Green Credit, Environmental Pollution and High-Quality Development of Green Economy

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Abstract: Based on the panel data of 30 provinces (cities and districts) in China from 2003 to 2019, this paper uses the Green Development Index System jointly formulated and released by the National Development and Reform Commission, the National Bureau of Statistics, the Ministry of Environmental Protection and the Central Organization Department to construct a comprehensive index system which can calculate the high-quality development index of green economy, and research the impact of green credit, environmental pollution and high-quality development of green economy. The results show that: (1) The improvement of green credit is conducive to promoting the high-quality development of green economy. Considering the high autocorrelation of the high-quality development of green economy, the impact of green credit on the high-quality development of green economy is still robust and does not depend on the specific metrology. (2) With Moran Index, it is found that the high-quality development of green economy has spatial characteristics. By using Spatial Dobbin Model (SDM), it is found that under both (0,1) weight matrix and geographical distance weight matrix, the impact of green credit on the high-quality development of green economy is positive, forming a positive spatial spillover effect on the high-quality development of green economy in surrounding areas. (3) By using the Intermediary Effect Model,it can be seen that environmental pollution plays a partial intermediary effect between green credit and high-quality development of green economy. There is a transmission channel of "green credit → environmental pollution → high-quality development of green economy". (4) By using Panel Quantile Regression Model, it is found, with the improvement of high-quality development of green economy, that the promotional effect brought by green credit increased.

Key words: green credit; environmental pollution; high quality development of green economy; spatial effect

1.Introduction

As it has been considered one of the most polluted countries in the world, China dropped from 94 in 2006 to 120 in 2020, in the ranking of the global Environmental Performance Index (EPI) (180 countries and regions in total), reflecting that China's environmental performance level lagged behind the global evaluation scale, and even lower than the average level of developing countries (Hao Chunxu et al. 2020). Facing such challenges brought by environmental pollution, the report of the 18th National Congress of the Communist Party of China has put forward "striving to promote green development, circulation development and low-carbon development", which means the mode of economic development designed by the domestic top-level will be conducted to improve the present situation of environmental pollution. In 2017, the report of the 19th CPC National Congress once made a crucial conclusion that China's economy has changed from a high-speed growth stage to a high-quality development stage. In 2020, The central government further proposed to accelerate the construction of a new development pattern prioritizing the domestic flows, and mutual promoting by both internal and international double development dynamic, which has put forward a strategic

blueprint for the high-quality transformation of China's economy. The high-quality development of green economy is a more deepen and advanced concept than the high-quality economic development. Compared with the high-quality economic development system, the high-quality development of green economy emphasizes the allocation efficiency of factors of green resources, and it also pays more attention to the control of environmental pollution degree and the optimization of green ecological environment.

Green credit is the lubricant and booster combining the financial resources and the socio-economic development level. It is an important way to deepen the Supply-side Reform, to accelerate the transformation of old and new kinetic energy and lead high-quality economic development (Wang Zhiqiang et al. 2020). Chinese financial market is still dominated by bank credit at present, so monetary credit remains the most important financial tool in the financial market. In the existing research, the relationship between green credit, high-quality development of green economy and environmental pollution has not aroused any attention by the academic community. Therefore, studying the impact mechanism of green credit on the high-quality development of green economy is of great significance to realize the transformation and upgrading of economic growth mode in China in the future.

Based on this, this paper further clarifies the realistic basis and theoretical logic of green credit, high-quality development of green economy and environmental pollution level. Meanwhile, it takes a former research (Shen Huiyun et al. 2020) as reference, according to the the Green Development Index System jointly formulated and released by the National Development and Reform Commission, the National Bureau of Statistics, the Ministry of Environmental Protection, and the Central Organization Department, and constructs a high-quality development index system of green economy, and takes quantitative metrology method to measure the high-quality development level of China's economy.

Then, the paper tries to answer the following key but unanswered questions, such as, what is the relationship between green credit and high quality of green economy? Is there a significant structural change in the marginal effect of green credit under different high-quality development levels of green economy? Should the extensity be considered in studying the high-quality development of China's green economy? When green credit affects the high-quality development level of green economy, will there be spatial spillover effect? While green credit has effects on the high-quality development of green economy, what is the transmission path of it? While under different levels of environmental governance, industrial structure, government expenditure scale, industrialization, and economic development, are there any differences in the impact of green credit on the high-quality development of green economy? Solving above problems scientifically, will provide a reference basis for realizing the high-quality development of China's green economy.

The quality of economic development has always been one of the key areas of academic attention. The earlier academic research began with the concept of "sustainable development" and has gradually extended to the concept of "quality of economic growth". Compared with the standard and mature concept of "economic growth", the concept of "economic growth quality" is more a reflection on the undesirable results of economic growth rate, and more a emphasis on the dual objectives of economic growth quantity and quality (Chao Xiaojing 2009). Starting from the study of the connotation and definition of economic growth quality, many scholars have constructed the index system of economic growth quality (Ren Baoping 2012;Yan Pengfei 2014). After the notion of high-quality economic development was first put forward in the report of the 19th National Congress of the Communist Party of China, relevant studies on high-quality development and high-quality economic development by

domestic scholars have sprung up one after another. In combination with the spirit of the policy-oriented documents, the academic community interpreted the high-quality economic development from its own connotation (Yang Weimin 2018;Yu Yongze 2018; Hong Yinxing 2019; Zhou Wen 2019), and preliminarily discussed the characteristic dimension on the high-quality economic development (Ren Baoping 2018). On this basis, scholars believed that innovation, supply of production factors, systems, policy environment and governance level are important motivations of high-quality economic development (Sun Zao 2018; Gu Shengzu 2018). Although different scholars had different definitions of high-quality economic development, the connotation of various definitions remains the same, which indicates high-quality economic development is a relatively comprehensive concept. They also thought that using a single index to measure high-quality economic development was quite limited, doing research on economic quality by constructing an index system has become a trend. According to the five dimensions of innovation, coordination, green, openness and sharing ,some scholars had built a new system (Yi Changliang 2016; Fang Dachun 2019; Li Mengxin 2019). However, due to different research objects, samples and methods, there is no consensus on the contribution rate and speed of the five dimensions to high-quality economic development. Even though the connotation of high-quality economic development has been explained, the constructed index system varies from each other due to the differences in individual cognition (Wei Min 2018; Zhang Zhen 2019; Li Jinchang 2019; Zhang Xia 2021).

Instead of concentrating on the impact of green credit on the high quality of green economy, the academic circles still take green credit as an integral part of green finance, studying the impact of green financial development on economic growth and believing that the green investment demand promoted by green financial activities will directly contribute to economic growth while the investment increased (Cowan 1998; Salazar 1998; Li Xiaoxi 2015; Ma Jun 2016). Green finance is a new growth point and a new engine to promote economic development (Liu 2020), while some of the scholars hold the opposite view that the promotion of green finance will have a certain negative impact on economic growth (Liu Sha 2019). Some scholars studied the impact of green credit on economic growth and believed that green credit investment can significantly promote the development of green industries and directly contribute to regional economic growth (Xie Tingting 2019; Liu Haiying 2020).

At present, the research has been rich enough in high-quality economic development. However, there still exist three deficiencies: (a) Currently, there is scarcely theoretical basis for high-quality economic development,the index evaluation system brought by scholars is not unified. Moreover, there is little research on high-quality development of green economy. Only a few domestic scholars have made a preliminary study on high-quality development of green economy from the characteristics of regional economic development (Shen Huiyun 2020) .Therefore, the prior concern of this paper is to build an index system of high-quality development of green economy in line with the objectivity and reality of China's economy, then to calculate the high-quality development index of green economy. (b) In research on high-quality economic development or high-quality development of green economy, few study takes green credit as the driving variable, neither does quantitative study. Therefore, whether green credit has an impact on the high-quality level of green economy? What is the degree of the impact? Whether it is affected by other factors, and whether there is an obvious spatial effect? Questions mentioned above are still waiting to be solved. (c) While doing research on the influence of environmental pollution level related to green credit or taking green credit as an integral part of green finance, some scholars pay attention to the relationship between green credit and economic growth only, but the depth and the scope of the research are hardly involved. Particularly, most literatures are drawn

conclusions by foreign banks as the research object, so these concluded statistics are inconsistent with domestic situations. At present, few scholars have extended its logical relationship to further discuss its impact on the level of economic development. It is still unknown whether green credit can change the high-quality development level of green economy by affecting the level of environmental pollution, neither the further explanation of the mechanism of green credit on the high-quality development of green economy.

The main contributions of this paper are as follows: (a) It builds a high-quality development index system of green economy from five dimensions (resource utilization, environmental governance, social construction, economic performance and green life) and 23 basic indicators, weighting each basic indicator via entropy method, then calculating the comprehensive evaluation index of high-quality development of green economy, so as to examine the possible positive impact on the high-quality development of green economy related to green credit through dynamic panel data metrology. (b) It adoptes Moran's Index to analyze the spatial spillover effect of green economy development, and the stability of its spatial effect is estimated through the Spatial Panel Model, which further enriches the research system of high-quality development of green economy. (c) By using the Intermediary Effect Model to explore the relationship between green credit, environmental pollution, and high-quality development of green economy, it study the ways in which green credit affecting the high-quality development of green economy and to find the evolution track of the marginal effect of green credit under the high-quality development level of green economy.

The rest of this paper is arranged as follows: The second part is the theoretical basis and research hypothesis. The third part is the design of the research, characteristic fact analysis, construction of the high-quality development system of green economy and analysis of the characteristics of green credit, environmental pollution, and high-quality development of green economy, then laying foundation for the following part. The fourth part is the empirical analysis aiming at conducting regression test on the impact of high-quality economic development of green economy related to green credit. Then, it further tests the impact by Dynamic Panel Data Metrology Model, and examines the spatial correlation of high-quality development of green economy, and builds a Spatial Metrology Model to analyze the impact of green credit on high-quality development of green economy. The fifth part uses Intermediary Effect Model to test the intermediate mechanism of environmental pollution. The sixth part is the marginal contribution analysis of green credit to the high-quality development of green economy. The seventh part is the conclusion and enlightenment.

2. Theoretical analysis and research assumptions

With the concept of green development gradually deepening into all sectors and fields of society, the former credit supply and demand model of manufacturing enterprises has been changing from competition for credit resources and investment to expand reproduction to the model of financial institutions actively supporting green and environment-friendly enterprises (Hu Jianbo 2020). Guided by the core value of social responsibility, commercial banks formulated differentiated interest rates and targeted credit granting mechanism by relying on the national environmental protection policies and relevant industrial policies. From the perspective of enterprise development, commercial banks provide preferential loans or preferential low interest rates to environmental protection enterprises with energy conservation, emission reduction and clean production. For enterprises with high energy consumption and high pollution, they take punitive high interest rates or even refuse to lend money to constrain their development (Li Yu 2020). (Labatts 2002) believed that leading the energy development by creating

green financial instruments including green credit, controlling the promotion of environmental pollution projects, the government will promote the optimization and upgrading of industrial structure and sustainable economic development. From the perspective of banking development, (Chami et al. 2002) and other researchers believed that the development of green credit by banks can help improve the bank's reputation and risk management, it can also help banks control the loan environment and social risks (Sun 2019). If a bank grants loans to a high pollution and high emission enterprise, once pollution event breaks out, not only hurt the social image of the bank, but also face the risk of loan debt (Zhang Hui 2021). Under the guidance of national policies, commercial banks that prefer credit funds lending to green industries and green enterprises will receive more policy support, such as higher MPA assessment score, lower capital support, lower reserve requirements and even more tolerant regulatory environment. Therefore, commercial banks tend to increase green credit to obtain "regulatory incentives", whose essence is to adjust the allocation of financial resources, using lower financing costs and better financing availability "to stimulate" environment-friendly enterprises to expand their production, and "to force" enterprises with higher environmental pollution to innovate their production skills. The greening of the production activities of enterprises will promote the greening of the regional economic development level, that is , the resource utilization rate of social production will be higher.

Therefore, hypothesis 1 is proposed: *The green credit has positive effect on promoting the high quality of green economy*

According to the theory of modern industrial division of labor, resources, labor force and capital of a region are limited after all. With the industrial expansion and transfer, comparative advantage industries are generated. They communicate and trade with adjacent spatial units in social and economic development, to achieve the optimal allocation of resources and produce inter regional spillover effect and feedback effect. (Ying 2003) found earlier that there is a strong interrelation between regions in China's economic growth. While further divided China into coastal areas and inland areas; or eastern, central and western areas; or southeast, Yangtze River Basin, Yellow River Basin, northeast and northwest, the results of (Burn 2002; Zhang 2002; Groenewold 2008) showed that there is an obvious spatial spillover effect between regions in China. Some scholars also used the theory of industrial organization to do the research. (Han 2014) and others believed that there existed a spatial effect between the economic development of port areas and hinterland areas. (Li 2020) and others held that environmental regulation also had a regional and municipal spatial effect on the efficiency of green innovation. From a micro angle, (Hanchen 2019) and others insisted that there was also an obvious spatial effect in the agglomeration and development of manufacturing enterprises. As the economic development of coastal areas is significantly higher than that of inland areas, the technology spillover effect and feedback effect of coastal areas on the inland are obviously higher than those of inland areas on the coastland (Zhang Yaxiong et al. 2005). When a region takes the road of high-quality green economic development, which means it should achieve the balanced and healthy development of social and economic environment in many aspects, such as the rational allocation of production factors, social resources and living facilities, the protection of environment and the continuous control of per capita resource consumption. To achieve the above objectives, it must carry out socialized production and exchange through different industries. Due to the present of natural and geographical factors such as water flow and wind direction, the environmental problems in a certain area will inevitably be affected by the adjacent areas (Ma Limei 2014). Anthropogenic factors such as industrial transfer and trade will

further deepen the spatial linkage between regional environmental quality and economic development. Therefore, the impact of spatial factors on environmental and economic problems should not be ignored (Anselin 2001). (Poon 2006) and others used spatial metrology to study the impact of energy, transportation and foreign trade on China's atmospheric environment, and confirmed that spillover effects do exist among provinces in China. (Ma Limei 2014) and others considered that there was a positive spatial autocorrelation of haze pollution in various regions of China, and the correlation was stable for a long time. Therefore, in the process of developing high-quality green economy, interrelationship exists between regions.

Therefore, hypothesis 2 is proposed: *An obvious spatial effect exists in the high-quality development of green economy*

The allocation of credit resources is closely related to environmental pollution. (Yu Xiang 2011) and others believed that financial development helps to reduce sulfur dioxide emission and industrial wastewater emission. (Heidari 2014) and others also confirmed that financial development reduces the degree of environmental degradation. Meanwhile, many studies have proved that financial institutions have reduced pollutions and emissions from enterprises by allocating credit resources. (Shahbaz 2013) and others used the time series data of South Africa from 1965 to 2008 and believed that the development of finance can reduce pollution emissions. (Salahuddin 2015) and others studied the relationship between carbon dioxide emissions, economic growth, power consumption and financial development in Gulf Cooperation Council (GCC) countries and found that financial development can significantly help to reduce carbon dioxide emissions. (Dogan 2016) and others also found that financial development led to reduction of carbon dioxide emissions by studying the impact of actual output, renewable and non-renewable energy, trade and financial development on carbon emissions in major renewable energy countries, i.e., when the scale of bank green credit is larger, enterprises make greater efforts to reduce emissions and the level of pollution control is more obvious (Hu Zhenyun 2013).

At present, green enterprises are mainly engaged in energy-saving and environmental protection equipment manufacturing, resource recycling equipment manufacturing, new energy vehicle and green ship manufacturing, energy-saving transformation, pollution control, cleaner production, clean energy, ecological agriculture, ecological restoration, building energy conservation, green building, green transportation, garden green and green services (Fu Yaping 2020). Green enterprises dealing with economic activities in the green field can be further divided into two categories. One is that the products and services of enterprises have lower pollution emission and less energy consumption than the original ones, such as new energy vehicles, resource recycling equipment manufacturing, ecological agriculture, green transportation, etc. The other is the greening of traditional social production activities with high energy consumption, such as pollution control, ecological restoration, energy-saving transformation, etc. After obtaining bank credit support, green enterprises will expand production or upgrade production technology, which will directly or indirectly reduce the emission of pollutants to the environment, while the level of environmental pollution is an important factor for us to measure the high-quality development level of green economy in a region.

Therefore, hypothesis 3 is proposed : *Green Credit stimulates the high-quality development of green economy via reducing the level of environmental pollution.*

3. Research design and feature fact analysis

（1）model building

To verify the impact of green credit on the high-quality development of regional economy, this paper constructs a model as follows:

$$gehqd_{it} = \beta_0 + \beta_1 * gc_{it} + \beta_n * \sum_{n=2}^{n} X_{it} + \delta_t + \gamma_i + \varepsilon_{it} \quad (1)$$

Among them, $gehqd_{it}$ represents the high-quality development level of green economy, gc_{it} represents green credit and X_{it} is for control variables, mainly including environmental governance level (egl_{it}), industrial structure (is_{it}), government expenditure scale (sge_{it}), industrialization degree (di_{it}) and economic development level (edl_{it}). δ_t means time fixed effect, γ_i means individual fixed effect, and $\varepsilon_{it} \sim N(0,\delta^2)$ is the random error term of the model.

(2) Variable selection

(a) Explained variable. Green economy and high-quality development ($gehqd$). The research on green economy is mainly divided into two parts. One part is to study the efficiency of green economy (Wang Bing and Liu Guangtian 2015; Lin Boqiang and Tan Ruipeng 2019). From the perspective of input-output, the common method to measure the whereabouts of green economy development is the DEA Model. The other part describes the development of green economy by building an index system (Dong Xiaohong and Fu Yong 2018; Zhang Wei 2021), and depicts the development of green economy by building a primary and secondary index system. In 2016, the “Green Development Index System” was jointly formulated and released by the National Development and Reform Commission, the National Bureau of Statistics, the Ministry of Environmental Protection, and the Central Organization Department. At this stage, China's economy is in a period of transformation, and high-quality development has become the focus point. Based on the research of (Shen Huiyun et al. 2020), this paper constructs a high-quality development index system of green economy from the five dimensions of resource utilization, they are environmental governance, social construction, economic performance, green life and 23 basic indicators, as shown in Table 1.

As for the measurement of green economy's high-quality development index, the common methods for multi-dimensional indicator calculation are Principal Component Analysis (Chao Xiaojing and Ren Baoping 2011; Zeng Yi et al. 2019) and Entropy Method (Li Hong and Zou Qing 2018). While Principal Component Analysis is mainly used to reduce the dimension of the indicator system and cannot be calculated completely through the original indicators.This paper uses Entropy Method to weight each basic index, calculating the comprehensive evaluation index of high-quality development of green economy based on the research of (Li Hong and Zou Qing 2018). The weight of each basic index is shown in Table 1.

Table 1 construction of green economy development index system

First-level Indicator	Basic Indicators	Unit	Property	Weight
Resource Utilization	per capita water resources	cubic metres per person	positive	0.13166
	per capita construction land area	m2 per person	positive	0.05848
	energy consumption per thousand	tons of standard	negative	0.00894

	people	coal/per thousand people		
	utilization rate of water for irrigation	%	positive	0.01220
	forest coverage	%	positive	0.05362
Environmental Protection	comprehensive utilization rate of industrial solid waste	%	positive	0.02688
	industrial solid waste disposal rate	%	positive	0.07867
	centralized treatment rate of sewage treatment plant	%	positive	0.01363
	city sewage treatment rate	%	positive	0.00988
	greenery coverage of urban area	%	positive	0.00639
Social Construction	registered urban unemployment rate	%	negative	0.01706
	doctors per thousand people	person	positive	0.06012
	education accounts for a proportion of local government spending in the general budget	%	positive	0.01626
	urbanization rate	%	positive	0.03161
	number of public transport vehicles in operation	10000 vehicles	positive	0.07902
Economic Performance	per capital GDP	ten thousand Yuan/per person	positive	0.05899
	per capita disposal income	ten thousand yuan	positive	0.06208
	energy consumptions per GDP	tons of standard coal/ten thousand yuan	negative	0.00658
	proportion of added value of tertiary industry in GDP	%	positive	0.02119
	proportion of R&D expenditure in GDP	%	positive	0.04514
Green Living	total number of sanitary toilets in rural areas	10000 families	positive	0.08683
	county public facilities built area green rate	%	positive	0.04488
	amount of passenger traffic of urban public transport	10000 persons	positive	0.06988

(b) Explanatory variable. Green credit (gc). In regard to the description of green credit, based on the practices of (Fu Yaping etc. 2020), and according to the "Green Industry Guidance Catalogue" jointly issued by seven ministries and commissions in China including the Ministry of Industry and Information Technology in 2019, besides enterprises whose main business involves energy-saving and environmental protection equipment manufacturing, resource recycling equipment manufacturing, new energy vehicle and green ship manufacturing, energy-saving transformation, pollution control, cleaner

production, clean energy, ecological agriculture, ecological restoration, building energy conservation, green construction, green transportation, green landscaping and green services. This paper has joined 358 listed companies setting foot in energy storage, new energy, wind power generation, charging pile, waste power generation, waste classification, hydrogen energy, photovoltaic, sewage treatment and tail gas treatment. Based on this, the research samples of green credit are selected as follows: firstly, green enterprises are manually selected from all A-share listed enterprises from 2003 to 2019, and then the samples of companies subject to ST and * ST are eliminated. Finally, an unbalanced panel data containing 6086 effective observations of 358 listed green enterprises is formed.

Environmental pollution (ep). The description of environmental pollution is mainly measured by carbon dioxide emission. At present, China only has nationwide carbon dioxide emission data, while data of provincial level is not counted, so researchers have to estimate it by themselves. By referring to the results of (Lin Boqiang and Liu Xiying 2010) that carbon dioxide comes from both fossil fuel combustion and cement production. According to (Xiong Ling and Qi Shaozhou 2016), carbon dioxide is estimated by the following equation:

$$co_2 = \sum_i^3 \alpha_i \beta_i x_i$$

α_i represents the consumption of i th fossil fuel. β_i is for the conversion coefficient of such energy into standard coal, and the conversion parameters are from the "Reference Coefficient of Various Energy Converted into Standard Coal" in China Energy Statistics Yearbook. x_i means the carbon dioxide coefficient of this energy, which refers to the calculation methods of IPCC and the Energy Institute of the National Development and Reform Commission. According to the research of (Lin Boqiang and Liu Xiying 2010), (Li Kai and Qi Shaozhou 2011), this paper also takes the carbon dioxide emission in the process of cement production into account. As there is no statistics on the provincial data of cement clinker, with reference to (Li Kai and Qi Shaozhou 2011)'s practice, it is assumed that the comprehensive clinker content of cement is 75%, that is, the carbon dioxide emission coefficient of cement is 0.3954. Therefore, CE is the cement output. The formula for calculating the total emission of carbon dioxide is as follows:

$$co_2 = \sum_i^3 \alpha_i \beta_i x_i + 0.3954 * CE$$

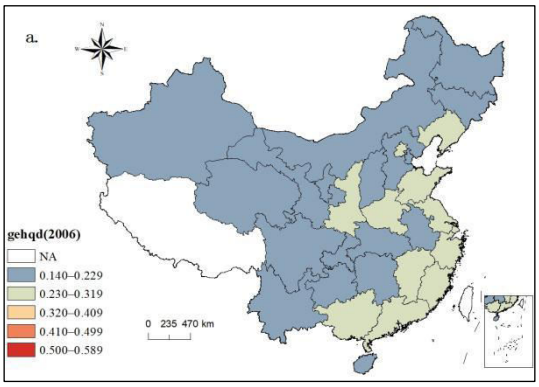
(c) Control variables. The high-quality development of green economy is not only affected by green credit, but also related to other factors. This paper further selects the level of environmental governance (egl), which is for the ratio of environmental pollution control investment to GDP. industrial structure (is), which means the ratio of the added value of secondary industry output value to GDP. The scale of government expenditure (sge), which is measured by the proportion of government general budget expenditure in GDP. The degree of industrialization (di) characterized by the ratio of industrial added value to GDP, and the level of economic development (edl) is described by the regional per capita GDP level.

(3) data sources

This paper selects the data of 30 provinces (cities and districts, excluded Tibet) in China from 2006 to 2019 as the research sample, in which the data of Tibet is seriously missing. The data of basic indicators, green credit, environmental pollution, and control variables included in the high-quality development of green economy come from China Statistical Yearbook, China Urban Statistical Yearbook, Provincial and Urban Statistical Yearbook, etc.

(4) Characteristic fact analysis

(a) The changing trend of green economy development. Figure 1 shows the changing trend of high-quality development of green economy in 30 provinces (cities and districts) in China in 2006, 2010, 2014 and 2019. In 2006, the high-quality development of green economy in 30 provinces (cities and districts) in China was mainly between 0.140 and 0.299, and the highest level was among 0.500 and 0.589. Compared with 2006, the overall green innovation level in 2010 promotes a lot, more provinces (cities and districts) was concentrated between 0.230 and 0.319, which has improved significantly. In 2014, in contrast to 2006 and 2010, the number of areas with high-quality development level of green economy exceeding 0.400 increased continuously. In 2019, the figure in some provinces (cities and districts) reached above 0.500. It is obvious that, from the changes in 30 provinces (cities and districts) of China, the high-quality development level of green economy continued to grow from 2006 to 2019.



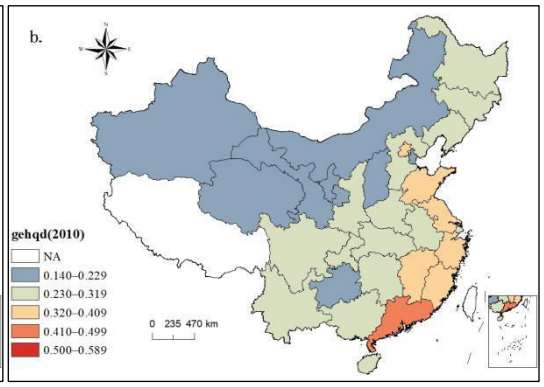
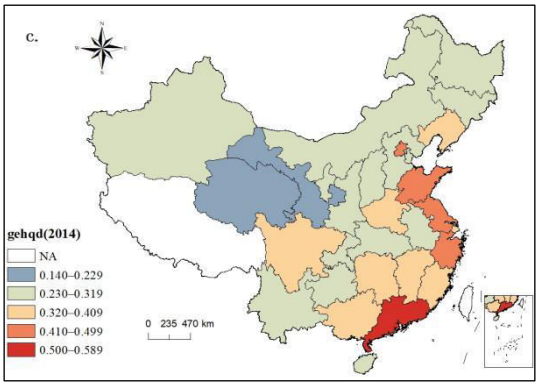


Figure 1 (a) Year 2006

Figure 1 (b) Year 2019



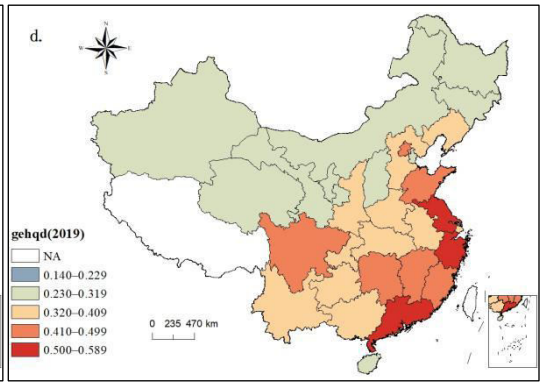


Figure 1 (c) Year 2006

Figure 1 (d) Year 2019

Figure 1 evolution trend of high-quality development of green economy from 2006 to 2019

(b) Test the relationship between green credit and high-quality development of green economy. Through the calculating of the comprehensive evaluation index of high-quality development of green economy and the utilizing of the scatter diagram, the relationship between green credit, environmental pollution and high-quality development of green economy is analyzed by scatter diagram, which lays a foundation for further research. Figure 2 is a scattered chart presenting green credit, environmental pollution, and high-quality development of the green economy. It also shows that there is a positive

correlation between green credit and high-quality development of green economy, indicating that green credit is the main factor affecting the high-quality development of green economy. From the relationship between environmental pollution and high-quality development of green economy, the negative correlation between environmental pollution and high-quality development of green economy indicates that the more serious the environmental pollution, the lower the high-quality development level of green economy.

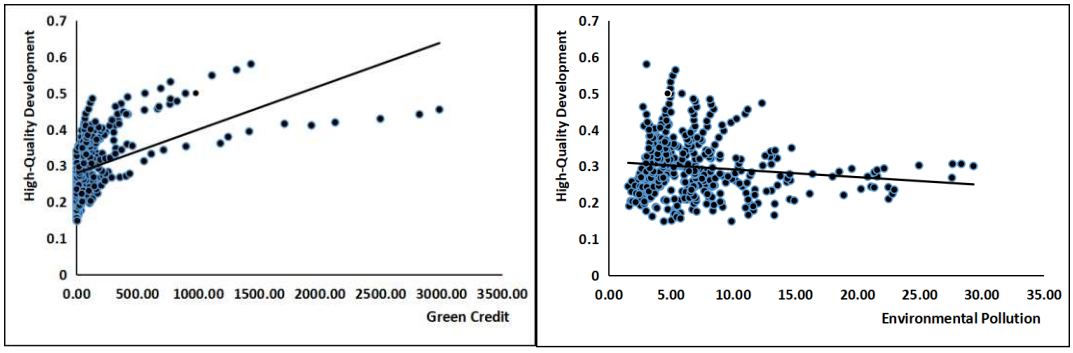


Figure 2 scattered chart of green credit, environmental pollution, and high-quality development of green economy

4. Empirical analysis

(1)Variable description analysis

The statistical results of each variable can be seen in Table 2, which shows that the average value of high-quality development of green economy is 0.298, the minimum value is 0.149 while the maximum is 0.581, which indicates that there are great differences in high-quality development of green economy in 30 provinces (cities, districts) in China from 2006 to 2019. The average value of green credit is 1.479, the minimum value is 0, and the maximum value is 29.820, demonstrating that the level of green credit in different regions of China is significantly different. The average value of environmental pollution is 7.085, the minimum value is 1.546, and the maximum value is 29.320, expressing that there exist significant distinctions in the level of environmental pollution in regions of China. The results of other variables are detailed in Table 2.

Table 2 Variable definition and description statistics

	Variable Name	Symbol	Sample Size	Average	Standard Deviation	Minimum	Maximum
Explained Variable	High-quality development of green economy	*gehqd*	420	0.298	0.080	0.149	0.581
Core Explanatory Variable	Green credit	*gc*	420	1.479	3.414	0.000	29.820
Mediate Variables	Environmental pollution	*ep*	420	7.085	4.659	1.546	29.320
Control Variable	Environmental	*egl*	420	1.338	0.707	0.150	4.240

	governance level						
	Industrial structure	*is*	420	45.490	8.536	16.200	61.500
	Scale of government spending	*sge*	420	0.228	0.098	0.084	0.628
	Degree of industrialization	*di*	420	0.382	0.087	0.111	0.536
	Economic development level	*edl*	420	4.450	2.691	0.579	16.420

(2) Benchmark regression analysis

Table 3 shows the regression results of green credit on the high-quality development of the green economy. Column (1), under the effects of non-fixed time and individual effects, displays the results of the impact of green credit on the high-quality development of the green economy. Column (2) reports the impact of green credit on the high-quality development of green economy when considering the time effect without considering the solid effect. Column (3), considering both time and solid effect, reports the results of the impact of green credit on the high-quality development of the green economy. Column (4) reports the impact of green credit on high-quality development of green economy after further consideration of robust standard error under the premise of considering both time effect and solid effect. From the results of the four columns, it is obvious whichever model is chosen, green credit is an important driver of high-quality development of green economy, indicating that the improvement of green credit level is conducive to promoting high-quality development of green economy, and the results under different regression models are consistent, representing that the regression results of this paper are stable.

Table 3 Benchmark regression analysis

	（1）	（2）	（3）	（4）
Green Credit	0.0119*** (11.947)	0.0125*** (13.697)	0.0026*** (5.388)	0.0026*** (3.352)
Level of environmental governance	-0.0374*** (-9.247)	-0.0396*** (-10.369)	-0.0052*** (-2.977)	-0.0052*** (-3.315)
Industrial structure	0.0016*** (4.215)	0.0020*** (5.300)	0.0015*** (5.329)	0.0015*** (5.970)
Scale of government spending	0.1636*** (4.804)	0.0205 (0.582)	0.0071 (0.194)	0.0071 (0.193)
Degree of industrialization	-0.0858** (-2.249)	-0.0775** (-2.033)	0.0197 (0.699)	0.0197 (0.561)
Economic development level	0.0099*** (7.812)	0.0017 (1.146)	0.0031** (2.451)	0.0031*** (2.658)
Constant term	0.2082*** (6.843)	0.1919*** (6.200)	0.2154*** (11.230)	0.2154*** (8.358)
Time fixed effect	NO	YES	YES	YES

Individual fixation effect	NO	NO	YES	YES
Robust standard error	NO	NO	NO	YES
Sample size	420	420	420	420
R^2	0.4977	0.5921	0.9635	0.9635

Note: (1) *, * * and * * * respectively represent they are significant at the level of 10%, 5% and 1%; (2) The T value in brackets is adjusted by the robust standard error. The following table is the same.

(3) further inspection based on dynamic panel model

Considering that the high-quality development of green economy has a high degree of self-correlation, that is, the high-quality development level of green economy may be affected by the previous value and shows the characteristics of inertia, and the high-quality development of green economy and green credit may have an endogenous relationship of mutual causation. This paper uses the research methods of (Zou Jin and others 2015) for reference, introduces the second-order lag term of high-quality development of green economy in the initial model, and takes the second-order lag term of pre-determined variables as the tool variable, so as to solve the endogenous problems in the model. The dynamic panel model is as follows:

$$gehqd_{it} = \beta_0 + \alpha_1 * gehqd_{i,t-1} + \alpha_2 * gehqd_{i,t-2} + \beta_1 * gc_{it} + \beta_n * \sum_{n=2}^{n} X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

$gehqd_{i,t-1}$ represents the first-order lag term of high-quality development of green economy, $gehqd_{i,t-2}$ means the second-order lag term of high-quality development of green economy, α_1 and α_2 respectively represent the estimated coefficients of the first-order lag term and the second-order lag term of the high-quality development of green economy. Other variables have the same meaning as above.

Table 4 reports the results of both system GMM and differential GMM estimates.The results show that the lag of first period and second period of high-quality development of green economy both have a significant positive impact on the high-quality development of green economy in the current period, representing that the high-quality development of China's green economy has obvious inertial characteristics. The impact of green credit on the high-quality development of green economy is consistent with the benchmark regression results under the system GMM estimation, while the impact of green credit on the high-quality development of green economy is consistent with the benchmark regression results under the differential GMM estimation, indicating that the impact of green credit on the high-quality development of green economy does not depend on specific metrology model or method, proving the robustness of the regression results in this paper.

Table 4 GMM regression analysis

	System GMM	Differential GMM
The first-order lag term of high quality development of green economy	0.5748*** (19.800)	0.7614*** (29.074)
The first-order lag term of high-quality development of	0.2719*** (11.634)	0.2065*** (7.161)

green economy		
Green Credit	0.0006* (1.819)	0.0000 (0.119)
Constant term	0.0438*** (8.801)	0.0179** (2.433)
Control variable	YES	YES
Sample size	330	360
AR(1)	0.0037	0.0031
AR(2)	0.1132	0.0369
Sargan	1.0000	1.0000

Note: (1) *, * * and * * * respectively represent they are significant at the level of 10%, 5% and 1%; (2) The original assumptions of AR (1) test, AR (2) test and sargan test are whether the residual term has sequence correlation of order 1 and order 2 and whether the instrumental variables are set reasonably.

(4) Reexamination considering space effect

(a) Spatial auto-correlation test. For the setting of spatial weight, the (0, 1) weight matrix is usually used, the weight of adjacent areas is 1, and the weight of non-adjacent areas is (Wrigley 1982) extended the traditional (0, 1) weight matrix and introduced the total measure of the potential interaction between 2 spatial units, constructed the spatial weight matrix as a function of distance. Therefore, this paper constructs (0, 1) weight matrix and geographic distance weight of 30 provinces (cities, districts) in China, and studies the relationship between green credit and green economic development from the perspective of geographic distance of spatial units. The construction of 0-1 adjacent space weight matrix is as follows:

$$W_{1,ij} = \begin{cases} 1 & \text{When zone i is adjacent to zone j} \\ 0 & \text{When zone i is non-adjacent to zone j} \\ 0 & \text{When i=j} \end{cases} \quad (3)$$

Geographic distance spatial weight matrix W_2: Based on the first law of geography, “the spatial correlation between units gradually decreases with the increase of distance”, the inverse distance spatial weight matrix is constructed as follows:

$$W_{2,ij} = \begin{cases} 1/d_{ij} & i \neq j \\ 0 & i = j \end{cases} \quad (4)$$

d_{ij} represents the straight European distance between the capitals of provinces i and j, d_{ij} calculated as follows:

$$\begin{aligned} d_{ij} = {} & \arccos[\sin(90 - lat_i) * \sin(90 - lat_j) * \cos(lon_i - lon_j) \\ & + \cos(lat_i) * \cos(lat_j)] * R * \pi / 180 \end{aligned} \quad (5)$$

lat_i means the north latitude dimension of the i region, lat_j represents the north latitude dimension of the j region, lon_i shows the east longitude of the i region, lon_j represents the east longitude of the j region, R is the regional radius, and is calculated in 6378.137 kilometers, π is the PI.

This paper selects (0, 1) weight matrix and geographic distance space weight matrix as the weight matrix of spatial econometric analysis, and tests the spatial correlation of high-quality development of green economy, mainly using the method of Moran Index.The results are shown in Table 5. From the results in Table 5, the high-quality development of green economy has positive spatial correlation regardless of the weight matrix of (0,1) and geographical distance space weight matrix and passes the significance test. That indicates that the high-quality development of green economy has spatial characteristics, the high-quality development level of green economy in one region will obviously drive the high-quality development level of green economy in adjacent regions. From the perspective of the Moran Index of high-quality development of green economy between 2006 and 2019, the Moran Index of high-quality development of China's green economy has obvious trend characteristics, indicating that the high-quality development level of green economy in China is not random in space. However, it has a certain trend of spatial auto-correlation, which means that it is particularly important to consider the space to analyze the high-quality development of green economy.

Table 5 Moran Index of high-quality development of green economy

Year	（0，1）weight matrix			geographical distance weight matrix		
	Moran's I	Z value	P value	Moran's I	Z value	P value
2006	0.295***	2.741	0.003	0.126***	4.089	0.000
2007	0.363***	3.356	0.000	0.099***	3.443	0.000
2008	0.322***	3.037	0.001	0.087***	3.156	0.001
2009	0.294***	2.788	0.003	0.081***	3.006	0.001
2010	0.341***	3.173	0.001	0.090***	3.226	0.001
2011	0.319***	3.002	0.001	0.075***	2.839	0.002
2012	0.333***	3.106	0.001	0.068***	2.661	0.004
2013	0.295***	2.797	0.003	0.069***	2.694	0.004
2014	0.309***	2.911	0.002	0.063***	2.520	0.005
2015	0.347***	3.230	0.001	0.070***	2.704	0.003
2016	0.329***	3.076	0.001	0.061***	2.487	0.004
2017	0.304***	2.867	0.002	0.039**	1.914	0.028
2018	0.280***	2.673	0.004	0.033**	1.744	0.041
2019	0.295***	2.786	0.003	0.034**	1.780	0.038

Note:*, * * and * * * respectively represent they are significant at the level of 10%, 5% and 1%;

(b) Spatial model selection.For the study of spatial econometric models, after determining the spatial correlation, it is necessary to further determine the regression model. From the classification of spatial econometric models, it is mainly divided into 3 types: Spatial Lag Model (SAR), Spatial Error Model (SEM) and Spatial Dupin Model (SDM). With reference to the selection method of (Elhorst 2012) model, the selection is based on the lagrange multiplier of the model residual (LM-lag and LM-err) and the significance of its robustness (Robust-LM-lag and Robust-LM- err)(Yang Bing etc. 2021). Table 7 shows the inspection results of LM test and robust LM test, which are significant both under (0, 1) weight matrix and geographical distance weight matrix, indicating the use of Spatial Lag Model (SAR) and the Spatial Error Model (SEM) are both feasible.That means the comprehensive

model of the two models, the Spatial Dupin Model (SDM) can be used for estimation (Yang Bing et al. 2021).

Table 6 LM test and robust LM test results

		LM test				robust LM test			
（0，1）weight matrix	SAR	Z value	75.264***	P value	0.000	Z value	49.490***	P value	0.000
	SEM	Z value	41.865***	P value	0.000	Z value	16.091***	P value	0.000
Geographical distance weight matrix	SAR	Z value	33.708***	P value	0.000	Z value	20.039***	P value	0.000
	SEM	Z value	29.691***	P value	0.000	Z value	16.023***	P value	0.000

(c)The construction of spatial econometric model. According to the selection of the model, the Spatial Dupin Model (SDM) is adopted to analyze the impact of green credit on the high-quality development of green economy. The Spatial Dupin Model is constructed as follows:

$$gehqd_{it} = \alpha + \rho * W * gehqd_{it} + \beta_1 * gc_{it} + \beta_k * \sum_{k=2} X_{it} + \lambda_1 * W * gc_{it} + \lambda_j * W * \sum_{j=2} X_{it} + \varepsilon_{it}, \varepsilon_{it} \sim N（0，\delta^2 I） \quad （6）$$

$gehqd_{it}$ represents the high quality development level of green economy, gc_{it} is for green credit and W is spatial weight matrix are indicated. In this paper, we choose (0, 1) weight matrix and geographic distance weight matrix, X_{it} means control variables, mainly including environmental governance level (egl_{it}), industrial structure (is_{it}), government expenditure scale (sge_{it}), industrialization level (di_{it}) and economic development level (edl_{it}), ε_{it} means the error term subject to the Normal distribution, α is the intercept term, and ρ，λ respectively represent the coefficients of the spatial auto-regression coefficient and the spatial error term.

(d) The results of Spatial Panel Model estimation. Table 7 shows the estimation results of the Spatial Panel Model of the high-quality development of the green economy by the green credit of each province (city, district) in China. In Table 7, column (1) shows the regression results of the impact of green credit on the high-quality development of the green economy under the (0, 1) weight matrix. Table (2) displays the regression results of the impact of green credit on the high-quality development of the green economy under the geographical distance weight matrix. In all models, the spatial lag coefficient of the green economic development is significant under the 1% confidence level. However, the difference in weight selection will affect the sign of coefficient of the spatial lag term, which confirms the correctness of introducing the spatial lag term of economic growth in this paper, and ignoring this correlation will lead to errors in model estimation. Furthermore, the impact of green credit on the high-quality development of green economy is significantly positive under (0, 1) weight matrix and geographic distance weight matrix, which is basically consistent with the estimation results, indicating that the regression results are robust.

Table 7 estimation results of Spatial Panel Models of provinces (cities, districts) in China

	（1）	（2）
	（0，1）weight	geographical distance weight
Green Credit	0.0025*** (5.970)	0.0024*** (5.152)

Green Credit*weight	-0.0060*** (-7.237)	-0.0039 (-1.265)
Direct effect	0.0023*** (5.450)	0.0025*** (5.464)
Indirect effect	-0.0062*** (-6.111)	-0.0035* (-1.650)
Total effect	-0.0039*** (-3.287)	-0.0010 (-0.437)
ρ	0.1472** (2.080)	-0.6124*** (-2.839)
sigma2_e	0.0002*** (14.665)	0.0002*** (14.323)
Control variable	YES	YES
Log - L	1210.3961	1176.2449
N	420	420
R^2	0.3335	0.0020

Note: (1) *, * * and * * * respectively represent they are significant at the level of 10%, 5% and 1%;(2) The values in '( )' represent the Z values.

5. Intermediate mechanism test of environmental pollution

Green credit has been proved as an important driving factor for the high-quality development of green economy by the empirical analysis above. Besides, it promotes the high-quality development of green economy in surrounding areas through the positive spatial spillover effect of high-quality development of green economy. In order to further verify the way through which green credit affects the high-quality development of green economy, this paper mainly studies whether green credit affects environmental pollution, and then affects the high-quality development of green economy. Referring to the intermediary effect test method of (Wen Zhonglin et al. 2004), the test steps in this paper are as follows:

The first step is to verify whether green credit affects the high-quality development of the green economy. The method is consistent with the benchmark regression model.

$$gehqd_{it} = \beta_0 + \beta_1 * gc_{it} + \beta_n * \sum_{n=2}^{n} X_{it} + \delta_t + \gamma_i + \varepsilon_{it} \quad (7)$$

The second step is to verify whether green credit affects environmental pollution. The model is constructed as follows:

$$ep_{it} = \alpha_0 + \alpha_1 * gc_{it} + \alpha_n * \sum_{n=2}^{n} X_{it} + \delta_t + \gamma_i + \varepsilon_{it} \quad (8)$$

The third step is to incorporate green credit and environmental pollution, the intermediate variables, into the regression model at the same time. The model is constructed as follows:

$$gehqd_{it} = \lambda_0 + \lambda_1 * gc_{it} + \lambda_2 * ep_{it} + \lambda_n * \sum_{n=3}^{n} X_{it} + \delta_t + \gamma_i + \varepsilon_{it} \quad (9)$$

Among them, ep_{it} means environmental pollution, and the meanings of other variables are the

same as above.

Table 8 displays the regression results of path analysis of "green credit → environmental pollution → high-quality development of green economy". The results of column (1) show that the impact of green credit on the high-quality development of green economy is significantly positive, indicating that green credit is the main factor to promote the high-quality development of green economy, and the direct effect exists. The results in column (2) tell that the impact of green credit on environmental pollution is significantly negative, indicating that green credit is conducive to reducing the level of environmental pollution. From column (3), it can explicitly be found that green credit has a significant positive impact on the high-quality development of green economy, demonstrating that green credit is conducive to promoting the high-quality development of green economy, and the value of the regression coefficient of green credit is lower than that in column (1)(0.0025<0.0026), which means that environmental pollution plays a part of intermediary effect between green credit and high-quality development of green economy. From the numerical perspective, the intermediary effect accounts for about 5.100%, stating clearly that there is a transmission channel of "green credit → environmental pollution → high-quality development of green economy" in the process of the impact of green credit on the high-quality development of green economy.

Table 8 Intermediate mechanism test of green credit on high-quality development of green economy

	（1）	（2）	（3）
	High-quality development of green economy	Environmental pollution	High-quality development of green economy
Green credit	0.0026*** (3.352)	-0.1506*** (-4.650)	0.0025*** (3.174)
Environmental pollution			-0.0009* (-1.853)
Constant term	0.2154*** (8.358)	5.1417*** (3.248)	0.2200*** (8.479)
Mediation	5.100%		
Time fixed effect	YES	YES	YES
Individual fixation effect	YES	YES	YES
Robust standard error	YES	YES	YES
Sample size	420	420	420
R^2	0.9635	0.8712	0.9638

Note: (1) *, * * and * * * show the results are significant at the level of 10%, 5% and 1%; (2) The T value in brackets is adjusted by the robust standard error. The following table is the same.

6. Marginal contribution Analysis of green credit to the high-quality development of green economy

In the above research, the impact of green credit on the high-quality development of green economy and the path effect are analyzed. However, under the circumstances of different levels of high-quality development of green economy, it is more noteworthy whether the significant structural changes in the marginal effect of green credit exists or not. In view of this, this paper uses the research

of (Tian Guoqiang and Li Shuangjian 2020) for reference and uses the Panel Quantile Regression Model to explore the evolution track of the marginal effect of green credit under the high-quality development level of the green economy. The Panel Quantile Regression Model is constructed as follows:

$$Q_{\tau}(gehqd_{i,t}|gc_{i,t}) = \varphi_{\tau 0} + \varphi_{\tau 1} gc_{i,t} + \rho_{\tau} X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (10)$$

$Q_{\tau}(gehqd_{i,t}|gc_{i,t})$ represents in the case of a given green credit ($gc_{i,t}$), the value of high-quality development of green economy in the τ quantile, and $\varphi_{\tau 1}$ means the regression coefficient vector of green credit in the τ quantile.

Table 9 reports the panel quantile regression results of the impact of green credit on the high-quality development of the green economy. The results of columns from (1) to (5) show that the regression coefficient of green credit on the high-quality development of green economy is increasing in all the quantiles, which are 0.0022, 0.0024, 0.0026, 0.0028 and 0.0029 , indicating that structural differences exist in the impact of green credit on the high-quality development of the green economy. Meanwhile, with the improvement of high-quality development of green economy, the promotion effect of green credit is inceasing constantly.

Table 9 marginal effect of green credit on high-quality development of green economy

	（1）	（2）	（3）	（4）	（5）
	$\tau = 0.1$	$\tau = 0.3$	$\tau = 0.5$	$\tau = 0.7$	$\tau = 0.9$
Green credit	0.0022 (0.737)	0.0024 (1.140)	0.0026* (1.878)	0.0028* (1.795)	0.0029 (1.289)
Control variable	control	control	control	control	control
Temporal and regional effects	control	control	control	control	control
Sample size	420	420	420	420	420

7. Conclusions and implications

It is how to achieve high-quality development of green economy that plays a crucial role for China to realize long-term development goals. The impact of green credit on the high-quality development of green economy is closely related to the realization of high-quality development goals of green economy. Based on the panel data of 30 provinces (cities, districts) in China from 2006 to 2019, empirical analysis is adopted to analyze the impact of green credit on the high-quality development of green economy at first. Considering the possible endogeneity, the dynamic panel model is introduced to further verify the robustness of regression. Secondly, spatial characteristics is verified within high-quality development of the green economy through Moran Index, which is further confirmed that the impact of green credit on the high-quality development of the green economy is still significant in the Spatial Metrology Model. Thus, this proves that green credit is an important driver of the high-quality development of the green economy. Furthermore, the Intermediary Effect Model is used to prove that the impact of green credit on environmental pollution is significantly negative, and environmental pollution plays an intermediary role between green credit and high-quality development of green economy. Finally, the Panel Quantile Regression Model is used to explore the evolution of the marginal effect of green credit under the high-quality development of green economy, and the analysis

shows that there are structural differences in the impact of green credit on the high-quality development of green economy.

The results show that: (1) Green credit is an important driving factor for the high-quality development of green economy, and the improvement of green credit is conducive to the high-quality development of green economy; (2) The high-quality development of China's green economy has a positive correlation and is stable for a long time. The high-quality development of green economy in the next period will be promoted by the high-quality development of green economy in the current period. While promoting the high-quality development of green economy, green credit will also promote the high-quality development of green economy in surrounding areas through space effect. (3) In the process of green credit influencing the high-quality development of green economy, there is a transmission channel of “green credit → environmental pollution → high-quality development of green economy”. (4) There are structural differences in the impact of green credit on the high-quality development of green economy. With the improvement of the high-quality development of green economy, the promotion effect of green credit is increasing.

The policy implications revealed by this paper: (1) The empirical results show that the development of green credit promotes the high-quality development of green economy. Therefore, policies and measures should be caried out to guide financial institutions to develop green credit so that the goal of high-quality development of China's green economy will be achievable. Firstly, governments at all levels should encourage commercial banks to develop green credit, and increase credit investment in green industries and green enterprises, and provide tax and financial support to commercial banks with large proportion of green credit; Secondly, the CBRC and other financial regulatory authorities should publish regulatory measures to encourage commercial banks to develop green credit and create a better regulatory environment in terms of institution opening, product innovation, and bad loans tolerance; Finally, commercial banks should promote the reform of their own organizational structure, product innovation, interest rate pricing, credit policy transformation and other aspects to accelerate the development of green credit business. (2) While promoting the high-quality development of green economy, green credit plays a positive role in promoting the high-quality development of green economy in surrounding areas through the space spillover effect of high-quality development of green economy. Therefore, regions should strengthen mutual contact and cooperation, build regional cooperative development organizations or economic circles to promote the development and exchange of green credit among regions, and then improve the ability of green enterprises and green industries to obtain credit among regions. (3) Green credit promotes the high-quality development of green credit by reducing environmental pollution. Therefore, the government should also introduce environmental protection policies and measures to increase the support for environment-friendly enterprises, and to strengthen the control of “two-high” enterprises and reduce environmental pollution emissions. (4) With the improvement of high-quality development of green economy, the promotion effect of green credit is increasing. Therefore, in order to achieve the goal of high-quality development of green economy in China, especially in economically backward areas, based on the regional advantages of green industry, we should accelerate the development of green credit business, encourage commercial banks to increase the green credit investment, and improve the high-quality development level of regional green economy,so as to play the role of green credit in promoting the high-quality development of green economy.

Declarations

Ethics approval ：This manuscript does not involve researching about humans or animals

Consent to participate：All of the authors consented to participate in the drafting of this manuscript.

Consent for publication ：All of the authors consented to publish this manuscript.

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