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DEVELOPING A GREEN ECONOMY AND INVESTING IN RENEWABLE ENERGY ALONG WITH GREEN CREDIT

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Abstract: *By analyzing 146 Chinese companies listed in renewable energy, this paper constructs a model effect threshold to study the non-linear relationship between investment in renewable energy and the economic development index from a green credit perspective. The results mainly show that: First, the impact of renewable energy investments on the green economy development index involves double-threshold effects of green credit, the effect is divided into three stages: promote, restrict and promote successively. Second, for large companies, the impact of renewable energy investments on the green economy development index involves a green credit threshold, with effect coefficients at each stage of 0.1034 and 0.0113, successively. However, for medium, small and micro enterprises, the impact of investments in renewable energies on the development of the green economy index involves the double-threshold effects of green credit, with the effect coefficients at each stage being 0.1308, 0.0033 and 0.0243, successively, and the inhibitory effect is not significant. Third, our results also show that improving spending on environmental pollution control and adjusting the industry structure contribute to increasing the rate of green economy development.*

Keywords: Threshold effect, Renewable energy investment, Green credit, Green economy development index.

Introduction

The essence of a green economy is the sustainable development of the economy with the coordinated development of the ecology and the economy. From the point of view of environmental protection, the development of a green economy will help guide traditional industrial society to achieve an energy revolution in the areas of production, circulation and consumption, so that the extensive development model of a country of "high energy consumption, high pollution and high emissions" can be changed. From the economic point of view, the “green transformation” can effectively promote the development of the process of “adjustment of the economic structure and stabilization of growth”. According to the

International Labor Organization (ILO), the development of a green economy can create about 60 million jobs worldwide. On this basis, all the countries of the world are committed to developing a green economy. The European Union (EU) launched a comprehensive green economy development plan in 2009 and invested € 105 billion to support the development of a green economy by 2013. The Obama administration quickly facilitated the passage of the recovery and reinvestment law in 2009, which mandated that this government allocate approximately USD 50 billion, of which USD 14 billion would be used for renewable energy projects to develop green energy and improve energy efficiency. Japan started advocating the idea of "Towards a low-carbon society in Japan" and proposed a specific goal to promote a low-carbon society in 2008 (He et al., 2019). China has always been active in exploring an effective model for developing a green economy: In the twelfth five-year economic and social development plan, new energy industries, such as wind power and photovoltaics, are listed as supported emerging national strategic industries. For the state, meanwhile in the 13th Five-Year Economic and Social Development Plan, "green" is one of the five development ideas aimed at promoting intensive economic development and sustainable growth.

However, the United Nations Environment Program (UNEP) indicates that financing is one of the greatest challenges in promoting the transformation of the green economy. As for China, on the one hand, the government-centered mode of financing promoted the development of the renewable energy industry in its early days, but it cannot adapt to the requirements of sustainable development (Zhao et al., 2020); On the other hand, direct financing channels are not yet developed, "green credit" continues to be the main channel for financing green projects and the main force for the construction of a green financial system. In view of the above analysis, it is of great practical importance to study the impact of green credit on the relationship between investment in renewable energy and the development of the green economy. Previous studies mainly pay more attention to the role of green credit and renewable energy investments in economic growth, energy savings and emission reduction. From a renewable energy and economic growth perspective, Altinay (2017) found that renewable energy consumption had a positive effect on economic growth. However, some researchers have concluded that renewable energy consumption does not have a significant effect on economic growth (Menegaki, 2011) and even inhibits economic growth (Ocal and Aslan, 2013). In addition, from the point of view of green credit, economic growth and energy

conservation, and the reduction of emissions, Biswas (2001) considers green credit as sustainable financing, that is, he says that banks provide financing facilities for green projects to achieve the goal of guiding sustainable projects. Development through credit means. Thompson and Cowton (2004) argue that green credit policies mean that, in the credit granting process, banks incorporate environmental information about projects and operating companies into their audit mechanism and make final loan decisions through this mechanism. . Furthermore, Zhang et al. (2019) and Pan et al. (2019) qualitatively confirmed that the development of green credit can promote green economic growth. Furthermore, when constructing a non-linear threshold panel model, Liu et al. (2016) consider that green credit regulation measures are conducive to achieving energy savings and reducing emissions under the limitations of industrial growth. Kang et al. (2016) noted that there is an inverse U-shaped curve between credit scale and carbon intensity in China, indicating that bank credit should gradually shift towards a green economy and a low-carbon economy. Sadorsky (2010) found that due to increased demand for energy consumption, financial development led to increased carbon emissions. Green credit has a negative impact on macroeconomic development (An,et al. 2014). In particular, a green credit policy could suppress investment in energy-intensive industries in the long term, and its effect in terms of adjusting the industrial structure is relatively small (Liu et al., 2015).

It should be noted that few studies have examined the relationship between green credit, renewable energy investments, and green economy development within a unified framework. In particular, Zhou (2012) stated that the enterprise is the most important issue of green investment and summarized the current situation, predicament and solution of green investment of enterprises. Ghaffari (2014) also pointed out that sustainable development is almost achieved through the implementation of the green economy concept at the global, national and corporate levels. According to previous literature review studies, the correlation between previous research and this study is presented in the following aspects. First, the role of renewable energy development and use in economic growth has been examined here. Second, the promoting effect of green credit on economic growth, energy conservation and emission reduction was studied. However, two aspects need to be investigated in more detail based on previous research, which can be described below. First, more attention is being paid to the impact of renewable energy consumption on economic growth and carbon emissions,

but the combined effect of economic growth and environmental protection has not been extensively studied. There is no research on the path to "invest in renewable energy - green economic development". Second, little research has been done on microenterprise investments in renewable energy. More importantly, the studies did not take into account the financial constraint of green credit. Overall, this study primarily helps fill the following gap. First of all, this article adopts renewable energy companies as a research object and further explores the effect of corporate investment in renewable energy on green economic development, which is a significant addition to the previous researcher in terms of investment in renewable energy and green economy. Second, from these three dimensions, such as energy consumption, environmental quality, and economic growth, this article builds a green economy development index to globally measure the level of development of China's green economy, and consider the green credit constraint and examine the different influences. investments in renewable energy in green economic development under different amounts of green credit. Third, from a micro point of view, this article analyzes the different effects of investments in renewable energy by companies of different scales on the development of the green economy, and finds that investments in renewable energy by small and medium-sized micro-enterprises and medium are the main forces to promote development. of the green economy. The rest of this article is organized as follows. The next section provides a theoretical basis on the mechanism of how green credit and renewable energy investments influence the development of the green economy, and section 3 here presents the model, variables and data. Details of the findings and discussions are presented in section 4. Finally, the conclusions and policy implications are presented in section 5.

Theoretical basis

Definitions of related concepts

July 30, 2007, to curb the indiscriminate expansion of industries characterized by high levels of energy consumption and pollution, the National Environmental Protection Office, the People's Bank of China and the Commission's Chinese banking regulator have issued joint suggestions on the implementation of environmental protection policies and regulations to prevent credit risk. It was the first time that China introduced the concept of green credit. In essence, green credit is a derivative financial tool and a means of macro control to coordinate

the financial system and environmental protection. Wang Yuanlong, former deputy director of the Bank of China International Financial Research Institute, pointed out that green credit is a series of policies, institutional arrangements and practices to promote energy saving and emission reduction through credit. He reflects that the state guides banks and other financial institutions to participate voluntarily and fulfill more social and environmental responsibilities through regulatory policies and appropriate regulatory measures. Generally speaking, first, one of the objectives of green credit is to integrate ecological environmental factors into the accounting process and decision-making of financial institutions and to help companies reduce their energy consumption. Second, green credit is a means of credit for the government and financial institutions to implement macroeconomic control. From the point of view of the Chinese reality, the introduction of green credit helps to alleviate the financing difficulties of renewable energy companies. Through differentiated services, banks can direct the flow of funds to energy saving and environmental protection industries and companies, which can more effectively promote the sustainable development of the green economy. At the same time, the development of the green credit business can strengthen the bank's ability to control risks and support energy-saving and environmental protection enterprises in a market-oriented manner, which favors the solution of the problem of delinquent loans.

In terms of “investing in renewable energy”, there is no consistent definition in existing research. Wang, et al. (2013) point out that investment in energy corresponds to the following: "to obtain future profits, investors invest in fixed assets in the field of energy production, circulation and consumption." Given the main role of companies in social production and economic growth, the research has focused mainly on the perspective of the company. More precisely, Abbasi et al. (2009) define investment in renewable energies as “investment by companies in the field of renewable energies”. Zhang et al. (2015) define it as “cash paid by renewable energy companies for the construction of fixed assets, intangible assets and other long-lived assets”. These definitions differ in terms of both the subject and the purpose of investing in renewable energy. In this perspective, in accordance with the research framework and taking into account the main role of companies in economic activities, this article defines the concept of investment in renewable energy as "the investment of renewable energy companies", which is the point of view of the subject. . A green economy is an economy that conserves resources and respects the environment. It is an economical way with low

consumption of resources, less pollution of the environment, high added value of products and intensive production methods, which means that it is necessary to take into account the two dimensions "green" and "economy". When it comes to measuring the level of green economic development, there is no consistent standard in current research. For example, the Green Innovation Index Rating System, published by the California government in the United States in 2009, establishes four first-level indicators: a low-carbon economy, energy efficiency, green technological innovation, and an economic policy system. In addition, the research group jointly organized by Beijing Normal University, Southwestern University of Finance and Economics and the Center for Economic Monitoring of the China National Bureau of Statistics produced an index of green economy development from the angle of the three dimensions: the green degree of economic growth. , the potential burden of resources and the environment, and the degree of support for government policies. Liu et al. (2015) use the System of Economic, Social and Ecological Indicators, provided by the United Nations Department of Economic and Social Affairs, to measure the development of the green economy, focusing on different dimensions, including ecological quality, renewable energies, green tourism, produced green GDP (GDP), energy intensity and greenhouse gas emissions. In general, the methods for constructing a green economy index are different from the specific indicators, but most of them pay attention to the dimensions of energy consumption, environmental quality and economic growth. This also provides a benchmark for building a green economic development index, as described below.

Path of influence of green credit and renewable energies investment in the development of a green economy

From the path of "green credit - investment in renewable energies", the objectives of the green economy are to reduce energy consumption, save energy, reduce emissions and, finally, achieve a situation of mutual benefit, economic growth and environmental optimization. The investment behavior of renewable energy companies, which represent one of the main bodies of economic activity, is related to the areas of environmental protection and the economy, and the environmental and economic benefits that result directly influence the level of development of the green economy. From a “financial investment” perspective, investing in renewable energy is essentially fund-raising behavior, requiring a funding source as collateral.

Furthermore, given the structure of corporate finance in China, the demand for domestic financing is generally low (Huang, 2010) and external financing is dominated by indirect bank credit financing methods. From the point of view of the current situation in China, green credit is the main source of financing for projects of industrial pollution control, energy saving and environmental protection. Through the allocation of credit resources and the orientation of consumption and investment behavior, green credit directly influences the level of investment in renewable energy. However, the above process can also produce a certain degree of financial loss. The first aspect of this economic loss is that the green credit guidelines enacted in 2012 make it clear that financial institutions must increase the scale of credit available to renewable energy industries. However, financial resources are limited and scarce, and preferential green credit for environmental protection projects and renewable energy industries has consumed the credit resources of other major financial institutions in the financial system. According to the basic theory of economics, this will have two consequences: (a) overinvestment in energy saving and environmental protection projects and (b) underinvestment in other entities of the economy. These essentially incorporate inefficient investments and can easily lead to "double losses of efficiency", which are not conducive to economic growth. The second aspect of the economic loss is that the development of renewable energy in China is not yet mature, with some energy saving and emission reduction technologies still in the development stage and the country is developing, depending on foreign inputs for most basic technologies. Therefore, significant investment costs are involved in technology research, development and upgrade, in addition to equipment purchase and maintenance, resulting in sunk costs and high risks. At the same time, green credit requires financial institutions to implement credit management and risk control systems that meet the characteristics of green businesses and projects. Therefore, banks should establish prudent and strict credit management and risk assessment systems in the early, mid and late stages of commissioning of credit resources, increase capital management costs and risk control and indirectly increase the cost of environmental governance.

From the path "investment in renewable energy - development of the green economy", investment in renewable energy is linked to environmental protection and economic areas, which can affect renewable energy consumption and economic growth. Thanks to numerous mediating effects, the effects are reflected in promoting economic growth, optimizing the

quality of the environment and reducing energy consumption. From a global perspective, investment in renewable energy influences the development of the economy in the end. These mediating effects include the substitution effect, displacement effect, endowment effect, and technological progress effect.

Model, variables and data

Models

Liu et al. (2020) recognized that financial development and green development show an inverted U-shaped relationship. Nouiri et al. (2019) found that the economic cost of increasing the consumption of renewable energy is asymmetric and there were differences before and after 2008. In addition, many studies have confirmed the threshold effect, known as the inflection point of the effect of financial development in the process of economic growth. Based on previous studies, this article considers that, firstly, the correlations between green credit, investment in renewable energies and development of the green economy do not have a simple linear relationship; and, second, that green credit is the presence of financial development and the development of the green economy is the deepening of economic growth. Existing studies confirm the threshold effect of financial development in the process of economic growth. Therefore, investments in renewable energy can also have the "threshold effect" of green credit on the development of the green economy, that is, with the change in green credit, the effect of investments in renewable energy on economic development green inflection points From the point of view of the research method, the threshold effect is mainly used to estimate the inflection points of the correlation of variables.

The basic idea is to estimate the possible value of the inflection point, then find the corresponding confidence interval and test it. Some researchers also use the threshold effect of the model to infer the characteristics of non-linear effects between variables, which provide the baseline for building the model in this paper. This paper constructs a threshold model to estimate the non-linear relationship between investment in renewable energy and green economic development from the perspective of green credit. Using Hansen's (2011) threshold regression method, taking variables as the inflection point of the system change, a variable that is above or below a certain threshold value can be used to measure different model

systems. The two-system threshold regression model can be expressed in the form of equations (1) and (2):

$$y_t = ß_1\, x_t + \varepsilon_{1t,}\ ifq_t \le r \qquad (1)$$

$$y_t = ß_2\, x_t + \varepsilon_{2t,}\ ifq_t \le r \qquad (2)$$

Where yt is the interpreted variable, xt is the explanatory variable, εt is the residual term, qt is the threshold variable, and r is the threshold value. When the threshold variable is less than or equal to the threshold value, the regression equation is formula (1). Otherwise, the regression equation is formula (2). We define the virtual variable It (r) = (qt ≤ r), where I(0) is an indicator function. When qt ≤ r, I = 1, otherwise I = 0. Also, we set xt (r) = xtIt (r), then equations (1) and (2) can be combined as a model (3):

$$y_t = ß\, x_t + \Theta x_{t,}\ (r) + \varepsilon_t \qquad (3)$$

Where ß = ß2, Θ = ß1 – ß2. The residual term is εt = [ε1t; ε2t [; and ß, Θ, and r are the parameters that must be estimated. After obtaining the estimated values of each parameter by regression, the residual sum of squares can be expressed as equation (4):

$$S1\ (r) = \varepsilon t\ (r).\ \varepsilon t\ (r) \qquad (4)$$

The threshold value that minimizes S1(r) in equation (4) is the optimal threshold estimation value, as shown in expression (5):

$$r = \text{argmin}S1(r) \qquad (5)$$

Based on the previous analysis, we also consider the selection of variables for the construction of the model. From the reality of economic development, many other factors in addition to the level of green credit, investment in renewable energy and other factors discussed in this paper, influence the growth of the green economy. Buzzi, et al. (2016) argues that changing the concept of development, adjusting both the energy and industrial structure, and optimizing pollution control methods can effectively promote the development of a green economy. Wu et al. (2017) indicate that there is an inverted U-shaped relationship between population density and the development of the green economy; meanwhile, the development of science

and technology can reduce energy consumption per unit and promote the development of a green economy. In view of this, this paper examines the following points: first, the factors that influence the development of the green economy can be summarized as political factors, factors of production and factors of consumption; second, these factors do not work in isolation, and the effect depends on some government support and capital contributions. The essence of green credit is the credit method, which to some extent reflects the directions of government policy and is closely related to other factors in the system. On this basis, this article takes the green economy development index, which is used to measure the level of development of the green economy, as an interpreted variable, green credit as a threshold variable, and investment in renewable energy as an explanatory variable. In addition, to make the model more reasonable based on the results of existing research, this article chooses the investment in the treatment of pollution as political factors, the technical level and the structure of the industry as production factors and the density of population as factors of consumption and uses these variables as consumption factors. Control variables to build a single threshold effect model, as shown in expression (6), and a double threshold effect model, as shown in expression (7), and choose the corresponding models depending on the threshold number test results.

$$LNGELit = \alpha_0 + \alpha_{11} LNINV_{it} [LNCRE_{it} \leq r_1] + \alpha_{12} LNINVit [LNCREit > r_1] + \alpha_2 LNIPGit + \alpha_3 LNTEit + \alpha_4 LNISit + \varepsilon it \quad (6)$$

$$LNGELit = \alpha_0 + \alpha_{11} LNINV_{it} [LNCRE_{it} \leq r_1] + \alpha_{12} LNINVit [r_2 \geq LNCREit > r_1] + \alpha_{13} LNINVit [LNCRE_{it} \leq r_2] + \alpha_2 LNIPGit + \alpha_3 LNTEit + \alpha_4 LNISit + \alpha_5 LNPSit + \varepsilon it \quad (7)$$

where i represents the year, t represents the companies and r1 and r2 are threshold values. GEIit represents the green economy development index, INVit is the investment level of renewable energy companies, α 11, α 12, α 13 are the coefficients of the effect of investment in renewable energy on the green economy under the effect of the threshold of green credit. CREit is a green loan. IPGit, TEit, ISit; and PSit are investments in pollution treatment, technological level, industrial structure and population density, respectively; and the effect coefficients are α 2, α 3, α 4; and α 5; respectively. α 0 is the intersection term and εit is the

random disturbance variable. To directly derive the elasticity, the associated variables are expressed as natural logarithms.

Variables and Data Sources

This document selects renewable energy companies in Ashare's Chinese market as samples. The internal time is from 2008 to 2019. Due to the absence of a precise definition of the renewable energy industry in the category of listed companies, this document chooses, as main samples, companies whose main activity is linked to the exploitation and use of renewable energies. Energy investment, According to the "Industry Classification Guidelines" issued by the China Securities Regulatory Commission in 2012, the selected samples are "electrical, mechanical and equipment manufacturing industries (code C38)", "power generation industries, heat, gas and water. And supply (codes D44, D45 and D46)"and"industries of ecology and environmental governance (code N77). "The selection principles are as follows:

Choose companies listed on the Chinese A-share market before December 31, 2009, Eliminate companies with incomplete data Based on the above principles, this document selects 148 companies, and the associated variables are described in Table 1.

Green Economy Development Index (IEG). It should be noted that the development of the green economy is different from the green GDP, which is obtained by deducting from the GDP the value of the depletion of natural resources and the losses due to environmental pollution. Of a green economy is a positive net effect of national economic growth. However, the level of development of the green economy in this document is the index that takes economic benefits and environmental benefits as equally important, which is the general consideration. Currently, universities do not have a recognized measure of the level of development of the green economy. Referring to Lin (2016), this article establishes the green economy index system.

Table 1: Description of the main variables and indicators of the model

Variable	indicators description
Green economy development	Index of green economy development
Green credit	Energy-conservation and environmental-protection loans balance of banks
Renewable energy investment	The cash paid by renewable energy enterprises for purchasing fixed assets, intangible assets and other long-term assets
Technical level	The number of patents granted over the years
Industrial structure	The proportion of the tertiary industry added value to GDP
investment of pollution treatment	Total investment of pollution treatment
Population density	The ratio of resident population to area

Note: We are willing to share the raw data in Excel format to those who wish to reproduce the results of this study.

The first level indicators to measure the development of the green economy are the quality of the environment, energy consumption and economic growth; the corresponding second level indicators are, respectively, the intensity of pollutant emissions per unit of GDP, energy consumption per unit of GDP and GDP per capita. The intensity of pollutant emissions per unit of GDP is calculated using the total emissions of five main pollutants [wastewater, sulfur dioxide, smoke (dust), general industrial solid waste, ammonia and nitrogen] divided by GDP. the unit is 10k t of standard coal / kM CNY. It should be noted that, the environmental bulletins have unified smoke (dust) statistics from 2011, therefore, before 2011, the smoke (dust) data was the sum of the dust and smoke data that are collected separately. Energy consumption per unit of GDP is calculated using energy consumption divided by GDP, the unit is 10k t of standard coal / kM CNY. The unit of GDP per capita is CNY. Taking X1, X2 and X3 as second level indicators, given that the aspects of "economy", "energy" and "environment" are also important for the development of the green economy, the weight of each second level indicator is 1 /3. The formula to calculate the green economy index is $GHG = \frac{1}{3} X1 + \frac{1}{3} X2 + \frac{1}{3} X3$. It should be noted that GDP per capita is a positive indicator; the higher the indicator, the higher the level of development of the green economy. However, energy consumption per unit of GDP and polluting emissions per unit of GDP are inverse indicators, which means that the higher the indicators, the lower the level of development of

the green economy. Taking this into account, the maximum and minimum normalization processes are carried out and the normalized values are 1 and 0. Let us take as an example the energy consumption per unit of GDP, after the maximum and minimum normalization process, if the values of the consumption of energy per unit of GDP is equal to 1, which indicates that, if the other conditions remain unchanged, the energy consumption per unit of GDP is the lowest and the level of development of the green economy is the highest, or vice versa. The data on energy consumption and polluting emissions come from the 2008e2019 National Environmental Statistics Bulletin published by the Ministry of Environmental Protection. The GDP data comes from the China Statistical Yearbook 2019.

-Investment in renewable energies (INV). Business investment can be divided into internal investment and external investment. Internal investment refers to funds deposited in companies for the acquisition of various assets for production and operation; includes investments in fixed assets, intangible assets and other long-term assets. External investment is investment in other units in the form of cash, materials, intangible assets, and securities such as stocks, bonds, and other securities that are not the main activity of companies. Therefore, external investment is not taken into account in this study, and internal investment in renewable energy companies can be a good measure of the level of investment in renewable energy. Based on Ji and Zhang (2019), investment in renewable energy can be expressed as the money that energy companies pay for the purchase of property, plant and equipment, intangible assets and other long-lived assets. Data on investments in renewable energy are obtained from the CCER Capital Market database.

-Green credit (CRE). The Green Credit Statistics System enacted by the China Banking Regulatory Commission in 2013 makes it clear that the current statistical caliber of green credit is the sum of two types of loans. The first refers to service loans to support projects related to energy saving, environmental protection and ecology, while the other refers to loans that support strategic emerging industries, such as energy saving, protection of the environment, new energy and new energy vehicles. Energy saving and environmental protection services projects and loans mainly comprise twelve types of loans supporting industrial energy saving, water saving and environmental protection projects, in addition to renewable energy and clean energy projects, which they cover the green credit statistics

system requirements comprehensively. Therefore, we select the balance of the banks' energy saving and environmental protection credits to measure the level of green credit. The data is derived from the 2008e2019 Bank of China Association Social Responsibility Report, published by the China Banking Association.

-Other control variables. This article selects the total investment in the treatment of pollution to measure the investment in the treatment of IPG pollution, the number of patents issued over the years to measure the technical level TE, the proportion of the value-added sector from industry to GDP to measure the industrial structure IS, and the ratio of the size of the resident population to the area to measure the population density Data on investment in pollution control were taken from the National Bulletin of Environmental Statistics 2008e2019. Data on technical level and population density are taken from China Statistical Yearbook 2017. Data on industrial structure are taken from Bulletin of National Statistics of Economic and Social Development 2008e2019.

Results and discussion

Long-run equilibrium relationship and Hausman test

Before estimating models (6) and (7), this article first tests the nature of all variables. By adopting the LLC test, the AD-Fisher test, and the PP-Fisher test based on panel data, the results indicate that all variables are stationary sequences. In addition, we use the cointegration test to judge the long-term equilibrium relationship between the related variables. The results are presented in Table 2. The results of the four tests show that there is a long-term equilibrium relationship between green credit, investment in renewable energy and the green economy development index, at the level of significance of the 1%. According to the Panel ADF -Statistic and Group ADF -Statistic statistical tests, there is also a long-term equilibrium relationship between the green economy development index and the other control variables. Based on the previous results, the model can be estimated further. Furthermore, the results of the Hausman test show (Chi-Sq value, P values of 58.0799, 0.0000) that the null hypothesis is rejected, so it is reasonable to establish a fixed effects model.

Table 2: The results of the cointegration test of the associated variables

Test method	Panel PP -Statistic	Panel ADF - Statistic	Group PP - Statistic	Group ADF - Statistic
Green economy development and renewable energy investment	17.1783* 0.0000	-17.221* 0.0000	14.3368* 0.0000	-16.6028* 0.0000
Green economy development and other control variables	5.1365 1.0000	-5.3372* 0.0000	10.0173 1.0000	-2.8332* 0.0023
Green economy development, green credit and renewable energy investment	-4.2228* 0.0000	-3.3148** 0.0943	-2.4683* 0.0068	0.1747 0.5694

Note: The values in parentheses are the P-value for each statistic. *, **, and ***indicate that the statistics are significant at 1%, 5%, and 10%, respectively.

To explore the threshold effect of green credit, we first use the likelihood ratio test to determine the number of thresholds. Based on the Hansen threshold effect test method, the test results are given in Table 3. The results show that the Lagrange multiplier statistic of an effect on a green credit threshold is 25550, 13 and the LM statistic for a two-threshold effect is 1106.69; the null hypothesis that there is no threshold and the null hypothesis that there is a threshold are both rejected at the 1% level of significance. Therefore, there are two green credit thresholds in the effect of renewable energy investment on the green economy development index, so it is reasonable to choose model (7). Also, the two threshold values for green credit are 7.1877 and 9.5945. The 95% confidence intervals for the two cut-off points are [6.7859, 7.6153] and [9.2210, 9.6832]. The two estimated threshold values ensure that the value of the LR function remains at a minimum (0), located at the lowest point of the trend, and the corresponding value below the 95% confidence interval is 7.35 It is necessary to emphasize that this article takes the logarithm of the green credit sequence before empirical testing. The original data for the two green credit threshold values of 7.1877 and 9.5945 are 132.31 kM CNY and 1468.4 kM CNY, corresponding to the years 2005 and 2011, respectively.

Table 3: Threshold effect test results

Threshold numbers	Threshold value	RSS	MSE	F-value	P-value	Critical value		
						1%	5%	10%
1	7.1872	6.8896	0.0041	25550.13	0.0000	1102	1102	1204
2	9.5943	4.0548	0.0024	1106.67	0.0000	816.2	853.1	941.6

Note: The critical value and the P-value in the table are obtained using the bootstrap method per 1000 samples. Considering the limited sampling interval in this article, the effect of three thresholds is not proven.

Estimated result of threshold effect

The estimated results of model (7) are shown in Table 4. Combining with the results of the threshold tests in Table 3, several of the conclusions of Table 4 can be drawn, as follows: 1) The values of two green credit thresholds divide the effect of investing in renewable energy on the green economy development index into three stages: The first stage is before 2005, when green credit is below 132.31k M CNY. At a 1% significance level, a 1% increase in investments in renewable energy will lead to a 0.099% increase in the Green Economy Development Index. From a practical point of view, this may be because this stage is the first stage in the development and use of renewable energy. The element substitution effect of renewable energy investments is always on the left side of the inverted U curve (Awerbuch and Sauter, 2006); thus, increased investment in renewable energies promotes diversified energy development at this time and avoids economic problems, which result from the increase in the price of fossil fuels. Therefore, it promotes economic growth. Meanwhile, the full benefits, such as economic growth, reduced energy consumption and environmental optimization, brought about by investments in renewable energy outweigh the losses. Therefore, investments in renewable energy significantly promote green economic development.

Table 4: Threshold effect results from full samples

Variable	**Coefficient**	**T statistic**	**P value**
α 11	0.0991	45.18	0.0000
α 12	-0.0148	-7.79	0.0000
α 13	0.0108	5.52	0.0000

α 2	0.5826	20.23	0.0000
α 3	-0.3925	-14.76	0.0000
α 4	7.5651	62.81	0.0000
α 5	-51.527	-35.62	0.0000
$\mathbf{R^2}$	0.9362	-	-

Note: constant term is not shown in table, same below

The second stage runs from 2005 to 2011, when green credit goes from CNY 132.31k M to CNY 1,468.4k. A 1% increase in investment in renewable energy will lead to a 0.0149% drop in the green economy development index, which means that increased investment in renewable energy has an inhibiting role in the development of the green economy. In the current situation in China, further investment in renewable energy in this phase would result in the following: First, financial resources are limited and scarce, the preference setting for credit from green renewable energy companies can reduce the amount of credit resources invested in other investments. Entities, which is not beneficial to overall economic growth. Second, due to the law of decreasing marginal compensation and the law of decreasing marginal rate of technical replacement, the substitution of elements is more difficult and expensive, the positive substitution effect decreases, and even the marginal compensation of the renewable energy supply is negative. (Qi and Li, 2017); Expanding investment in renewable energy is not beneficial for economic growth at this stage. Third, the development and use of renewable energy belong to the fields of high technology. Given the characteristics of high risk and high inputs, the risk of income and the difficulty of repayment of investment projects in renewable energy would increase, thus increasing the workload of financial institutions in risk assessment and monitoring and management of the credit allocation process. This would imply high direct costs of capital management and risk control and indirect costs of environmental governance, which would ultimately generate economic losses. In summary, the positive effect of investments in renewable energy on the development of the green economy is less than the economic losses; therefore, increased investment in renewable energy hinders the development of the green economy.

The third stage is after 2011, when green credit exceeds CNY 1,468.4 km. At the 1% level of significance, a 1% increase in investment in renewable energy will result in a 0.0109%

increase in the green economy development index. This may be due to the following reasons: First, at this stage, the scale of development and use of renewable energies increases, the resource endowment and the effect of scale are revealed more, as well as the initial cost and the operating cost of the renewable energies. Investments are drastically reduced, stimulating technological progress in renewable energy and the redeployment of components. Second, the risk assessment and prudential supervision system of financial institutions is more mature than in previous stages and, meanwhile, risk management and control costs are considerably reduced, avoiding substantial economic losses. Third, from the Chinese reality, at this point, the government has enacted a series of policies and measures to help companies invest in renewable energy and promote the development of a low-carbon economy such as additional capital subsidies for renewable energy electricity prices, renewable energy fees and valuation methods. Additionally, in the Twelfth Five-Year Economic and Social Development Plan, new energy industries, such as wind power and photovoltaics, are listed as state-backed emerging national strategic industries. The policy guidelines strongly encourage companies to invest in renewable energy and promote energy saving and emission reduction behaviors, and the final positive effect of the environmental and economic synthesis outweighs the negative effect. Therefore, the development of investments in renewable energy is useful to promote the development of a green economy. It should be noted that the effect of promoting investments in renewable energies in the development of the green economy during the third stage is less than that of the first stage, which means that after the “turning point” of the suppression of the green economy the development during In the second stage, the role of promoting investment in renewable energy in green economic development is gradually being resumed. However, due to the law of decreasing marginal compensation and the law of decreasing marginal rate of technical replacement, it still offsets some positive benefits.

2) At the 1% level of significance, each 1% increase in investment in environmental pollution control increases the green economy development rate by 0.5827%, showing that the increase in investment in the control of environmental pollution can significantly promote the development of the green economy. It also reflects the effectiveness of the implementation of environmental policies in China. The coefficient of effect of the technical level is 0.3915, which means that the improvement of the technological level cannot effectively promote the development of the green economy. Perhaps the reason is that the cycle of technical

innovation is relatively long, and the process of transforming technical advantages into terminal product advantages and eventually the development of the green economy will take a long time, the role of positive technical innovation in the development. of the green economy can not be seen in a short time. The adjustment of the industrial structure has a significantly positive effect on the development of the green economy; the coefficient of effect is 7.5657. In fact, the more balanced the industrial structure, the more rational is the allocation of factors and the higher the technical level and energy efficiency, which favors the development of the green economy. Every 1% increase in population density reduces the Green Economic Development Index by 51.2008%, which means that the higher the population density, the lower the level of development of the green economy. Perhaps this is because, when other factors are held constant, an increase in population density leads to an increase in energy consumption and deterioration in the quality of the environment, which means that the increase in the density of population inhibits the development of the green economy. To further analyze the threshold effect of green credit in the renewable energy investment process that influences the development of the green economy, this study starts from the scale attributes of renewable energy companies. According to the statistical measures for the classification of companies into large, medium, small and microscale, formulated by the National Statistics Office of China in 2011, the sample companies are divided into two groups: one group includes large companies and the other group includes medium, small and micro enterprises. We estimated them separately and found that the samples from large companies had a cut-off value, which is 7.1872. The samples of medium, small and micro-enterprises have two cut-off points, whose values are 7.1872 and 9.5943. The results of the combined estimation are shown in Table 5.

As shown in Table 5: the scale of the company affects the number of green credit thresholds and the magnitude of the effect of investing in renewable energy for the development of the green economy. There are two stages in the effect of large companies investing in renewable energy for the development of the green economy: initial promotion, followed by phase-out. At the 10% significance level, the effect coefficients are 0.1034 and 0.0113. There are three stages of the effect of investment in renewables by medium, small and micro enterprises on the development of the green economy: these are the initial promotion, the subsequent phase-out and the promotion. At the 1% level of significance, the effect coefficients in the

promotion stage are 0.1310 and 0.0244. In the elimination step, the effect coefficient is 0.0033, however, the P-value is not significant. As can be seen, the promoting effect of investments in renewable energies by large companies on the development of the economy is weaker than that of medium, small or micro companies. However, the inhibiting effect of investments in renewable energy by large companies for the development of the economy is stronger than that of medium, small or micro companies. Possible reasons for this are as follows: First, the scale of a company influences its management strategy and its ability to raise capital compared to the external financing capacity of companies, medium, small, and micro businesses. The allocation of green credit only serves to close the financing gap for companies, so providing green credit effectively stimulates investment in renewable energy and promotes green economic development.

Table 5: The results of grouped estimation

Variable	**large-sized enterprise**			**medium, small and micro-sized enterprises**		
	Coefficient	T statistic	P value	Coefficient	T statistic	P value
α 11	0.1034*	16.34	0.0000	0.1310*	11.24	0.0000
α 12	-0.0113***	-1.90	0.058	-0.0033	-0.54	0.5900
α 13	-	-	-	0.0244*	3.52	0.0010
α 2	0.1934*	3.49	0.0010	0.3725*	1.75	0.0880
α 3	-0.1098**	-2.12	0.0360	-0.2636	-1.31	0.1970
α 4	7.3032*	29.94	0.0000	7.1508*	7.79	0.0000
α 5	-37.2764*	-13.15	0.0000	-47.4305*	4.31	0.0000
R^2	0.8525			0.9075		

However, larger companies have larger funds and most of them have a solid funding base. At this point, green credit can lead to inefficient use of funds, which is not beneficial for economic growth. Second, in general, there are serious principal agent phenomena in large companies, which can easily cause overinvestment and lead to wasted resources and economic losses. Third, in order to expand their scale and market share, medium, small and micro enterprises have more competition and therefore adopt more radical business strategies than large enterprises and will be based on investment behavior. Investing in renewable energy, to strengthen your market base and make a profit. Finally, investment in renewable energies by medium, small and micro-enterprises produces positive effects of optimizing the quality of the environment, reducing energy consumption and promoting economic growth. It

also shows that medium, small and micro enterprises are the main force in promoting the development of the green economy.

Conclusions and policy implications

By constructing a green economy development index to measure the level of green economy development, taking 148 publicly traded renewable energy companies as sample data, this article builds a threshold effect model to explore the non-linear relationship between investment in renewable energy and the green economy development index from a green credit point of view. The main conclusions are as follows: first, there are two green credit thresholds of the effect of renewable energy investments on the green economy development index; the cut-off values are 7.1877 and 9.5945, respectively, in 2005 and 2011. The cut-off value divides the effect of investments in renewable energies on the green economy development index into three stages; the effect in the first stage is promotion, the effect in the second stage is inhibition, and the effect in the third stage is also promotion, although less than that of the first stage. The action coefficients in the three stages are 0.0990, 0.0149, and 0.0109. These results indicate that investments in renewable energy can effectively increase the level of development of the green economy after 2011 under the effect of the green credit threshold. Second, large companies have a green credit threshold of the effect of renewable energy investments on the green economy development index; and medium, small and micro enterprises have two green credit thresholds. The role of large companies (the coefficient of effect is 0.1034) in promoting the development of the green economy is weaker than that of medium, small or micro companies (the coefficient of effect is 0.1310), but the The inhibiting effect of large companies (the effect coefficient is 0.0113) is stronger than that of medium-sized, small or micro companies (the effect coefficient is 0.0033). This shows that medium, small and micro enterprises are the main force in promoting the development of the green economy. Third, improving spending on environmental pollution control and adjusting the industry structure leads to increasing the rate of development of the green economy, while the increase in population density greatly inhibits the increase in the rate. development of the green economy and the role of technology in promoting investment. in renewable energy has not yet been proven. Furthermore, based on the above results, regarding the policy perspective, we can also draw the following conclusions.

The development of the green economy cannot be based solely on the behavior of companies in terms of investment in renewable energy; the limitations of financial behavior must also be taken into account. Specifically, it is necessary to combine the green credit policy of the government and financial institutions, in order to maximize the promotion of the effect of investments in renewable energy in the green economy. According to the conclusions of this article, the number of green credits is more than 1,468.4 million CNY after 2011. Below this threshold, the higher the investment in renewable energy, the higher the level of development of the energy sector. The green economy is high, which means that green credit resources currently flowing into the renewable energy industry are conducive to promoting green economic development. Therefore, the government should put in place a series of incentives to support and encourage investment and financing of renewable energy. Financial institutions should build a reasonable and efficient green financial system and control the volume of green credit within the optimal investment range, so that we can guide and foster more social capital in green industries through policy and system support measures. Innovative financials, focusing on the leading role of medium, small and micro enterprises in promoting investments in renewable energy and developing the green economy, the key to this lies in: First, improve the financing environment and solve financing problems for companies and adapt green credit trends. to medium, small and micro enterprises. Second, financial institutions should improve their risk management mechanism and establish or improve their credit management and approval mechanism to meet the characteristics of medium, small and micro-enterprises, reduce risk assessment and cost management. By granting credit and avoiding economic losses. In addition, we must also pay attention to the basic elements and the leading role of large enterprises in promoting the development of investment in renewable energy and the green economy, and fully mobilize the enthusiasm of all kinds of enterprises to promote the development of the green economy.

Formulate a comprehensive and multidimensional ecological economic development policy plan based primarily on government, industry, and the public. Think carefully about the important role of investment in combating environmental pollution, conserving energy and economic growth. In addition, due to the fact that the technical level of green economy development still has a long way to go, corresponding policy incentives should be established to support the improvement of the technical level. From the industry point of view, we must

adhere to the low consumption, low pollution and high efficiency industrial adjustment guidance, and fully play its role of adjusting the industrial structure in promoting the development of the green economy.

-Ethical Approval:
No act disagree with the ethic

- Consent to Participate
All authors are consent and agree about the manuscript submission

-Consent to Publish
We agree with the journal guidelines to publish our manuscript

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Our contributions are equal in the preparation of the manuscript, but the corresponding author is the principal one in the conception and proofreading

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