Research on the Impact of Green Credit on Green Economic Growth in the Yangtze River Delta

Danying Chen(✉)

Beijing University of Technology, Beijing, China
cdy3562386063@163.com

Abstract. Green finance has had a vigorous growing trend in China in the last few years. Green credit as the main tool for developing green finance makes essential contributions to the growth of a green economy. Thus, exploring how green credit affects green economic growth, and then making targeted green credit development policies, is of great significance to China to establish a mature green finance system. This study selects the Yangtze River Delta, which is a prior developer of green credit in China, as the study area, uses the DEA model and Malmqulist-Luenberger index to measure green economic growth, and uses panel data of the four provinces in this region from 2006 to 2020 to study the specific impact of green credit on the local green economy. The following conclusions are reached: (1) Green credit level in the Yangtze River Delta significantly affects local green economic growth. (2) The promoting effect of green credit level on green economic growth is realized through technical efficiency, instead of technical progress. (3) The regression results of the one-period lag term of green total factor productivity are insignificant, possibly because the local green economy has not formed a stable growth mechanism. Accordingly, this paper puts forward corresponding policy suggestions.

Keywords: Green credit · Green economic growth · Yangtze River Delta · Influence path

1 Introduction

Green finance is defined as preferential financial policies for green economy projects to encourage the growth of low-polluting economic projects and restrain the expansion of the high-polluting industry in recent years [1]. The concept of green credit stems from green finance. It specifically refers to the policy instrument of financial institutions with commercial banks as the core to limit the number of project loans for economic projects that cause major pollution to the environment and enhance the loan amount for low pollution and low energy-consuming enterprises [2]. China has proposed a series of policies about green credit, which has gradually become an essential tool of China's green financial field. At present, the development degree of green credit in the Yangtze River Delta region is at the forefront of China, and its market size is relatively complete. The

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Yangtze River Delta includes four provinces, Shanghai, Jiangsu, Zhejiang and Anhui. In 2021, the government of the Yangtze River Delta proposed to vigorously develop green credit and made the Yangtze River Delta Integration Demonstration Zone a pioneering area for innovation in green financial products and services. Whether green credit, as a current development hotspot in the Yangtze River Delta, has contributed to local green economic growth is a topic worth exploring.

Current domestic and international research on green credit has mainly focused on the influence of green credit on traditional high-polluting industries and the business development of green credit. Jiang Shiyin et al. [3] found that green credit will increase employment in the traditional energy sector to some extent, but this positive effect declined as the size of green credit increased. Yu Haiting [4] used a dual differential model to conclude that green credit can stimulate the green innovation of heavy pollution enterprises. Hyunjin Kang et al. [5] analyzed the role of green credit on industrial transformation through an optimal control model and found that green credit contributed to the creation of additional value by reducing the cost of suppliers for manufacturers. Zhang Xue [6] illustrated on the basis of the equatorial principle that the development of green credit will reduce the profit of commercial banks, but it had a positive effect in the long run. Teng Minyao [7] found that the green credit business broadens the business scope of commercial banks and brings additional income to them. Aizawa and Yang [8] pointed out that green credit had a financial incentive effect on commercial banks.

It can be seen that domestic and foreign scholars have studied green credit mainly to explore its development mode and influence on the transformation of traditional industries, and there was less research on specific regions. In addition, when exploring the relationship between green credit and economic development, it is usually associated with macroeconomics rather than the specific green economy. Therefore, this study selects the Yangtze River Delta, which is a prior developer of green credit in China, as the study area, uses the DEA model and Malmqulist-Luenberger index to measure green economic growth, and uses panel data of the four provinces in this region from 2006 to 2020 to test the impact of green credit on the local green economy. Thus, it is possible to provide a reference for similar regions to improve green credit policies and achieve green and coordinated economic development.

2 Model Building

2.1 Variable Definition

2.1.1 Explained Variable: Green Economic Growth

Green total factor productivity as a measure of green economic growth level is a relatively scientific measurement method. The total factor productivity will be measured by the directional distance function and the Malmquist-Luenberger productivity index. This paper constructs the green total factor productivity evaluation index system as shown in Table 1.

Table 1. Green total factor productivity evaluation index system

Indicator Categories	Variable	Data and description	Unit
Input	Labor (L)	Employment in the productive sector at the end of the year	people
	Capital (K)	Total value of fixed assets of large enterprises	100 million yuan
	Energy (R)	Total energy consumption in the productive sector	10 thousand tons
Desirable Output	Industrial added value (I)	Industrial added value of the provinces	100 million yuan
Undesirable Output	Solid waste (S)	Production of industrial solid waste by each province	10 thousand tons
	Sulfur dioxide (G)	Provincial emissions of sulfur dioxide	10 thousand tons
	Waste water (W)	Provincial waste water discharge	10 thousand tons

2.1.2 Core Explanatory Variable: Green Credit Level

At present, there are four common methods to measure the level of green credit in the current academic world [9]. The acquisition and calculation of such data are mostly conducted at the national level, and the "bank loan" data of industrial pollution control investment has not been counted since 2010. The sample of this paper is based on the Yangtze River Delta of China, so other measurement methods are no longer applicable. Considering the continuity and availability of data, this paper selects the ratio of interest expenditure of six energy-consuming industries to the total interest expenditure of industrial industries in each province as the reverse indicator to measure green credit.

2.1.3 Control Variables

Based on the reference and reference to existing scholars' studies, other variables that may have an impact on green economic growth are used as control variables in this paper. First, foreign direct investment (Foreign). The current role of FDI on green total factor growth productivity is more complex and influenced by the level of the foreign investment market and the direction of foreign investment [10]. This variable is measured by the share of foreign direct investment in GDP. Second, R&D expenditure (RD). It is likely that increasing R&D investment can accelerate the upgrading of green technologies and greatly promote the growth of the green economy in surrounding areas [11]. This study uses the proportion of total R&D expenditure in fiscal expenditure to measure R&D expenditure. Third, the development level of secondary industry (Second). An increase

in the share of secondary industry output in GDP has a vital negative impact on the progress of the green economy while increasing the share of tertiary industry in the industrial structure is more conducive to green economic growth [12]. The development level of the secondary industry is measured by the share of the output value of the secondary industry in GDP. Fourth, degree of education (Educa). With the improvement of education level, people's awareness of green environmental protection will increase, which will increase the development of green economy projects to a certain extent [13]. This paper uses years of schooling per capita to measure the level of education.

2.2 Data Source

This study takes the Yangtze River Delta as a research sample. The data interval is from 2006 to 2020. The relevant data are from China Statistical Yearbook, China Industrial Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook, and China Provincial and municipal Statistical Yearbook. For a small amount of missing data, the interpolation method and trend prediction method are used to replenish.

2.3 Model Specification

In order to explore the specific effect of green credit on green economic growth in the Yangtze River Delta, this paper constructs the following model:

$$GTFP_{it} = a + kGTFP_{i(t-1)} + qGC_{it} + rC_{it} + \mu_{it} + bt + bt^2 + \varepsilon_{it} \quad (1)$$

In the above Eq. (1), $GTFP_{it}$ is the explained variable, green total factor productivity, and $GTFP_{i(t-1)}$ is the green total factor productivity lagging one period. GC_{it}, as the core explanatory variable, is the proportion of interest expenditure of the six energy-intensive industries of industrial enterprises in the Yangtze River Delta, and serves as the reverse indicator of green credit. C_{it} is the control variable, and μ_{it} is the individual heterogeneity that does not change with time. The time term t means the difference between the remaining years and 2006 with 2006 as the base period. The time term t and its square t^2 are to control the time trend and nonlinear change of the dependent variable. ε_{it} is the random disturbance term.

3 Results and Analysis

3.1 Regression Results

This paper first performs an F-test on the model, which significantly rejects the original hypothesis and therefore uses fixed effects for the analysis. The local development of the green economy is more complete than that of other regions in China. This paper considers the influence of the green economy in the previous period on the current period and adds it into the model as a variable. The regression results are shown in Table 2.

According to the model regression results in Table 2, it can be seen that the regression coefficient of the one-period lag term of green total factor productivity in the Yangtze

Table 2. Regression results of the impact of green credit on green economic growth in Yangtze River Delta

Variable	Coefficient	t-Statistic	Prob.
GTFP1	−0.098853	−0.703555	0.4850
GC	−0.020023**	−2.239749	0.0329
Educa	−0.010796	−0.417566	0.6781
RD	0.150426*	1.755278	0.0853
Second	−0.095677*	−1.838204	0.0726
Foreign	−0.012056**	−1.948622	0.0474
C	0.883234***	4.137530	0.0001

(GTFP1 indicates that the corresponding variable is lagged by 1 period; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.)

River Delta is negative, but the probability value is greater than 0.1, so the result is not significant. This indicates that the change of this variable will not cause great changes to the green economy, which may be due to the fact that the state of the local green economy is not yet mature and has not formed a stable growth status, so the lag term does not have a significant effect on it. The regression coefficient of the reverse measure index of green credit level (GC) is -0.020, and passes the 5% significance level test, which means that the improvement of green credit level in the Yangtze River Delta can bring a positive effect on the growth of the green economy. Although green finance in the Yangtze River Delta is still in its initial stage, its development momentum is good, providing more adequate financial conditions for local green projects, thus promoting the local emergency of the green economy.

In control variables, the role of education degree (Educa) on green economic growth is not remarkable. It is likely that green knowledge promotion and education have not yet been popularized and deepened in the Yangtze River Delta, and has not been enough to drive local people to change the traditional mode of the economic situation. The impact of RD expenditure (RD) on green economic growth is significantly positive. Increasing investment in scientific and technological research can transform the production technology and mode that are not green and upgrade the existing technology, reduce unnecessary waste of energy and resources and industrial pollution emissions in the production process of enterprises, and play a positive role in the development of the regional green economy. The R&D expenditures in the Yangtze River Delta can significantly promote green economic growth, which indicates that local science and technology R&D gradually focuses on green technology and can be more effectively transformed into actual production. The development level of the secondary industry (Second) is not beneficial to the growth of the green economy but limits the normal development of the green economy. The secondary industry mainly includes manufacturing, chemical industry and other industries with serious pollution emissions. The discharge in the production process has caused great damage to the environment. The influence of foreign direct

investment (Foreign) on green economic growth is significantly negative, which indicates that foreign investment not only does not contribute to green economic growth but also inhibits green economic growth in the Yangtze River Delta. It may be because the current foreign investment in the Yangtze River Delta region mainly flows to traditional industries such as manufacturing [14]. This may lead to less investment in green industries with low emissions, pollution, and energy consumption, resulting in increased foreign direct investment supporting the development of non-green economy industries, while acting as a disincentive to green economic growth.

3.2 Influence Path

The specific ways in which green credit in the Yangtze River Delta contributes positively to green economic growth are also the subject of further study in this paper. Green total factor productivity can be decomposed into green technical efficiency and green technical progress. Green credit can affect green economic development by enhancing or reducing factor allocation efficiency and enhancing or hindering scientific and technical progress. Therefore, this paper adjusts the model and replaces the growth rate of the green economy with technical efficiency and technical progress respectively. The specific models are shown in Eqs. (2) and (3) below:

$$EC_{it} = a + kEC_{i(t-1)} + qGC_{it} + rC_{it} + \mu_{it} + bt + bt^2 + \varepsilon_{it} \quad (2)$$

$$TC_{it} = a + kTC_{i(t-1)} + qGC_{it} + rC_{it} + \mu_{it} + bt + bt^2 + \varepsilon_{it} \quad (3)$$

EC is technical efficiency, TC is technical progress, and other variables are consistent with (1). Table 3 demonstrates the regression results.

The results in Table 3 show that there is a significant positive correlation between green credit level and technical efficiency (EC), but no significant correlation between green credit level and technical progress (TC). It suggests that green credit in the Yangtze River Delta region has an impact on green economic growth mainly through improving technical efficiency. Among them, EC1 is significant for EC at the 10% level, which indicates that the green efficiency development in the Yangtze River Delta is stable, and thus the lag term plays a role in green efficiency in the latter year. However, the one-period lag term of green total factor productivity in the Yangtze River Delta region does not have a significant effect on green economic growth. So this may be caused by the insignificant one-period lag term of green technical progress, which indicates that the technical progress in the Yangtze River Delta is currently unstable.

Table 3. Influence path of green credit on green economic growth in Yangtze River Delta

EC		TC	
EC1	GC	TC1	Gt
0.2514*	−0.319**	0.0510	0.2503

(EC1 and TC1 respectively represent the one-period lag term of green technical efficiency and green technical progress. The results omit the regression results of control variables.)

Table 4. Robustness test results

Variable	Coefficient	t-Statistic	Prob.
GTFP1	−0.098705	−0.703274	0.4851
GC	−0.051349*	−1.826475	0.0786
Educa	−0.024771	−0.844443	0.4024
Techn	0.187241	0.856328	0.3959
Industry	−0.032503*	−1.893241	0.0580
Foreign	−0.013960*	−1.873311	0.0613
C	1.060221***	6.881200	0.0000

3.3 Robustness Test

The stability of regression results needs to be checked again. The added value of the secondary Industry (Industry) is used to replace the proportion of the secondary industry output in GDP (Second) to represent the development level of the secondary industry. The proportion of science and technology expenditure to fiscal expenditure (Techn) is used instead of total R&D expenditure (Rd) to represent the level of science and technology, and the model is returned again. The results are shown in Table 4.

It can be seen that the regression result of green credit level (GC) is still significantly negative, which is consistent with the regression result above, so the regression result is somewhat robust and The level of green credit in the Yangtze River Delta has greatly supported and encouraged the growth of the local green economy. The green economy situation of the previous year did not contribute significantly to the green economy growth of the current period. The regression results of Edu, which represents education level, are still not significant. However, the influence of Techn on the green economy in the Yangtze River Delta region changed from significant to positive. The reason may be that the expenditure of R&D institutions represented by the previous measurement index RD is mainly used to improve the development of green economy technology, while the total expenditure on science and technology is less investment in green economy. The coefficients of Industry, an indicator representing the level of development of the secondary industry, and foreign investment are significantly negative consistent with the regression results above. Table 4 shows evidence of industrial pollution in the secondary industry of the Yangtze River Delta, which has a suppressive effect on the development of the green economy. In summary, the regression results of the original model are somewhat robust.

4 Conclusions

In this paper, through empirical analysis, the following conclusions are obtained: (1) The level of green credit in the Yangtze River Delta has a significant positive effect on local green economic growth; (2) Green economic growth is divided into two aspects: green technical efficiency and green technical progress. The influence of local green credit

level on technical efficiency is significantly positive, but not significantly on technical progress, indicating that the effect of strengthening the level of green credit is mainly on the efficiency of green technology, and the growth of the green economy is mainly realized through the improvement of the technical efficiency of the green economy. (3) The regression results of the one-period lag term of green total factor productivity in the Yangtze River Delta are not significant, which may be due to the fact that the local green economy is in its infancy and has not formed a stable growth mechanism. (4) Among the control variables of the model, the influence of R&D expenditure on green economic growth in the Yangtze River Delta is significantly positive, while the development level of secondary industry and foreign direct investment significantly inhibit the growth of the green economy in the region.

5 Policy Suggestions

The conclusion of this paper has some reference value for encouraging the development of the green economy. This paper makes the following suggestions: (1) Yangtze River Delta needs to improve the unified standards and relevant laws and regulations for local green credit business, avoid unscientific and unreasonable green credit phenomenon, make the management process of green credit business in financial institutions more standardized, systematic and efficient, effectively improve the service quality of green credit business and support for green projects, and better play the promoting role of green credit. (2) Yangtze River Delta should strengthen efforts to improve the factor allocation efficiency of the green economy and formulate differentiated environmental regulation policies for different industries and regions. Environmental constrindustrial-intensiveion industrial intensive areas should be increased accordingly, and strict emission limits should be formulated. Also, it needs to increase government spending on science and technology in the Yangtze River Delta region and raise the ability of green technology innovation. On the one hand, fiscal and monetary policies can be used to inject more green credit funds into environmental science and technology projects. On the other hand, green credit can give more support to the production and conversion of existing green technologies. (3) Local governments should improve the accountability system to ensure the implementation of environmental protection. It could reward government personnel and enterprises who implement environmental protection policies, hold accountable those who falsely implement environmental protection policies, and give full play to the long-term effects and sustainability of green economic policies. (4) Local governments can expand financial assistance and subsidies for R&D institutions in green technologies, and establish supervision and evaluation systems for R&D expenditure of R&D institutions to ensure that the injected funds of R&D institutions are implemented into green projects. The secondary industry in the Yangtze River Delta should accelerate the upgrading of its industrial structure and transform from the extensive economic development mode relying on resource input to the intensive growth mode relying on technical progress and capital. The secondary industry should also research and develop technologies to reduce pollutant emissions and develop and utilize new clean energy. Local governments can also implement preferential policies such as subsidies and tax cuts for green economy projects to guide foreign investors to increase investment in green economy projects.

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