paper, we take the Chinese manufacturing industry as the research object and explore whether green financial policies can effectively mitigate GHG emissions. This study not only provides policy recommendations for China to achieve the "dual carbon" goal (i.e., peak carbon and carbon neutrality), but also provides lessons for other developing countries in the design of policies in the green transition.

Literature Review

GFRI Policy and "Dual-Carbon Goals".

The GFRI Policy, as an important practice to promote green finance development in China, supports environmental protection projects and low-carbon technologies through financial innovation in order to promote the green transformation of the regional economy. Studies have shown that these policies can significantly improve the financing efficiency of green projects (Gu et al., 2021) and play a positive role in promoting carbon emission reduction (Han et al., 2022). In addition, green financial policies are closely related to the "dual-carbon" goal, and through financial instruments such as green credit and green bonds, they can effectively promote the economic transition to low-carbon direction (Sartzetakis 2021). Further research shows that the pilot zone policy has a significant guiding role in realizing the dual-carbon goal,

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especially in resource-intensive industries (Hu et al., 2023).

Relationship Between Manufacturing and Carbon Emissions

As an important pillar industry of China's economy, manufacturing industry is also a major source of carbon emissions. Studies have shown that the high energy consumption characteristics of the manufacturing industry make it one of the major contributors to carbon emissions, especially in high-emission industries such as iron and steel and chemicals (Yan & Fang, 2015). Although the energy efficiency of China's manufacturing industry has been improved in recent years, the total carbon emissions are still at a high level, making it difficult to achieve substantial emission reductions (Xu & Lin., 2017). There are also significant differences in the carbon emission characteristics of different manufacturing sub-sectors, with high-technology manufacturing industries having greater low-carbon potential than traditional manufacturing industries (Fu et al., 2021). In addition, the carbon emission problem in the manufacturing industry chain should not be ignored, and the cooperation and technological innovation between upstream and downstream enterprises is the key to reduce the overall carbon emission (Wang et al., 2021). The green transformation of the manufacturing industry not only relies on technological progress, but also requires guidance and support at the policy level (Mathiyazhagan, 2019).

Relationship Between GFRI Policies and Corporate Carbon Emissions

The impact of green financial policies on corporate carbon emissions has attracted much attention. Research shows that green financial policies can reduce carbon emissions by reducing financing costs and prompting enterprises to invest in low-carbon technologies (Guo et al., 2022). The inhibitory effect of green credit policies on corporate carbon emissions is particularly significant in high-emission industries (Qin & Cao, 2022). By raising funds through green bonds, firms are better able to implement environmental protection projects and thus achieve emission reduction targets (Tuhkanen & Vulturius., 2022). In addition, the effective implementation of green financial policies can guide enterprises to reduce emissions on their own through the market mechanism and promote the low-carbon development of the whole industry (Zhang et al., 2022)

In summary, existing studies are limited to macro-level analysis and lack in-depth exploration of specific industries, especially in the manufacturing sector. In addition, most scholars focus on the short-term effects of policy implementation, and there are fewer studies on the differential impacts of policies in different sub-sectors and regions. This paper explores the impact mechanism of the GFRI policy on greenhouse gas emission reduction in China's manufacturing industry through the DID method, and discusses the spatial effect of the pilot zone as well as the specific impact differences between the traditional manufacturing industry and the modern manufacturing industry, which not only fills in the blank of the research on the impact of the green finance policy on manufacturing industry's carbon emission, but also provides policy makers with empirical evidence of industry segmentation. This study not only fills the gap of research on the impact of green financial policies on carbon emissions in the manufacturing industry, but also provides policy makers with empirical evidence of industry segmentation, which helps to formulate and adjust green financial policies more accurately to achieve more effective greenhouse gas emission reduction targets.

Theoretical Analysis and Research Hypotheses

GFRI Policies and Environmental Performance in the Manufacturing Sector

Green finance policies have the potential to reduce GHG emissions from the manufacturing sector by directing financial resources towards low-carbon and environmentally friendly areas, prompting enterprises to pay more attention to environmental protection in the production process. By lowering the financing costs of highly polluting enterprises or providing financial support, such policies guide enterprises to invest in cleaner technologies and production methods, promoting the low-carbon transformation of the entire industry (Zhao, et al., 2024). In addition, green financial policies can also promote enterprises to increase environmental protection investment and reduce carbon footprint through tools such as green credit and green bonds (Xu et al., 2022). Meanwhile, some studies have pointed out that the implementation of green

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financial policies can enhance the sense of environmental responsibility of enterprises and prompt them to take the initiative to reduce greenhouse gas emissions (Chen et al., 2023). However, the actual effects of green finance policies still depend on the implementation strength of the policies and the specific responses of enterprises, which may not be significant if the policies are poorly implemented or enterprises fail to fully utilize the policy support (Yeow & Ng, 2021). Overall, green finance policies may have a dampening effect on manufacturing GHG emissions through financial incentives.

H1: GFRI policies can significantly reduce GHG emissions of manufacturing firms.

Mechanisms Affecting GFRI Policies to Mitigate GHG Emissions in Manufacturing Industries

Green finance policies can effectively reduce the financing constraints of enterprises through means such as green credit, thus promoting their investment in low-carbon technologies and environmental protection facilities, and ultimately realizing the reduction of greenhouse gas emissions (Su, et al., 2022). Specifically, green finance provides enterprises with more sources of funds and reduces financing costs, making it easier for enterprises to obtain funds for environmental protection projects (Jin et al., 2021). For example, financial instruments such as green bonds and green funds can be specifically used to support enterprises' green project investments, which not only improves the level of enterprises' environmental protection technology, but also promotes the application of low-carbon production methods (Chygryn et al., 2019). Therefore, the implementation of green financial policies can promote enterprises to reduce greenhouse gas emissions by alleviating financing constraints.

H2: GFRI policies can significantly reduce the GHG emissions of manufacturing firms by lowering their financing constraints.

Green Finance Policies Can Improve ESG Performance and Mitigate GHG Emissions of Enterprises.

GFRI policies not only directly affect the financing channels of enterprises, but also indirectly contribute to the reduction of GHG emissions by improving the environmental, social and corporate governance (ESG) performance of enterprises (Yang et al., 2022). Specifically, GFRI often require firms to improve their ESG scores, and these policies push firms to pay more attention to environmental protection and social responsibility in their production and operation processes, thereby reducing pollution and GHG emissions. In addition, as investors and consumers pay more attention to firms' ESG performance, firms take the initiative to improve their ESG performance in order to be more competitive in the market, which ultimately leads to a reduction in GHG emissions (Li & Xu, 2024). Therefore, green finance policies can further contribute to the reduction of corporate GHG emissions by promoting corporate ESG performance.

H3: GFRI policies can significantly reduce the GHG emissions of manufacturing firms by improving their ESG performance

Research Design

The Empirical Model

In the study of policy effects, the double difference model (DID) based on the quasi-natural experiment is favored by scholars, which can more accurately assess the effect of policy implementation, so this paper takes the green financial policy-"green financial reform and innovation pilot zone(GFRI) policy" as a quasi-natural experiment, and uses the DID method to study the impact and effect of its GHG emissions of China's manufacturing enterprises. In 2017, the central bank took the lead in setting up the first batch of pilot zones for green finance innovation and reform in five provinces, namely, Zhejiang, Guangdong, Jiangxi, Guizhou, and Xinjiang Uygur Autonomous Region, and started the five-year experiment. Although, in 2019, and 2022 respectively, Gansu and Chongqing will join the pilot zones as new pilot zones, but taking into consideration of the policy's lagging. This paper only takes the first phase of the five pilot provinces as the research object of this paper, takes 2017 as the policy occurrence period, and constructs the following

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DID model:

$$GHG_{it} = \alpha_0 + \alpha_1 DID_{it} + \beta \sum Controls_{it} + \eta_i + \theta_t + \varepsilon_{it}$$

$$DID_{it} = Treat_i * Post_t$$

In the above model, *i, t* represent enterprises and years, The explanatory variable GHG_{it} is the GHG emission intensity of enterprise *i* in year *t*; $Treat_i$ is a dummy variable for the treatment effect area, which indicates whether the enterprise is a manufacturing enterprise in the "Green Finance Reform and Innovation Pilot Zone", and if the enterprise is located in the Pilot Zone, then it is 1, otherwise it is 0; $Post_t$ is a dummy variable for the period of treatment effect, indicating whether it is the time of policy implementation, if the time is after 2017, then $Post_t$will take the value of 1, and vice versa will be 0; DID_{it} is the interaction term of $Treat_i$ and $Post_t$. η_i and θ_t are the firm fixed effects and year fixed effects, respectively; ε_{it} is the random perturbation term.

Variables

*Implicit variable GHG***.** In this paper, we use the logarithm of the ratio of the greenhouse gas, i.e., carbon dioxide emissions (tons), and the enterprise's turnover (millions of dollars) to measure the intensity of greenhouse gas emissions, i.e., the smaller the value of GHG, the lower the enterprise's greenhouse gas emissions.

The Core Explanatory Variable DID_{it} , $Treat_i * Post_t$, is based on the policy of "Building Green Financial Reform and Innovation Pilot Zones", which can identify the first five provinces that have been set up as green financial reform and innovation pilot zones, and then determine the policy release period of 2017 as the starting year, and if the enterprises are within the coverage of the green financial innovation and reform pilot zone policy, then DID_{it} assigns the value of 1, otherwise 0. α_1 is the regression coefficient of the core explanatory variables of this paper, which measures the degree of influence of GFRI policy on GHG emissions of manufacturing enterprises, and this paper expects the coefficient to be negative, i.e., the GFRI policy has a significant inhibition of GHG in the manufacturing industry.

ESG Performance (ESG). This paper adopts the CSI ESG rating index to measure the ESG performance of the sample firms. The CSI ESG rating classifies all listed companies into 9 grades, with grades from AAA, AA, A, BBB, BB, B, CCC, CC, C. In this paper, the ESG ratings of the companies are assigned from 9 to 1 in descending order, and the larger the value, the higher the ESG score.

*Financing Constraint SA Index***.** This paper mainly uses the constructed SA index absolute method (Hadlock & Pierce, 2010) to measure the degree of corporate financing constraints, SA index is negative, the larger the absolute value of the SA index, the higher the financing constraints, and vice versa, the lower.

*Control Variables***.** This paper selects seven control variables, Tobin's Q (**Tobin Q**), measured by the ratio of market value to asset replacement cost; equity concentration (**CR1**) indicates the ratio of the shares held by the top shareholder to the company's total share capital, net profit margin (**NPM**), net profit divided by the ratio of operating income, enterprise age **(Age**), the difference between the current year and the year of the enterprise's founding, the number of patent applications in the city (**Pat**), the logarithm of the number of patent applications in the selected city in the current year. Logarithm of the number of patent applications in the current year, **GDP** per capita in the city, GDP Logarithm of GDP per capita, Return on Equity (**ROE**), Ratio of firm's net profit to average shareholders' equity.

Data: China's Shanghai and Shenzhen A-share manufacturing industry is selected as the research object from 2014 to 2022, and the interpolation method is used to fill in the missing data, and after removing the abnormal data and in order to avoid the impact of extreme values on the estimation results, this paper shrinks the tail of all the continuous variables at the 1% level to get 3,370 sample observations finally. The raw data are mainly from the State Intellectual Property Office, China Urban Statistical Yearbook, and other

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data are from CSMAR financial research database.

Empirical Analysis

Descriptive Statistics.

This paper selects China's Shanghai and Shenzhen A-share manufacturing industry from 2014 to 2022 as the research object, and uses interpolation method to fill in the missing data, after eliminating abnormal data and in order to avoid the impact of extreme values on the estimation results, this paper shrinks the tail of all the continuous variables at the 1% level to get 3,370 sample observations finally. The primary data are mainly from the State Intellectual Property Office, China Urban Statistical Yearbook, and other data are from CSMAR Financial Research Database. Table 1 shows the descriptive statistics of the main variables. The maximum value of the GHG value of the sample enterprises in the sample period is -7.728, the minimum value is -13.291, the average value is -10.012, and the standard deviation is 0.549, which indicates that the carbon emission level of China's manufacturing industry tends to be stabilized in recent years, which is related to the policy of China's "Carbon Neutral, Carbon Peak". The explanatory variable DID, with a mean value of 0.189, indicates that about 19% of the enterprises in the sample are covered by the policy of green financial reform and innovation pilot zone. Among the control variables, Tobin Q, the standard deviation of the number of patents filed by cities is relatively high, and the remaining variables have low dispersion.

Table 1. Descriptive Statistics of The Main Variables

Variables	Obs	Mean	Std.Dev	Min	Max
GHG	3370	-10.012	.549	-13.291	-7.728
DID	3370	.189	.391	0	1
Tobin Q	3370	2.301	1.437	.891	8.69
CR1	3370	.33	.137	.077	.675
NPM	3370	.043	.059	-.192	.212
Age	3370	2.932	.288	2.079	3.497
Pat	3370	10.429	1.431	6.292	12.612
GDP	3370	11.298	.429	10.361	12.142
ROE	3370	.072	.109	-.39	.364

Benchmark Regression of The Impact of Gfri on Ghg Emissions in Manufacturing Industry

Table 2 reports the results of the benchmark regression of the impact of green financial reform and innovation policies on GHG emissions in manufacturing industry, according to the results, it can be seen that the estimated coefficient of the core explanatory variable DID is significantly negative at the 5% level, and the results are significantly negative at the 1% level when control variables are added to control the individual and the year, respectively, which indicates that the green financial reform and innovation policies can significantly reduce the GHG emissions of the manufacturing industry. enterprises' greenhouse gas emissions, hypothesis H1 is valid.

Table 2. Base Regression Results

	(1)	(2)	(3)	(4)
	GHG	GHG	GHG	GHG
DID	-0.069**	-0.177***	-0.124***	-0.180***
	(-1.988)	(-5.633)	(-3.617)	(-5.579)
Tobin Q			-0.013	-0.003
			(-1.496)	(-0.359)
CR1			-0.113	-0.199
			(-0.652)	(-1.302)

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NPM			-0.016	0.110
			(-0.035)	(0.268)
Age			0.540***	-0.701***
			(3.036)	(-3.724)
Pat			-0.726***	0.027
			(-26.137)	(0.645)
GDP			1.103***	-0.023
			(8.446)	(-0.100)
ROE			-0.019	-0.012
			(-0.084)	(-0.059)
_cons	-9.999***	-10.082***	-16.397***	-8.126***
	(-912.957)	(-499.535)	(-16.117)	(-3.106)
ID FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES
N	3370	3370	3370	3370
R^2_{adj}	-0.124	0.337	0.155	0.339

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness Testing

Balanced Trend Test

In the basic regression this paper tests the policy effect of GFRI policy on the GHG emissions of the manufacturing industry, but the above results must also satisfy the basic premise of the parallel trend assumption, that is, the greenhouse gas emissions of the treatment group and the control group before the implementation of the GFRI policy should have the same trend of change, for this reason, this paper is further re-estimated and analyzed through the parallel trend test in order to control the potential endogeneity problem and ensure the reliability of the results. As shown in Figure 1, this paper takes 2017 as the policy implementation period, selects 3 years before the time point of policy implementation and 5 years after the test, and takes 1 year before the policy as the base period, and the results show that the treatment group and the control group have the same development trend before the time point of the policy, and there is a downward trend of the treatment group after the time point of the policy, which further verifies that the GFRI policy has significant inhibitory effects on China's manufacturing industry's GHG emissions", and the parallel trend test is passed.

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Figure 1. Equilibrium Trend Detection

Placebo Test

Although a series of observable influencing factors have been controlled in the previous section, the estimation results may still be substantially affected by other unobservable factors, in order to further verify the inhibiting effect of green financial reform and innovation policies on GHG emissions of China's manufacturing industry, this paper randomly selects manufacturing enterprises in the green financial reform and innovation pilot zone and randomly generates the year of implementation of the initiative for the test, and repeats the above mentioned Random sampling is repeated 500 times, and finally the estimated coefficients and probability density distribution are plotted as shown in Figure 2, the estimated coefficients of the core explanatory variables DID are centrally distributed in the neighborhood of 0 and obey the normal distribution, which indicates that the unobservable factors do not have a substantial impact on the benchmark regression results, and that the inhibition effect of the green financial reform and innovation policy on China's greenhouse gas emissions from Chinese manufacturing industry is real and effective.

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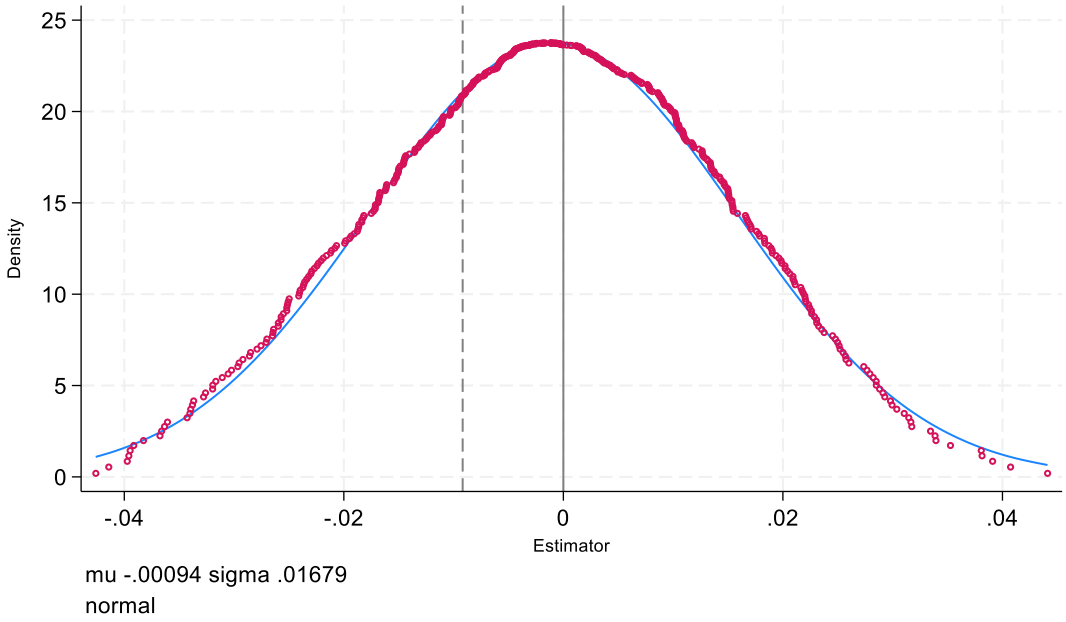

Figure 2. Placebo Test Results

Heterogeneity Detection

Considering the local characteristics of resource endowment and economic development level in the east, central and west regions, we further test the regional heterogeneity of the benchmark regression results. The specific regression results are listed in Table 3.

This paper distinguishes the sample into eastern region and central and western region according to the province where the pilot area is located, and conducts empirical test of heterogeneity of the sample. The negative coefficients from the results of the heterogeneity analysis of the eastern and central and western regions indicate that the green finance innovation and reform pilot zone policy significantly reduces the greenhouse gas emissions of the manufacturing industry in both regions. This suggests that the implementation of the policy has had a positive effect on promoting low-carbon development nationwide, both in the economically developed eastern region and the relatively less developed central and western regions. However, the effect of the policy is more significant in the central and western regions than in the eastern regions. In other words, green finance policies have a stronger effect on reducing manufacturing GHG emissions in the Midwest. This may reflect the relatively weaker level of infrastructure and technology in the Midwest prior to the implementation of the policy, and thus the introduction of the policy resulted in more significant marginal improvements. In contrast, the marginal effect of the policy may be smaller in the eastern region due to its higher level of economic development, more mature environmental technologies and relatively well-developed financial markets.

This result may be due to the fact that the eastern region is relatively economically developed, with more mature environmental awareness and environmental technology, so there is limited room for further policy improvement. In contrast, the central and western regions are relatively backward, and the financial support and technological improvements brought about by the introduction of the policy have a more significant impact on the reduction of GHG emissions. In addition, the manufacturing industries in the central and western regions are more susceptible to green finance policies because they are mainly resource-intensive and energy-intensive. These industries may be more inclined to make technological upgrades and environmental protection investments under the policy incentives, thus significantly reducing GHG emissions. Moreover, economic development in the central and western regions may be more dependent on national policies to drive development, so the implementation of green finance policies has received higher attention and positive response in these regions, leading to greater policy effects.

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According to the characteristics of the manufacturing industry and the state of development of the industry, the manufacturing industry can be categorized into traditional manufacturing and modern manufacturing based on the technological content of the industry, innovation-driven and the degree of fit with modern economic development. Modern manufacturing industry usually has higher investment in technology research and development and innovation, and in line with the development trend of green and intelligent. For example, the pharmaceutical manufacturing industry, the electrical machinery and equipment manufacturing industry, the computer, communication and other electronic equipment manufacturing industry, and the railroad, shipbuilding, aerospace and other transportation equipment manufacturing industry are modern manufacturing industries, while the traditional manufacturing industry usually refers to the manufacturing industry based on traditional crafts and technologies, which may have a long history of development, with mature crafts, and rely on a higher level of labor or resource inputs in some cases, for example Furniture Manufacturing, Automobile Manufacturing Alcohol, Beverage and Refined Tea Manufacturing, Food Manufacturing, and so on. Therefore, this paper further distinguishes the manufacturing industry and then conducts the heterogeneity test. Specific regression results are listed in the table 3, In the regression results in Table 3, the negative coefficients indicate that the green finance innovation and reform pilot zone policy significantly reduces GHG emissions in both manufacturing categories. This suggests that the green finance policy plays a positive role in environmental protection in both traditional and modern manufacturing industries and helps to promote the low-carbon transformation of the industry.

However, the policy's emission reduction effect is significantly stronger in the modern manufacturing sector than in the traditional manufacturing sector. This suggests that the modern manufacturing sector is more affected by green finance policies and that the policies are more effective in promoting the reduction of GHG emissions in the modern manufacturing sector. This may be due to the fact that modern manufacturing industries usually involve high-tech and innovative industries, and these enterprises are able to adopt cleaner technologies and environmental protection measures more rapidly with the support of green financial policies. Therefore, modern manufacturing enterprises tend to have stronger technological innovation capabilities and are better able to utilize green financial resources for environmental technology upgrading, thus achieving greater emission reductions.

On the contrary, traditional manufacturing industries are often dominated by resource-intensive and high-energy-consumption industries, and although these industries are also promoted by green financial policies, the emission reduction effect brought about by the policies is relatively limited due to the more obsolete technological basis and the difficulty of transformation.

Table 3. Detection of Regional Heterogeneity

	Regions		Industries	
	East	Midwest	Modern Manufacturing	Traditional manufacturing
	GHG	GHG	GHG	GHG
DID	-0.169***	-0.220***	-0.214***	-0.130***
	(-4.634)	(-2.805)	(-4.509)	(-2.975)
Tobin Q	-0.007	0.008	-0.014	-0.001
	(-0.685)	(0.450)	(-1.108)	(-0.068)
CR1	-0.133	-0.341	-0.475**	0.127
	(-0.762)	(-1.049)	(-2.026)	(0.626)
NPM	-0.205	0.728	0.254	0.013
	(-0.431)	(0.895)	(0.369)	(0.025)
Age	-0.912***	-0.134	-1.221***	-0.177
	(-4.228)	(-0.334)	(-4.274)	(-0.715)
Pat	0.063	0.024	-0.049	0.086
	(1.242)	(0.303)	(-0.802)	(1.507)
GDP	0.616	-0.501	0.112	0.055

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	(1.585)	(-1.500)	(0.322)	(0.183)
ROE	0.197	-0.436	-0.245	0.163
	(0.827)	(-1.100)	(-0.691)	(0.685)
_cons	-15.772***	-4.702	-8.179**	-12.030***
	(-3.660)	(-1.257)	(-2.152)	(-3.267)
ID FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	2388	982	1746	1624
R^2_{adj}	0.494	0.496	0.436	0.570

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Mechanism of Action Tests

Through the previous analysis, it can be seen that the green financial reform and innovation policy can significantly reduce the greenhouse gas emissions of manufacturing enterprises, therefore, on the basis of this regression model, taking into account that the mediating effect model may have serious endogeneity problems, drawing on the research of Jiang T, (2022), the main test of the green financial reform and innovation pilot zones on the mechanism variables, to construct the following econometric regression model:

$$Med_{it} = \alpha_0 + \alpha_1 DID_{it} + \beta \sum Controls_{it} + \eta_i + \theta_t + \varepsilon_{it}$$

Where Med_{it}denotes the mechanism variable, ESG performance (ESG) and SA financing constraint index (SA) are selected in this paper, and the regression results are shown in Table 7:

Table 7. Results of Mechanism of Action Tests

	(1)	(2)	(3)
	GHG	ESG	SA
DID	-0.180***	0.481***	0.094***
	(-5.579)	(8.064)	(3.397)
Tobin Q	-0.003	-0.001	-0.045***
	(-0.359)	(-0.083)	(-6.300)
CR1	-0.199	0.731**	-0.548***
	(-1.302)	(2.573)	(-4.154)
NPM	0.110	1.580**	-0.491
	(0.268)	(2.080)	(-1.391)
Age	-0.701***	0.004	0.655***
	(-3.724)	(0.012)	(4.042)
Pat	0.027	0.282***	0.090**
	(0.645)	(3.645)	(2.505)
GDP	-0.023	-0.043	-0.060
	(-0.100)	(-0.100)	(-0.300)
ROE	-0.012	-0.344	0.907***
	(-0.059)	(-0.914)	(5.180)
_cons	-8.126***	1.614	2.660
	(-3.106)	(0.333)	(1.181)
ID FE	YES	YES	YES
Year FE	YES	YES	YES
N	3370	3370	3370

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R^2_{adj}	0.339	-0.047	0.446

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results show that, according to column (2) of Table 7, the green financial reform and innovation experimental zone policy significantly increases the SA index of the manufacturing industry, because the SA index is negative, the larger the absolute value of the SA index, the higher the financing constraints, and vice versa, the lower the financing constraints, therefore, the green financial reform and innovation experimental zone policy significantly reduces the financing constraints of the manufacturing industry enterprises, and based on the studies of other scholars, the relatively loose financing environment can significantly reduce the greenhouse gas emissions of enterprises (Caragnano et al., 2022, Enkvist, et al., 2010). Based on other scholars' studies, a relatively loose financing environment can significantly reduce the greenhouse gas emissions of enterprises (Caragnano et al., 2022, Enkvist, et al., 2010), combined with the previous experimental results of this paper, "green financial reform and innovation policies can significantly reduce the greenhouse gas emissions of manufacturing enterprises", it can be concluded that green financial reform and innovation policies can reduce the greenhouse gas emissions of manufacturing enterprises. reform and innovation policies can reduce the financing constraints of manufacturing enterprises and thus reduce the greenhouse gas emissions of the manufacturing industry. Hypothesis H2 is established.

According to column (3) of Table 7, the green financial reform and innovation experimental zone policy significantly improves the ESG performance of the manufacturing industry, and according to the research of other scholars, the good ESG performance of the enterprises can reduce the greenhouse gas emissions (Long, & Feng, 2024., Mneimneh al., 2023) based on the previous "green financial reform and innovation policy can significantly reduce the greenhouse gas emissions of manufacturing enterprises". Based on the results of the previous study "Green financial reform and innovation policies can significantly reduce greenhouse gas emissions of manufacturing enterprises", it is concluded that green financial reform and innovation policies can significantly reduce greenhouse gas emissions of manufacturing enterprises by improving their ESG performance, and hypothesis H3 is established.

Conclusion and Recommendations

Based on empirical analysis using data from the manufacturing sector in Green Finance Reform and Innovation Pilot Zones (2014-2022), this paper examines the impact of green finance policies on mitigating greenhouse gas (GHG) emissions. The following conclusions have been drawn:

Significant Mitigating Effect: The Green Finance Reform and Innovation Pilot Zone policy has a significant suppressive effect on GHG emissions in the manufacturing industry. This effect is more pronounced in the relatively underdeveloped central and western regions compared to the economically advanced eastern regions. Moreover, the impact of green finance policies on reducing GHG emissions is stronger in modern manufacturing industries than in traditional ones. Overall, green finance policies significantly reduce GHG emissions in the manufacturing industry by alleviating financing constraints and improving ESG performance.

Given these findings, the following recommendations are proposed:

Expand Coverage of Green Finance Policies, Especially in Central and Western Regions: Considering the more significant suppressive effect of green finance policies on GHG emissions in the relatively underdeveloped central and western regions, it is recommended to further expand the coverage of Green Finance Reform and Innovation Pilot Zones, particularly in these areas. This expansion will help direct resources toward environmentally friendly projects, thereby effectively promoting green transformation in these regions.

Enhance Green Finance Support for Traditional Manufacturing: Although green finance policies have a stronger impact on reducing emissions in modern manufacturing industries, traditional manufacturing remains a

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major source of carbon emissions. It is recommended that the government formulate differentiated financial policies, providing more green credit, green bonds, and other financial instruments to encourage traditional manufacturing to undergo technological upgrades and green transformation, thereby improving its emission reduction performance.

Optimize Green Finance Policies to Improve ESG Performance: Green finance policies have proven effective in reducing GHG emissions by enhancing corporate environmental, social, and governance (ESG) performance. It is recommended to further optimize policy design to encourage companies to improve their ESG performance actively. This could include establishing incentive mechanisms that offer more favorable financing conditions and policy support to companies with outstanding ESG performance, thus driving sustainable development across the entire industry.

Strengthen Policy Coordination to Promote Green Finance Innovation in the Eastern Region: Although the policy effects in the central and western regions are significant, the eastern region's higher level of economic development provides greater financial market potential and innovation capacity. It is recommended to promote the successful experiences from the central and western regions to the eastern region through policy coordination and encourage more innovation in the field of green finance in the eastern region to further harness the potential of green finance policies.

Establish and Improve Green Finance Policy Performance Evaluation Mechanisms: To ensure the effectiveness of green finance policies, it is recommended to establish and improve performance evaluation mechanisms, regularly assessing the impact of policies, especially considering the differentiated effects across regions and industries. By dynamically adjusting and optimizing policy measures, it is essential to ensure that green finance policies continue to play a role in promoting low-carbon development in the manufacturing industry.

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