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Green Financial Policies, Environmental Regulation Intensity, and Green Transformation of Industrial Structure

--Mechanism Testing and Regional Comparison

Huiheng Zhang, Xiaofan Yu

School of Economics, Anhui University of Finance and Economics, Bengbu, Anhui, China

1972699438@qq.com

Abstract

This paper examines how green finance and environmental regulation jointly promote the green transformation and upgrading of industrial structure. Based on data from 31 provinces during 2014–2023, the results show that both green finance and environmental regulation significantly drive the greening of industrial structure, and environmental regulation plays a mediating role in their relationship. The study also finds that the impact of green finance is more pronounced in western and northeastern regions, while it is relatively moderate in eastern and central regions. This paper provides implications for policy-making, suggesting the enhancement of green finance support and optimization of environmental regulation, as well as the formulation of differentiated policies according to regional heterogeneity.

Keywords

Green Finance; Environmental Regulation; Industrial Structure Upgrading; Heterogeneity Test.

1. Introduction

In recent years, global climate change and tightening resource and environmental constraints have become increasingly severe, making the green and low-carbon transition an international consensus. Countries around the world have adopted financial instruments to direct capital toward clean energy, energy conservation, emission reduction, and green industries. As a major driver of the green economic transition, green finance has become a critical bridge linking environmental protection and economic development [1]. In China, the introduction of the "Dual Carbon" goals has charted a low-carbon and sustainable course for economic development. In recent years, the state has intensively rolled out policies including green credit, green bonds, and green funds, guiding financial resources toward energy conservation, environmental protection, green manufacturing, and related sectors. Meanwhile, the optimization and upgrading of industrial structure has emerged as a core task for high-quality economic development, promoting a shift from resource-intensive industries to technology- and innovation-oriented industries through improved industrial layout and higher technological content and added value. Against the backdrop of China's current economic and social development, the industrial structure upgrading examined in this study is, in essence, a transformation toward green, low-carbon, and sustainable development. Nevertheless, in the process of promoting the green transformation of industrial structure, green finance exhibits distinct differences in its mechanism and effectiveness due to variations in environmental regulation intensity, policy implementation, and local government behaviors.

Although existing studies generally agree that green finance helps improve environmental quality and facilitate industrial transformation, its transmission mechanism affecting industrial

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structure upgrading remains unclear. In particular, the interactive relationship between green finance and environmental regulation has been rarely discussed in academic circles. Environmental regulation not only directly influences corporate production behavior but may also serve as a mediating channel through which green finance affects industrial structure upgrading. On the one hand, green finance can strengthen enterprises' capacity to comply with environmental regulations through capital allocation and risk pricing. On the other hand, environmental regulation may reinforce the incentive effects of green finance, thereby accelerating the exit of energy-intensive and highly polluting industries and fostering the development of green industries [2]. Therefore, exploring how green finance empowers industrial structure upgrading through environmental regulation carries both theoretical significance and practical implications for policy formulation.

2. Literature Review

Existing literature on green finance mainly focuses on its connotation, measurement, and evaluation. Green finance is at the intersection of finance and the green economy, emphasizing the coordinated development of the economy and the environment, and directing financial capital toward environmental protection, covering investment and financing research related to ecological conservation and climate change [3][4]. With the development of green financial products such as green credit, green securities, and green investment, Ding Ning and Gao Jing et al. [5] constructed an indicator system for the green finance development index from six dimensions—green credit, green bonds, green insurance, green investment, green funds, and green equity—and analyzed the positive impact of green finance on environmental governance effects. Zhan Shuke and Wang Renzeng [6] established a green finance indicator system from five dimensions: green credit, green investment, green securities, green insurance, and green support, and found that green finance exerts a significant direct promoting effect on industrial structure change. Hou Jianming et al. [7] conducted an empirical analysis using panel data from 30 provinces in China and found that green finance can actively promote the development of ecological urbanization in China, with considerable room for further application. During the process of ecological urbanization, Guosheng and Liu Rongbing [8] adopted the Dagum Gini coefficient to analyze regional disparities in green finance development across the country and three major economic zones, and used a spatial Durbin model to investigate its influencing factors, revealing significant spatial heterogeneity and dispersion.

Research on environmental regulation concentrates on its classification, tool selection, and measurement. Environmental regulation mainly includes formal regulation and informal regulation [9][10]. Formal environmental regulation refers to government actions, that is, regulations formulated and implemented through formal channels such as laws, regulations, and policies. Tian Shuying and Guo Hao [11] divided formal regulation into command-and-control instruments and market-incentive instruments. Informal environmental regulation involves voluntary public participation, arising from voluntary compliance by social organizations, industry associations, and enterprises, or pressure from public opinion. In terms of regulatory tool selection, command-and-control, market-incentive, and voluntary instruments each have their own advantages. Yang Yanfang and Cheng Xiang [12] argued that command-and-control instruments can effectively promote corporate innovation in the short run but have limitations in sustaining long-term innovation incentives, whereas market-incentive regulatory instruments are more effective and provide continuous incentives for innovation. Yue Wei [13] pointed out that although public voluntary participation has limitations in governance effectiveness, it incurs relatively low costs. The measurement of environmental regulation mainly adopts the single-index method and the comprehensive-index method. For the single-index method, some scholars measure environmental regulation

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intensity from the government perspective, using the number of environmental administrative penalty cases [14] or the ratio of the total frequency of environmental regulation words to the total length of corresponding government work reports [15]. Other scholars measure it from the enterprise perspective, using the proportion of completed industrial pollution control investment in the secondary industry [16] or the natural logarithm of actual pollution discharge fees (environmental protection taxes) paid [17]. For the comprehensive-index method, Hu Jianbo et al. [18] constructed a comprehensive environmental regulation indicator using three indices: industrial wastewater discharge, industrial SO_2 discharge, and industrial smoke and dust discharge. Guo Anhui and Han Limin [19] selected four indicators to reflect environmental regulation effects: industrial SO_2 removal rate, industrial smoke (dust) removal rate, industrial wastewater discharge compliance rate, and comprehensive utilization rate of industrial solid waste.

In research on the relationship between green finance and industrial structure upgrading, the mechanism mainly manifests in structural effects and technological effects. On the one hand, from the perspective of structural effects, Yu Xulan et al. [20] took the dual perspectives of emission reduction and development as their starting point and found that under green credit policies, highly polluting enterprises improved emission reduction efficiency but faced development constraints, further analyzing their pollution abatement pathways under policy restrictions. Li Hang [21] examined the impact of regional green finance development on corporate "greenwashing" behavior, its mechanism, and moderating effects, conducting moderation analyses from internal and external perspectives including government supervision, fintech, internal control, and financing constraints. On the other hand, from the perspective of technological effects, Meng Dabin et al. [22] and Su Chong [23] found from the perspective of corporate financing costs that green finance development can reduce financing costs and thereby improve enterprises' green innovation capabilities. On this basis, Hu Jie et al. [24], Zhao Zheyue et al. [25], and Liu Guangyong [26] found that green finance encourages enterprises to conduct green technology research and development in industry, agriculture, and manufacturing, respectively, thus enhancing the overall technological level of industries.

Through analysis and sorting of existing literature, several shortcomings are identified in research on green finance, environmental regulation, and the green transformation of industrial structure. First, many studies fail to deeply explore the combination of green finance and environmental regulation, usually treating them as independent variables and lacking systematic analysis of their interaction. Second, research on environmental regulation as a mediating variable is relatively scarce, and its specific mechanism as a bridge between green finance and industrial structure upgrading remains unclear. Therefore, this study aims to investigate the interaction mechanism between green finance and environmental regulation and the mediating effect of environmental regulation on industrial structure upgrading, providing new insights for industrial structure optimization.

3. Theoretical Analysis and Research Hypotheses

Green finance promotes the upgrading of industrial structure by providing financial support for green technologies and environmental protection projects. On the one hand, green finance helps achieve the balanced development of the economy, society, and the environment. By directing capital toward green industries such as renewable energy and green manufacturing, it drives the transformation of traditional highly polluting industries toward low-carbon and green development, thereby advancing the greening and efficiency improvement of industrial structure. On the other hand, according to industrial structure theory, green finance, as a capital flow instrument, can accelerate the optimization of industrial structure. By supplying low-cost funds to support green technological innovation and environmental projects, it promotes the

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upgrading of low-tech industries toward high value-added and green technology-oriented industries. In summary, green finance effectively drives the transformation and upgrading of industrial structure from traditional highly polluting and energy-intensive industries to low-carbon, green, and efficient industries, fostering sustainable economic development. On this basis, the following hypothesis is proposed:

H1: Green finance and environmental regulation effectively promote the green transformation of industrial structure.

Environmental regulation encourages enterprises to transform from traditional, highly polluting, and energy-intensive production modes to green, low-carbon, and efficient modes through dual mechanisms of constraint and incentive, thereby promoting the green upgrading of industrial structure. Specifically, strict environmental regulation requires enterprises to improve pollution control and adopt clean technologies, while green finance provides enterprises with financial support to implement such transformations. The two are complementary: green finance promotes the research, development, and application of green technologies through capital flows, and environmental regulation encourages enterprises to adopt these green technologies through policy constraints. Therefore, environmental regulation not only strengthens the role of green finance but also drives industries toward green and low-carbon development, facilitating the sustainable upgrading of industrial structure.

H2: Environmental regulation plays a mediating role between green finance and industrial structure upgrading.

Regions differ in economic development level, environmental regulation intensity, and green financial policy support. In developed regions, more mature green financial policies and a sounder financial market lead to a more significant guiding role of green finance, which can promote the green upgrading of local industrial structure. In less developed regions, green finance may face higher institutional costs and financing difficulties, so its effect in promoting industrial structure upgrading may be weaker.

H3: Green finance exhibits regional heterogeneity in promoting industrial structure upgrading.

4. Variables, Model Construction and Data

4.1. Variable Selection

4.1.1. Dependent Variable

Industrial structure upgrading (IS) is taken as the dependent variable.Referring to the research methods of Li Chunsheng [27], Li Jianming [28], and others, this paper measures the level of industrial structure upgrading (IS) by the weighted sum of the proportions of the three industries in GDP. The specific formula is as follows:

$$IS=1\times S1+2\times S2+3\times S3$$

where S1, S2, and S3 represent the proportions of the primary, secondary, and tertiary industries in GDP, respectively.

4.1.2. Independent Variable

Green finance (GF) is used as the core independent variable.Based on the research methods of Ding Ning [5], Zhan Shuke [6], and others, this paper constructs the green finance index (GF) using the entropy method from seven sub-indicators: green credit, green investment, green insurance, green bonds, green support, green funds, and green equity (see Table 1).

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Table 1 Green Finance Indicators

Green Finance	Green Credit	Total credit for environmental protection projects in the province / Total provincial credit
	Green Investment	Investment in environmental pollution control / GDP
	Green Insurance	Premium income from environmental pollution liability insurance / Total premium income
	Green Bonds	Total issuance of green bonds / Total issuance of all bonds
	Green Support	Fiscal expenditure on environmental protection / General fiscal budget expenditure
	Green Funds	Total market value of green funds / Total market value of all funds
	Green Rights	Total credit for environmental protection projects in the province / Total provincial credit

4.1.3. Control Variables

Variables that may affect industrial structure upgrading are selected as control variables:Fiscal support (fiscal): measured by the ratio of local fiscal expenditure to regional GDP;Economic development level (pergdp): measured by per capita GDP;Urbanization level (urb): measured by the ratio of urban permanent population to total permanent population in each region;Human capital (rlz): measured by the ratio of the number of students in ordinary institutions of higher education to the permanent population at the end of the year.

4.1.4. Mediating Variable

Environmental regulation is adopted as the mediating variable.Drawing on the research method of Liu Rongzeng et al. [16], it is measured by the proportion of completed investment in industrial pollution control in the added value of the secondary industry.

Table 2 Variable Definitions

Variable Type	Variable Name	Symbol	Calculation Method
Dependent Variable	Industrial Structure Upgrading	IS	Weighted sum of the proportions of three industries in GDP
Independent Variable	Green Finance	GF	Calculated by entropy method
Mediating Variable	Environmental Regulation	ER	Completed investment in industrial pollution control / Value-added of secondary industry
Control Variables	Fiscal Support	fiscal	Local fiscal expenditure / Regional GDP
	Economic Development Level	pergdp	Per capita GDP
	Urbanization Rate	urb	Urban permanent population / Total permanent population
	Human Capital	rlz	Students in regular institutions of higher education / Year-end permanent population

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4.2. Model Construction

To examine the promoting effect of green finance on industrial structure upgrading, the following model is constructed:

$$IS = \alpha_1 + \beta_1 GF + \gamma_1 Controls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t}$$

where i denotes provinces and t denotes years;IS is industrial structure upgrading;GF is green finance;Controls i,t denotes the set of control variables;α1 represents the natural growth rate of green finance;β1 is the coefficient reflecting the impact of changes in GF on IS;γ1 is the coefficient reflecting the impact of changes in control variables on IS;λt is the time fixed effect;μi is the provincial fixed effect;εi,t is the random disturbance term.

To further explore the transmission mechanism of green finance on industrial structure upgrading, this paper draws on the research methods of Wang Wenjie [29], Ma Dongdong et al[30].First, the mediating variable ER is set as the dependent variable, with GF as the core independent variable, to analyze how green finance affects the mediating variable.Second, both ER and GF are used as core independent variables, with IS as the dependent variable, to examine how environmental regulation affects industrial structure upgrading.On this basis, the following mediating effect models are constructed:

$$ER = \alpha_2 + \beta_2 GF + \gamma_2 Contorls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t}$$

$$IS = \alpha_3 + \beta_3 GF + \tau_3 ER + \gamma_3 Contorls_{i,t} + \lambda_t + \mu_i + \varepsilon_{i,t}$$

where ER denotes environmental regulation, and τ3 represents the coefficient of the impact of ER on IS.

4.3. Data Description

Based on data availability, this paper selects statistical data of 31 provinces in China from 2014 to 2023. Relevant data are mainly obtained from the China Statistical Yearbook, provincial statistical yearbooks, Wind Database, etc. Individual missing data are supplemented by the linear interpolation method. To eliminate potential heteroscedasticity, the natural logarithm of per capita GDP is taken before being introduced into the model.

5. Empirical Test and Analysis

5.1. Descriptive Statistical Analysis

Based on the variables selected in this paper, the results of descriptive statistical analysis for each variable are shown in Table 3:

Table 3 Descriptive Statistical Analysis

Variable Name	Observations	Mean	SD	Min	Max
IS	310	2.425	0.115	2.157	2.846
GF	310	0.336	0.134	0.090	0.664
ER	310	0.002	0.003	0.000	0.025
fiscal	310	0.289	0.203	0.105	1.354
lnpergdp	310	11.006	0.429	10.131	12.207
urb	310	0.606	0.137	0.000	0.893
rlz	310	0.022	0.006	0.009	0.044

It can be seen from the above table that the total number of samples is 310.The mean value of IS is 2.425, with a standard deviation of 0.115, a minimum value of 2.157, and a maximum value of 2.846.The mean value of GF is 0.336, with a standard deviation of 0.134, a minimum value of 0.090, and a maximum value of 0.664.It can be concluded that the mean values of both IS and

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GF are larger than their standard deviations, indicating a low overall dispersion of industrial structure and green finance.The relatively small gaps between their extreme values suggest that the level of industrial structure optimization and green finance development is relatively high in some regions, while relatively low in others.

5.2. Baseline Regression

Table 4 presents the baseline regression model constructed using both year and provincial fixed effects based on the data in this paper.Columns (1) and (2) show the regression results with green finance and environmental regulation as the main independent variables and industrial structure upgrading as the dependent variable, without adding control variables.The results indicate that, without the interference of control variables, both green finance and environmental regulation exert a positive promoting effect on industrial structure upgrading, with coefficients of 0.654 and 4.396 respectively, both significant at the 1% confidence level.Column (3) shows the results after adding control variables with green finance as the core independent variable, with a coefficient of 0.398, meaning that a one-unit increase in green finance improves industrial structure optimization by 0.398 units.Column (4) shows the results after adding control variables with environmental regulation as the core independent variable, with a coefficient of 3.720, meaning that a one-unit strengthening of environmental regulation improves industrial structure optimization by 3.720 units.Both are significant at the 1% confidence level.Column (5) presents the results incorporating green finance, environmental regulation, and the set of control variables, which remain significant at the 1% confidence level.Thus, Hypothesis H1 of this paper is verified.

Table 4 Baseline Regression Results

	(1)	(2)	(3)	(4)	(5)
	IS	IS	IS	IS	IS
GF	0.654***		0.398***		0.298***
	(6.65)		(3.99)		(3.05)
ER		4.396***		3.720***	3.301***
		(5.91)		(5.63)	(4.97)
fiscal			0.165***	0.171***	0.140***
			(3.29)	(3.56)	(2.88)
lnpergdp			-0.139***	-0.166***	-0.148***
			(-4.55)	(-5.68)	(-5.06)
urb1			-0.00313	-0.0171	-0.00725
			(-0.21)	(-1.22)	(-0.51)
rlz			2.706***	2.512***	2.541***
			(2.99)	(2.85)	(2.93)
cons	2.205***	2.415***	3.714***	4.146***	3.858***
	(66.75)	(1188.45)	(10.68)	(12.72)	(11.53)
id	YES	YES	YES	YES	YES
year	YES	YES	YES	YES	YES
N	310	310	310	310	310
R2	0.970	0.969	0.976	0.977	0.978

5.3. Mediating Effect Test

The analysis is carried out based on the mediating effect model constructed in this paper, and the results are shown in Table 5.Column (1) shows the regression result of the impact of the

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independent variable GF on the mediating variable ER without control variables. The result shows that the coefficient of GF on ER is 0.0307, significant at the 1% level.Column (3) shows the regression result of the impact of GF on ER with control variables added, with a coefficient of 0.0304, also significant at the 1% level.This indicates that the improvement of green finance can significantly strengthen environmental regulation.Column (2) shows the regression result of the impact of the mediating variable ER on the dependent variable IS without control variables, with a coefficient of 4.396.Column (4) shows the regression result of the impact of ER on IS after adding control variables, with a coefficient of 3.720.Both are significant at the 1% level, indicating that strengthening environmental regulation contributes to the optimization of industrial structure.Column (5) shows the combined impact of the independent variable GF and the mediating variable ER on the dependent variable IS. The results show that both GF and ER have a significantly positive impact on the dependent variable.According to the three-step mediating effect method proposed by Wen Zhonglin et al. [31], it is concluded that green finance can further improve the level of industrial structure optimization by strengthening environmental regulation.Thus, Hypothesis H2 of this paper is verified.

Table 5 Mediating Effect Test Results

variable	(1)	(2)	(3)	(4)	(5)
	ER	IS	ER	IS	IS
GF	0.0307***		0.0304***		0.298***
	(3.85)		(3.45)		(3.05)
ER		4.396***		3.720***	3.301***
		(5.91)		(5.63)	(4.97)
fiscal			0.00773*	0.171***	0.140***
			(1.74)	(3.56)	(2.88)
lnpergdp			0.00287	-0.166***	-0.148***
			(1.06)	(-5.68)	(-5.06)
urb			0.00125	-0.0171	-0.00725
			(0.95)	(-1.22)	(-0.51)
rlz			0.0501	2.512***	2.541***
			(0.63)	(2.85)	(2.93)
cons	-0.00813***	2.415***	-0.0438	4.146***	3.858***
	(-3.04)	(1188.45)	(-1.42)	(12.72)	(11.53)
Id	YES	YES	YES	YES	YES
year	YES	YES	YES	YES	YES
N	310	310	310	310	310
R^2	0.624	0.969	0.631	0.977	0.978

5.4. Endogeneity Test

Green finance helps promote the optimization of industrial structure, while industrial restructuring may in turn boost the development of green finance.Thus, there may be a two-way causal relationship between green finance and industrial structure optimization, which

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could lead to endogeneity and biased estimation in the aforementioned models.To address this issue, the instrumental variable method is adopted, using the first-order lagged term of the green finance index as the instrumental variable for green finance development.Past green finance development affects current green finance, satisfying the correlation requirement of instrumental variables.Meanwhile, current industrial structure optimization cannot influence past green finance development, satisfying the exogeneity requirement.Therefore, the two-stage least squares (2SLS) method is employed with this instrumental variable to conduct the endogeneity test, and the results are shown in Table 6.It can be seen from the regression results that:In the first-stage regression, the coefficient of the instrumental variable IV on GF is 0.574, significant at the 1% level, indicating a strong correlation between them.Meanwhile, the Underidentification test statistic is 276, significant at the 1% level.The Weak identification test statistic is 33000, much larger than the critical value of 16.38 at the 10% level.Both tests confirm that the instrumental variable is valid.In the second-stage regression, the coefficient of GF on IS is 0.118, significant at the 1% level.This shows that after solving the endogeneity problem using the instrumental variable, GF still exerts a significantly positive effect on IS, further verifying the robustness of the conclusions in this paper.

Table 6 Endogeneity Test Results

variable	Instrumental variables	
	Phase one	Phase one
GF		0.118***
		(3.12)
IV	0.574***	
	(9.43)	
fiscal	0.00738	0.185***
	(0.27)	(6.81)
lnpergdp	-0.0625***	0.178***
	(-3.65)	(13.38)
urb1	-0.0188**	0.203***
	(-2.59)	(5.02)
rlz	0.462	-0.435
	(0.92)	(-0.52)
cons		0.258*
		(1.93)
id	YES	YES
year	YES	YES
N	279	279
R^2	0.996	0.607

5.5. Robustness Test

To further verify the reliability of the baseline regression results, this paper conducts robustness tests from multiple perspectives, including excluding the 2020 sample severely affected by the pandemic, applying 1% bilateral winsorization to key variables, and adding financial development level (fin) as an additional control variable in the model. The regression results are shown in Table 7.(1) Excluding the 2020 sample.The coefficient of GF remains stable at 0.373 and is highly significant, indicating that the pandemic shock did not change the direction and significance of the conclusion.(2) 1% bilateral winsorization.To reduce the impact of outliers on the regression analysis, all variables are winsorized at the 1% level. As

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shown in Column (2), the promoting effect of green finance on industrial structure optimization is still significant at the 1% level, proving that the results are robust.(3) Adding financial development level (fin) as a control variable.Referring to the method of Sheng Qiaoyan [32], fin is added to the model. The coefficient of GF decreases to 0.297 and the significance level drops to 5%, but it remains significantly positive, indicating that the conclusion is highly robust.

Table 7 Robustness Test Results

	(1)	(2)	(3)
	Excluding 2020 Sample	1% Bilateral Winsorization	Adding Control Variable fin fin
GF	0.373***	0.372***	0.297**
	(3.27)	(3.27)	(2.47)
fiscal	0.181***	0.161*	0.106
	(3.07)	(1.94)	(1.34)
lnpergdp	-0.102***	-0.106**	-0.0846*
	(-2.98)	(-2.29)	(-1.76)
urb1	-0.0112	-0.0120	-0.0113
	(-0.71)	(-1.01)	(-1.09)
rlz	2.660***	2.547**	1.836
	(2.65)	(2.55)	(1.64)
fin			0.0355**
			(2.14)
cons	3.322***	3.368***	3.134***
	(8.50)	(6.52)	(5.90)
id	YES	YES	YES
year	YES	YES	YES
N	279	310	310
F	14***	10***	11***
r^2	0.971	0.972	0.974

5.6. Heterogeneity Analysis

This paper divides the 31 provinces into eastern, central, western, and northeastern regions in accordance with the classification of the National Bureau of Statistics. The regression results are shown in Table 8.The results indicate that the regression coefficients of the western and northeastern regions are significantly positive at the 1% level, while those of the eastern and central regions are not significant. This may be because these regions have a relatively weak economic foundation, greater demand for development, and stronger urgency and implementation of relevant policies. In contrast, the economic development of the eastern and central regions is relatively mature, so the effect of fiscal policies may be milder.In addition, the regression coefficients of the eastern, western, and northeastern regions are positive, whereas that of the central region is negative. This may be because the economic development of the three regions lags behind, so the stimulus effect of government fiscal policies is more significant and plays an obvious role in promoting the economy. The negative coefficient in the central region may stem from its mature economic development, the diminishing marginal effect of fiscal policies, and even problems such as inefficient fiscal expenditure and restricted market vitality caused by excessive reliance on fiscal policies, which in turn exert a negative impact on the economy.Thus, Hypothesis H3 of this paper is verified.

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Table 8 Heterogeneity Analysis

variable	(1)	(2)	(3)	(4)
	IS	IS	IS	IS
GF	0.154	-0.131	0.372***	1.436***
	(0.144)	(0.365)	(0.138)	(0.279)
fiscal	0.311***	-0.594	0.043	-0.135
	(0.073)	(0.508)	(0.082)	(0.092)
lnpergdp	-0.005	-0.434***	-0.206***	0.075
	(0.043)	(0.091)	(0.063)	(0.070)
urb1	0.006	-0.251	0.422	-0.019
	(0.010)	(0.648)	(0.300)	(0.011)
rlz	3.834***	9.069**	2.685**	5.867***
	(1.192)	(3.989)	(1.241)	(1.558)
cons	2.358***	7.227***	4.217***	0.897
	(0.502)	(1.056)	(0.714)	(0.719)
N	100	60	120	30
R^2	0.996	0.913	0.890	0.996

6. Conclusions and Suggestions

Based on the panel data of 31 provinces in China from 2014 to 2023, this paper conducts an empirical analysis and explores the mechanisms and paths through which green finance promotes industrial structure upgrading via environmental regulation. The results show that both green finance and environmental regulation have a significant positive impact on industrial structure upgrading. The mediating effect test indicates that environmental regulation plays an intermediary role between green finance and industrial structure upgrading. By directly restricting the behaviors of high-polluting enterprises, environmental regulation not only promotes the development of green industries but also enhances the incentive effect of green finance, further advancing the greening of the industrial structure. Heterogeneity analysis shows that there are significant differences in the relationship between green finance and industrial structure upgrading across different regions. The positive impact of green finance on industrial structure upgrading is more significant in the western and northeastern regions, while it is not significant in the eastern and central regions. Based on the above conclusions, the following policy recommendations are put forward:

(1) Strengthen and improve green finance policies: The government should continue to strengthen the guidance of green finance policies and provide more financial support, tax incentives, and policy incentives. To promote the development of green industries, the government can increase the innovation of green financial products such as green credit, green bonds, and green funds. Meanwhile, it should improve relevant laws and regulations to reduce the financing costs of green industries and help enterprises transform and upgrade. In particular, in the field of low-carbon and sustainable development, the government should encourage financial institutions to increase support for green projects and promote the improvement of the green financial ecosystem.

(2) Optimize environmental regulation measures: The role of environmental regulation in promoting the development of green industries cannot be ignored. The government should continue to strengthen the enforcement of environmental regulations while avoiding excessive intervention. Moderate market-oriented incentive policies should be promoted, which can not

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only promote innovation in environmental protection in regions but also ensure the effective application of green technologies. To maximize the effect of environmental regulation, the government should flexibly adopt different types of environmental regulation measures (such as command-and-control, market-incentive, and voluntary types) according to the characteristics of different industries.

(3) Promote the differentiation of regional policies: In view of the differences in green finance and environmental regulation policies across regions, it is recommended that policymakers formulate relevant policies in a targeted manner based on the economic development level of each region, the demand for green transformation, and the adaptability of green finance and environmental regulation. Especially in the central region, efforts can be made to reduce reliance on traditional industries and enhance the role of market mechanisms in resource allocation, rather than simply relying on government financial incentives. For regions with weak economic foundations, it is necessary to further strengthen policy implementation and the guidance of green financial products to help them break through the bottleneck of green transformation.

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References

[1] Zhang Zhenhua, Chen Xi, Wang Jing, et al. The Impact of Green Finance Reform and Innovation Pilot Zone Policy on Carbon Emissions——A Quasi-Experimental Study Based on Panel Data of 282 Cities[J]. China Population, Resources and Environment, 2024, 34(02): 32-45.

[2] Li Su, Zhao Jun, Da Tanfeng. An Empirical Test of the Impact Mechanism of Green Finance on Industrial Green Development[J]. Statistics & Decision, 2024, 40(14): 137-143.

[3] Li Chenggang. Heterogeneity Study on the Impact of Green Finance on High-Quality Economic Development[J]. Journal of Guizhou Normal University (Social Sciences Edition), 2025, (04): 65-75.

[4] Ganesh L, Kusuma S, Radhakumari D, et al. Financing a Greener Future: Analyzing the Integral Role of Green Finance in Environmental Protection [J]. MATEC Web of Conferences, 2024, 392: 01046.

[5] Ding Ning, Gao Jing, Wu Xiao. Research on the Environmental Governance Effect of Green Finance——Empirical Evidence from Chinese Cities[J]. Journal of Business Economics, 2025, (04): 87-100.

[6] Zhan Shuke, Wang Renzeng, Liu Yaobin. The Impact of the Coordination between Fintech and Green Finance on Industrial Structure Upgrading——From the Perspective of Heterogeneous Environmental Regulation[J]. China Population, Resources and Environment, 2023, 33(11): 152-162.

[7] Hou Jianming, Zhu Kefei, Wang Shanzhu. The Impact Mechanism of Green Finance on the Development of Ecological Urbanization in China[J]. China Population, Resources and Environment, 2024, 34(11): 23-35.

[8] He Guosheng, Liu Rongbing. Research on Regional Differences and Influencing Factors of Green Finance Development in China[J]. Journal of Guangxi University (Philosophy and Social Sciences Edition), 2024, 46(05): 100-112.

[9] Li Yangyang. Research on the Impact of Environmental Regulation on China's High-Quality Economic Development[D]. Jilin University, 2023.

[10] Sun Jingbing, Meng Yuling. Research on the Spillover Effect of Heterogeneous Environmental Regulation on Regional High-Quality Economic Development[J]. Statistics & Decision, 2022, 38(13): 122-126.

[11] Tian Shuying, Guo Hao. The Impact and Mechanism of Different Environmental Regulation Tools on Carbon Emission Performance[J]. Journal of Natural Resources, 2025, 40(03): 812-832.

ISSN: 2710-0170

[12] Yang Yanfang, Cheng Xiang. Research on the Impact of Environmental Regulation Tools on Corporate Green Innovation[J]. China Soft Science, 2021, (S1): 247-252.

[13] Yue Wei. Research on the Impact of the Coordination between Green Finance and Environmental Regulation on the High-Quality Development of the Manufacturing Industry[D]. Dongbei University of Finance and Economics, 2024.

[14] Li Jiajia, Li Siyuan. The Impact of Heterogeneous Environmental Regulation on the Green High-Quality Development of Transportation Enterprises[J]. China Population, Resources and Environment, 2025, 35(04): 122-134.

[15] Dai Xiang, Hua Xiaoye, Lin Jinguan. Environmental Regulation, Green Total Factor Productivity and Economic Growth——The Economic Logic of Harmonious Coexistence between Man and Nature[J]. Economic Review, 2025, (03): 66-86.

[16] Liu Rongzeng, He Chun. Research on the Threshold Effect of Environmental Regulation on Urban Residents' Income Inequality[J]. China Soft Science, 2021, (08): 41-52.

[17] Shen Kaiyan, Shi Bingchen, Fu Dajun. The Impact of Environmental Regulation and Tax Incentives on the Innovation Efficiency of China's New Energy Vehicle Enterprises[J]. Journal of Beijing Institute of Technology (Social Sciences Edition), 2024, 26(06): 84-97.

[18] Hu Jianbo, Xiang Gang, Chen Xing. Environmental Regulation, Green Technology Innovation and Carbon Emission Efficiency in the Yangtze River Delta Urban Agglomeration[J]. Journal of Soochow University (Philosophy and Social Sciences Edition), 2024, 45(06): 42-54.

[19] Guo Anhui, Han Limin. The Impact of Environmental Regulation and Industrial Agglomeration on the Green Innovation Efficiency of High-Tech Industries[J]. Statistics & Decision, 2025, 41(02): 173-178.

[20] Yu Xulan, Zhou Ying. Green Credit Policy and Green Transformation of High-Pollution Enterprises: From the Perspective of Emission Reduction and Development[J]. Journal of Quantitative & Technical Economics, 2023, 40(07): 179-200.

[21] Li Hang. Research on the Impact of Green Finance Development on the "Greenwashing" Behavior of Heavy-Pollution Enterprises[J]. Scientific Decision-Making, 2024, (09): 80-96.

[22] Meng Dabin, Li Xinyu, Li Lei. Green Finance Policy and Financing Costs of "Two High" Enterprises——The Intermediary Response of Green Innovation under Signaling Game[J]. Science & Technology Progress and Policy, 2024, 41(18): 23-32.

[23] Su Chong. Green Finance Development, Financing Costs and Corporate Green Innovation[J]. Communication of Finance and Accounting, 2024, (10): 57-62.

[24] Hu Jie, Zhang Xue'er. The Impact of Green Finance Development on Green Technology Innovation of Industrial Enterprises——An Empirical Study Based on Listed Companies[J]. Science and Technology Management Research, 2025, 45(06): 185-196.

[25] Zhao Zeyue, Cui Jianjun. How Does Green Finance Dynamically Empower Agricultural Green Innovation in China?[J]. Journal of Northwest A&F University (Social Sciences Edition), 2025, 25(04): 127-135.

[26] Liu Guangyong. Research on the Impact of Green Finance on the Technological Innovation Efficiency of the Manufacturing Industry[J]. Journal of Technology Economics and Management Research, 2023, (12): 81-85.

[27] Li Chunsheng, Lu Lile. Digital Economy, Factor Substitution Elasticity and Industrial Structure Upgrading[J]. Statistics & Decision, 2025, 41(09): 117-122.

[28] Li Jianming, Wang Dandan, Liu Yuncai. Has the Construction of High-Speed Railway Network Promoted the Upgrading of China's Urban Industrial Structure?[J]. Industrial Economics Research, 2020, (03): 30-42.

[29] Wang Wenjie, Kang Yumei. The Impact of New Quality Productivity and Industrial Structure Upgrading on Common Prosperity[J]. Statistics & Decision, 2024, 40(18): 10-15.

[30] Ma Dongdong, Cai Yuying, Li Guifang. Environmental Regulation, Digital Economy and Green Total Factor Productivity——Empirical Evidence from the Central Plains Urban Agglomeration[J]. Ecological Economy, 2025, 41(04): 169-176.

ISSN: 2710-0170

[31] Wen Zhonglin, Ye Baojuan. Mediation Effect Analysis: Methods and Model Development[J]. Advances in Psychological Science, 2014, 22(05): 731-745.

[32] Sheng Qiaoyan. Green Finance Innovation Empowers High-Quality Development of the Real Economy: Impact Effects and Mechanisms[J]. Statistics & Decision, 2024, 40(24): 122-126.