Analysis of the Coupling Relationship between Green Finance and Rural Revitalization in Anhui Province

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Abstract: This article conducts a theoretical analysis of the relationship between green finance and rural revitalization, and builds an evaluation system using entropy method. It measures the condition of green finance and rural revitalization of 16 cities in Anhui Province during 2015 and 2022. The coupling correlation and coordination models are used to empirically study the relevance between them. The results indicate that the coupling coordination of green finance and rural revitalization in Anhui Province has been continuously improving in recent years, with an overall good level, while the differences between regions are gradually narrowing. Using a random effects model analysis, it is confirmed that the economic, financial, and population levels have a positive impact on the coupling coordination degree of the local area, while the industrial level has a negative impact. Based on this, suggestions are put forward on pushing further coordinate the development of green finance and rural revitalization.

Keywords: Green Finance; Rural Revitalization; Coupling Coordination; Random Effects

1. Introduction

The matter of agriculture, rural areas, and farmers has always been a top priority in China's modernization construction, and an essential issue related to the national economy and people's livelihood. Governments have introduced a large number of measures to promote economic development in rural areas, while also paying more attention to resource and environmental issues, striving to build modern villages that are both prosperous and livable. Entering a new stage of development, compared to conventional finance, green finance follows the concept of sustainable development and has more advantages in the rural economic growth. It is conducive to achieving the goals of optimizing and adjusting the industrial structure, creating a beautiful and livable natural environment, and upgrading people's quality of life in rural areas of China as soon as possible. Therefore, in order to accelerate the achievement of the rural revitalization strategy under the "dual carbon" goal, studying the relationship between green finance and rural revitalization has positive significance, China must attach importance to the role of green finance.

Over recent years, due to climate change and other reasons, green finance has become appealing to scholars around the world. Rasoulinezhad E, Taghizadeh Hesary F (2022) used a random effects model to study the top ten economies worldwide and demonstrated that green finance (green bonds) can significantly promote renewable energy production and reduce carbon dioxide emissions [1]. Li Xiaoxi, Xia Guang, and others (2015) believe that green finance is a new tendency for financial growth in the future. Conducting green finance is of great importance for stimulating industrial structure revolution, promoting sustainable regional economic development, and accelerating social progress[2]. The internal association between green finance and rural revitalization is a material topic being studied by Chinese scholars. Chen Fang (2018) affirmed the positive role of finance in achieving rural revitalization, while also believing that the rural financial system must be reformed[3]. Yang Lin and Zou Jiang (2019) explored the principle of how green finance can promote rural revitalization, and believed that green finance should be combined with inclusive finance and technology finance to jointly promote rural revitalization[4]. Shu Taiyi et al. (2022) discovered the coupling relationship between green finance and rural revitalization in China and found a spatial pattern that strong in the east but weak in the west[5]. Ouyang

Hongbing and Wu Xinke (2022) confirmed the positive role of green finance in rural revitalization through empirical analysis, but also pointed out that the grade of green finance in rural areas of China remains relatively low, so achieving rural revitalization is a long and arduous task[6].

2. Theoretical Analysis

2.1 Green Finance Promotes Rural Revitalization

Lack of funds is one of the biggest challenges restricting rural revitalization. Developing green finance can alleviate the shortage of funds in rural areas. Green credit can provide direct financial support for agricultural industries, promote industrial prosperity and structural improvement, thereby raising rural residents' income, narrowing the income gap between urban and rural residents. Green insurance can protect rural industries, share risks, and lead rural residents to live a prosperous life as soon as possible. Green investment has strengthened infrastructure construction, which has eased the ecological pressure in rural areas and enabled residents to enjoy a more beautiful and livable living environment. Simultaneously, green finance is a technology intensive industry, and its development brings about the gathering of highly educated talents and the upgrading of supporting facilities in education, healthcare, and other areas, which can improve the civilized appearance of rural areas.

2.2 Rural Revitalization Promotes the Deepening of Green Finance

Rural revitalization means that the industries in rural areas are thriving and the demand for funds is strong, offering a broader platform and market for the growth of green finance. The beautiful ecological environment and civilized rural culture reflect the local government's green development concept, which is a crucial policy favor for the low-carbon development of enterprises and the deepening of green finance. Effective governance not only means good rural governance, but also good results in the growth of green finance are part of the governance achievements. Its positive feedback can maximize the high profits for green finance and promote its development. As villagers live a prosperous life, their savings and investments will correspondingly increase, resulting in sufficient loanable funds and faster capital flow, thereby promoting the expansion of the green finance market and the enrichment of products. Due to previous analysis, this study proposes the following research hypothesis: green finance and rural revitalization have mutual influence, mutual promotion, and coordinated development.

3. Research Design

3.1 Data Sources and Processing

The data used in this article mainly comes from the Anhui Statistical Yearbook, statistical bulletins of cities in Anhui, and the Wind database. Firstly, standardize the data of each indicator and shift the original values by 0.001 units to ensure the mathematical significance of logarithmic operations. Then use the entropy method to assign weight of each indicator, and calculate the required index through linear weighting.

Positive indicator:

$$Y_{ijt} = \frac{max(X_{jt}) - X_{ijt}}{max(X_{jt}) - min(X_{jt})} + 0.001 \quad (1)$$

Negative indicator:

$$Y_{ijt} = \frac{X_{ijt} - min(X_{jt})}{max(X_{jt}) - min(X_{jt})} + 0.001 \quad (2)$$

Among them, i indicates the region, j indicates the indicator, and t is the time. The specific calculation of entropy method is divided into the following three steps.

Calculate feature density based on standardized data, where m is the amount of sample years and n is the amount of sample individuals. Under the jth indicator, the feature weight of the ith evaluation object in the tth year is:

$$P_{ijt} = Y_{ijt} / \sum_{t=1}^{m} \sum_{t=1}^{n} Y_{ijt} \quad (3)$$

Calculate the information entropy E_j and redundancy d_j of the jth indicator:

$$E_j = - ln(m)^{-1} \sum_{t=1}^{m} \sum_{t=1}^{n} P_{ijt} \, lnP_{ijt} \quad (4)$$

The weight of the jth indicator is:

$$W_j = \frac{d_j}{\sum d_j} \quad (5)$$

3.1.1 Green finance evaluation index system

On the basis of current situation of green finance development in rural areas of China, measured the grade of green finance development in various cities in Anhui Province from 2015 to 2022 from six dimensions: green credit, green insurance, green fiscal, green funds, green equity, and green bonds. The specific indicators selected and the weights calculated by entropy method are displayed in Table 1.

Table 1. Evaluation Index System for the Development Level of Green Finance in Anhui Province

First level indicator	Second level indicator	Indicator attribute	Entropy weight
Green credit	Credit amount for environmental protection projects/Total credit amount(%)	Positive	16.63%
Green insurance	Income from environmental pollution liability insurance/Total insurance income(%)	Positive	14.57%
Green fiscal	Fiscal expenditure for environmental protection/Total fiscal budget expenditure(%)	Positive	18.97%
Green funds	Market value of green funds/Total market value of funds(%)	Positive	15.28%
Green equity	Trading amounts of carbon trading, energy use rights trading, and emissions /Total amount of equity transactions(%)	Positive	17.73%
Green bonds	Issuance amount of green bond/Total amount of bond issuance(%)	Positive	16.82%

3.1.2 Rural revitalization evaluation index system

According to the "Rural Revitalization Strategy Plan (2018-2022)" and draws on existing research by domestic and foreign scholars, following the principles of scientific nature, rationality, and feasibility, corresponding indicators are selected from five dimensions: prosperous industry, livable environment, effective governance, civilized custom, and affluent living. The same method as the previous article is used to establish an indicator system to evaluate the level of rural revitalization in Anhui Province. The specific results are represented in Table 2.

Table 2. Evaluation Index System for Rural Revitalization Level in Anhui Province

First level indicator	Second level indicator	Indicator attribute	Entropy weight
Prosperous Industry	Total output value of agriculture, forestry, animal husbandry and fishery(Ten thousand yuan)	Positive	18.31%
	Total power of agricultural machinery(10000 kW)	Positive	20.00%
Ecological livability	Afforestation area(hm2)	Positive	24.99%
	Number of days with air quality reaching or exceeding level II/365(%)	Positive	5.96%
civilized custom	Expenditure on education, culture, and entertainment for rural residents/Total expenditure(%)	Positive	7.55%
Effective governance	Number of people receiving the minimum living allowance in rural areas	Negative	4.01%
Affluent life	Per capita disposable income of rural residents (yuan)	Positive	13.80%
	Income gap ratio between urban and rural residents (rural residents=1)	Negative	5.38%

3.2 Coupling Correlation and Coordination Model

Previous studies have shown a correlation between green finance and rural revitalization in China. However, due to differences in natural geographical environment, historical and cultural factors, and local support policies, the conditions of green finance and rural revitalization, as well as the extent of mutual influence between them, are not entirely consistent across regions. Because green finance and rural revitalization are two complex systems, this study selects the commonly used coupling correlation and coordination models to determine the relationship between the two subsystems[7], and analyzes the level of mutual correlation and coordination between green finance and rural revitalization in Anhui Province. The calculation method is as follows.

3.2.1 Coupling correlation measurement

According to the results calculated through the entropy method in the previous text, the comprehensive index of green finance is denoted as V1, and the comprehensive index of rural revitalization is denoted as V2. The coupling correlation between them is denoted as:

$$C = 2 \times \frac{\sqrt{V_1 V_2}}{V_1 + V_2} \qquad (6)$$

The range of C values is between 0 and 1. The larger the value, the higher the coupling correlation between systems, and the more synchronous the growth of green finance and rural revitalization inclines to be. This article

refers to existing literature[8] and divides the coupling correlation degree into four stages: if C does not exceed 0.3, it can be considered that the coupling correlation level between systems is very low; If C is greater than 0.3 and less than or equal to 0.5, it is in the antagonistic stage; If C is greater than 0.5 and less than or equal to 0.8, it is in the mixing stage; If C is greater than 0.8, it can be considered that the coupling correlation between the systems is exceedingly high.

3.2.2 Coupling coordination measurement

After assessing the degree of mutual influence between green finance and rural revitalization systems, it is also integral to measure the degree of coordination between them through coupling coordination. If the coordination index of them is denoted as T, then:

$$T = \alpha V_1 + \beta V_2 \quad (7)$$

Among them, α and β represent the respective weights of the two subsystems. Referring to relevant research and combined with practical situations[9], this article believes that rural revitalization is equally vital as green finance, so both are taken as 0.5. If the coupling coordination level between green finance and rural revitalization is denoted as D, then:

$$D = \sqrt{C \times T} \quad (8)$$

On the basis of existing research, this article categorizes coupling coordination into the following levels. The larger the D value, the higher the coupling and coordination between green finance and rural revitalization. Result from existing research[10], this article categorizes coupling coordination into the following levels, displayed in Table 3.

Table 3. Coupling and Coordination Levels of Green Finance and Rural Revitalization

Value of D	Level
0<D≤0.2	Serious imbalance
0.2<D≤0.4	Medium imbalance
0.4<D≤0.5	Light imbalance
0.5<D≤0.6	Primary coordination
0.6<D≤0.8	Medium coordination
0.8<D≤1	High coordination

In the following charts, the levels are referred to as SI, MI, LI, PC, MC and HC.

4. Empirical Results and Analysis

4.1 Analysis of the Development Trends of Green Finance and Rural Revitalization in Anhui Province

The green finance and rural revitalization index of sixteen cities in Anhui Province from 2015 to 2022, computed via the entropy method in the previous text, will be averaged to represent the conditions of green finance and rural revitalization in Anhui. At the same time, because there are two natural geographical boundaries between the Huaihe River and the Yangtze River in Anhui Province, and the natural environment in the north and south is obviously different, Anhui Province is divided into three regions according to its geographical location: six cities in northern Anhui (Suzhou, Bozhou, Huainan, Huaibei, Fuyang, and Bengbu), four cities in central Anhui (Hefei, Lu'an, Chuzhou, and Anqing), and six cities in southern Anhui (Wuhu, Xuancheng, Ma'anshan, Tongling, Chizhou, and Huangshan). The average values are calculated respectively to explore whether there are spatial differences in the situations and tendencies of green finance and rural revitalization in various regions of Anhui Province. For ease of analysis, the data was also visualized and plotted into several line charts.

4.1.1 Green finance

Table 4. Comprehensive Index of Green Finance Level in Anhui Province and Sub Regions

	NA	CA	SA	Average
2015	0.2687	0.2901	0.2760	0.2683
2016	0.2678	0.3350	0.2861	0.2873
2017	0.3308	0.3878	0.3508	0.3546
2018	0.3496	0.3311	0.3474	0.3314
2019	0.3130	0.3135	0.3232	0.3294
2020	0.4132	0.3120	0.3642	0.3488
2021	0.3734	0.3664	0.3792	0.3796
2022	0.4308	0.3685	0.4217	0.4209

NA, CA, SA represent to northern Anhui, central Anhui, southern Anhui respectively. From Table 4 and Figure1, it can be fond that the green finance index of Anhui Province increased from 0.2683 to 0.4209 between 2015 and 2022, showing an overall upward trend, with only a slight decrease from 2017 to 2019. From a temporal perspective, the evolution trend of green finance in Anhui and three regions is basically consistent, gradually deepening in fluctuations over time. From a spatial perspective, before 2018, the green finance level in central Anhui was in a leading position, followed by southern Anhui and the lowest in northern Anhui; This is because Hefei, the financial center and capital of Anhui Province, is

located in the central Anhui region. It has a solid base for the growth of green finance and has received policy and resource support, thus having a first mover advantage. The southern and northern regions of Anhui achieved a rebound in 2019 and 2020 respectively, and thereafter the grade of green finance in the three regions tended to be unified.

Figure 1. Development Trends of Green Finance in Anhui Province and Regions

4.1.2 Rural revitalization

Table 5. Development Index of Rural Revitalization in Anhui Province and by Region

	NA	CA	SA	Average
2015	0.2854	0.3507	0.2049	0.2715
2016	0.3165	0.3537	0.2247	0.2914
2017	0.2832	0.3750	0.2290	0.2858
2018	0.2894	0.3866	0.2497	0.2988
2019	0.3098	0.4143	0.2666	0.3197
2020	0.3467	0.4541	0.3067	0.3586
2021	0.3917	0.4796	0.3614	0.4023
2022	0.4150	0.5595	0.3923	0.4426

Figure 2. Development Trends of Rural Revitalization in Anhui Province and by Region

With analyzing Table 5 and Figure 2, it can be concluded that the rural revitalization index in Anhui Province increased from 0.2715 to 0.4426 from 2015 to 2022, and continued to steadily rise over time. The development trends in the three regions of northern, central, and southern Anhui are relatively consistent, with only a slight decline in the northern Anhui region in 2017. In terms of space, the level of rural revitalization in central Anhui has always been leading the province, followed by northern

Anhui, and the lowest in southern Anhui. The gap between southern and northern Anhui is gradually narrowing. The rural revitalization in Anhui presents a situation of "high in the north but low in the south" because northern Anhui is a traditional agricultural area with a strong agricultural foundation; central Anhui is the economic center of the province with developed industries; However, the southern Anhui region is mountainous and has limited space for agricultural development. In recent years, the southern Anhui region has vigorously developed tourism and characteristic agriculture, resulting in an increase in farmers' income[11]. At the same time, the important city of Wuhu in the region has experienced rapid economic development, which has played a driving role in enhancing the speed of rural revitalization in the southern Anhui region.

The expeditious growth of green finance and rural revitalization in various regions of Anhui Province from 2015 to 2022 can be attributed to three main reasons: firstly, the foundation of green finance and rural revitalization in the early stage was relatively weak, which easily led to high-speed growth; Secondly, green financial products like green loans, green bonds, green funds, and green insurance have developed rapidly in recent years, with a wider variety and expanding scale, providing the market with sufficient financial support and more investment tools to choose from; Thirdly, the country has released many relevant policies these years, such as the goals of peaking carbon emissions, achieving carbon neutrality, which provide strong policy favor for this trend.

4.1.3 The relationship between green finance and rural revitalization
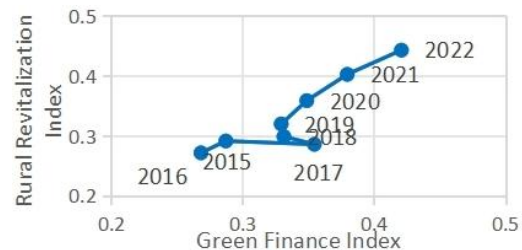

Figure 3. The Relationship between Green Finance and Rural Revitalization in Anhui Province

In Figure 3 above, the horizontal axis represents the Green Finance Index and the vertical axis represents the Rural Revitalization Index. It can be seen that although the line fluctuates, it generally presents a tortuous upward trend. It

can be preliminarily judged that there is a positive correlation between the degree of rural revitalization in Anhui and the improvement of green finance in most years. This is also the basis and prerequisite for the subsequent coupling analysis of the two systems.

4.2 Coupling Analysis of Green Finance and Rural Revitalization in Anhui Province

4.2.1 Coupling correlation degree

After calculation, the coupling correlation between green finance and rural revitalization in most cities of Anhui in the vast majority of years is greater than 0.8, indicating a high degree of interdependence between the two systems. Only Chuzhou City had a coupling correlation between green finance and rural revitalization of less than 0.8 in 2015, indicating a stage of adjustment, but it rapidly improved in the following years. From Table 6, it can be seen that the minimum coupling correlation between green finance and rural revitalization in Anhui Province during the measurement period was 0.9540 in 2015, and the maximum was 0.9883 in 2022. The degree of mutual influence between two systems continues to deepen. The coupling degree of each region fluctuates slightly, but is all greater than 0.9. By 2022, the coupling grade of the three regions of northern, central, and southern Anhui has become very close.

Table 6. Coupling Correlation between Green Finance and Rural Revitalization in Anhui Province and Various Regions

	NA	CA	SA	Average
2015	0.9417	0.9212	0.9881	0.9540
2016	0.9866	0.9359	0.9704	0.9679
2017	0.9667	0.9882	0.9665	0.9720
2018	0.9513	0.9925	0.9757	0.9708
2019	0.9963	0.9937	0.9779	0.9887
2020	0.9928	0.9773	0.9694	0.9801
2021	0.9938	0.9529	0.9846	0.9801
2022	0.9892	0.9873	0.9879	0.9883

4.2.2 Coupling coordination degree

The calculation results show that the coupling coordination extent of green finance and rural revitalization in sixteen cities of Anhui ranges from 0.3 to 0.8, with most of them in the stages of light imbalance, primary coordination, and medium coordination. Only Tongling had a medium imbalance in 2015. As of 2022, no city in the province has achieved high coordination. As shown in Table 7, the coupling coordination extent of green finance and rural revitalization in

average has increased from 0.5025 to 0.6506, and the level has risen from primary coordination to medium coordination. The coupling and coordination extent between green finance and rural revitalization in the province and various regions has steadily increased over the past eight years, and the grade of mutual coordination between the two systems has been continuously strengthened. Figure 4 clearly reflects this trend. Horizontally, the coupling coordination grade in the central Anhui has been leading since 2017, while the northern and southern Anhui are relatively lagging behind. The southern Anhui caught up from behind and basically reached the level of northern Anhui in 2019. As time go through, the gap in coupling coordination among the three regions has gradually narrowed, means that the collaborative development of green finance and rural revitalization in different regions of the province continues to deepen and spatial differences weaken. The reason is that the relevant support policies and effective measures have gradually been promoted from the regions that were the first to implement them to the whole province. The development speed of areas with better foundations, namely central Anhui, has slowed down, while the development speed of underdeveloped areas, namely southern and northern Anhui, has accelerated. As a result, the gap between different regions has narrowed, showing obvious regional convergence.

Table 7. Coupling and Coordination of Green Finance and Rural Revitalization in Anhui Province and Various Regions

		NA	CA	SA	Average
2015		0.5089	0.5321	0.4764	0.5025
		PC	PC	LI	P C
2016		0.5726	0.5203	0.4817	0.5255
		PC	PC	LI	P C
2017		0.5594	0.5963	0.5193	0.5536
		PC	PC	PC	P C
2018		0.5480	0.6008	0.5202	0.5508
		PC	MC	PC	P C
2019		0.5419	0.6289	0.5399	0.5629
		PC	MC	PC	P C
2020		0.5777	0.6210	0.5723	0.5865
		PC	MC	PC	P C
2021		0.6114	0.6257	0.6149	0.6163
		MC	MC	MC	MC
2022		0.6279	0.6960	0.6430	0.6506
		MC	MC	MC	MC

4.3 Analysis of Influencing Factors

To further investigate the influencing factors of the coupling coordination extent between green finance and rural revitalization in Anhui, this paper selects four variables: per capita GDP (X1), industrial production value (X2), rural population size (X3), and financial institution deposit and loan balance (X4), and uses Stata software to test whether they are correlated with the coupling coordination degree (Y). After proving the existence of correlation and excluding collinearity, a random effects model was used for regression, and the output results are as follows.

Figure 4. Development Trend of Coupling Coordination between Green Finance and Rural Revitalization in Anhui Province and Various Regions

Table 8. Regression Analysis Results

VARIABLES	Y
X1	0.144***
	(3.93)
X2	-0.101***
	(-4.73)
X3	0.108***
	(4.02)
X4	0.039*
	(1.66)
Constant	-2.165***
	(-5.01)
Observations	128
R-squared	0.3586

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table 8, it can be seen that there is a prominent correlation between per capita GDP, industrial production value, rural population size, financial institution deposit and loan balance, and coupled coordination. The coefficients of per capita GDP and rural population are both positive at the 1% significance level, the coefficient of the balance of deposits and loans of financial institutions is positive at the 10% significance level, and the coefficient of industrial production value is negative at the 1% significance level. This indicates that the coupling coordination extent between green finance and rural revitalization in various cities of Anhui Province is positively correlated with the local economic condition, rural population, and financial state, and negatively correlated with the industrial development situation. Therefore, the more developed the economy, population, and finance of a region, the higher the extent of coordinated development between green finance and rural revitalization, while industrial development is not conducive to improving the coupling and coordination between them.

5. Conclusions and Suggestions

This study explores the coupling relationship between the condition of green finance and the level of rural revitalization in sixteen cities in Anhui Province from 2015 to 2022 from both theoretical and empirical perspectives, and analyzes the influencing factors. The final conclusions and recommendations are as follows.

5.1 Conclusions

In terms of time, there has been a significant improvement in the state of green finance, rural revitalization, and coupling coordination between the two systems in Anhui Province from 2015 to 2022. With the support of relevant policies, the condition of green finance has deepened, and the rural revitalization strategy has taken effect. The extent of mutual influence between the two has deepened, and they are progressing together in unison. The coupling and coordination level of the whole province has not yet achieve a high-quality coordination level, and there is much room for enhancement yet. From a spatial perspective, the levels of coupling and coordination between green finance and rural revitalization in the northern, central, and southern regions of Anhui are different. However, the development trends are basically the same, and the differences between regions continue to narrow, leading to a more balanced spatial pattern. The position of green finance and rural revitalization in the central Anhui has long been leading in terms of their coupling and coordination; The levels of green finance in northern and southern Anhui is accelerating and approaching that of central Anhui; However, there is a tendency towards

solidification in the positions of rural revitalization in the three regions, with northern and southern Anhui consistently lagging behind central Anhui. The regression results of the random effects model confirm that economic, demographic, and financial levels have a positive impact on improving the coupling coordination between green finance and rural revitalization, while industrial levels have a negative impact.

5.2 Suggestions
Concluded from the research findings and the actual situation in Anhui Province, this article comes up with the following three recommendations for promoting further coordinated development of green finance and rural revitalization.

5.2.1 Optimize the rural industrial structure
The sustained high-quality development of the economy is the prerequisite and foundation for achieving green finance and rural revitalization. It is necessary to continue to prioritize economic growth and vigorously stimulate the evolution of industrial structure in rural areas. Strictly restrict high polluting and high energy consuming industries, eliminate excess production capacity, improve production processes, and support enterprises to take the path of green development; Based on local endowments, allocate resources reasonably, and encourage the healthy and rapid development of high-tech and characteristic industries.

5.2.2 Improve the green finance system
Local governments should introduce more pertinent policies and increase favors of the growth of green finance; Financial institutions should attach importance to talent introduction and technological updates, develop more green financial products that fulfill the needs of agriculture, and guide the flow of funds to rural areas; At the same time, through publicity and education, we aim to raise the environmental awareness and financial management concepts of rural residents, stimulate the initiative of the people, and elevate green finance to a common cause for all.

5.2.3 Building a multi-party collaboration platform
Guided by accelerating the growth of green finance and rural revitalization, a cross departmental and cross domain collaboration platform should be established. The government should deeply participate and strengthen exchanges and cooperation between academia and the business community. Accelerate the transformation speed from technology to products, from concepts to systems, efficiently integrate relevant resources, and foster a joint power while leveraging the advantages of various departments, so as to realize high-quality coordinated development of green finance and rural revitalization as soon as possible.

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