

Study on the Impact of Green Finance on Regional Coordinated Development

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Abstract. This paper is situated within the frameworks of technological innovation and industrial structural upgrading, aiming to scrutinize the impact and mechanisms of green finance in fostering regional coordinated development. Empirical findings underscore that green finance significantly promotes regional coordinated development, and this conclusion retains robustness through various stability tests. Technological innovation and industrial structural upgrading emerge as pivotal factors influencing regional coordinated development through the conduit of green finance. Moreover, the influence of green finance on regional coordinated development manifests heterogeneity, with the Eastern region exhibiting a more pronounced promotional effect. In conclusion, the paper culminates with a set of policy recommendations.

Keywords: Green finance, Regional coordinated development, Technological innovation, Industrial structural upgrading, regional heterogeneity.

1. Introduction

Due to the implementation of the reforms and opening-up policy, the Chinese economy has shown remarkable growth. In 2022, the Chinese economy expanded by 5.3%, maintaining its status as the second-largest economy globally. This achievement is particularly noteworthy considering the average annual growth rate of 9.4% over the past two years. However, accompanying this growth is the increasingly prominent contradiction between economic development and deteriorating ecological environment due to the excessive consumption of energy and resources resulting from extensive economic development. Therefore, green finance has become an inevitable requirement. Currently, China's green finance system encompasses diversified products such as green loans and green bonds, forming a wide range of varieties. According to a report from the People's Bank of China, the balance of China's foreign exchange green loans reached 28.58 trillion yuan in the third quarter of 2023. This represents a significant increase of 36.7% compared to the same period the previous year. The rise in green loans indicates a growing focus on environmentally friendly projects and sustainable development in China.

Also, the widening regional development gaps require urgent attention, not only in China but other countrys. Resolving this lack of coordination in regional development hinges on prioritizing technological innovation and industrial structure upgrades to bolster the real economy. Our findings suggest that the impacts of green finance align with the objective of achieving coordinated regional development. Therefore, investigating the role of green finance in promoting regional coordination is warranted.

Existing research suggests that the effect of green finance on the high-quality development of a region is manifested in multiple aspects. At the macro level, studies have found that green finance significantly promotes the high-quality development of regional economies [1]. From a spatial perspective, the development of green finance in China exhibits regional heterogeneity [2] [3]. Typically, regions are categorized into eastern, western, and central areas for research, finding that the effect of green finance on the economic development of the central region is most distinct [4]. At the micro level, notably, green credit products have a noticeable constrain impact on carbon emissions and pollution from enterprises [5]. Moreover, by improving the efficiency of credit resource allocation, can further stimulate high-quality regional development [6]. Also, green finance can

optimize resource allocation efficiency through fund control, encouraging technological innovation in enterprises and promoting the use of low-carbon technologies [7]. In terms of regional coordinated development, foreign studies primarily focus on factors such as the allocation of production factors, government involvement, and convenient transportation [8]. Research indicates that achieving coordinated regional development requires joint participation of the government and the market [9]. In China, relevant studies suggest that to achieve regional coordinated development, attention should be paid to "opportunity balance" rather than development timing [10]. To accomplish this goal, emphasis should be placed on the "suitability to local conditions" in policy development [11]. In conclusion, green finance advancement in China lags behind that of foreign countries [12]. Investigation on the direct effect of green finance on regional coordinated development is limited in China [13].

Based on this, the paper innovatively approaches the research perspective. Building on the foundation of technological innovation and industrial structure upgrading, it establishes a model reflecting the specific impact of green finance on regional coordinated development by constructing indicators for various variables. Through empirical research, the paper analyzes the effect of green finance on regional coordinated development and explores the regional heterogeneity of this impact.

The structure of the subsequent sections is as follows: the second part consists of theoretical analysis and research hypotheses, mainly focusing on analyzing how green finance, technological innovation, and industrial structure upgrading affect the coordinated development of regions; the third part comprises research design, including model settings, explanations of relevant variables, and data source specifications; the fourth part presents empirical results and analysis, encompassing benchmark regression, mediation analysis, heterogeneity analysis, and robustness checks; the fifth part presents research conclusions, summarizing the overall findings and offering some policy suggestions.

2. Theoretical analysis and research hypotheses

2.1. The direct impact of green finance on regional coordinated development

As shown in Figure 1, green finance promotes regional coordinated development by providing funding support, optimizing resource allocation, and managing risks.

Firstly, green finance provides funding support by directing investment towards environmentally friendly and sustainable development sectors. This encourages enterprises to invest in green industry innovation and guides funds towards energy-saving and environmental protection enterprises, thus playing a role in fund allocation. Simultaneously, it provides necessary financial support for regional coordinated development, ensuring the development of public services, enhancing people's living standards, promoting industrial upgrading and structural adjustments within regions, and driving the development of green finance and regional coordination.

Secondly, green finance optimizes resource allocation. On one hand, supported by policies, green finance can guide financial resources towards green industries. It is also more feasible to attract investor backing in capital markets, fostering the enhancement of industrial structure within regions, thus elevating regional economic efficacy and ecological environment standards, and advancing regional sustainable development. Also, green finance can encourage the development of eco-friendly consumption attitudes among consumers, improve the ecological environment, thereby improving the basic living standards of the people, and promoting regional coordinated development.

Thirdly, green finance can manage risks. Green finance plays a important role in risk management, emphasizing the assessment and management of environmental, social, and governance (ESG) risks, enhancing information transparency, facilitating supervision by government departments and market participants, achieving better management of industrial risks, maintaining market stability, and promoting green economic development, thereby achieving the goal of regional coordinated development. In conclusion, the following hypothesis is proposed:

H1: Green finance can directly promote regional coordinated development.

2.2. The mechanism of green finance in influencing regional coordinated development

2.2.1. Technological innovation

Technological innovation serves as the foundation of economic progress, driving scientific progress, and is an crucial guarantee for achieving regional coordinated development.

Green finance promotes technological innovation through various measures. Firstly, green finance provides funding to green enterprises through investment products such as green loans and green bonds, meeting the capital needs of enterprises. With financial support in the high-risk early stages of technological innovation, innovation can proceed smoothly [14]. Secondly, governmental endorsement significantly bolsters green finance, mitigating the financing hurdles faced by new energy enterprises stemming from substantial information asymmetry and inadequate supervisory oversight [15], thereby reducing enterprise information costs, alleviating resource misallocation issues, and enabling enterprises to invest more in technological innovation. Thirdly, the ongoing development of green finance has made the financing environment for heavily polluting enterprises more severe, while also leading to stronger incentives for green technological innovation in enterprises, continuously improving the level of technological advancement [16].

Meanwhile, technological innovation drives regional coordinated development. Firstly, inter-regional resource allocation is the core mechanism for promoting regional economic coordinated development [17]. Technological innovation promotes continuous improvement in social labor productivity, and only by accelerating production efficiency can energy conservation and environmental protection be more effectively achieved, realizing sustainable development, and continuously optimizing social resource allocation efficiency, thereby promoting regional coordinated development. Secondly, technological innovation can achieve overall synergy of resource elements, making regional development more balanced and gradually narrowing regional disparities, thereby achieving regional coordinated development [18]. In conclusion, the following hypothesis is proposed:

H2: Green finance promotes regional coordinated development through driving technological innovation.

2.2.2. Industrial structural upgrading

With the continuous growth of the Chinese economy, the contradiction between economic development and environmental degradation is becoming increasingly prominent. Therefore, to achieve sustainable development, upgrading the industrial structure has become crucial.

There are various ways in which green finance promotes the upgrading of industrial structures. Firstly, green finance promotes industrial structure upgrading by attracting investment. With strong government support, green finance has developed rapidly, enhancing the market competitiveness of green industries and attracting more enterprises and investors to invest, thereby incentivizing the green transformation of enterprise industrial structures and further promoting industrial structure upgrading. Secondly, green finance promotes industrial structure upgrading through resource allocation. Green finance policies restrict the funding channels of heavily polluting enterprises, allocate more credit resources to green enterprises, and lower lending standards for green enterprises, encouraging enterprises to transform into green ones, thus promoting industrial structure upgrading [19]. Thirdly, green finance promotes industrial structure upgrading, reflecting the emphasis on environmental protection and sustainable development principles. This development not only brings new profit growth points to the financial industry but also brings new momentum to market competition [20].

At the same time, industrial structure upgrading also promotes regional coordinated development. Firstly, the level of public services and infrastructure conditions are important indicators of regional coordinated development. Industrial structure upgrading promotes coordinated development by improving the level of public services and infrastructure conditions. Secondly, industrial structure upgrading increases labor productivity, raises residents' consumption levels, gradually alleviates the problem of excessive regional wealth disparity, and thereby promotes regional coordinated

development [21]. In conclusion, the following hypothesis is proposed:

H3: Green finance promotes regional coordinated development by driving industrial structure upgrading.

The mechanism and pathway diagram of this paper is shown in Figure 1:

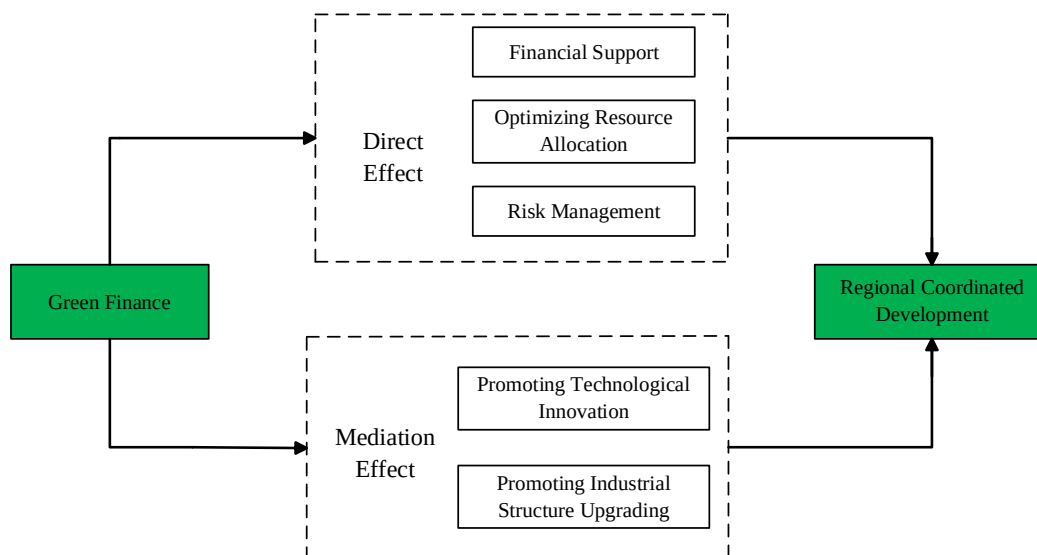


Figure 1. Mechanism and pathway

3. Approach and data

3.1. Model

3.1.1. Benchmark model

To investigate the role of green finance in regional coordinated development, we construct the following baseline econometric model:

$$RCD_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where, $i=1,2,3,\dots,N$ delegates various regions, $t=1,2,3,\dots,T$ delegates sample periods; RCD_{it} represents the regional coordinated development level of region i at time t . GF_{it} represents the green financial development level of region i at time t . X_{it} represents a set of control variables, mainly including the level of economic development (ED), the level of marketization (M), the level of human capital (HC), and the degree of openness to foreign investment (FDI); μ_i represents provincial fixed effects, λ_t represents time fixed effects, ε_{it} represents random disturbance terms, and α_1 is the important coefficient.

3.1.2. Mechanism analysis

Based on the preceding discussion, to verify the mediating effect, we constructs a transmission mechanism model of green finance on technological innovation and industrial structure upgrading, as well as a regression model of the joint influence of green finance and intermediary variables on regional coordinated development, to examine whether the mediating effect exists. The specific transmission mechanism model is as follows:

$$M_{it} = \omega_0 + \omega_1 GF_{it} + \omega_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$RCD_{it} = \varphi_0 + \varphi_1 GF_{it} + \varphi_2 M_{it} + \varphi_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Where M_{it} represents the mediating variables, namely technological innovation (Innov) and industrial structure upgrading (upgrade), ω_0 is the intercept term, and ω_1 , ω_2 , φ_1 , φ_2 , φ_3 are variable coefficients. Other settings are the same as equation (1).

3.2. Variables

3.2.1. Dependent variable

This study draws on the research findings of Liu Qiang and Li Zejin (2022). Starting from three dimensions: residents' biochemical levels, infrastructure conditions, and basic public services, the data of each indicator are standardized. The entropy weighting method is subsequently applied in calculations to derive the Regional Coordinated Development Index, thus constructing the Regional Coordinated Development Evaluation Index (RCD). The specific index construction is shown in Table 1.

Table 1. Regional Coordinated Development Index System

Primary Indicators	Secondary Indicators	Tertiary Indicators
RCD	Resident living standard	Per capita disposable income
		Per capita consumption expenditure
	Infrastructure conditions	Total urban natural gas supply
		Total water supply
		Per capita road area
		Proportion of total postal and telecommunications services
	Basic public services	Local fiscal education funds
		Number of hospital beds per ten thousand people
		Per capita public library holdings
		Proportion of local employment to end-of-year population
		Proportion of local social security expenditure to GDP

3.2.2. Independent variable

This study draws on the research findings of Meng Weifu and Liu Jinghan (2023). The Green Finance Development Index (GF) is employed as the explanatory variable. After standardizing the data for each indicator, the entropy weighting method is utilized for calculation to obtain the GF. Specific indicators are detailed in Table 2.

Table 2. Regional Coordinated Development Index System

Primary Indicators	Secondary Indicators	Tertiary Indicators
GF	Green Credit	Proportion of interest expenditure in high-energy-consuming industries
		Proportion of balance of green credit
	Green Securities	Proportion of market value of environmental protection enterprises
		Proportion of market value of high-energy-consuming enterprises
	Green Insurance	Scale of environmental pollution insurance
		Payout ratio of environmental pollution insurance
	Green investment	Proportion of investment in environmental pollution control
		Proportion of fiscal expenditure on environmental protection

3.2.3. Mediating variable

Firstly, technological innovation (Innov) is assessed by selecting the quantity of granted domestic invention patents to evaluate the level of technological innovation, followed by logarithmic

transformation.

Secondly, industrial structure upgrading (Upgrade) is inspired by the work of Xu Min and Jiang Yong (2015) [22]. The hierarchical coefficient of industrial structure is utilized to illustrate the level of industrial structure upgrading in each province. In this context, q_i delegates the output proportion of the i -th industry, and the calculated values are logarithmically transformed. The expression is as follows:

$$upgrade = \sum_{i=1}^3 q_i \times i \quad (4)$$

3.2.4. Control variable

Control variables for the selected regions include: Economic development level (ED): Assessed based on the per capita GDP of individual provinces, adjusted for purchasing power parity utilizing the per capita GDP index. Marketization level (M): Assessed using the Fan Gang Marketization Index [23]. Human capital level (HC): Assessing the human capital level by examining the ratio of higher education institution students to the overall population in each region. Degree of openness (FDI): Assessed by the proportion of total imports and exports to regional gross domestic product (GDP).

3.3. Data

The study selects 30 provinces across the nation (with partial data missing for Tibet) as research subjects. The time frame is set from 2012 to 2021. Relevant data is sourced from the Statistical Yearbooks of provinces, the China Statistical Yearbook, and the China Industrial Statistical Yearbook. Data for the calculation of green finance development indicators are sourced from the CSMAR database and EPS database.

The descriptive statistics for each variable are shown in Table 3. There is a significant difference between the maximum and minimum values of the Regional Coordinated Development Index, with a standard deviation of 0.167, indicating substantial disparities in the level of regional coordinated development across different areas. Additionally, there are significant regional differences in technological innovation, while industrial structural upgrading exhibits relatively minor discrepancies. There are also noticeable variations in the levels of economic development, marketization, human capital, and degree of openness across different regions.

Table 3. Descriptive statistics of variables

	Obser	Mean	Sd	Min	Max
RCD	300	0.333	0.167	0.103	0.910
GF	300	0.767	0.0648	0.642	0.899
Innov	300	9.705	1.365	5.697	12.40
upgrade	300	5.483	0.0534	5.220	5.647
ED	300	9.325	0.464	8.598	10.78
M	300	8.138	1.882	3.359	12.39
HC	300	0.021	0.0055	0.00852	0.0425
FDI	300	0.259	0.277	0.00757	1.441

4. Empirical results and discussions

4.1. Benchmark regression results and analysis

Table 4 presents the baseline regression results of the influence of GF on RCD. From columns (1) and (2) of Table 4, it can be observed that the regression coefficient of GF on RCD is significantly positive at the 1% level. This indicates that green finance significantly promotes regional coordinated development, thus validating hypothesis 1 of this study.

Next, the regression analysis indicates a significantly positive coefficient for ED, suggesting that the continuous improvement of economic development level is conducive to regional coordinated development. The regression analysis indicates a significantly positive coefficient for M, indicating that a higher level of regional marketization is more favorable for regional coordinated development. The regression coefficient of HC is significantly negative at the 5% level, suggesting that the improvement of regional human capital level has not effectively promoted regional coordinated development. This may be due to the lack of effective policies to attract talents in the region, leading to a significant brain drain and thereby failing to become a driving force for promoting regional economic development. The regression coefficient of FDI is significantly positive, suggesting that expanding the degree of openness is helpful to regional coordinated development. This may be attributed to an increase in foreign investment, which better promotes regional economic development.

Table 4. Results of benchmark regression

	(1)	(1)
	RCD	RCD
GF	1.359*** (0.0626)	1.397*** (0.0948)
ED		0.0798*** (0.0300)
M		0.0177*** (0.00614)
HC		-3.966** (1.859)
FDI		0.148*** (0.0473)
Constant	-0.709*** (0.0536)	-1.583*** (0.266)
Obser	300	300
Province FE	Yes	Yes
Year FE	Yes	Yes
R2	0.2731	0.7109

Note: The values within parentheses represent standard errors. The symbols *, **, and *** denote significance levels based on tests at 10%, 5%, and 1%, respectively. The same conventions apply throughout.

4.2. Intermediary effect test

4.2.1. Technological innovation

Columns (1) and (2) of Table 5 present the results of the mediation effect regression analysis for technological innovation. In Column (1), the coefficient linked to GF is significantly positive at the 1% significance level, implying that green finance supports technological innovation. In Column (2), both the coefficients of GF and Innov are significantly positive at the 1% level. Additionally, when compared to the baseline regression outcomes, the coefficient of GF has marginally decreased. This suggests that green finance can promote regional coordinated development by fostering technological innovation, thereby validating hypothesis 2.

4.2.2. Industrial structure upgrading

Columns (3) and (4) of Table 5 present the results of the mediation effect regression analysis for industrial structure upgrading. In Column (3), the coefficient associated with GF is notably positive at the 1% significance level, implying that green finance can facilitate the upgrading of industrial structure. In Column (4), both the coefficients of GF and Upgrade are positive, but the latter is not significant. Therefore, a Sobel test is conducted, yielding a calculated statistic value of $Z=2.86$, which exceeds the critical value of 0.97 at the 5% level. Moreover, compared to the baseline regression results, the coefficient of GF has slightly decreased. This suggests that green finance can promote regional coordinated development by facilitating industrial structure upgrading, thus validating hypothesis 3.

Table 5. Results of intermediary effect test

	Technological innovation		Industrial structure upgrading	
	(1)	(2)	(3)	(4)
	Innov	RCD	upgrade	RCD
GF	3.464*** (0.511)	1.363*** (0.0924)	0.243*** (0.0369)	1.380*** (0.102)
Innov		0.0318*** (0.00917)		
upgrade				0.0681 (0.154)
ED	0.384* (0.198)	0.0733** (0.0284)	0.0506*** (0.0119)	0.0763** (0.0311)
M	0.184*** (0.0352)	0.00400 (0.00703)	-0.00123 (0.00244)	0.0178*** (0.00615)
HC	-11.84 (11.91)	-4.301** (1.724)	-0.183 (0.748)	-3.965** (1.862)
FDI	-0.210 (0.256)	0.150*** (0.0457)	0.0471** (0.0183)	0.144*** (0.0479)
Constant	2.267 (1.829)	-1.686*** (0.252)	4.826*** (0.105)	-1.911** (0.786)
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obser	300	300	300	300
R2	0.5410	0.7396	0.5552	0.7114

4.3. Robustness test

The empirical results above indicate that green finance can promote regional coordinated development. This study uses a method of replacing the explained variable in order to test whether its findings are robust. Following the approach outlined by Zhong Wen and Zheng Minggui (2021) [24] in constructing the Regional Coordinated Development Index, the study replaces the Regional Coordinated Development Index with the Development and Livelihood Index (DLI). The results from the robustness test in Table 6 reveal that the regression coefficients for GF are all significantly positive, mirroring the previous findings. This suggests that green finance can significantly promote regional coordinated development, indicating the robustness of the research results.

Table 6. Results of the robustness test

	(1)	(2)
	DLI	DLI
GF	0.977*** (0.0229)	0.752*** (0.0333)
ED		0.103*** (0.0108)
M		0.0117*** (0.00222)
HC		4.928*** (0.687)
FDI		0.0546*** (0.0164)
Constant	-0.198*** (0.0254)	-1.196*** (0.0959)
Province FE	Yes	Yes
Year FE	Yes	Yes
Obser	300	300
R2	0.2764	0.9231

4.4. Heterogeneity test

Green finance manifests variances in its influence on regional coordinated development among different regions. Specifically, customized development policies should be enacted according to local conditions to achieve more effective promotion. Thus, it is essential to analyze the heterogeneity in the level of regional coordinated development resulting from green finance. Given the vast expanse of China and the inclusion of data from 30 provinces, there is considerable regional diversity in terms of economic development, transportation, level of information accessibility, etc. [25] Hence, this study partitions regions into eastern, central, and western sectors and explores the variances in the effects of green finance on regional coordinated development within these sectors.

Columns (1), (2), and (3) of Table 7 respectively present the regression results for the eastern,

central, and western regions. It can be inferred from the results that green finance significantly contributes to regional coordinated development across all regions. However, in the eastern region, the positive effect of green finance on regional coordinated development is more pronounced, while the influence in the central and western regions is roughly similar but relatively weaker.

Table 7. Results of the heterogeneity test

	(1)	(2)	(3)
	Eastern	Central	Western
	RCD	RCD	RCD
GF	1.443*** (0.156)	1.032*** (0.136)	1.116*** (0.216)
ED	0.0851 (0.0524)	-0.0964* (0.0557)	0.0848 (0.0715)
M	0.0215* (0.0113)	0.00852 (0.00881)	0.0235* (0.0142)
HC	-2.367 (3.521)	3.749 (2.819)	-2.100 (3.667)
FDI	0.0813 (0.0610)	-0.190 (0.242)	-0.368 (0.228)
Constant	-1.701*** (0.484)	0.222 (0.523)	-1.417** (0.620)
Province FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obser	120	90	90
R2	0.6879	0.6652	0.5247

5. Conclusion

As a way to support regional coordinated development, green finance plays a crucial role in promoting sustainable economic development. As a result, we can draw the following conclusions about green finance's influence on regional coordinated development: First, green finance significantly promotes regional coordinated development, and even after robustness tests this conclusion remains valid. Second, green finance has a stronger impact on regional coordinated development in the eastern region than the western and central region. Third, encouraging technological innovation and promoting industrial structure upgrading are important mechanisms through which green finance influences regional coordinated development, serving as key pathways for achieving high-quality and efficient economic.

Based on the empirical results mentioned above, the following policy directives are recommended:

First, vigorously promote the development of green finance. Regions should fully utilize their geographical and resource advantages. For example, in coastal areas of the eastern region where economic development is rapid, financial technology companies could be encouraged to utilize innovative technologies such as blockchain to promote the development of green finance. This can be achieved by providing policy support and financial assistance to foster green technological innovation. Furthermore, strengthening cooperation with other countries and international organizations can facilitate cross-border green investment and collaboration. In contrast, the green finance industry in central and western regions, which is relatively underdeveloped, needs to expedite the transition from traditional industries to green industries. This transition will facilitate the flow of human resources and capital from traditional sectors to green industries. Tailored policies can better promote the development of local green finance, thereby fostering regional coordinated development.

Second, accelerate the improvement of the green finance system. Firstly, it is essential to enact and reinforce relevant laws and policies pertaining to green finance, providing incentives such as tax breaks to encourage financial institutions and businesses to invest in and finance environmental protection and sustainable projects. Secondly, enhancing environmental information transparency for enterprises and financial institutions will enable investors and borrowers to better understand their environmental and social responsibility performance. Additionally, efforts should be made to establish evaluation standards and certification systems for green finance to ensure that investment projects meet environmental standards. Finally, establishing a robust risk management system will reduce uncertainty in investment environments and projects. Encouraging financial institutions to adopt Environmental, Social, and Governance (ESG) standards to assess and manage the

sustainability risks of investment projects is crucial.

Third, encourage technological innovation and promote industrial structural upgrading. On one hand, incentivize innovation among key participants in green finance, such as financial institutions establishing departments for innovative financial products. Strengthening government support for innovative green finance products through initiatives such as redirecting funds or implementing tax incentives is essential. Additionally, formulate policies to attract talent and enhance human capital to facilitate innovation in green products. On the other hand, drive industrial structural upgrading through measures like technological transformations and continual elimination of outdated production capacity to enhance enterprise productivity. Government departments should strongly support the green finance industry by lowering loan standards, thereby attracting traditional enterprises to undergo green transformation and industrial structural upgrading, ultimately achieving the grand goals of sustainable development and regional coordinated development.

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