The Impact of Green Finance Development on Industrial Structure Upgrading—— Evidence from 244 Prefecture-Level Cities in China

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Abstract. In the alteration of China's industrial structure, it is crucial to promote the green upgrading of traditional industries and the cultivation of new green industries. Therefore, on the basis of panel data from 244 prefecture-level cities in China from 2016 to 2023, The effect of green finance development on industrial structure upgrading is empirically analyzed in this paper using a two-way fixed effects model (TFE). The results indicates that green financial development significantly promotes industrial structure upgrading. Heterogeneity analysis shows that the promoting effect is more pronounced in underdeveloped regions and eastern regions. The innovative points of this paper lie in breaking through the traditional perspective of financial development, focusing on the impact of green finance development instead of finance development on industrial structure upgrading, and creatively employing prefecture-level city data for research. This study provides important references for formulating green financial development plans scientifically, clarifying its development direction, and boosting the systematic upgrading of the industrial structure in an orderly manner.

Keywords: Green Finance Development, Industrial Structure Upgrading, Prefecture-Level Cities, China.

1. Introduction

Green finance, served as a financial model with the role of promoting the harmonious coexistence of the environment, economy, and the society., is commonly perceived as a powerful means to achieve structural transformation and green economic growth receiving significant attention from governments around the world[1]. In 2016, France passed an energy transition law mandating financial institutions to disclose climate carbon risks, as well as the United Kingdom formed a task force and developed a green finance standard. From 2016 to 2024, under the G20 framework, Germany, Argentina, Indonesia, and other successive presidencies have promoted the topic of green finance, expanded research on sustainable finance, and constructed a framework for transition finance. In 2024, China, the European Union, and Singapore jointly released the "Multilateral Sustainable Finance Common Classification Directory" to enhance standard interoperability. These practices fully demonstrate the strategic consensus and proactive actions of governments in various countries towards the expansion of green finance.

At the stage of upgrading industrial structure, China attaches great significance to aligning green finance with industrial structure. In 2016 and 2024, the *Guiding Opinions on Building a Green Financial System* and the *Guiding Opinions on Further Strengthening Financial Support for Green and Low-Carbon* Development were successively published by the People's Bank of China and six other departments. Both documents proposed improving policy instruments including green bonds, insurance, and credit, guiding funds towards clean energy, energy conservation, environmental protection, and other green industry sectors, and advancing the industrial structure transition for green and low-carbon development.

The majority of current literature studies the effect of financial development on industrial structure optimization. In terms of theoretical research, Raymond (1969)[2] points out that the development of finance can boost industrial structure upgrading, and deeply dissected the intrinsic correlation between the two through capital, technology and other elements. In terms of empirical research, Neusser and Kugler (1998)[3], Wurgler(2001)[4], and Pradhan et al. (2015)[5] discover that financial development has a constructive contribution to industrial upgrading. While Marcel Jänicke (2001)[6] claims that the relationship between the two evolves with different economic stages, and the financial industry needs to dynamically optimize according to adjustments in the industrial structure. It is evident that the academic research on the association between industrial structure upgrading and financial development is abundant.

In recent years, partial literature has begun to study the mechanism of green financial development on the advancement of industrial structure. The existing literature is mainly based on provincial-level and enterprise-level figures. Wang et al. (2021)[7] believe that green finance exerts the greatest driving force on the tertiary industry and promotes the upgrading of industrial structure using provincial evidence. Zhang (2023)[8] confirms green finance indirectly stimulate upgrading of industrial structural by mitigating carbon emissions through provincial panel data. Xiong et al. (2023)[9] likewise assert that a regional development imbalance between industrial structure optimization and green finance based on provincial data. At the enterprise level, He and Liu. (2023)[10] reveal that the optimization of green enterprises is facilitated by green finance through enhancing their debt financing capacity and inhibiting the financing of heavy polluters from a micro perspective. In general, current research is dominated by the provincial and enterprise levels, while the city-level exploration is still relatively lacking.

Comparing with the existing literature, this essay provides the following marginal contributions.

First, this paper concentrates on the impact of green financial development on the industrial structure upgrading. Most of the current literature primarily discusses the relationship between industrial structure and financial development[5-6], leaving the green financial development undiscussed in-depth. Nevertheless, the development of green finance plays an essential role in promoting sustainable economic development and facilitating the upgrading of industrial structures towards greening and low-carbonization[11]. Therefore, this paper highlights the channels of green financial development on the optimization of industrial structure.

Second, this essay undertakes research on urban evidence, expanding the research boundary of green finance empowering the upgrading of industrial structure. Most existing research utilizes the provincial or enterprise dimension[8][10], with insufficient attention paid to the city dimension. Cities are not only the key nodes of the regional economy, but also the core carriers of implementation of green development strategy. And there are significant ecological, industrial, and policy differences between cities[12]. Cities perform a unique and critical role in capturing the different trajectories of green finance, assisting in resource allocation, risk control, and promoting the implementation of policies. Consequently, this research is developed from city level. Based on this, this paper conducts further heterogeneity analysis from both economic and geographic location dimensions to discover the differentiated effect of green finance on empowering industrial structure upgrading, which provides empirical support for the green capital attraction policy of prefecture-level cities.

The outline of empirical analyses is as Figure1.

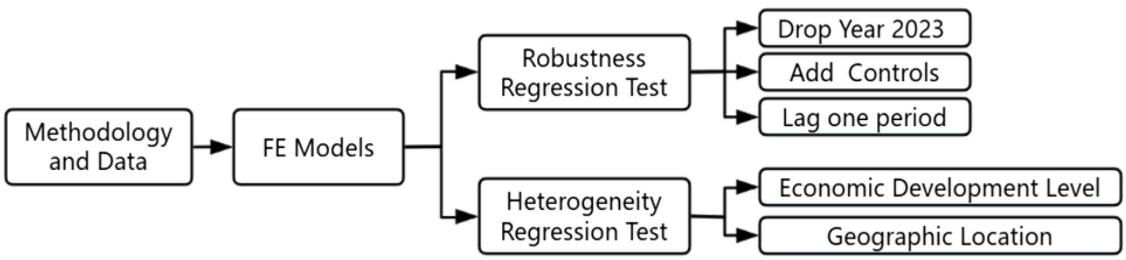

Figure 1. Flowchart of empirical analysis

2. Theoretical Foundations and Research Hypotheses

The research is supported by the externality theory, Clark's law and the theory of capital leverage and resource reallocation to measure the function of green financial development on the upgrading of industrial structure.

The theory of externality[13] is proposed by the British economist Pigou, claiming the effects of production or consumption behavior on the non-market price mechanism of third parties in economic activities. That is means traditional industries commonly generate negative externalities, while the green industry possesses positive externalities. According to the theory of externality, green finance supports green industries with positive externality, restrains traditional industries from negative externality, corrects market failure and optimizes industrial structure by means of green credit, green bonds and so on.

Clark's law[14] is proposed by Colin Clark. With the economic development, the workforce sequentially shifts from the primary sector to the secondary and tertiary sectors, reflecting the pattern of evolution of industrial structure. This essay utilizes the law to study the function of green finance on industrial structure upgrading. In other words, green finance impels the emergence of green industries, stimulates the transformation of the industrial structure from the traditional resource-dependent and highly polluting type to the technology-intensive and environmentally friendly type, which is in conformity with the law of evolution of industrial structure advanced and rationalization revealed by the law.

Due to the capital leverage and resource reallocation theory, green finance plays a leveraging role and resource reorganization function. In terms of capital leverage, green finance transforms overcapacity and highly polluting industries into green industries through guiding capital by decapacitating and deleveraging capacity. In the aspect of resource allocation, the reasonable capital allocation and credit ratio decline the green industry financing cost, raise the market share of green industry, enhance the efficiency of bank transformation, and drive the upgrading of industrial structure[15].

Referring to the above theories, the following hypotheses are formulated:

H1: The development of green finance has a driving effect on the industrial structure upgrading.

3. Data and Model

3.1. Variables

3.1.1 Independent Variable

This study establishes a green bond index (*GRB*) to proxy the level of regional green finance development. On the one hand, the Chinese government has launched a series of policies (https://www.gov.cn/xinwen/2015-12/22/content_5026636.htm et.al) recently to favor the development of green bonds, which are considerable in scale and growing at a rapid rate. On the other hand, data on green bonds at the urban level is more easily accessible, while data on other green financial instruments at the city level is relatively difficult to obtain, because issuers of green bonds are mostly commercial banks and corporations, which disclose more details. Hence, this essay selects the green bond index as a kind of proxy variable to measure green finance development, and the research on it is advantageous in terms of both practical value and feasibility.

3.1.2 Dependent Variable

On the basis of the above theories, the following hypotheses are formulated. Given that this study utilizes city-level data, it draws on the research of He and Zheng (2023)[16], selecting industrial structure advancement (*ADV*) as the dependent variable to show the level of industrial structure upgrading. It represents the trend where the primary industry's share in the economy shrinks, and the secondary, especially the tertiary sector's shares expand as the national economy progresses. A two-step methodology is adopted in this paper to compute industrial structure advancement. First, the paper segments GDP by the three major sectors to form a spatial vector $\boldsymbol{X}_0 = (x_{1,0}, x_{2,0}, x_{3,0})$. Subsequently, the paper calculates the angles θ_j (j = 1,2,3) between $\boldsymbol{X}_0$ and the vectors $\boldsymbol{X}_1 = (1,0,0)$, $\boldsymbol{X}_2 = (0,1,0)$, $\boldsymbol{X}_3 = (0,0,1)$ representing each sector, using the formula(1):

$$\theta_j = arccos \frac{\sum_{i=1}^{3}(x_{ij} \times x_{i0})}{\left\{\left(\sum_{i=1}^{3}(x_{ij}^2)^{\frac{1}{2}} \times \sum_{i=1}^{3} x_{i0}^2\right)^{\frac{1}{2}}\right\}} \tag{1}$$

In the second step, the paper utilizes the formula(2):

$$Advance_{it} = \sum_{k=1}^{3}\sum_{j=1}^{k}\theta_{ijt} \tag{2}$$

where, $Advance_{it}$ denotes the degree of industrial advancement value of city *i* in time *t*, with a higher degree reflecting a more advanced structure.

3.1.3 Control Variable

Besides the development of green finance, there are many other variables that also have an effect on the industrial structure upgrading. Reference to Zeng et al.(2025)[17], Zhang and Sun(2025)[18] and Xu and Lin(2024)[19], this study utilizes the following control variables: *FDI, URB, STE, EDU*, and *ECO*. Among them, FDI is the ratio of actual foreign direct investment to GDP, representing the scale of foreign direct investment relative to the economy. *URB* is the ratio of the urban population to the total population, indicating the level of urbanization. *STE* is the ratio of local fiscal expenditure on science and technology to local general public budget expenditure, reflecting the local government's investment in science and technology. *EDU* is the proportion of local educational fiscal expenditure to local general public budget expenditure, reflecting the investment intensity of local governments in education. *ECO* is the logarithmic value of per-capita GDP,embodying the degree of economic development. All variables are displayed in the Table 1.

Table.1. Variables and description

Variables		Description	Sources
Dependent Variable	*ADV*	Industrial Structure Advancement	NBS(National Bureau of Statistics)
Independent Variable	*GRB*	Aggregate Issuance Amount of Green Bonds / Total Bond Issuance Amount	Wind database
Control Variable	*FDI*	Actual Foreign Direct Investment / GDP	Wind database
	URB	Urban Population / Total Population	NBS
	STE	Local Fiscal Expenditure on Science and Technology / Local General Public Budget Expenditure	NBS
	EDU	Local Fiscal Expenditure on Education / Local General Public Budget Expenditure	NBS
	ECO	ln(Per Capita GDP)	NBS

3.2. Data

3.2.1 Data Processing

This research employs panel data from 244 cities in China from 2016-2023 to develop the analysis, and the reasons for choosing this are as follows. One is that in 2016, Shanghai and Shenzhen launched the pilot(https://www.sse.com.cn/, https://www.szse.cn/index/index.html), since then the state has intensively issued relevant regulations, which means that China's green bond market has entered a booming stage. Thus it is more policy timely to use that year as the starting point of the study(https://www.mee.gov.cn/gkml/hbb/gwy/201611/t20161124_368163.htm et al.). Another is that the figure period allows for the acquisition of a more detailed sample information of these prefecture-level cities. The dataset of this essay is mainly derived from the China Urban Statistical

Yearbook, Wind database and the National Bureau of Statistics. Furthermore, this survey utilizes the interpolation method to process the *ADV, URB, STE, EDU, ECO* variable data and take the logarithm of *ADV* to vertify the reliability and accuracy of the analysis results. The processed results for each variable are *ADV* (1944), *GRB* (1179), *FDI* (1929), *URB* (1944), *STE* (1944), *EDU* (1944), *ECO* (1944). The absence of samples arises because certain prefecture-level cities have not disclosed the relevant data.

3.2.2 Descriptive Statistics of Variables

The descriptive results are shown in the Table 2. In this study, the mean value of *ADV* is 6.7175, with a standard deviation of 0.3018, demonstrating that the overall degree of *ADV* in the target cities is stable, and the dispersion among cities is low. However, the difference in extreme values (5.9607-7.8361) suggests that there are gaps in *ADV* among different cities. The average value of *GRB* is only 0.0301, with a standard deviation of 0.1221, meaning that the proportion of green bonds in the overall bond issuance is generally low. Meanwhile, there are large differences in the proportion of green bond issuance among cities: the minimum value of 0 indicates that some cities did not issue green bonds during the sample period, while the maximum value of 1.6667 shows that the proportion of green bond issuance in certain cities is relatively high, reflecting the uneven participation of cities in the green bond market.

Table.2. Summary statistics

Variable	Obs	Mean	Std.dev.	Min	Max
ADV	1,939	6.7175	0.3018	5.9607	7.8361
GRB	1,179	0.0301	0.1221	0.0000	1.6667
FDI	1,929	0.0028	0.0049	0.0000	0.0614
URB	1,919	0.4014	0.2335	0.0346	1.0000
STE	1,938	0.0227	0.0222	-0.0001	0.2091
EDU	1,934	0.1693	0.0389	0.0146	0.3465
ECO	1,930	11.0572	0.4970	9.7060	15.6752

Nots: This table reports the summary statistics of variables in this industry

3.3. Model

The following fixed-effect model is constructed in this study to test how green finance development impacts industrial structure upgrading.

$$ADV_{it} = \beta_0 + \beta_1 GRB_{it} + \beta_k \boldsymbol{X}_{it} + \mu_i + \theta_r + \epsilon_{ti} \quad (3)$$

where, ADV_{it} represents the industrial structure advancement of city *i* in period *t*.$\beta_0$is the intercept term. GRB denotes the level of green financial development for city *i* in period *t*. $\boldsymbol{X}_{it}$ indicates the control variable vector. μ_i and θ_r serve as the city fixed effect and the time fixed effect severally. ϵ_{ti} shows the term of random error.

4. Results and Discussion

4.1. Benchmark Regressions Results

The benchmark regression results are presented in the Table 3. After incorporating city fixed effects and time fixed effects, in columns (1)-(5), the impact of *GRB* on *ADV* is significantly positive at the 10% level. Columns (1)-(5) respectively present the regression results of sequentially adding control variables *FDI, URB, STE, EDU*, and *ECO*. Notably, *GRB* consistently maintains significance at the 10% level across all specifications, indicating that green bonds exist a significantly positive promoting effect on the industrial structure upgrading. Xiong et al. (2023)[9], in line with the findings of this paper, also assert that green finance fosters the rationalization and industrial structure upgrading significantly by using provincial data. Similarly, He and Liu (2023)[10] , employing enterprise-level evidence,assert the development of green finance enhances the debt-raising capacity of green corporations, inhibits the debt absorption capacity of heavy polluters, and encourages industrial structure upgrading.

Table.3. Benchmark regression results

	(1)	(2)	(3)	(4)	(5)
	ADV	*ADV*	*ADV*	*ADV*	*ADV*
GRB	0.005*	0.005*	0.005*	0.005*	0.005*
	(1.73)	(1.75)	(1.75)	(1.72)	(1.72)
FDI	-0.015	-0.021	-0.021	-0.026	-0.023
	(-0.16)	(-0.23)	(-0.22)	(-0.28)	(-0.24)
URB		-0.007	-0.007	-0.006	-0.006
		(-0.72)	(-0.71)	(-0.60)	(-0.59)
STE			0.007	0.010	0.011
			(0.18)	(0.27)	(0.29)
EDU				0.027*	0.028*
				1.66	(1.70)
ECO					0.005
					(1.38)
_cons	1.959***	1.965***	1.965***	1.961***	1.907***
	(311.91)	(177.33)	(169.99)	(166.54)	(46.19)
City FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	1179	1179	1179	1179	1179
R-squared	0.9620	0.9620	0.9620	0.9621	0.9622

Note: Values in parentheses are t-statistics, and *** **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

4.2. Robustness Test Results

(1) Removing data of 2023

In 2023, China released a series of green financial policies such as the Notice on Supporting Central Enterprises to Issue Green Bonds , which promoted the development of green finance and may interfere with the relationship between the green bonds and the industrial structure (http://www.csrc.gov.cn/csrc/c100028/c7448198/content.shtml). To ensure that the regression results are not impacted by special policies, the data for 2023 was removed for testing. As shown in columns (1) to (5) of the Table 4, the results present the regression outcomes from sequentially incorporating control variables. Notably, all regression coefficients of GRB are significantly positive, which confirms the robustness of the benchmark conclusion.

Table.4. Remove the data of 2023 and Add new control variables

	(1)	(2)	(3)	(4)	(5)	(6)
	ADV	*ADV*	*ADV*	*ADV*	*ADV*	*ADV*
GRB	0.006*	0.006*	0.006*	0.006*	0.006*	0.005*
	(1.74)	(1.74)	(1.72)	(1.69)	(1.66)	(1.68)
FDI	0.060	0.062	0.063	0.053	0.068	-0.004
	(0.49)	(0.50)	(0.51)	(0.43)	(0.55)	(-0.04)
URB		0.003	0.002	0.003	0.003	-0.007
		(0.24)	(0.21)	(0.26)	(0.25)	(-0.78)
STE			-0.019	-0.016	-0.016	0.011
			(-0.47)	(-0.39)	(-0.38)	(0.32)
EDU				0.020	0.020	0.053***
				(1.07)	(1.04)	(3.11)
ECO					0.007*	0.007*
					1.89	1.91
GOV						0.004***
						(3.27)
SO_2						0.001
						(1.35)
_cons	1.958***	1.956***	1.958***	1.955***	1.873***	1.886***
	270.10	(152.32)	(146.93)	(144.25)	(41.25)	(46.72)
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	968	968	968	968	968	1160
R-squared	0.9641	0.9641	0.9641	0.9642	0.9644	0.9655

Note: Values in parentheses are t-statistics, and *** **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

(2) Adding New Control Variables

This article adds control variables *GOV* (measuring the government intervention degree) and SO_2 (measuring the degree of sulfur dioxide emission reduction, representing the level of environmental governance) to explore the potential effects of government intervention and environmental governance on the industrial structure upgrading. As presented in column (6) of Table 4, the regression coefficient of GRB remains consistent with the benchmark regression results after incorporating control variables, further validating the conclusion's reliability.

(3) One-period Lag of GRB and Control Variables.

This paper performs a one-period lag treatment on *GRB* and control variables to exclude potential reverse causality. The results are presented in the Table 5. After this treatment, the regression coefficient of the *GRB* remains significantly positive, providing strong support for the basic regression conclusion. The findings imply that green bonds have a consistent and trustworthy beneficial effect on industrial structure upgrading.

Table.5. Remove the data of 2023 and Add new control variables

	(1)	(2)	(3)	(4)	(5)
	ADV	*ADV*	*ADV*	*ADV*	*ADV*
LGRB	0.005*	0.005*	0.005*	0.005*	0.005*
	(1.82)	(1.81)	(1.84)	(1.77)	(1.77)
LFDI	-0.142	-0.139	-0.140	-0.165	-0.162
	(-1.34)	(-1.31)	(-1.32)	(-1.55)	(-1.53)
LURB		0.003	0.004	0.005	0.005
		(0.37)	(0.41)	(0.54)	(0.54)
LSTE			0.037	0.044	0.044
			(1.03)	(1.25)	(1.25)
LEDU				0.050***	0.050***
				(3.13)	(3.12)
LECO					0.001
					(0.31)
_cons	1.991***	1.988***	1.985***	1.978***	1.967***
	(318.19)	(179.37)	(172.72)	(170.24)	(50.40)
City FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	968	968	968	968	968
R-squared	0.9723	0.9723	0.9723	0.9727	0.9727

Note: Values in parentheses are t-statistics, and *** **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

4.3. Heterogeneity effect results

4.3.1 Economic development level

Based on the research by Jia et al. (2023) [20], this essay performs a heterogeneity analysis by grouping samples according to the urban financial development level. Cities with a GDP greater than or equal to the average are classified as developed regions, while those with a GDP lower than the average are categorized as underdeveloped regions. Heterogeneity analysis results are shown in the Table 6. In underdeveloped regions, the *GRB* coefficient estimate is positive and significant. while developed regions show insignificant *GRB* coefficients. This finding indicates that green bonds' effect on industrial structure upgrading differs by urban development level.

This may because in underdeveloped regions with the single-structure of the industrial structure, the dominance of traditional industries, and the urgent need for transformation, green bonds exert a significantly positive effect on industrial structure upgrading by channeling resources effectively. to be allocated to green industries and supporting green transformations. In developed regions, the industrial structure is diverse and advanced, and its upgrading relies more on scientific and technological innovation, talent, etc. With different key points of resource allocation, the effect of green bonds is less obvious[21]-[22].

4.3.2 Geographic location

This section categorizes the evidence into eastern, central, western, and northeastern regions based on the classification standards of China's National Bureau of Statistics. The results are displayed in the Table 7. In the eastern region, the *GRB* coefficient estimate is statistically significant at the 10% level and retains a positive sign, while the estimated coefficients of *GRB* in the northeastern, western and central regions are all insignificant, meeting the requirements of heterogeneity test. This result represents that the effect of green bonds on the industrial structure upgrading has significant regional geographical differences.

First, the pilot advantages of green financial policies in the eastern region reduce the issuance costs and risks of green bonds. Second, the alignment between industries and the capital allocation of green bonds helps accelerate the upgrading of industrial structure[23]. In the northeastern region, there is insufficient matching between green bond financing and funding needs of industrial transformation. In the western and central regions, traditional industries dominate, lacking incentive policies and low participation from market entities, making it difficult for green bonds to exert a promoting effect on industrial structure[7].

Table.6. Heterogeneity effect results -Economic development level

	(1)					(2)				
	Undeveloped region					Developed region				
GRB	0.008**	0.008**	0.008**	0.008**	0.008**	-0.005	-0.005	-0.005	-0.006	-0.005
	(2.10)	(2.11)	(2.11)	(2.12)	(2.13)	(-1.29)	(-1.32)	(-1.31)	(-1.34)	(-1.33)
FDI	-0.140	-0.172	-0.170	-0.173	-0.177	0.067	0.077	0.078	0.041	0.040
	(-0.87)	(-1.07)	(-1.06)	(-1.07)	(-1.09)	(0.68)	(0.78)	(0.79)	(0.42)	(0.40)
URB		-0.031*	-0.031*	-0.032*	-0.033*		0.013	0.013	0.012	0.012
		(-1.78)	(-1.75)	(-1.78)	(-1.81)		(1.33)	(1.35)	(1.29)	(1.24)
STE			0.055	0.055	0.054			0.013	0.022	0.022
			(0.58)	(0.59)	(0.58)			(0.38)	(0.65)	(0.68)
EDU				-0.010	-0.010				0.061***	0.061***
				(-0.33)	(-0.33)				(3.34)	(3.36)
ECO					-0.004					0.005
					(-0.50)					(1.23)
_cons	1.950***	1.981***	1.976***	1.978***	2.019***	1.887***	1.864***	1.863***	1.854***	1.819***
	(241.92)	(103.42)	(94.90)	(90.28)	(24.01)	(238.16)	(235.28)	(234.67)	(221.67)	(37.01)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	497	497	497	497	497	677	677	677	677	677
R-squared	0.9450	0.9455	0.9456	0.9456	0.9456	0.9717	0.9718	0.9718	0.9724	0.9724

Note: Values in parentheses are t-statistics, and *** **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

Table.7. Heterogeneity effect results -Economic development level

	(1)					(2)					(3)					(4)				
	Easten region					Northeastern region					Central region					Western region				
GRB	0.006*	0.006*	0.006*	0.006*	0.006*	0.004	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
	(1.72)	(1.74)	(1.70)	(1.72)	(1.74)	(0.32)	(0.40)	(0.33)	(0.32)	(0.29)	(0.94)	(0.95)	(0.90)	(0.90)	(0.88)	(0.76)	(0.75)	(0.72)	(0.63)	(0.72)
FDI	0.040	0.037	0.036	0.032	0.031	0.673	0.743	0.689	0.736	0.820	-0.459	-0.518	-0.515	-0.511	-0.504	-0.192	-0.209	-0.066	-0.076	0.003
	(0.57)	(0.52)	(0.51)	(0.44)	(0.44)	(0.89)	(0.95)	(0.86)	(0.86)	(0.94)	(-1.13)	(-1.27)	(-1.26)	(-1.25)	(-1.23)	(-0.34)	(-0.37)	(-0.12)	(-0.13)	(0.00)
URB		-0.004	-0.005	-0.005	-0.006		-0.040	-0.025	-0.026	-0.023		-0.024	-0.024	-0.024	-0.025		-0.006	-0.005	-0.002	-0.005
		(-0.39)	(-0.42)	(-0.42)	(-0.55)		(-0.41)	(-0.25)	(-0.25)	(-0.22)		(-1.27)	(-1.31)	(-1.30)	(-1.32)		(-0.32)	(-0.27)	(-0.11)	(-0.25)
STE			-0.042	-0.039	-0.043			0.196	0.240	0.302			-0.047	-0.047	-0.051			0.132	0.142	0.145
			(-0.99)	(-0.91)	(-1.01)			(0.53)	(0.54)	(0.66)			(-0.73)	(-0.73)	(-0.76)			(1.49)	(1.61)	(1.63)
EDU				0.017	0.021				0.027	0.012				0.006	0.004				0.032	0.034
				(0.72)	(0.89)				(0.19)	(0.08)				(0.14)	(0.11)				(1.33)	(1.39)
ECO					0.005					-0.017					-0.002					-0.006
					(1.13)					(-0.61)					(-0.23)					(-0.87)
_cons	1.964*	1.968	1.971*	1.970*	1.912*	1.883*	1.900*	1.893*	1.889	0.000	1.893*	1.872*	1.874*	1.873*	1.895*	1.828*	1.885	1.883	1.879	1.928***
	(442.90)	(163.97)	(157.26)	(154.28)	(36.27)	(131.84)	(42.57)	(40.17)	(35.84)	.	(208.66)	(97.71)	(96.91)	(91.66)	(19.23)	(184.21)	(186.90)	(186.03)	(175.54)	(21.72)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	455	455	455	455	455	53	53	53	53	53	385	385	385	385	385	286	286	286	286	286
R-squared	0.9805	0.9805	0.9805	0.9805	0.9806	0.9239	0.9244	0.9253	0.9254	0.9255	0.9058	0.9063	0.9065	0.9065	0.9065	0.9764	0.9764	0.9767	0.9768	0.9769

Note: Values in parentheses are t-statistics, and *** **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

5. Conclusions and Policy

5.1. Conclusions

Utilizing panel data from 244 prefecture-level cities over the 2016–2023 period in China, this study empirically investigates how green financial development impacts industrial structure upgrading. Results imply that green financial development boosts the upgrading of industrial structure. This impact persists even after accounting for multiple control variables. Heterogeneity analysis shows that in less-developed regions, where industrial structures are singular and transformation demands are pressing,the development of green financial notably speeds up industrial structure upgrading. Conversely, its effect is weaker in developed regions. In the eastern region, strengths like policy backing and a strong match between industrial structure and green financial investment fuel the advancement of industrial structure upgrading driven by the development of green finance. However, in the northeastern, central, and western areas, this effect is insignificant due to constraining factors.

5.2. Policy

According to the above conclusions, it is necessary to systematically promote the deep coordination between industrial structure upgrading and green finance. First, the government should continuously expand the scale of the green bond market. Through measures such as optimizing the issuance mechanism, reducing financing costs, and strengthening fund supervision, social capital can be guided to flow accurately into green industries, with the capital leverage effect of green finance being fully unleashed.Second, differentiated strategies need to be implemented according to regional heterogeneity characteristics. Specifically, for less developed regions, more policy support and financial subsidies should be provided, and regional green industry project databases should be established to lower the financing threshold, driving the eco-oriented restructuring of conventional industries and the development of nascent industries For developed regions, efforts should focus on integrating green finance with scientific and technological innovation, guiding funds towards high-end areas such as low-carbon technology research and development. Meanwhile, the eastern region can explore innovative models such as cross-regional green financial cooperation. On the contrary, the northeastern, central, and western regions need to improve the infrastructure of green finance, introduce special incentive policies, and cultivate green industry clusters, so as to enhance the spatial layout of the green finance and narrow the green finance empowerment gap for industrial upgrading among regions.

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