

The Impact of Green Finance on Carbon Emissions Within the Power Sector

Junyu Chen^{1,a,*}

¹Department of Civil Engineering, Imperial College London, South Kensington, London, The United Kingdom

a. chenjunyu2022w@163.com

**corresponding author*

Abstract: This study examines the impact of green finance on reducing carbon output within the energy sector. The research finds that green finance, by utilizing green finance instruments, such as green credit and bonds, allocate funding to low-carbon sectors, promotes the transformation of the energy sector, and effectively curbs carbon output. Trends in green finance indicate that green bonds and green credit serve as key mechanisms. They have significantly propelled the low-carbon transformation and facilitated the carbon reduction efforts within China's energy sector. Empirical results suggest that the expansion of green finance, especially the expansion of green credit and green bonds, substantially lower carbon output in the energy sector. Overall, green finance plays a beneficial role in lowering carbon output in the energy sector by providing financial support and guiding enterprise transformation. This research holds significant value in supports the energy sector's shift towards a low-carbon future and in shaping green finance policies.

Keywords: Green Credit, Green Bonds, Carbon Emissions.

1. Introduction

In recent years, global climate change has become increasingly severe, prompting countries worldwide to implement measures to combat gases that contribute to the greenhouse effect. As a significant factor in global carbon output, China has set ambitious targets for “carbon neutrality” and “carbon peaking”. The energy sector, being a significant source of carbon output, urgently needs to undergo transformation and upgrading to achieve carbon reduction. Green finance is an essential instrument in advancing green development and sustainable economic growth, serving as a key mechanism for facilitating efforts to reduce carbon output within the energy sector. Green finance contributes significantly to reducing carbon output in the energy sector by directing investments towards low-carbon industries and providing financial backing for green initiatives.

This study examines how green finance influences carbon output within the energy industry, analyzing its carbon reduction mechanisms and actual effects, which are crucial for advancing the green transformation within China's energy sector and achieving the dual goals of “carbon neutrality” and “carbon peaking”. In summary, green finance has actively contributed to decreasing carbon output within the energy sector, but there is still a need for further policy refinement and market mechanisms to achieve greater reductions. This study provides empirical support and theoretical basis for the practical application of green finance in lowering carbon output within the energy sector. It

also offers valuable insights for policymakers and enterprises to optimize financial tools and enhance emission reduction efforts in their pursuit of the “dual carbon” goals.

The remainder of the paper is structured as follows: Section 2 examines the mechanisms through which green finance influences carbon output in the energy sector. Section 3 explores the development trends of green finance. Sections 4 and 5 offer empirical analyses of green finance’s impact on carbon output within the energy sector. Finally, Section 6 summarizes the research findings and provides policy recommendations.

2. An Analysis of how Mechanism of Green Finance Affects Carbon Output in the Energy Sector

2.1. Research on Carbon Output in the Energy Sector

To better address the problem of elevated carbon output within the energy sector, Researchers have employed various techniques to investigate the factors contributing to carbon output in this sector. He Ying, Xing Yuantong, and Ji Yijun [1] adopted the Logarithmic Mean Divisia Index (LMDI) method and quadrant analysis to examine the key contributing factors influencing carbon output in the energy sector across 30 provinces in China. Their results showed that economic growth rate is the primary factor influencing carbon output within the energy sector. Other factors include the share of energy consumption from thermal power sources, electricity intensity, and the energy structure of the energy sector. Hou Jianchao and Shi Dan [2] analyzed the factors driving the rise in carbon output within China's energy sector from 1991 to 2012, revealing that per capita GDP is the primary positive driving force for the increase in CO₂ emissions from the energy sector. Liu Yiwen [3], employing the Toda-Yamamoto test procedure, analyzed the energy sector, including the energy sector, and found that economic growth and increased energy consumption result in higher CO₂ emissions. Anandarajah G., Liyanage M. H., and Shrestha R. M. [4] applied the Logarithmic Mean Squared Deviation Index decomposition method to investigate the key factors affecting carbon output in the energy sectors of 15 Asia-Pacific nations. They found that in 10 countries, including China and Japan, economic growth is the primary factor driving the increase in carbon output, while in the Philippines, Indonesia, and Bangladesh, the increase in electricity intensity is the main driver. In New Zealand and Sri Lanka, changes in the power generation structure are the main reasons for fluctuations in carbon output. These studies indicate that carbon output in the energy sector are primarily related to economic growth, followed by factors such as The energy mix, electricity intensity in the energy sector, and the proportion of energy consumed by thermal power.

2.2. The Connection Between Green Finance and Carbon Emissions

With the introduction of targets for “carbon neutrality” and “carbon peaking”, enterprises have increasingly focused on environmental protection, particularly on reducing carbon output. Green finance has emerged as one of the tools to help companies lower carbon output, and its financial model has gained popularity in recent years. The effect of green finance on carbon output can be observed in two main aspects. First, the comprehensive green finance framework helps in controlling and reducing carbon output. Gao Yuan and Shen Zhenzhen [5], using a difference-in-differences method, studied the carbon reduction effects of green finance reform initiatives and innovation pilot areas. Their studies concluded that policies aimed at reforming green finance play a crucial role in lowering carbon output, with the impact increasing year by year. Second, green finance includes various financial tools like green venture capital, green credit, and green bonds. These tools channel capital toward low-carbon industries through their respective mechanisms, assisting energy-intensive companies in shifting towards low-carbon business models. Jiang Hongli, Wang Weidong, and Wang Lu [6], through an empirical study of the carbon reduction effects of environmentally focused credit

and green venture funding in China, showed that both can suppress carbon output. Moreover, there is an absence of notable "crowding-in" or "crowding-out" impact between them. Cai Haijing [7] analyzed data-backed evidence following the execution of green credit initiatives, including in the energy sector, and found that green credit policies are particularly effective in short-term loans, especially after the financial crisis. Xu X. and Li J. [8] did a research on green bond data from Chinese cities, which revealed that green bonds, via technological innovations and environmental policies, are helpful to lower carbon output.

2.3. The Effect of Green Finance on the Transition of the Power Industry

The carbon reduction effects of green finance on the energy sector are primarily reflected in its ability to assist power companies in transitioning. Driven by the effect of green finance, traditional thermal power companies can access financing to facilitate their transformation, accelerating the shift in the energy sector's energy structure toward cleaner and low-carbon alternatives. Additionally, green finance channels capital into emerging clean energy fields including wind power and solar power, meeting the transition needs of the energy sector and helping achieve carbon reduction goals. Li Zheng, Chen Siyuan, Dong Wenjuan, and others [9] developed a joint optimization model to explore the pathways for China's energy sector's shift to a low-carbon model. Their findings underscore the vital significance of green finance in ensuring the necessary investment for the energy sector to achieve the "dual carbon" goals. Wang Kai [10] found that green asset securitization can reduce company financing costs and, under this policy, help save standard coal consumption and achieve effective greenhouse gas emission reductions.

3. Development Trends in Green Finance

Green finance tools have played a significant role in advancing the low-carbon transformation of China's energy sector, with green credit and green bonds playing a particularly important role in driving carbon reduction and energy transformation. Currently, green finance tools in China rely primarily on green credit, with green bonds serving as secondary tools to support the transition of the new energy industry in China [11].

3.1. Green Credit

Green credit mainly supports power companies in implementing renewable energy projects and improving energy efficiency through offering loans at reduced interest rates and other advantageous financial terms [12]. Many wind and photovoltaic power generation projects have received support from green credit, thereby reducing reliance on fossil energy sources like coal and decreasing carbon output [11].

The China Banking Regulatory Commission (CBRC) introduced the "Green Credit Guidelines" in 2012, marking the launch and formal establishment of the green credit market [13]. From 2015 to 2020, the green credit market steadily grew in size over time, supported by policies such as the "Guiding Opinions on the Establishment of a Green Finance System" (2016). Liu et al. evaluated the influence of green credit on energy-intensive sectors and found that, in its early stages, green credit policies focused primarily on pollution control and energy-saving projects, but due to immature policies and markets, their overall impact was limited [14]. By the 2020s, the green credit market had matured significantly, not only promoting corporate carbon reduction but also facilitating the restructuring and advancement of China's industrial framework. According to Song et al., green credit is crucial to improvements in corporate energy efficiency and carbon reduction [15]. Cheng et al. identified the contribution of green credit to the active promotion of industrial advancement, especially in the eastern regions [16].

3.2. Green Bonds

Green bonds offer financial assistance to renewable energy and green technology projects, promoting the implementation of low-carbon energy projects and green technology innovation, thereby driving carbon reduction in the energy sector.

In 2016, the Industrial and Commercial Bank of China (ICBC) launched green bonds within the interbank bond market, which marked the formal introduction of the green bond market in China. In a short period, the Chinese green bond market experienced rapid growth, and China has since ranked the second in issuing green bonds globally [17]. According to the "China Green Bond Annual Report" by the Central University of Finance and Economics, the issuance of green bonds in China has seen a significant increase, rising from 201.785 billion yuan in 2016 to 838.87 billion yuan in 2023, reflecting a year-on-year growth rate of 312.45%. According to data from the China Central Depository & Clearing Co., Ltd., the energy sector has consistently been the largest issuer of green bonds among all industrial sectors. From 2016 to 2021, the issuance of green bonds in the energy sector grew from 19.3 billion yuan to 187.8 billion yuan, with a notable drop only in 2020. However, in 2021, the issuance volume rebounded sharply, growing by 423.12% year-on-year (Figure 1). The growth in green bond issuance within the energy sector has facilitated the sector's transition towards a low-carbon model, helping to lower carbon output [18].

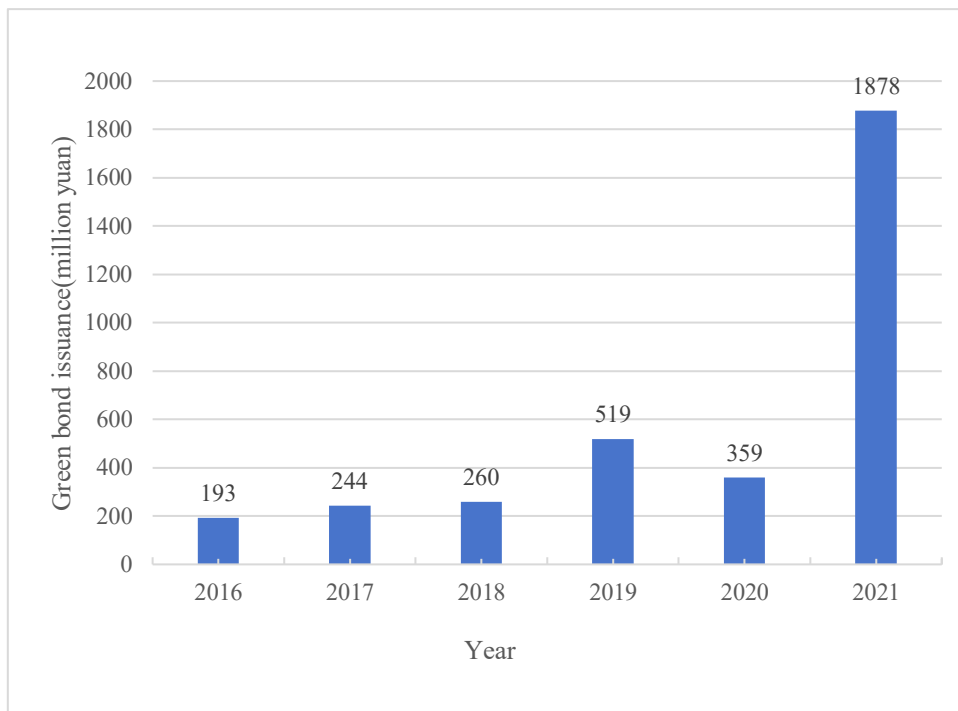


Figure 1: Issuance of Green Bonds in China's Power Industry from 2016 to 2021.

4. Model Setup and Data Sources

4.1. Model Setup

Based on existing research, the model used in this paper is set up as follows:

$$y_t = \alpha + \beta X_t + \gamma Z_t + \varepsilon$$

y_t represents the carbon output of China's energy sector in year t ; X_t includes two financial instruments most closely related to the energy sector: green credit (GC) and green bonds (GB). The

metric for green credit is derived from the proportion of interest expenses attributed to industries outside the six key high-energy-consuming sectors above a designated size to total interest expenditures, representing the growth level of green credit. The green bond level (GB1) is assessed through the ratio of the issuance volume of green bonds to the total bond issuance volume for each year. Since green bonds were only issued starting in 2016, the data for earlier years is zero, and the results are standardized accordingly (Liu Jinhua et al.) [19]. Model (3) uses a second measure of green bond levels (GB2), which is the ratio of green bonds issued by the energy sector to the total bond issuance volume from 2016 to 2021; Z_t represents control variables, including economic development level (GP), notably affecting carbon output. Economic development is measured using per capita GDP, and the results are logarithmically transformed; ε represents the random disturbance term.

4.2. Data Sources

Carbon emission data for China's energy sector is obtained from the China Carbon Accounting Database (CCAD) and covers national electricity, heating, and gas figures from 2012 to 2021. Green credit information is sourced from the China Industrial Statistics Yearbook, while green bond data is drawn from the GTA database and the China Central Depository & Clearing Co., Ltd. Per capita GDP data is taken from the China National Statistical Yearbook.

4.3. Descriptive Statistics

This research utilized data spanning from 2012 to 2021, focusing on indicators like green credit (GC) and green bonds (GB) in China, amounting to 10 datasets. Based on statistical significance, the descriptive statistics of different variables, including means, standard deviations, minimum values, and maximum values, are presented in the table below.

Table 1: Descriptive Statistics Results.

Variable	Observation	Mean	Standard Deviation	Min	Max
Y	10	3.632	0.0455	3.585	3.720
GC	10	0.530	0.011	0.517	0.550
GB1	10	6.11e-17	1.000	-1.070	1.776
GB2	6	2.31e-18	1.000	-0.567	1.987
GP	10	4.754	0.103	4.600	4.910

5. Empirical Analysis

Table 2 presents the regression results of the study. According to Model (1), green credit exerts a notable negative effect on carbon output within the energy sector, exhibiting a coefficient of -1.598, accompanied by a p-value of 0.004, indicating that a rise in green credit leads to a substantial reduction in carbon output. The coefficient for green bonds has a p-value of 0.099, suggesting that its impact is not significant. Per capita GDP shows a notable positive impact on carbon output, with a coefficient of 0.257 and a p-value of 0.021, indicating that a rise in per capita GDP substantially contributes to higher carbon output. The R-squared value of the model is 0.9645, indicating a high explanatory power of the model for carbon output and good model fit. Overall, green credit and per capita GDP have significant effects on carbon output, while the effect of green bonds is not significant.

Table 2: Regression Results Analysis.

Variable	(1)	(2)	(3)
GC	-1.598*** (0.349)	-1.344*** (0.384)	
GB	0.0168* (0.00860)		0.00403 (0.00230)
GP	0.257** (0.0826)	0.404*** (0.0403)	0.621*** (0.0362)
Constant	3.258*** (0.488)	2.425*** (0.281)	0.660** (0.175)
N	10	10	6
R-squared	0.965	0.942	0.996

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Due to the absence of green bond data from 2012 to 2015, this study separately examines the effect of green credit on carbon output in the energy sector for the period from 2012 to 2021. According to Model (2), green credit shows a marked negative impact on carbon output, with a coefficient of -1.344 and a p-value of 0.010, indicating an expansion in green credit leads to a significant decrease in carbon output. Per capita GDP exerts a notably positive influence on carbon output, with a coefficient of 0.404, demonstrating that higher per capita GDP leads to a substantial increase in carbon output. The R-squared value of the model is 0.942, indicating a high explanatory power and good model fit.

Green bonds were first issued in 2016, and this study analyzes their impact using data from 2016 to 2021. According to Model (3), economic development positively and significantly influences carbon emission intensity, with a coefficient of 0.621, suggesting that economic development increases carbon output. However, the influence of green credit on carbon output intensity does not appear to be significant. The R-squared value of the model is 0.996, indicating a very high explanatory power for carbon output. Overall, the effect of green bonds remains insignificant.

6. Conclusion

Ongoing advancements in green finance are essential for promoting energy savings and emission reductions. The energy sector is one of the main sources of carbon output. To investigate the effect of green finance development on carbon output in the energy sector, this research first reviews the existing literature, then analyzes the mechanisms by which green finance facilitates carbon reduction in the energy sector, examining the link between the growth of green finance initiatives and carbon emissions in this sector. After conducting a data analysis of the current state of green finance development and carbon output in the energy sector, the findings reveal that the expansion of green finance, particularly green credit and green bonds, has effectively mitigated the overall growth of carbon output in the energy sector. In the regression results, green credit and economic growth significantly contribute to the reduction of carbon output in the energy sector, while the impact of green bonds is not significant. This is likely because the green bond market was established later, and obtaining detailed data, especially for the energy sector, is challenging.

In conclusion, green finance supports carbon reduction efforts in the energy sector through various methods such as providing financial support and services, innovating green financial products and services, policy guidance and incentive mechanisms, and promoting the synchronized advancement of green finance and the power market. These measures provide the necessary funds and resources

for the energy sector and accelerate its green transformation and sustainable development. Future developments could explore the integration of green finance with digital technologies to optimize resource allocation, enhance energy efficiency and lower carbon emission intensity in the energy sector. For example, leveraging new technologies such as big data and cloud platforms can help establish full-process monitoring and supervision of major green projects in the energy sector, addressing information asymmetry issues and enabling financial institutions to offer more precise and efficient green financial services. Moreover, challenges remain in the development of green finance in China, such as the late start of the market, lack of unified standards for green finance, and insufficient sustainable information disclosure. It is recommended to unify green finance standards and improve relevant systems and regulations.

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