

The Regional Impact Mechanism of Green Finance on the Level of Sustainable Development--Based on the panel data of Chinese s from 2011 to 2020

You Wu *

College of Economics and Management, Nanjing Forestry University, Nanjing, China, 210000

* Corresponding author: w1728628389@163.com

Abstract. With the deterioration of the global ecological environment, sustainability is gradually becoming the main theme of economic development. The promotion of green finance can help alleviate the contradiction between the environment and the economy and therefore enhance sustainable development. This paper selects panel data of each from 2011 to 2020 as the research object and explores the effects of green finance, technology development level, the urbanization process, marketization level, and economic openness on the level of sustainable development and the regional differences by using the combination weight measure, convergence test, K-means clustering, and panel data analysis. The empirical results show that the overall degree of differences in sustainable development levels among s and cities tends to decrease from 2011 to 2020. From the overall results, the positive development of green finance, technology development, urbanization, marketization, and economic openness all contribute to sustainable development; from the regional analysis results, except for the western region, the sustainable development patterns of s and cities are coordinated, and factors such as green finance still play a positive role in sustainable development. Finally, combined with the findings, this paper suggests that the relevant suggestions to achieve high-quality development nationwide.

Keywords: Green Finance, Sustainable Development Level, Panel Data Analysis.

1. Introduction

Since the Industrial Revolution, the relationship between humans and nature has undergone comprehensive and profound changes. The influence of nature on the human economy and society has tended to change from relative stability to absolute imbalance. While this change has brought great risks to economic development, it has also reminded human economic development that sustainable development must be considered. Scholars at home and abroad have conducted extensive research on sustainable development, and there is a mature system for measuring the level of sustainable development. Wang Penglong and Gao Feng et al. argued that a more open SDGs-oriented urban sustainability evaluation index system can be established using multiple data such as remote sensing and network big data [1], which provides development goals for building a new sustainable city that is inclusive, safe, and resilient. Yu Huan and Lei Min established a sustainable development evaluation system based on energy value analysis, combining green GDP with eco-efficiency research to reflect the sustainable development capacity of ecological and economic systems, and the key to improving sustainable development capacity lies in improving unit socio-economic efficiency and controlling unit integrated environmental pressure [2]. Liu Shanshan designed a two-way fixed-effects double-difference model in time and countries to investigate the radiation effects and impact paths of the Belt and Road on the sustainable development of the countries along its route [3]. Huang Tianhang et al. used the Super-SBM model, which takes into account the undesired output, to measure the sustainable development level of countries along the Belt and Road, and used the GML index to analyze the dynamic trend of the level and the reasons for the change, and further used the Tobit model to identify the main drivers of sustainable development improvement in all countries along the Belt and Road and different types of countries [4].

In recent years, green finance, as an important tool under the goal of "double carbon", is a kind of extension of traditional financial theory and has received a lot of attention from domestic scholars.

Cai Qiang and Wang Xuxu theoretically proposed that green finance has a certain impact on the development of high-quality sustainable development and constructed a spatial Durbin model to measure the interaction differences due to the disparity of economic development levels between regions [5]. Jintao Wang and Heng Huang argued that green credit can help reduce carbon emissions and thus improve sustainable development, but due to the threshold effect of environmental regulations, green credit can significantly suppress carbon emissions only when the environmental rules regime is strict [6]. The tools of green finance promote the rational allocation of various production factors in an ideal structure, improve the utilization rate of resources and reduce energy consumption, which means that greater production capacity can be achieved with the same production factors, and ultimately coordinate economic development and ecological protection.

In summary, green finance has flourished in recent years and has also produced many cutting-edge theories and studies, and sustainable development has been a development issue that has received much attention, and some connection between the two is worth exploring. The marginal contribution of this paper is as follows: (1) A comprehensive index evaluation system is established with reference to the measurement indexes established by Huijuan Wang [7] regarding the level of green finance and sustainable development, and the entropy value-Critic is proposed to obtain the combination of secondary indexes Weights and comprehensive scores. (2) The level of sustainable development was seen to be steadily improving over the decade from the discrete degree, and the fluctuation between s was gradually decreasing. Hypothesis H1 has been tested. (3) Considering that the green level and sustainable development are different in different regions, the hypothesis H2 is put forward in this paper. The panel data analysis is divided into three major regions to find out the differences in the interaction between sustainable development level and green finance in central and coastal regions, western and northern regions and therefore hypothesis H2-H5 is tested.

2. Research Mechanism

Green finance allocates more social funds to environmental protection and energy conservation projects through diversified financial instruments, provides capital financing channels for related green industries and enterprises [8], optimizes the energy consumption structure, and fundamentally alleviates the coexistence of human and nature from both environmental and energy aspects. pressure. In addition, the long-term development of green finance is conducive to gradually correcting the deviation of the government's deployment of resources, improving the quality of life and happiness of the people, and enhancing the sustainable development of cities from the social level. The signal of the times and the policy tendency to vigorously develop green finance have prompted enterprises to optimize or transform their internal production sectors with high energy consumption to bring them in line with environmental protection requirements [9]. This shows that the promotion of green finance will implicitly promote industry-wide industrial restructuring and business upgrading, leading to sustainable economic development. Based on the above paper, the following hypotheses are proposed.

H1: Green finance will significantly enhance the overall sustainable development

The level of technological development represents to some extent the level of education in this region, and in the long run, the higher the average level of education, the higher the level of knowledge and skills possessed by educated people, which leads to a more efficient combination of labor and other factors of production, resulting in increased output and economic growth. Based on the above paper, the following hypothesis is proposed.

H2: The development of science and technology will promote the level of sustainable development.

The level of marketization will affect the efficiency of resource allocation. With the increasing marketization, the market share of resource-intensive, low value-added, and low development potential industries will be continuously compressed, and the smaller and smaller survival space will inevitably eliminate some backward-capacity enterprises and thus reduce pollution emissions [10],

so the effect of green financial instruments will be different in the face of different levels of marketization. Based on the above paper, the following hypothesis is proposed.

H3: Marketization will promote the level of sustainable development.

The level of urbanization reflects the difficulty of settling in the city for workers working in the city, for example, some big cities have requirements such as years of social security payment, years of residence permit, and a high threshold of the points-based system for settlers, which discourage many people who want to settle in the city and thus obtain the rights and benefits of home purchase, medical care, and children's education, and turn to settle in smaller cities where the difficulty of settling and the cost of living are lower [11]. Based on the above this paper proposes the following hypothesis.

H4: Urbanization will promote the level of sustainable development.

The level of external openness is mainly measured by import and export trade and international capital flows. With the adoption of the 2030 Agenda for Sustainable Development in 2015, China committed to actively strengthening international cooperation to implement the 2030 Agenda for Sustainable Development. Openness promotes exchange, renewal, and change, and is the path to sustainable development. Based on the above analysis, the following basic hypothesis is proposed.

H5: Opening up to the outside world will promote the level of sustainable development.

3. Research Methodology

3.1. Variable selection

3.1.1. Explained variable

The 2015 Sustainable Development Summit adopted the "Transforming Our World: The 2030 Agenda for Sustainable Development", which provides guidance for sustainable development in countries around the world. According to Table 1, there are 20 tertiary indicators under the secondary indicators, and the evaluation system of the sustainable development level is constructed with the characteristics of localization. Considering that the entropy method can judge the information quantity and dispersion degree of indicators, and the Critic weight method can measure the size of the standard deviation of data and reflect the volatility of data and the correlation between indicators, this paper proposes a combined measurement method, i.e., the entropy method and the Critic weight method are used to measure the comprehensive level of sustainable development together.

3.1.2. Core explanatory variables

Agricultural insurance mainly provides economic protection for the risks of various accidents occurring during the production of agriculture, forestry, animal husbandry, and fishery in which the agricultural workers are involved, and the investment expenditure on energy conservation and environmental protection industry mainly reflects the proportion of capital flowing to the related industries, and the attention and investment tendency of the government and the society on energy conservation and environmental protection industry can reflect the breadth of green finance popularity to a certain extent. After standardizing the data, the entropy value method was used to measure the level of green finance.

Table 1. The evaluation system of green finance and sustainable development level

Tier 1 Indicators	Secondary Indicators	Tertiary Indicators	Nature of Indicator
Green Finance	Green Insurance	Agricultural insurance expenditure / agricultural insurance income	+
		Agricultural insurance expenditure/total insurance expenditure	+
	Green Investment	Fiscal expenditure on energy saving and environmental protection industry/total fiscal expenditure	+
		Pollution control investment/GDP	+
	Carbon Finance	Carbon Finance Total Carbon Emissions/GDP (tons per million yuan)	-
Sustainable Development	Resources	Sustainable development Resources Gas supply per capita (cubic meters)	+
		Energy consumption per unit of GDP(tons of standard coal / 10,000 Yuan GDP)	-
		Water resources per capita (cubic meters)	+
		Electricity consumption (billion kWh)	-
	Ecology	Ecology Forest coverage rate (%)	+
		Sewage treatment rate (%)	+
		Harmless domestic waste treatment rate (%)	+
		Tailpipe emission per unit of GDP (NOx emissions/GDP)	-
	Economy	Economy Disposable income per capita (yuan) +	+
		GDP per capita (yuan)	+
		Industrial structure (tertiary industry output value share/GDP)	+
		Gini coefficient	-
		Financial Inclusion Digitalization Index (%)	+
	Social	Social Unemployment rate (%)	-
		Social security and employment expenditure (million yuan)	+
		Average years of schooling (years)	+
		Green space per capita in parks (m ²)	+
		Population density (%)	-
		Number of Internet broadband access ports (million)	+
		Urban road area per capita (square meters)	+

3.1.3. Control variables

In this paper, the level of scientific and technological development (TI), the level of marketization (ML), the level of urbanization (UL) and the level of import and export (IEL) are selected as control variables for the level of sustainable development. The level of scientific and technological development is mainly measured by the number of granted patent applications, and the effect of the market environment on the efficiency of sustainable development under different technical efficiency is more significant when it is more technically efficient [12]; the level of urbanization is measured by the proportion of the urban population to the total population, and the level of urbanization usually reflects the direction of population mobility, and the degree of urban livability is an important influencing factor; the level of marketization is measured by the total marketization index.

3.2. Panel data model

Given that the panel data model can reveal the differences in the impact of explanatory variables on sustainable development in different regions, has advantages in studying dynamic adjustment, and can alleviate the problem of covariance among variables compared with other econometric models,

the data of 30 s nationwide from 2011 to 2020 are selected for panel data analysis, and the panel data model contains a mixed estimation model (POOL), a fixed effects model (FE) (FE) and random effects model (RE). The model is set as follows.

$$y_{it} = \alpha_i + \sum_{k=2}^K \beta_k x_{kit} + \varepsilon_{it} \quad (1)$$

In the above equation, t represents time, y represents sustainable development levels, x represents green finance levels, and α_i represents individual effects, i.e., the effects of all unobserved deterministic variables affecting sustainable development levels, except green finance and control variables, vary only individually but not over time. The panel data model controls for area-fixed effects and time-fixed effects, x denotes the explanatory variables for sustainable development level, β denotes the coefficients of the explanatory variables, and ε_{it} represents the random error term.

3.3. Dispersion degree

3.3.1. Theil Index

The Thiel index was introduced to measure the inequality of sustainable development levels between regions, modeled as follows.

$$Tl = \frac{1}{n} \sum_{i=1}^n \left(\frac{y_i}{y} \times \ln \frac{y_i}{y} \right) \quad (2)$$

In the above equation, y_i indicates the national average sustainable development level. The smaller the Theil Index, the smaller the difference in sustainable development level among s.

3.3.2. Coefficient of convergence and coefficient of variation

The coefficient of convergence and coefficient of variation are introduced to measure the convergence and dispersion of the sustainable development level, respectively, and the model is as follows

$$\tau = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\ln(y_i) - \frac{1}{n} \sum_{i=1}^n \ln(y_i) \right)^2} \quad (3)$$

$$CV = \frac{\sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \bar{y})^2}}{\bar{y}} \quad (4)$$

Where τ denotes the coefficient of convergence and CV denotes the coefficient of variation, both of which are smaller to indicate stronger data convergence.

4. Empirical Results

4.1. Data sources

Considering the availability of data, Tibet and Hong Kong, Macao and Taiwan are excluded, and the data of 30 s from 2011 to 2020 are finally selected for panel data analysis. The data are obtained from China Statistical Yearbook, China Urban Construction Statistical Yearbook, China Energy

Statistical Yearbook, China Environmental Statistical Yearbook, China Insurance Statistical Yearbook, China Financial Yearbook, China Industrial Statistical Yearbook, and provincial statistical yearbooks, wind database, Peking University Digital Inclusive Finance Index [13], etc. Individual missing values were filled by linear interpolation or mean value.

4.2. Sustainability index weights and measurement results

In this paper, the combined weights are obtained by the entropy method and Critic weights, and then the comprehensive index method is used to further obtain the sustainable development level and green financial development index. Due to the limitation of space, the specific results are not shown. Specifically, the national average sustainable development level jumped from 0.281181 to 0.435919 from 2011 to 2020, a significant increase. Southern China generally has a highly sustainable development level, Central China mostly shows a medium level, and Northern China produces an obvious agglomeration effect. The southern regions have maintained a high and steady level of sustainable development because they are located on the coastal economic base. From north to south, from east to west, the overall sustainable development process is in step, with the north developing more rapidly than the south and the west developing more rapidly than the east.

From the table 2, the sustainable development process is slower in the northwest, southwest, northeast, and some central s. The reason for this situation in the west is that the utilization of natural resources is inadequate and inefficient due to the backwardness of the overall level of science and technology and innovation capacity, despite the abundance of resources [14]. Combined with the variable geological and climatic conditions, harsh natural environment, and infrastructure in the west, the overall survival environment is not favorable.

Table 2. clustering results

Grade	Mean±std	Province
Low	0.211±0.025	Anhui , Gansu , Guizhou , Hebei , Henan , Hubei , Ningxia Hui Autonomous Region, Shanxi , Xinjiang Uygur , Yunnan
Relatively Low	0.282±0.009	Guangxi Zhuang Autonomous Region, Heilongjiang , Jilin , Jiangxi , Liaoning , Qinghai , Shandong , Shaanxi , Shanghai , Tianjin
Medium	0.329±0.009	Fujian , Hunan , Jiangsu , Inner Mongolia Autonomous Region, Sichuan , Chongqing
High	0.381±0.008	Beijing, Guangdong , Hainan , Zhejiang

4.3. Regional convergence analysis

From Fig. 1, the sustainable development Thayer indexes are all below 0.1 and have remained at very low levels in the past two to three years. The convergence coefficient and the coefficient of variation are at the medium variation level from 2011 to 2014 but have largely shown a decreasing trend, and gradually tend to weak variability from 2015. The General Program for Reforming the Ecological Civilization System promulgated in 2015 and the Guiding Opinions on Building a Green Financial System issued in 2016 indicate that green financial tools and related policies are continuously popularized and improved, and the policy The effects gradually spread from developed pilot areas to middle and backward regions, and regions with originally lower sustainable development levels accelerate to catch up with regions with higher sustainable development levels, so the difference between the two gradually decreases. According to the Global Sustainable Development Goals Report 2020 released by the United Nations, the reason for the slight rebound of the Thiel index, convergence coefficient and coefficient of variation in 2020 may be the impact of the COVID-19 pandemic, the rise of unemployment and poverty, the decrease of investment flow, and the severe impact of the epidemic on all aspects of the economy, health care and education, while different regions have different capacities to withstand the epidemic due to the differences in their development levels. The gap has increased briefly because of the uneven ability of different regions to withstand the epidemic due to differences in development levels.

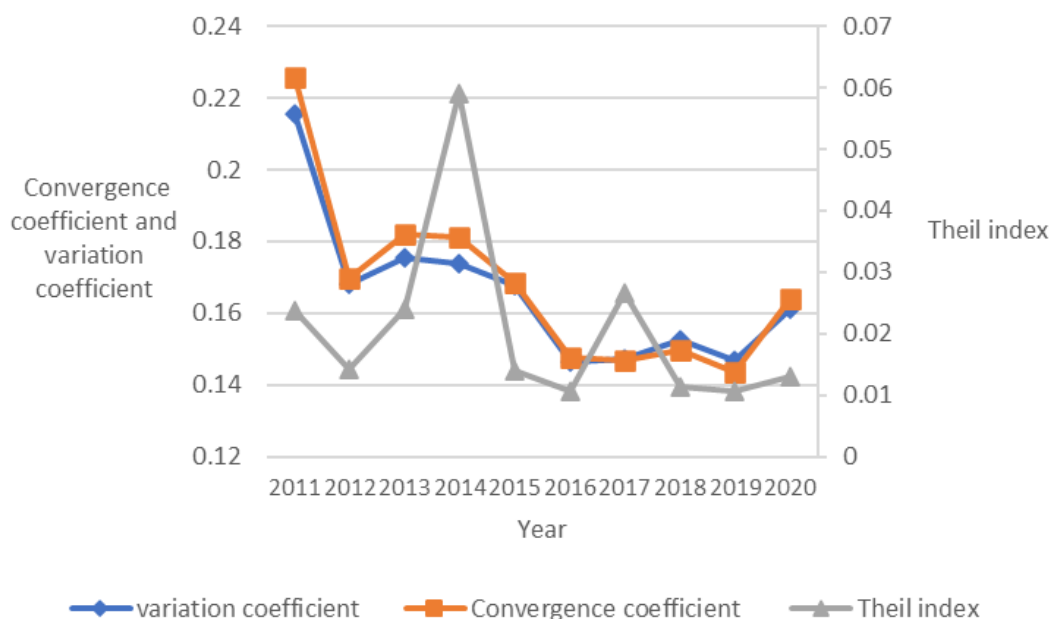


Figure 1. The trend of convergence coefficient, variation coefficient and Thiel's index

4.4. Results of panel data analysis

4.4.1. Overall regression results

The panel data were analyzed using SPSS with clustered robust standard errors, and three models were generated first, fixed effects model (FE), random effects model (RE), and mixed effects model (POOL), followed by the cardinality test, F-test, and Hausman test jointly to determine the optimal model. The baseline regression results are shown in Table 3: According to the results of F-test and Hausman test, the statistic of the F-test is 22.789 with a p-value of 0.000*** and the statistic of the Hausman test is 123.761 with a p-value of 0.000***, both with p-values, less than 0.05 and high significance level, the fixed-effects model is considered to be better than the random-effects model and the mixed estimation. The regression results of the model are better than the random effect model and the mixed estimation model, so the fixed effect model is chosen. According to Table 3, green finance has a positive impact on sustainable development, i.e., green finance has a significant role in promoting sustainable social development. The level of technological development, the level of urbanization, the level of opening to the outside world and the level of marketization all have positive effects on sustainable development at a higher confidence level, so H1-H5 have been proved.

Table 3. Panel model regression results

Index	FE	RE	POOL
GF	0.11** (2.101)	0.152*** (2.854)	-0.079* (-1.766)
TL	0.078* (1.931)	0.13* (1.847)	0.192*** (4.011)
UL	0.514*** (10.261)	0.252*** (4.531)	0.091*** (3.509)
IEL	0.08*** (3.265)	0.066** (2.334)	0.016 (0.517)
ML	0.106** (2.455)	0.145*** (3.293)	0.017 (0.499)
n	300		
F	97.416***		

Note: The values in the table are the coefficients of the explanatory variables; ***, **, and * represent 1%, 5%, and 10% significance levels, respectively; t-values are in parentheses.

4.4.2. Heterogeneity analysis

According to Table 4, the F-test statistic of North China is 11.221 and the Hausman test statistic is 123.761; the F-test statistic of Central and East China is 25.098 and the Hausman test statistic is 153.212; the F-test statistic of Northwest China is 11.221 and the Hausman test statistic is 30.658. After the F-test and Hausman test, the optimal regression models for all three regions are FE models, and all are significant at the level of 0.01.

Table 4. Results of panel data analysis for North, Central and East China

Region	North China			Central and East China		
Index	FE	RE	POOL	FE	RE	POOL
GF	0.056** (2.101)	0.078*** (2.854)	-0.04* (-1.766)	0.037* (1.233)	0.05* (1.766)	0.045 (1.063)
TL	0.078* (1.931)	0.13* (1.847)	0.192*** (4.011)	0.008 (0.166)	0.068 (1.085)	0.203*** (3.59)
UL	0.514*** (10.261)	0.252*** (4.531)	0.091*** (3.509)	0.492*** (7.62)	0.299*** (3.177)	0.084** (2.011)
IEL	0.08*** (3.265)	0.066** (2.334)	0.016 (0.517)	0.05** (1.983)	0.044 (1.412)	0.027 (0.835)
ML	0.106** (2.455)	0.145*** (3.293)	0.017 (0.499)	0.136*** (2.634)	0.115* (1.752)	-0.057 (-1.123)
n	80			150		
F	97.416***			47.156***		

For North China, green finance has a positive effect on the level of sustainable development with an impact coefficient of 0.056. The t-statistic of the significance test is 2.101, which is significant at the 0.05 level of significance, so the hypothesis H1 is confirmed. The effect of the remaining impact factors on sustainable development is also significant, and hypotheses H3-H6 are confirmed. As a whole, the eight s in North China maintain a high consistency from the level of green finance to the quality of sustainable development.

For central and eastern China, the coefficient of the effect of green finance on sustainable development is 0.037. The level of urbanization, the level of import and export, and the level of marketization can significantly contribute to the improvement of sustainable development, while the level of science and technology development fails to significantly contribute to the level of sustainable development, which may be caused by the uneven level of science and technology innovation in central and eastern China, with eastern China leading the country in the level of science and technology innovation, while The number of scientific and technological talents and innovative projects need a lot of support funds for long-term investment to achieve effective results.

Table 5. Results of panel data analysis in Northwest China

Index	FE	RE	POOL	FE(Robustness analysis)	
GF	0.004 (0.077)	-0.038 (-0.929)	-0.086*** (-3.545)	0.115** (2.298)	0.055** (2.235)
TL	0.043 (0.595)	0.087* (1.733)	0.13** (2.266)	0.087** (2.259)	0.181*** (4.728)
UL	0.312*** (4.769)	0.268*** (4.161)	0.216*** (5.932)	0.486*** (10.124)	0.584*** (10.911)
IEL	0.029** (0.817)	0.029 (0.919)	0.047 (1.035)	0.08*** (3.434)	0.106*** (4.534)
ML	0.024 (0.472)	0.01 (0.209)	-0.092** (-2.316)	0.114*** (2.761)	0.087** (2.233)
n	70			300	270
F	35.352			101.972	108.605

For the northwest region, the p-value of green finance is greater than 0.05, which has no significant effect on the level of sustainable development, because the development of green finance in the northwest region is at a preliminary stage, due to the relatively weak foundation of green industry, and thus the scale of credit investment is also small, and secondly, the traditional financial system in the northwest region is not complete compared with the developed regions, and there are still many shortcomings in the financial system.

To test the robustness of the above regression results, this paper uses two different methods for robustness testing. W1: using the mean replacement method, i.e., replacing the sustainable development level in 2020 with the average value of sustainable development water for each in the three years from 2018 to 2020, and conducting panel model regression with this data, the results show that the positive effect of green finance and control variables on the sustainable development level remains significant. w2: excluding the data in 2020, only the data from 2011-2019 A panel model analysis is conducted and the influence mechanism is found to remain stable as well, and the results of the two robustness tests are presented in the following table 5.

5. Conclusions and Recommendations

This paper adopts the entropy value method and Critic combination weights to construct an evaluation system for the comprehensive level of green finance and sustainable development, selects relevant data from 30 s in China from 2011 to 2020 for panel model analysis, and obtains the following important conclusions: (1) Controlling for the constant level of scientific and technological development, urbanization, import and export, and marketization, green finance has a significant impact on the sustainable development level of sustainable development. (2) There is a development imbalance between regions in terms of sustainable development level, and the problem of green finance is more prominent. (3) Geographically, there is heterogeneity in the mechanism of action of green finance and other influencing factors on sustainable development. (4) There is regional agglomeration at the sustainable development level. Based on the above findings, the following recommendations are given.

1. Improve the unified green finance standard system. Each region should standardize the implementation process of green finance, strengthen the strictness of green finance granting and other aspects of supervision, and clarify the mechanism of authority and responsibility. The system basis and strict implementation can guarantee green finance to maintain a safe and healthy development direction.

2. Strengthen inter-provincial cooperation and play a linkage role. From the development of green finance index in the past ten years, although the scale has been expanded, the problem of unbalanced development is prominent. The eastern coastal region can play the role of a leader, benchmark the relatively backward regions, strengthen the exchange of talent flow, and introduce each other's reasonable practical solutions to homogeneous problems, so as to produce a greater radiation effect on the surrounding areas.

3. Strengthen the deep integration of green finance and other industries. For example, in some ecologically special places, it is difficult to obtain relevant geographic information and ecological situation externally, and digital technology can help to obtain ecological information, estimate the degree of pollution, alleviate the information asymmetry between polluters and regulators [15].

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