Analysis of the Impact of Green Finance on High Energy Consumption Industry

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Abstract. The rapid development of China's economy in recent years has brought up serious ecological and environmental problems. The development of green finance can help the coordinated development of economy, society, resources and environmental protection. This paper applied the gray correlation advantage analysis method, in which selected the main indicators of the green financial system, and analyzed the correlation of the development of the six high energy-consuming industries. The results show that the green financial system has obvious relevance to the development of high-energy-consuming industries.

1. Introduction
Since the rapid development of the Chinese economy following the reform and opening up, the industrialized society has gradually transformed into a post-industrial society, and the living standards of the residents have also been greatly improved. However, economic development at the expense of huge resource consumption has made resources increasingly tense, environmental pollution has increased, and the deterioration of the ecological environment, to some extent, has limited economic development [1]. To encounter such problem, the World Commission on Environment and Development in 1987 proposed the concept of sustainable development, which advocates the development of the economy while focusing on the protection of the ecological environment. The Chinese government has also fully recognized this problem and raised the issue of mutual coordination between economic development and environmental protection to the level of national strategy. In the report of the 18th National Congress of the Communist Party of China, the construction of ecological civilization is an independent chapter. It puts forward the concept of green development, circular development, low-carbon development and the construction of “beautiful China”. The construction of ecological civilization has risen to an unprecedented important position. Acting as the core of the modern economy and in order to achieve sustainable development, the financial industry is in urgent need of continuous innovation and the integration of financial development and sustainable development concepts. For one thing, sustainable development requires strong financial support, and the healthy development of finance also depends on sustainable economic growth[2]; for another thing, finance is based on sustainable economic development, and sustainable development guaranteed the long-term prosperity of financial industry [3]. Green finance is the objective demand under the new situation, and its role is crucial.

As a new concept of financial theory and financial practice, green finance is also called environmental financing or sustainable finance. It mainly re-adjusts the financial industry's business philosophy, management policies and business processes from the perspective of environmental protection to achieve sustainable development. Early foreign literature defined green finance to seek economic development in environmental protection and achieve a balance between economy and
environment. Green finance is mainly to study the issue of green economy financing, and it is an organic combination of economic sustainable development and financial issues\[4, 5\]. There is no unified definition of green finance in China. There are three representative views\[6\]: First type, the financial industry that favors green industry in terms of loan policies, loan targets, loan conditions, types and methods of loans, and offers priority and tilt policy in terms of credit delivery, investment volume, maturity and interest rates. Second type is that the financial sector consider environmental protection as a basic national policy, and carry out the “sustainable development” strategy through the operation of financial services, thereby promoting the protection of environmental resources and coordinated economic development, and thereby achieving a financial operation for sustainable financial development. The third is to use green finance as a financial and capital market instrument in environmental economic policies, such as green credit and green insurance.

In order to promote the development of green finance, China has launched a series of policy measures in the areas of green credit, green insurance and green securities, which provide policy guarantee for the development of green finance. In recent years, research on green finance has also been increasing. At present, domestic research mainly focuses on the concept of green finance and the construction of mechanisms. For example, the research on the status and problems of green finance concept and domestic green finance development\[7\], Li Renjie studies the impact of financial marketization on green financial supply and connotation from the market perspective\[8\], Zhang Chenghui discussed the logic and framework of developing green finance in China \[9\], Du Li\[10\], Wang Xiaojing\[11\], Fan Shaohong\[12\], Ge Chazhong, etc\[13\] did research on different perspectives of green finance ranging from state-owned banks, policy enforcement, legal system, green financial policies and products. At present, there are many studies on the construction of green financial systems, policy implementation and application, and legal systems. However, there are relatively few studies on the effects and impacts of green finance. Most of the research focuses on the impact of green finance on industrial structure\[14\] and the impact on different periods of macroeconomics\[15\], and there are few studies on the impact and correlation of specific industries. Green finance mainly affects the two high and one surplus industries stipulated by the state. This paper attempts to analyze the impact and relevance of green finance on these industries, so as to have a certain understanding of the specific effects of green finance.

2. Data selection and Modeling

2.1. Data Selection

The People's Bank of China, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Environmental Protection, the China Banking Regulatory Commission, the China Securities Regulatory Commission, and the China Insurance Regulatory Commission jointly issued the “Guiding Opinions on Building a Green Financial System” in 2016. The opinion pointed out that the green financial system refers to the “institutional arrangements to support the transition of the economy to green through financial instruments such as green credit, green bonds, green stock indices and related products, green development funds, green insurance, carbon finance and related policies”. Therefore, the data selected in this paper is mainly based on several aspects indicated by the guidance, and then the secondary indicators are formed according to the data that can be collected. The specific indicators are as follows:

| Primary indicators | Secondary indicators | Indicator definition |
|--------------------|----------------------|---------------------|
| Green credit       | Green credit balance ratio | Green credit as a percentage of total credit balance |
| Green investigation| Industrial pollution control investment ratio | Industrial pollution control investment as a percentage of total environmental investment ratio |
| Green insurance    | Environment liability insurance | Environmental pollution mandatory liability insurance insured amount |
| Carbon finance     | Carbon trading amount | On-site and off-site carbon allowance trading amount |

Table 1. Green financial system impact indicators
After the launch of China's green finance, green credit has become the major financial instrument. Banks have always been the majority part of China's financial system, thus green credit is a credit policy introduced by the Ministry of Environmental Protection and the People's Bank of China and the China Banking Regulatory Commission to curb high-energy and high-pollution industries and solve environmental problems. The main type of green insurance in China is environmental pollution liability insurance[16]. The issuance of the “Guiding Opinions on Environmental Pollution Liability Insurance Work” in 2007 marked the official launch of the pilot work on environmental pollution liability insurance. Since then it has played an active role in resolving contradictions and disputes and promoting environmental risk prevention and management[17]. Carbon financial products are an emerging green financial product. Keir (2014) believes that carbon finance is an important part of the development of green finance[18]. At present, carbon financial products are constantly innovating, and their forms are increasingly diversified, including a variety of innovative products.

This paper selects the green financial impact indicator system from 2011 to 2016 as reference data, and selects the percentage of fixed assets investment in the six high energy-consuming industries in the country as a comparative factor. The high energy consuming industries are selected according to the “2010 National Economic and Social Development Statistics Report”.

Table 2. National Green Finance Statistics and Investment Data of Six High Energy Consumption Industries

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|------|------|
| Green credit | Green credit ratio | 2.39 | 5.68 | 7.23 | 7.36 | 7.46 | 8.83 |
| Green investigation | Industrial pollution control investment ratio | 7.37 | 6.06 | 9.40 | 10.42 | 8.79 | 8.88 |
| Green insurance | Environment liability insurance (10K) | 7000 | 14600 | 10800 | 7000 | 27333.97 | 28400 |
| Carbon trade volume | total (10K ton) | 11 | 22 | 44.55 | 27 | 1723.1 | 655 | 3338.97 | 9760.44 |

Source: China Banking Social Responsibility Report, China Statistical Yearbook, China Carbon Emissions Trading Network

2.2. Model selection
The grey relational analysis method is based on the gray system theory proposed by Professor Deng Julong in China[19]. The basic idea of this method is to determine the degree of association of geometric similarity of sequence curves. The greater the geometric similarity, the greater the degree of correlation. Compared with other measurement models, the grey correlation analysis method can better describe and analyze the degree of association between a small number of samples with no typical distribution based on a small number of calculations[20].

In this paper, the generalized grey relational degree based on Deng's grey relational analysis model is adopted, and the similarity of sequences can be investigated based on the whole or the whole perspective. The model sets the industrial carbon emission data $X_0$ of Henan Province as the system characteristic parent sequence, and the Henan industrial structure data as the relevant factor sequence, namely $X_1$, $X_2$, ..., $X_n$, then
\[ X_i = \{ x_i(1), x_i(2), \ldots, x_i(n) \} \]

Where, \( i \) is the parent sequence and the comparison sequence, \( i=0,1,\ldots,n \) is the time series length, and the calculation will calculate the gray comprehensive relevance of the green financial data of 2011-2016 with the fixed investment ratio of each industrial sector as the original data. The calculation steps are as follows:

1. Calculation of the absolute correlation degree of gray. The gray absolute correlation degree is the degree of similarity between the parent sequence \( X_0 \) and the comparison sequence \( X_i \). The greater the similarity between \( X_0 \) and \( X_i \) geometrically, the larger the \( \epsilon_0i \). The calculation formula is:

\[
X_0 = (x_0(1), x_0(2), \ldots, x_0(n), 1) = \left( x_0^0(1), x_0^0(2), \ldots, x_0^0(n) \right)
\]

\[
X_i = (x_i(1) - x_i(1), x_i(2) - x_i(1), \ldots, x_i(n) - x_i(1), 1) = \left( x_i^0(1), x_i^0(2), \ldots, x_i^0(n) \right)
\]

The starting point zeroing image of each series can be calculated as

\[ X_0^0 = \left( x_0^0(1) - x_0(1), x_0^0(2) - x_0(2), \ldots, x_0^0(n) - x_0(n), 1 \right) = \left( x_0^0(1), x_0^0(2), \ldots, x_0^0(n) \right) \]

\[ X_i^0 = \left( x_i^0(1) - x_i(1), x_i^0(2) - x_i(2), \ldots, x_i^0(n) - x_i(n), 1 \right) = \left( x_i^0(1), x_i^0(2), \ldots, x_i^0(n) \right) \]

The gray absolute correlation can be calculated as:

\[ \epsilon_{oi} = \frac{1}{1+|s_0|+|s_i|} |s_0| + \frac{1}{1+|s_0|+|s_i|} |s_i| \]

2. Calculation of the gray relative correlation degree. The grey relative correlation degree is a representation of the relationship between the parent sequence \( X_0 \) and the rate of change of the comparison sequence \( X_i \) with respect to the starting point. The closer the rate of change of \( X_0 \) and \( X_i \) is, the larger \( r_{oi} \) is, and vice versa. Set

\[
X_0^\prime = \left( \frac{x_0(1)}{x_0(1)}, \frac{x_0(2)}{x_0(1)}, \ldots, \frac{x_0(n)}{x_0(1)} \right) = \left( x_0^0(1), x_0^0(2), \ldots, x_0^0(n) \right)
\]

\[
X_i^\prime = \left( \frac{x_i(1)}{x_i(1)}, \frac{x_i(2)}{x_i(1)}, \ldots, \frac{x_i(n)}{x_i(1)} \right) = \left( x_i^0(1), x_i^0(2), \ldots, x_i^0(n) \right)
\]

It can be calculated that the initial values of each series are like \( X_0^\prime \), \( X_i^\prime \), then the starting point zeroing image of \( X_0^\prime \), \( X_i^\prime \) is

\[
X_0^\prime_0 = \left( x_0^0(1) - x_0(1), x_0^0(2) - x_0(2), \ldots, x_0^0(n) - x_0(n), 1 \right) = \left( x_0^0(1), x_0^0(2), \ldots, x_0^0(n) \right)
\]

\[
X_i^\prime_0 = \left( x_i^0(1) - x_i(1), x_i^0(2) - x_i(2), \ldots, x_i^0(n) - x_i(n), 1 \right) = \left( x_i^0(1), x_i^0(2), \ldots, x_i^0(n) \right)
\]

Then by

\[ |s_0| = \left| \sum_{k=2}^{n-1} x_0^0(k) + \frac{1}{2} x_0^0(n) \right| \quad \text{and} \quad |s_i| = \left| \sum_{k=2}^{n-1} x_i^0(k) + \frac{1}{2} x_i^0(n) \right|, \]

the grey relative correlation degree can be calculated as:

\[ r_{oi} = \frac{1}{1+|s_0|+|s_i|} \left( |s_0| + \frac{1}{2} |s_i| \right) \]

3. Calculation of the gray comprehensive correlation degree. The grey comprehensive correlation degree is a quantitative index that comprehensively represents whether the sequences are closely related. It not only shows the similarity between the parent sequence \( X_0 \) and the comparison sequence \( X_i \) but also reflects the change of the proximity of the rate of the parent sequence \( X_0 \) and the comparison sequence \( X_i \) relative to the starting point. If the relationship between the absolute quantities is concerned, \( \theta \) may be larger; if the rate of change is more important, \( \theta \) may be smaller. Generally, the resolution coefficient \( \theta = 0.5 \) indicates the same concern for the absolute amount and the rate of change by:

\[ \rho_{oi} = \theta \epsilon_{oi} + (1 - \theta) r_{oi} \]

The closer the gray comprehensive correlation degree is to 1, the greater the correlation between sequences. Generally, when the resolution coefficient is equal to 0.5, the comprehensive correlation degree is greater than 0.6, indicating that there is a significant correlation between the sequences.
3. Empirical Analysis
Using the grey correlation analysis advantage analysis, the correlation analysis of the data in Table 3, the results are

Table 3. The correlation matrix of green finance impact on high energy consumption industry

|                                | Green credit ratio | Environment liability insurance | Industrial pollution control investment ratio | Carbon trade volume |
|--------------------------------|-------------------|---------------------------------|---------------------------------------------|--------------------|
| petroleum processing coking    | 0.5404            | 0.5198                          | 0.6903                                      | 0.5002             |
| and nuclear fuel processing    |                   |                                 |                                             |                    |
| chemical raw materials and     | 0.5188            | 0.5190                          | 0.6139                                      | 0.5002             |
| chemical products manufacturing|                   |                                 |                                             |                    |
| non-metallic mineral products  | 0.5556            | 0.5204                          | 0.7436                                      | 0.5002             |
| non-ferrous metal smelting and | 0.5672            | 0.5207                          | 0.7840                                      | 0.5003             |
| calendering                    |                   |                                 |                                             |                    |
| ferrous metal smelting and     | 0.5299            | 0.5194                          | 0.6537                                      | 0.5002             |
| rolling processing             |                   |                                 |                                             |                    |
| electric power production and  | 0.6943            | 0.5444                          | 0.8352                                      | 0.5007             |
| supply                         |                   |                                 |                                             |                    |

It can be seen from the results of the correlation matrix row that the correlation value of the second row is the smallest, which indicates that the corresponding chemical raw materials and chemical manufacturing industries are least affected by the indicators of the green financial system, that is, the financial systems of the green financial’s impact of the measures on their development is not great. Relatively speaking, the electric heat production supply industry has the highest correlation value, indicating that this industry is most affected by various indicators of the green financial system. From the perspective of vertical correlation, industrial pollution control investment has the greatest impact on various energy-consuming industries, indicating that this index can effectively limit investment in high-energy industries and expand production. The carbon emissions trading has the lowest correlation with each industry, indicating that the current carbon emission industry is still in its infancy, and its ability to limit emissions from various high-energy industries is not outstanding.

From the perspective of single correlation degree, the impact of industrial pollution investment governance on the electric power industry is the most relevant. China's current energy structure is still dominated by coal, supplemented by oil and natural gas, and more than 60% of the energy source is coal. Electric power is a high-energy sector and an industrial sector that consumes coal. In 2016 alone, there were 166 million tons of coal consumed, accounting for 44% of the total industrial consumption. The emission of industrial waste gas such as carbon dioxide and sulfur dioxide is huge. The investment of industrial pollution control is mainly based on the treatment of industrial waste water and waste gas, which makes it have a great restriction on the investment and expansion of the electric power industry.

4. Discussion and Conclusion
From the analysis results, the indicators of the green financial system have certain influence on China's high energy consumption industry. Among them, green credit is the main component of green finance, and the impact on various high energy consumption industries is also very important. However, in practice, due to the lack of incentive and restraint mechanisms, the government, banks, and enterprises lack the driving force for green credit. For the government departments, high-pollution and high-energy-consuming industries are both the mainstay of the economy and the taxpayers and large-scale employment, thus been treated differently from normal industry, which affects the development of green credit. For banks, the government lacks supporting incentives in terms of interest subsidies, tax reductions, provisioning and bad debt write-offs, and the bank’s internal assessment mechanism is not perfect. Green credit lacks competitive advantage in cost revenue, input and output. The environmental protection industry has low efficiency, high cost, high project risk and low operational
efficiency. Under the lack of strict environmental protection supervision requirements, no targeted incentive system has been established, and green credit support is insufficient in performance appraisal and resource allocation. In terms of credit product innovation, China's green credit products mainly focus on corporate project financing, credit constraints on “two high” industries, and support for the environmental protection industry. They are generally targeted at corporate customers and have not achieved diversified development of customer groups. Comparing with other countries, China's green credit products have problems such as small variety, small business volume, and homogenization tendency, which is difficult to meet market needs.

In addition to continuing to develop green credit, domestic banks should also actively carry out green financial innovation, especially in the two emerging fields of carbon finance and green bonds. In 2015, the global green bond issuance reached about 50 billion US dollars. In 2016, the first domestic issue of green bonds reached 200 billion yuan, accounting for nearly 40% of the global issuance. The banks should also innovate green financial products and business models. For example, to strengthen green credit innovation, introduce green environmental protection concepts into credit policy formulation, business process management, product design, and actively develop new products, such as to encounter the issue of insufficient collateral in green credit, introduce carbon rights pledge financing loans, and allow green enterprises to provide Intellectual property pledge, export tax rebate pledge, carbon emission rights pledge.

References
[1] Zhang Yuanshuo, Coordination of economic development and environmental protection, D 2016 University of International Business and Economics
[2] Yu Yongda and Guo Peiyuan 2003 Research and Practice of Financial Industry for Sustainable Development Environmental Protection, pp 50-53
[3] Wang Huizhen and Chen Baoqi 2006 Environmental Finance: A Win-Win Path for Financial Innovation and Circular Economy Shanghai Finance pp 29-31
[4] Labatt, S. and R.R. White 2003 Environmental finance: a guide to environmental risk assessment and financial products John Wiley & Sons Vol. 200
[5] Jeucken, M., 2010 Sustainable finance and banking: The financial sector and the future of the planet. (Routledge)
[6] Research Group, Development Research Institute of Southwestern University of Finance and Economics, Environmental and Economic Policy Research Center, Ministry of Environmental Protection, et al. 2015 Green Finance and Sustainable Development Financial Forum pp30-40
[7] Yi Jinping, Jiang Chun, and Peng Yu 2014 Research on the Status Quo and Countermeasures of Green Finance Development in China Special Economic Zone pp 81-83
[8] Li Renjie 2014 Marketization and Green Finance Development China Finance pp 17-19
[9] Research Group of the State Council Development Research Center "Greening China's Financial System", et al. 2016 Developing the Logic and Framework of Green Finance in China Financial Forum pp. 17-28
[10] Du Li and Zhang Xin 2012 Green Finance, Social Responsibility and Behavioral Choice of State-owned Commercial Banks Journal of Social Sciences Jilin University pp 82-89+160
[11] Wang Xiaojiang and Zhu Xiaoguang 2009 Ways to Improve the Implementation of Green Financial Policies Environmental Protection pp 45-46
[12] Fan Shaohong 2013 Green Finance Legal System: The Choice and Reality of Sustainable Development Journal of Wuhan University (Philosophy and Social Sciences) pp 75-79+128-129
[13] Ge Chazhong, Weng Zhixiong, and Duan Xianming 2015 Green Financial Policy and Products: Current Status and Recommendations Environmental Protection pp 32-37
[14] Huo Dongsheng 2017 Analysis of the role of green credit in industrial restructuring Hebei Finance pp 3-8
[15] Liu Yuyu, et al. 2015 Analysis of short-term and medium-term impacts of China's green credit policy based on the financial CGE model *Chinese Journal of Management Science* pp 46-52
[16] Tian Hui 2014 Current Status and Future Development of China's Green Insurance *Development Research* pp 4-7
[17] Chen Jingyuan 2016 Thoughts and Countermeasures for Developing Green Insurance *Southern Finance* pp 14-17
[18] Keir, G 2014 Carbon bond financial system and method for reducing green house gases and carbon footprint *Google Patents*.
[19] Deng Julong M 1990 *Grey System Theory Course*. (Huazhong University of Science and Technology Press)
[20] Liu Sifeng, Yang Yingjie, and Wu Lifeng B 2014 *Grey System Theory and Its Applications*. (Science Press)