

Research on sustainable development of green credit in China

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Abstract

At present, China's economic development has entered a new stage. In order to coordinate the development of society, economy and nature, China has established a sustainable development strategy. As an important part of advocating green civilization, green credit is of great significance to promote China's sustainable development. This paper studies the development of green credit under the background of sustainable development strategy. The grey prediction model is used to predict the factors influencing the development of green credit in China. According to the forecast index data, a multiple linear regression model is established to forecast the balance of green credit in China. The research shows that: from 2018 to 2027, the average annual growth rate of China's green credit balance is 0.564%, and the green credit will continue to increase in the future and will remain at a high level. Finally, the paper puts forward countermeasures and suggestions for the sustainable development of green credit in China from four aspects of government departments, financial institutions, residents' quality and environmental governance.

Keywords

Green credit, Sustainable development; Grey prediction model, Multiple linear regression.

1. Introduction

In recent years, environmental pollution and resource waste under the extensive development model have become the primary factors affecting China's economic development. Therefore, we must increase the energy and resources conservation and ecological environment protection measures. As an important capital hub, China's financial industry has its special economic and social responsibilities. In July 2007, opinions on implementing environmental protection policies and regulations and preventing credit risk were jointly issued by the people's Bank of China, the General Administration of environmental protection and the China Banking Regulatory Commission. The release of this policy marks that green credit will enter the economic means of energy conservation and emission reduction in China, creating a new financial tool for ecological construction, ecological protection and green industry financing. At present, China's green credit is still in the initial stage, which has great development potential and faces many restrictive factors. It is of great significance to study the sustainable development of green credit to promote the construction of ecological civilization in China. Therefore, this paper explores the influencing factors of green credit, analyzes the prediction results of green credit, and then puts forward relevant policy suggestions on how to realize its efficient, stable and sustainable development in the new economic environment.

Green credit is a new credit policy proposed by the people's Bank of China, the State Environmental Protection Administration and the China Banking Regulatory Commission in 2007. For how to better implement the green credit policy, Fan Xiuli (2019) based on the research of CVaR model thinks that there is still a gap between China's actual green credit and

the optimal green credit portfolio, and then proposes that the loan for energy conservation and environmental protection, ecological agriculture, exhaust gas treatment and sewage treatment should be increased, and the credit for new energy vehicles should be reduced [1]. In the field of research on the development of green credit policy, Wang Yufeng (2018) believes that "green" policy improves the allocation efficiency of green finance, but at present, China's green finance is still at a relatively low allocation level [2]. Jiang Yeqing (2019) believes that obstacles to the development of green finance in China still exist, mainly reflected in the small proportion of green financial products and the lack of professionals in green finance [3]. Lin Boqiang (2019) believes that China's green finance, due to its late start and lack of a complete system, should increase policy support to promote the development of green finance [4]. Tang Jihang (2019) analyzed the challenges faced by green credit from four aspects of laws and regulations, incentive mechanism, professional ability and risk assessment and control, and believed that although China's green credit development has broad prospects, there are still many deficiencies [5]. In the research on how green credit affects China's green economic growth, Xie Tingting and Liu Jinhua (2019) conduct empirical analysis through dynamic panel GMM model, and show that green credit has a significant positive role in promoting green economic growth from two aspects of impact mechanism and transmission path [6]. It can be seen that the development of green credit plays a promoting role in China's economic development, so how to realize the development of green credit is very important to promote China's economic development. Zhou Yi (2011) put forward reasonable suggestions on the development of green credit from the aspects of carbon finance development, banks' social responsibility, profitability of bank loans and lack of effectiveness of environmental information [7]. Yu Fuqiang (2019) proposed from the government and commercial banks that a sound environmental protection legal system, precise policy incentive mechanism and spontaneous standardization standards can promote the development of green credit [8].

To sum up, the existing literature on the sustainable development of green credit in the future is still lacking. Therefore, based on the existing literature, based on the grey prediction model and econometric model, this paper studies and analyzes the problem, and then puts forward reasonable suggestions for the sustainable development of green credit.

2. Theoretical analysis of sustainable development of green credit

At present, China is in the stage of economic transformation, and promoting high-quality and sustainable economic development is the main goal. The essence of green credit lies in the correct handling of the relationship between financial industry and sustainable development. Its development helps environmental protection departments and banking industry to limit the emergence and development of high pollution and high energy consumption enterprises, reduce the illegal activities of enterprise environment, and promote the development of energy conservation and emission reduction in China. It is an important financial tool to prevent financial risks. By consulting the relevant literature and understanding the green credit policy, this paper makes the following theoretical analysis on the factors influencing the development of green credit and how the factors affect the green credit

(1) The non-performing loans of financial institutions. According to the theory of expected income, commercial banks should focus on the repayment of loans on schedule or the smooth realization of assets, and arrange the term and mode of loans according to the expected income of borrowers. The increase of non-performing loans will directly lead to the profitability of financial institutions, which will also reduce the credit ability of financial institutions, and affect the sustainable development of green credit. At the same time, according to the loan competition theory proposed by Eaton, Stiglitz and Gersovitz (1986), banks often relax the loan approval standards and implement low interest rates to attract customers and reduce the

quality of bank credit assets. On the one hand, this will lead to the decline of bank profits, on the other hand, it will increase the non-performing loans of banks. The decline of bank profit will directly affect its loan ability, and then affect the development of green credit.

(2) Education level. The impact of education level on green credit is mainly reflected in two aspects: first, education level not only refers to the level of education, but also the ability of a person to accept new things. Green credit is a new credit policy proposed in recent years, and its development speed will also be affected by the acceptance ability. Second, education belongs to the category of cultural industry. Kanatas and S-Tefanadis (2005) proved that culture is an important factor in promoting economic development and improving the efficiency of financial system by building theoretical models. It can also be seen that education level is closely related to green development.

(2) The level of economic development. As the core indicator of national economic activities, GDP can reflect the level of economic development of a country. According to the expenditure method, $GDP = \text{consumption} + \text{investment} + \text{government's purchase of goods and services} + \text{net export}$, that is, $GDP = C + I + G + (x-m)$. According to the formula, there is a close relationship between investment and GDP. When the scale of GDP increases, the investors' investment in financial institutions increases, which makes the input-output of financial institutions increase correspondingly, thus promoting the profit increase of financial institutions, which has a positive impact on the development of green credit for financial institutions.

(4) Environmental governance. The purpose of bank loans should not be pure profits, but should pay more attention to the benefits of loans, including social benefits including environmental benefits. In terms of environmental problems and credit security, China has had profound lessons. For example, in 1996, in order to solve the problem of environmental pollution in the Huaihe River Basin, nearly 1000 chemical pulp and paper mills were closed one after another. Among them, 42 paper mills in Huaibei City of Anhui Province lost nearly 350 million yuan in loans due to environmental pollution control. It can be seen that there is a close relationship between credit and green governance.

(5) The loan ability of financial institutions. As the embodiment of financial institutions' ability to absorb funds, the deposit balance of financial institutions can be used to measure the loan capacity of financial institutions. According to the deposit theory of commercial banks, deposits play an important role in the source of funds of financial institutions. Under normal circumstances, deposits have certain stability. The balance of deposits reflects the comprehensive strength and development potential of financial institutions, and then affects the loan capacity of financial institutions. Therefore, the deposit balance of financial institutions is closely related to the development of green credit.

3. Empirical analysis

3.1. Variable selection

Through reading a large number of literature and understanding the content of green credit policy, this paper believes that the main factors affecting green credit are the loan quality of financial institutions, the degree of residents' support, the level of economic development, the strength of environmental governance and the loan capacity of financial institutions. Therefore, the explanatory variables of the model are as follows:

Non performing loans of financial institutions (X1). The credit funds of Chinese financial institutions are basically extensive operation. The non-performing loans will seriously restrict the transformation of banking business from extensive to intensive, and affect the lending ability of financial institutions. When the balance of non-performing loans is large, it will not only seriously affect the bank's ability to support the economy, but also increase financial risks and social crisis, thus affecting the development of green credit in China.

Residents' support (X2). As a new credit policy, green credit needs the strong support of residents to get better development. When the residents know more about the green credit policy, the green credit can get better development. Under normal circumstances, the education level of residents is positively proportional to their understanding of green credit policy. Therefore, the number of undergraduates is selected to reflect the degree of residents' support.

Economic development level (X3). With the continuous development of green credit, the funds needed will also continue to increase, so the economic development promotes the development of green credit to a large extent. As an important indicator to reflect the development of the national economy, GDP has a good reflection on the level of China's economic growth.

Environmental governance (X4). One of the main contents of green credit policy is to limit the loans of high energy consumption and high pollution enterprises, so as to avoid the vicious circle of pollution first and then treatment. Environmental governance is conducive to promoting the construction of an environment-friendly society, promoting the development of energy conservation and emission reduction, which is conducive to promoting the development of green credit.

Loan capacity of financial institutions (X5). As one of the main contents of green credit policy is to support the development of environmental protection industry and ecological industry, we should pay attention to the long-term interests of human beings and promote the virtuous circle of Finance and ecology. Therefore, the higher the degree of development of financial institutions, the greater the support for environmental protection industry and ecological industry will be. The deposit balance of financial institutions reflects the ability of financial institutions to absorb funds, which can be used as an important indicator to measure the development degree of financial institutions.

The explained variable is the development of green credit, measured by the balance of green credit, and the symbol is Y.

3.2. Data sources

In order to ensure the preciseness and accuracy of the research, the non-performing loans of financial institutions, GDP, environmental pollution control expenditure and deposit balance of financial institutions are from the 2008-2017 EPS database, the number of undergraduates graduated is obtained from the official website of the National Statistical Yearbook, and the balance of green credit is obtained from the official website of CBRC and the official website of the people's Bank of China.

3.3. Model establishment

3.3.1 GM (1,1) model

(1) Data preprocessing

The data of each factor influencing the development of green credit is set as follows:

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), L, x^{(0)}(10))$$

By adding the original data to weaken the randomness of the random sequence, the new data sequence is obtained as follows:

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), L, x^{(1)}(10)). \text{ Where, } x^{(1)}(t) = \sum_{k=1}^t x^{(0)}(k), t = 1, 2, L, 10.$$

(2) Establishing differential equations

The first order linear differential equation of $x^{(1)}(t)$ is established:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = u$$

Where a and u are undetermined coefficients, which are called development coefficient and grey action quantity respectively.

Let a and u form a matrix as follows: $\hat{a} = \begin{pmatrix} a \\ u \end{pmatrix}$.

The mean value of the accumulated data is used to generate B and constant vector Y_n .

$$B = \begin{bmatrix} 0.5(x^{(1)}(1) + x^{(1)}(2)) \\ 0.5(x^{(1)}(2) + x^{(1)}(3)) \\ M \\ 0.5(x^{(1)}(9) + x^{(1)}(10)) \end{bmatrix}, \quad Y_n = (x^{(0)}(2), x^{(0)}(3), L, x^{(0)}(n))^T.$$

The least square method is used to solve the parameters $\hat{a} = \begin{pmatrix} a \\ u \end{pmatrix} = (B^T B)^{-1} B^T Y_n$.

Replace parameter \hat{a} into $\frac{dx^{(1)}}{dt} + ax^{(1)} = u$, We get the following formula:

$$\hat{x}^{(1)}(t+1) = (x^{(0)}(1) - \frac{u}{a})e^{(-at) + \frac{u}{a}}.$$

Then, the discrete analysis of $\hat{x}^{(1)}(t+1)$ and $\hat{x}^{(1)}(t)$ is carried out, and the difference between them is calculated to restore the original sequence $x^{(0)}$ and obtain the approximate data sequence $\hat{x}^{(0)}(t+1) = \hat{x}^{(1)}(t+1) - \hat{x}^{(1)}(t)$.

(2) Model checking

The residual error $e^{(0)}(t)$ and relative error $q(t)$ between $x^{(0)}$ and $\hat{x}^{(0)}(t)$ are calculated, and the mean value and variance s_1 of the original data $x^{(0)}$ and the mean value and residual error s_2 of $e^{(0)}(t)$ are obtained.

The probability of small error is $P = P\{|e(t)| < 0.6745s_1\}$. If $P > 0.95$, it is considered to meet the better requirements.

(2) Data forecast

GM (1,1) is used to forecast the influencing factors of green credit development in 2018-2027.

3.3.2. Multiple linear regression model

This paper uses multiple linear regression equation to study the linear causality between the development of green credit and its influencing factors. The linear regression model was as follows:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + L + \beta_k X_{ki} + c_i. \text{Where, } i=1,2,\dots,n.$$

3.4. Prediction results and analysis

3.4.1 Prediction of influencing factors by using GM (1,1)

Grey prediction is made on the data of influencing factors of green credit development. Through the prediction results, the residual values of the simulation values of each influencing factor are small, and the prediction results are reasonable. The forecast results of factors affecting the development of green credit are shown in Table 1.

Table 1:prediction results of influencing factors in 2018-2027 by using GM (1,1)

Year	Non performing loans of financial institutions (100 million yuan)	Number of undergraduates graduated (ten thousand)	GDP (100 million yuan)	Expenditure on environmental pollution control (100 million yuan)	Deposit balance of financial institutions (100 million yuan)
2018	28540.75	418.4297	915557.9845	10580.1142	1893671.5588
2019	33241.69	442.8365	1006230.3621	11131.6235	2139219.8012
2020	38716.91	468.667	1105882.4878	11711.8812	2416607.7463
2021	45093.95	496.0041	1215403.6718	12322.386	2729963.9785
2022	52521.35	524.9358	1335771.2973	12964.7146	3083952.4268
2023	61172.12	555.5551	1468059.5428	13640.5258	3483841.7817
2024	71247.75	587.9604	1613448.9681	14351.565	3935583.9132
2025	82982.93	622.2558	1773237.0498	15099.6685	4445902.4572
2026	96651.00	658.5517	1948849.7604	15886.7683	5022392.8888
2027	112570.34	696.9648	2141854.2935	16714.8973	5673635.5717

3.4.2. Multiple linear regression model

Eviews software is used to model the data from 2008 to 2017, in which the green credit balance is taken as the explanatory variable, and the non-performing loans of financial institutions, the number of undergraduate graduates, GDP, environmental pollution control expenditure and the deposit balance of financial institutions are the explanatory variables. After passing the test of economic significance, this paper conducts statistical inference test on the model and eliminates autocorrelation, multicollinearity and heteroscedasticity, and obtains the result of multiple linear regression model. Among them, the deposit balance of financial institutions fails to pass the significance test and removes it.

$$\ln Y = -0.7530 \ln X_1 + 9.7679 \ln X_2 - 2.7231 \ln X_3 + 2.4630 \ln X_4 - 24.7419$$

$$\begin{matrix} (0.1999) & (1.9027) & (1.1981) & (0.4217) & (4.7356) \\ t=(-3.7668) & (5.1336) & (-2.2727) & (5.8384) & (-5.2246) \end{matrix}$$

$$R^2 = 0.9938, \bar{R}^2 = 0.9897, F = 241.9045$$

3.4.3. Result analysis

It can be seen from the grey prediction model that the balance of non-performing loans of financial institutions is increasing year by year. Obviously, due to the imperfect market mechanism and the backward loan management mechanism, the non-performing loans of China's financial institutions are still showing an increasing trend. In addition, the number of undergraduate graduates, GDP, environmental pollution control expenditure are increasing. It can be seen from Figure 1 that the error between the real value and the predicted value of the green credit balance is very small when the multiple linear regression model is used to predict the development of green credit. Therefore, we use multiple linear regression model to forecast the data of green credit balance in 2018-2027. The forecast results are shown in Table 2.

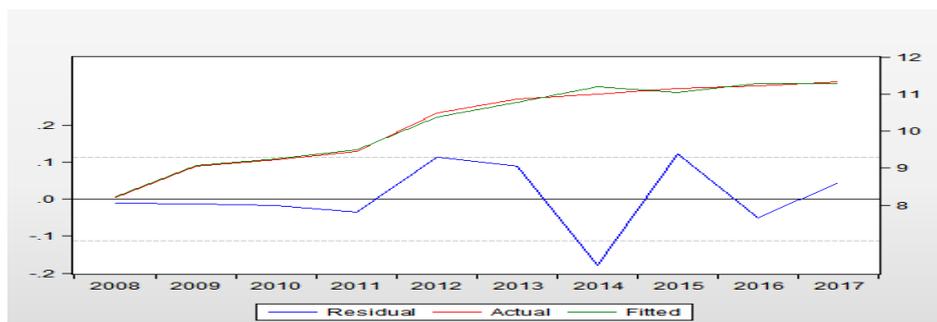


Figure 1: Comparison of true value and fitting value of green credit balance

Table 2:forecast results of green credit balance

Year	2018	2019	2020	2021	2022
Green credit balance (100 million yuan)	126970.17	156706.13	193406.15	238701.19	294604.16
Year	2023	2024	2025	2026	2027
Green credit balance (100 million yuan)	363599.40	448753.09	553849.47	683559.04	843646.14

According to the results of the combined forecasting model, the green credit balance will continue to increase from 2018 to 2027. The predicted balance of green credit in 2018 is 12697.017 billion yuan, and that in 2027 is 84364.614 billion yuan. The total growth rate was 5.64%, with an average annual growth rate of 0.564%.

4. Conclusions and suggestions

Based on the data of China's green credit balance and its influencing factors from 2008 to 2017, this paper explores the factors influencing green credit through multiple linear regression model. The results show that the degree of financial institutions' support, residents' support, economic development level, environmental governance and other factors have a significant impact on the development of green credit in China. In addition, based on the grey prediction model, this paper obtains the development prospect of green credit in China from 2018 to 2027, that is, the future value of China's green credit balance has been maintained at a high level and growing at a faster speed.

Based on the research results of this paper, four suggestions are put forward for the development of green credit.

(1) Improve the green credit supervision mechanism from the government department level. According to the results of the model, the non-performing loans of financial institutions have a negative correlation with the balance of green credit. The increase of non-performing loans of financial institutions will seriously hinder the growth of green credit balance and affect the lending ability of financial institutions. Therefore, it is necessary to strengthen the supervision of green credit. First of all, the regulatory authorities should strictly investigate the responsibility of financial institutions for illegal loans to enterprises, and establish incentive mechanism to encourage the development of green credit of financial institutions by formulating policies such as tax relief and financial discount. Secondly, the regulatory authorities should improve the information communication system of green credit to ensure that the effective and accurate environmental protection information can be transmitted to the environmental protection department and the financial institution supervision department in time, which is conducive to the regulatory department to provide reasonable data reference for the supervision of green credit behavior of financial institutions. Finally, the regulatory

authorities should establish an evaluation system of green credit, summarize the experience and lessons in the implementation of green credit policy, analyze the future development trend of green credit, and ensure the sustainable development of green credit.

(2) Enrich the development mode of green credit from the level of financial institutions. First of all, financial institutions should take the sustainable development of green credit as the basis, according to the market demand of green credit and the economic and social development strategy of China to formulate a scientific and reasonable green credit development strategy. Secondly, on the one hand, financial institutions should strengthen their own capital absorption capacity to ensure the stable and sustainable development of green credit. On the other hand, while making profits, they should limit the loans to enterprises with high energy consumption and high pollution, which are not up to the standard, so as to promote the progress of energy conservation and emission reduction. Finally, financial institutions should innovate green credit products and services and provide comprehensive green credit services for the society, which can not only enhance the core competitiveness of financial institutions, but also guide funds into the environmental protection industry.

(3) Improve the cultural quality of the residents in China. According to the results of the model, there is a positive correlation between the improvement of residents' cultural quality and the balance of green credit. Strengthening the cultural quality is the requirement of the development of the times, which is conducive to promoting the development of green credit. On the one hand, the improvement of residents' cultural quality can promote China's economic development, and then play a positive role in the development of green credit; on the other hand, higher cultural quality is conducive to better understanding of the content and concept of green credit policy, which plays a role in promoting the implementation of green credit policy. Therefore, the cultural quality of residents plays an important role in the development of green credit.

(4) Increase energy conservation and emission reduction from the aspect of environmental governance. Environmental problems have become an important factor restricting the sustainable development of China's economy. As the core of modern economy, the financial industry should give full play to its role in energy conservation and emission reduction. According to the results of the model, increasing environmental governance is positively proportional to the balance of green credit. Strengthening environmental governance will not affect China's economic development. On the contrary, increasing investment in environmental pollution control will help to promote China's economic growth and improve economic quality, which also has a promoting effect on the development of green credit.

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