Research on the Implementation Effect of Green Finance Based on Grey Relational Model

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Abstract. The development of green finance in China is still in its initial stage, and there is little research on the implementation effect of green finance. In this paper, using grey relational model, the green credit balances of 21 major domestic banks from 2013 to 2017 are selected to reflect the capital investment of green finance, while the net profit of listed banks reflects the development of financial industry and the net profit of environmental protection enterprises reflects the development of green industry. The results show that the green credit balance has a higher grey correlation with listed banks but it has a higher correlation with environmental protection enterprises, which proves that the implementation of green finance can promote the development of financial industry and green industry, but it can promote green industry even more.

1. Introduction

In recent years, the economic development mode centered on pursuing single growth has aggravated the deterioration of ecological environment. At the same time, the deterioration of ecological environment has hindered the healthy development of economy, forcing the economy to change its development mode, adjust the industrial structure, change the path dependence of high pollution and high energy consumption, and bring the green and healthy standards of ecological environment into the development goal. Chinese enterprises generally rely heavily on external funds. Therefore, the financial industry plays a vital role in promoting sustainable economic development and green environmental development. China constantly explores the development path of adjusting the economic structure to achieve the goal of environmental protection by exerting the financial function. Green finance came into being, which became an important tool for environmental protection and a strong support for economic development, and undertook the dual mission of environmental protection and economic development.

Green finance develops a new model of modern financial methods, provides new ideas for the development of financial industry, is a reform and innovation in the financial field, and glows new vitality for the long-term development of the financial field. However, there is no unified definition of green finance at present. Foreign scholars tend to define green finance in favor of environmental finance, and think that green finance is a financial tool to achieve the goal of environmental protection. The definition of domestic scholars is biased towards sustainable finance, holding that green finance is the purpose of realizing economic development while protecting the environment, economic development is the main goal pursued, and environmental friendliness is an auxiliary means to promote development. The Guiding Opinions on Building a Green Financial System gives
the definition of green finance: Green finance is an economic activity aimed at supporting
environmental improvement, coping with climate change and saving and efficient use of resources.
In essence, it is a financial service, and its service objects are project investment and financing,
project operation and risk management in the fields of environmental protection, energy
conservation, clean energy, green transportation and green buildings.

Salazar [1] (2017) pointed out that green finance is a financial innovation aiming at seeking a path of
environmental protection, and has built a bridge for the common development of financial industry and environmental industry. Soundarrajan & Vivek [2] (2016) believes that green finance is a strategic approach to integrate the financial sector into the transition process of low-carbon and resource-efficient economies to adapt to the context of climate change. Chamiet al. [3] (2016) believed that the implementation of green finance by financial enterprises can not only help enterprises to improve reputation and meet the increasing demands of stakeholders, but also help enterprises to better manage risks and make strategic decisions conducive to their development. Finger et al. [4] (2017) took 78 commercial banks in the world from 2003 to 2015 as a sample to analyze the changes in financial performance before and after the adoption of the Equator Principles. The results show that interest income and return on net assets of commercial banks in developed countries have increased, while the growth rate of commercial bank loans and interest income in developing countries declined.

2. Overview of Grey Relational Model

Grey relational analysis model is a basic branch of grey system theory system, which has a wide range of applications. Its core idea is to judge whether the sequences are closely related according to their similarity by depicting the geometric shapes of the sequence curves after selecting the system behavior sequences. The basic idea can be divided into the following two steps: the first step is to transform the discrete behavior observations of system factors into piecewise continuous polylines by linear difference method; the second step is, according to the geometric characteristics of polylines, to construct a model to measure the grey correlation degree. The closer the geometric shapes of polylines are, the greater the correlation between corresponding sequences. The advantage of grey relational analysis model is that, according to the development trend of things, there is no requirement for the number of samples and typical distribution rules, and the amount of calculation is small, which overcomes the defects of general mathematical statistics methods, and its results are in good agreement with qualitative analysis results, so grey relational analysis is a practical and reliable analysis method with its own unique advantages [5].

2.1. Grey Absolute Correlation Degree

In this paper, the selected sequences have the same length, so only the definition and calculation steps of grey absolute correlation degree based on sequences with the same length are given.

Step 1: Set system characteristic behavior sequence \( X_i = x_i(1), x_i(2), \ldots, x_i(n) \), \( i = 0, 1, 2, \ldots, n \);

Step 2: Zero the starting point of the system characteristic behavior sequence and record the broken line \( X_i - x_i(1) = (x_i(1) - x_i(1)), x_i(2) - x_i(1), \ldots, x_i(n) - x_i(1) \);

Step 3: Calculate the similarity between two polylines, which is measured by area
\[ s_i = \int_t^1 (X_i - x_i(1))dt ; \]

Step 4: If the \( X_o \) and \( X_i \) sequence and length are the same, it is called

\[
\gamma_{oi} = \frac{1+|s_o| + |s_i|}{1+|s_o| + |s_i| + |s_i - s_o|} \tag{1}
\]

is the grey absolute correlation degree with \( X_o \) and \( X_i \).

After examination, it satisfies the grey relational axiom.

### 2.2. Grey Relative Correlation Degree

Let the sequence \( X_o \) and \( X_i \) be the same as the length, and that initial value are not equal to zero, \( X_o' \), \( X_i' \) is the initial image of \( X_o \), \( X_i \). The absolute grey correlation degree with \( X_o \) and \( X_i' \) is said to be the relative grey correlation degree with \( X_o \) and \( X_i \), referred to as the relative correlation degree, recorded as \( \epsilon_{oi} \).

The main difference between the calculation of grey relative correlation degree and the calculation of grey absolute correlation degree is that the former needs to process the original sequence to obtain the initial image, and carries out the initial value process of the original sequence before the above calculation, so as to obtain \( X_o' \) and \( X_i' \).

Step zero: sequence initialization \( X_i' = \frac{X_i}{x_i(1)} = \left( \frac{x_i(1)}{x_i(1)}, \frac{x_i(2)}{x_i(1)}, \ldots, \frac{x_i(n)}{x_i(1)} \right) \);

Then, the \( X_o' \) and \( X_i' \) is taken as the original sequence, and the above calculation process is repeated to obtain the grey relative correlation degree of the sequence and \( X_o \) and \( X_i \).

### 2.3. Grey Comprehensive Correlation Degree

Grey absolute correlation degree indicates the similarity between polylines \( X_o \) and \( X_i \), and grey relative correlation degree indicates the proximity between polylines \( X_o \) and \( X_i \) and the rate of change relative to the starting point. The grey comprehensive correlation degree can fully combine the two, and can comprehensively characterize whether the sequences are closely related.

Let's assume that the sequences \( X_o \) and \( X_i \) are the same length and the initial values are not equal to zero. \( \gamma_{oi} \) and \( \epsilon_{oi} \) is the grey absolute correlation degree and relative correlation degree of sequence \( X_o \) and \( X_i \) respectively, \( \theta \in [0,1] \), then

\[
\rho_{oi} = \theta \gamma_{oi} + (1-\theta) \epsilon_{oi} \tag{2}
\]

is the grey comprehensive correlation degree of \( X_o \) and \( X_i \), which is called comprehensive correlation degree for short. Combined with different characteristics of variables \( \theta \), different values can be selected to meet our requirements for results. If the similarity of variables has a greater impact on the results, the greater the value \( \theta \) will be; if the rate of change of the variable has a greater impact on the result, the smaller the value \( \theta \). In this paper, considering the similarity of
polylines and the proximity of change rates, the comprehensive correlation degree is used to study the promotion effect of green finance implementation on the development of financial industry and green industry.

3. Research and Design

3.1. Sample Selection and Indicator Selection

At present, green credit is an important part of China's green finance construction, and it is also a major external source of funds for the green industry. China Banking Regulatory Commission has made statistics on the green credit balance of 21 major banks, and announced the green credit scale from the first half of 2013 to the first half of 2017, which is updated every six months. The balance of green credit increased from RMB5.2 trillion at the end of the first half of 2013 to RMB820 million at the end of the first half of 2017, with rapid growth and good development. This paper selects it as an indicator to study the implementation effect of green finance. The financial industry and green industry have a large scope, many enterprises and complex financial indicators. In this paper, listed banks are selected as the financial industry sample and listed environmental protection enterprises as the green industry sample, all of which are selected as the financial indicator of net profit. After excluding the companies and ST companies with incomplete data, this paper selects the panel data of annual reports and social responsibility reports of 16 listed banks and 36 listed environmental protection enterprises from 2013 to 2017 for data processing, and studies the implementation effect of China's green finance by analyzing the grey correlation among bank net profit, environmental protection enterprise net profit and green credit balance of 21 banks. The green credit balance data of 21 banks are derived from the CBRC, and the net profits of banks and environmental protection enterprises are derived from the National Tai'an Database.

3.2. Model Application

Before the gray correlation analysis, the data series reflecting the behavior characteristics of the system should be selected based on the result orientation. In this paper, the green credit balances of 21 banks are selected to reflect the capital investment of green finance, which is set as a sequence $X_0$. The net profit of listed banks reflects the development of the financial industry and is set as a sequence $X_1$. Net profit of environmental protection enterprises reflects the development of green industry and is set as a sequence $X_2$. The grey correlation degree between $X_0$ and $X_1$ is calculated separately, so is the grey correlation degree between $X_0$ and $X_2$, and then analyze which of the green credit's promotion effects on the net profit of banks and environmental protection enterprises is greater. The grey correlation degree here adopts the comprehensive correlation degree of Professor Sifeng Liu [6], considering the similarity degree and the change rate of the sequences comprehensively, taking $\theta = 0.5$, the higher the grey correlation degree, the greater the promotion effect is proved.

Among them: $X_0 = (485268400, 519830900, 572172600, 601282900, 663613300, 700661300, 726352900, 750468700, 829566300), X_1$ and $X_2$ are the series of net profit values of banks and environmental protection enterprises in June 2013, December 2013, June 2014, December 2014, June 2015, December 2015, June 2016, December 2016 and June 2017 respectively.
3.3. Qualitative Analysis

Green finance is a strategic tool to realize the goal of environmental protection while adjusting our economic structure. From a qualitative point of view, before the green financial business, financial institutions tended to invest in industries with heavy assets and high costs, most of which were enterprises with high pollution, high energy consumption and overcapacity. The investment efficiency was low and the risk was high. After the financial institutions started the green business, the capital began to flow to the green industry, on one hand, reducing their own investment costs and improving the efficiency of capital investment; On the other hand, it can improve the corporate image of financial institutions, enhance social reputation and goodwill, enhance the trust of stakeholders, easily capture more market share, seize the market blue sea of green financial development, open up new business growth poles, and enhance its profitability and competitiveness. At the same time, to solve the difficulty of financing the green industry, to provide a strong capital guarantee for the development of the green industry. Therefore, green finance has promoted the development of both financial industry and green industry, i.e. the grey correlation degree between green credit balance and banks and environmental protection enterprises is high.

The increase in audit costs resulted in an increase in operating costs due to the green credit business carried out by financial institutions; At the same time, it has given preferential loans to the green industry, which objectively results in a decrease in the profits of financial institutions. For the green industry, the green credit business reduces the financing cost of enterprises and directly enhances the profit of the green industry. Therefore, the promotion of green finance to green industry is greater than that to financial industry, i.e. the grey correlation degree between green credit balance and environmental protection enterprises is higher than that with banks.

Based on the above analysis, the following assumptions are put forward in this paper: (1) the grey correlation degree between green credit balance and banks and environmental protection enterprises is high (greater than 0.5); (2) However, the grey correlation degree with environmental protection enterprises is higher than that with banks.

4. Empirical Results Analysis

The seventh edition of grey modeling software is used to analyze and process the data, and the grey comprehensive correlation degree obtained in this paper is shown in the following tables 1 and 2 (accurate to four decimal places).
Table 1. Grey Comprehensive Correlation Degree with Banks.

| Ping An Bank Co., Ltd. | Bank of Ningbo Co., Ltd. | Shanghai Pudong Development Bank Co., Ltd. | Hua Xia Bank Co., Ltd. | China Minsheng Banking Co., Ltd. | China Merchants Bank Co., Ltd. | Bank of Nanjing Co., Ltd. |
|----------------------|--------------------------|------------------------------------------|------------------------|----------------------------------|-------------------------------|--------------------------|
| ping an              | bank of ningbo           | shanghai pudong development bank         | hua xia bank           | china minsheng banking           | china merchants bank          | bank of nanjing          |
| 0.5951               | 0.6230                   | 0.6100                                   | 0.6146                 | 0.6657                           | 0.6310                        | 0.6032                   |

Industrial Bank Co., Ltd. | Bank of Beijing Co., Ltd. | Agricultural Bank of China Limited | Bank of Communications Co., Ltd. | Industrial and Commercial Bank of China Limited | China Everbright Bank Company Limited | China Construction Bank Co., Ltd. |
|-------------------------|--------------------------|-----------------------------------|------------------------------|-----------------------------------------------|-----------------------------------|-------------------------------|
| 0.6263                  | 0.6485                   | 0.6719                             | 0.6880                      | 0.6704                                        | 0.6807                           | 0.6812                       |

Bank of China CITIC Bank Corporation Limited

| 0.6452 |

Table 2. Grey Comprehensive Correlation Degree with Environmental Protection Enterprises.

| Shenzhen Fountain Corporation | China Tianying Inc. | Zhongyuan Environment -protection Co., Ltd. | TUS-SOUND | SOUTH HUTTON CO., LTD | Infore Environment Technology Group Co., Ltd. | Wangneng Environment Co., Ltd |
|-------------------------------|---------------------|---------------------------------------------|------------|----------------------|-----------------------------------------------|-------------------------------|
| 0.6150                        | 0.6723              | 0.6555                                      | 0.6633     | 0.6650               | 0.6422                                        | 0.6364                        |

Hunan Kaimeite Gases Co., Ltd. | Beijing SPC Environment Protection Tech Co., Ltd. | Guangdong Chant Group Inc. | Beijing SDL Technology Co., Ltd. | Dongjiang Environmental Company Limited | Beijing Water Business Doctor Co., Ltd. | Xiamen Savings Environmental Co., Ltd. |
|-------------------------------|---------------------|---------------------------------------------|------------|----------------------|-----------------------------------------------|-------------------------------|
| 0.6798                        | 0.7069              | 0.6126                                      | 0.6795     | 0.8130               | 0.7240                                        | 0.6015                        |

BEIJING ORIGINWA TER TECHNOLOGY CO., LTD. | Beijing Sanju Environmental Protection & New Materials Co., Ltd. | Anhui Shengyun Environment Protection Group Co., Ltd. | Hebei Sailhero Environmental Protection High-tech Co., Ltd. | Xiongan Kerong Environment Technology Co., Ltd. | Shenwu Environmental Technology Co., Ltd. | Cec Environmental Protection Co., Ltd. |
|-------------------------------|---------------------|---------------------------------------------|------------|----------------------|-----------------------------------------------|-------------------------------|
| 0.5848                        | 0.5849              | 0.7649                                      | 0.6048     | 0.6979               | 0.7144                                        | 0.6208                        |

Yonker Environmental Protection Co., Ltd. | WELLE Environmental Group Co., Ltd. | Shenzhen Techand Ecology and Environment Co., Ltd. | focused Photonics Inc. | Shanghai Saibon Service Co., Ltd. | Xingyuan Environment Technology Co., Ltd. | Canature Health Technology Group Co., Ltd. |
|-------------------------------|---------------------|---------------------------------------------|------------|----------------------|-----------------------------------------------|-------------------------------|
| 0.6197                        | 0.6030              | 0.7837                                      | 0.7257     | 0.6147               | 0.6322                                        | 0.6203                        |
In order to make a more intuitive comparison of the grey comprehensive correlation degree between the two, this paper uses the scoring system (percentile system) to calculate the average score of the two. The comprehensive correlation degree is 90 points between 0.8 and 0.9, 80 points between 0.7 and 0.8, 70 points between 0.6 and 0.7, and 60 points between 0.5 and 0.6. After calculating the total score of grey comprehensive correlation degree of two industries, this paper divide by the number of enterprises, and finally get the average value of grey comprehensive correlation degree between each industry and green finance. The calculation results are as follows:

Average of grey comprehensive correlation degree with banks:

\[
\frac{60 \times 1 + 70 \times 15}{16} = 69.3750
\]

Average grey comprehensive correlation degree with environmental protection enterprises:

\[
\frac{60 \times 2 + 70 \times 22 + 80 \times 10 + 90 \times 2}{36} = 73.3333
\]

The calculation results show that the grey comprehensive correlation degree between the two is high, which proves that green finance has a greater role in promoting the financial industry and green industry; However, the grey correlation degree with environmental protection enterprises is higher than that with banks, that is, the contribution of green finance to green industry is greater than that of financial industry. Hypothesis (1) and (2) have been verified.

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