

Understanding the Dual Effects of Green Finance on Carbon Emission Reduction and Economic Growth

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Abstract. In recent years, as countries have attempted to achieve economic development and environmental protection simultaneously, green finance has drawn the attention of many governments and institutions around the world and is now a popular subject of discussion. Review of previous studies on the relationship between green finance, carbon emission reduction and economic growth. First, it will review the interpretations of the concept of green finance in the literature and compare the methods of measurement. Next, the three primary channels for the impact of green finance on environmental performance and economic development are introduced. Most of the current studies have found that green finance can reduce carbon emissions by providing funds for the construction of eco-friendly facilities and fostering the development of green technology. At the same time, it will also promote the long-term development of the economy by driving industrial upgrading and creating new sources of revenue. The results of the studies mentioned in the literature are not the same either; this is mainly because they used different indices, data sources and empirical approaches. Based on the above studies, some deficiencies in the present research have been identified and future directions for study proposed.

Keywords: Green finance, emission reduction, green growth

1. Introduction

Recently, climate change, environmental damage and resource depletion have become increasingly severe problems around the world. The old model of economic growth is high-energy-consumption and high-emission, and therefore is no longer feasible in the long run. In line with the Paris Agreement and other international commitments, many countries have set goals for carbon neutrality or carbon-free development and are promoting the transition to a low-carbon economy around the world. Given the above, green finance has gradually developed into a key policy and market mechanism that channels funds for environmental protection into green sectors and projects.

In recent years, green finance has gained the attention of many people, but there are still two serious deficiencies. On the other hand, there is a lack of all-encompassing coverage in the implementation evaluation. Most of the existing research has simply examined the reduction in pollution by green finance, and some studies have only covered total production in that area, employment and technology innovation. They both lack a system review of the connection between environmental effects and economic benefits, and as a result, policymakers are unable to determine

whether green finance can actually achieve the goal of a double win for the environment and the economy. At the same time, there is no combination and comparison. There are indeed some single paths, such as credit allocation, technology improvement and industrial structure promotion, but the dual effect, conduction sequence and conditional dependence have not been considered, and thus the core question of green finance—what paths and conditions should be taken—remains unanswered.

Review of research on the impact of green finance on carbon emissions reduction and economic growth. Determine whether green finance can achieve both environmental and economic benefits simultaneously, and identify the primary mechanisms proposed in previous research. The remainder of this paper is as follows. Section 2 introduces the main ideas and theoretical basis. Section 3 introduces the indicators and measurement methods for the two effects of green finance. Section 4 introduces the principal paths by which green finance influences environmental and economic performance. The last part is an outline of what will be presented and future work in this paper.

2. Conceptual definition and analytical framework

Although there is a general agreement on the goal of green finance, scholars and policies have provided many different specific definitions. Green finance refers to the application of financial instruments, investment and other financial tools in the development of a green economy. Lindenberg proposes an all-encompassing system of green finance that covers all kinds of financial instruments for directing funds to environmentally friendly projects, such as green credit, green bonds, green insurance and carbon finance [1]. Green finance is closely related to the above several concepts but is not the same as them. Sustainable finance has a broad scope and considers the goals of environment, society and governance (ESG) simultaneously. Climate finance generally refers to problems of climate change adaptation and mitigation; transition finance helps reduce the carbon footprint of high-emission industries during the transition to a low-carbon economy.

A problem that has been mentioned in the literature is greenwashing. It is a case where the company or financial institution has exaggerated the environmental benefits of its products and projects to obtain green finance without making actual environmental improvements. Given that greenwashing has occurred, in addition to the amount of green investment, the actual environmental results of such green finance need to be considered in the assessment. Delmas and Burbano believe that the main reasons for greenwashing are information asymmetry, weak regulation and a lack of reputation incentives [2]. Under the above circumstances, the company may disclose only favourable environmental information and make minimal adjustments to production and investment. Therefore, the expansion of green finance has not resulted in actual environmental improvements. Set reasonable standards for disclosure and have an independent party confirm that the new-energy financial products are genuinely environmentally friendly.

The first kinds of tools in green finance are listed below. Green credit offers special loan arrangements for environmentally friendly projects, and by 2022, green bonds had raised approximately 680 billion US dollars worldwide for green investment. ESG investing considers environmental, social and corporate governance factors in portfolio selection, and carbon finance combines carbon emission trading with related financial products. These instruments have different ways of working, so they will also be applied differently in terms of policy and market.

The two effects that this paper considers are environmental performance and economic performance. The environment-friendly features of green finance are to reduce pollution, and they can be reflected in indices such as carbon emissions, carbon intensity, energy efficiency and ecological footprint. Economic performance refers to all kinds of indicators of development quality

in addition to GDP growth, such as green total factor productivity and green technological innovation and employment creation.

Theoretically, the three possible relationships between the environment and economy under green finance are shown below. The first is synergy, and at the same time, carbon emissions will be reduced with economic growth or even increased. The second is a trade-off; that is, environmental benefits are gained by sacrificing some speed in economic development, or, on the other hand, high-speed economic growth incurs future environmental costs. A third possibility is that green finance has little or no measurable effect on one of the two dimensions. Identify the reasons for the different results and design corresponding green finance policies. Some studies believe that the transition to a low-carbon economy will inevitably have adjustment costs in the short run, and particularly in carbon-intensive industries, investment, output and employment may decline before the new green industries are able to absorb these displaced resources [3]. Therefore, although green finance will have good results in the long run, there may be some temporary sacrifices.

To organise the existing literature, this paper takes the form of several linked paths through which green finance affects environmental and economic performance: resource allocation, green technological innovation, risk pricing, industrial restructuring and institutional governance. The Strength of these mechanisms will vary according to the development level of the region and industrial structure. As a result, the empirical results may have been affected by the reasons for selection and differences in measurement and research design. Therefore, the following sections will present the measurement methods, transmission mechanisms and empirical evidence in order.

3. Review of measurement methods: quantifying green finance and dual effects

The earliest types of green finance are scale and share indicators. Typically, the data used in this way are the total amount of green credit, green bond issuance or green investment, etc., and these indicators are often expressed as a proportion of total financial activities. Since the data are relatively easy to obtain, most empirical research has used this method. Only the scale of green finance is shown, and little data on its actual environmental benefits are available.

Another way is to construct an all-encompassing composite index of green finance. Lee and Lee have constructed a multidimensional index by integrating green credit, green investment, green insurance and government support, and believe that a single index cannot comprehensively reflect the progress of green finance [4]. Based on the above research, it can be determined that composite indicators are more encompassing of green finance. Wang and Zhi believe that different green financial products have various environmental functions, and thus, a single index will not be suitable for all these attributes [5]. Therefore, many scholars have combined several indicators into a single index; however, the selection of variables and the method of weighting are inherently subjective.

The third way is to use text analysis based on a green-related dictionary, and it is mainly applied at the firm level. Researchers examine corporate annual reports, sustainability reports and ESG disclosures, identify whether a company is involved in green finance based on how often environmental terms appear, etc. Singh and Verma have observed that this way has become increasingly popular in recent years; however, they have also pointed out that its reliability is highly dependent on the quality of corporate disclosures and the completeness of the keyword dictionary used [6].

The fourth is the use of ESG ratings and climate risk indicators. Most of the above indicators are generally provided by external institutions such as Bloomberg, MSCI and FTSE Russell. Although ESG ratings are often applied in empirical studies, there are still considerable differences among the rating agencies, and therefore the results of these studies are inconsistent.

All of the above measurement methods have certain strengths and weaknesses. Scale indicators are simple and have readily available data, but they mainly focus on the amount of green finance rather than its environmental effectiveness. Composite indices are more all-encompassing evaluations that combine many dimensions, and the results can vary due to different selections and weights of the indicators. Text-based indicators offer richer firm-level information but are subject to errors in the disclosure of these companies. The problems of ESG ratings are the same; different agencies have assigned different scores to the same company. Therefore, due to different measurement methods, the results of the studies are not directly comparable, and some of the reasons for different conclusions in previous studies about the effectiveness of green finance may be attributed to this.

The other reason for the discrepancy in the empirical evidence of green finance is differences in measurement. Although all scholars have the same topic of green finance and economic growth, they select different specific indicators for measurement in their studies, such as green credit indicators or multi-dimensional composite indices, and thus obtain different research results.

Most of the evaluation of emission reduction is based on carbon-related indicators. A general index of carbon emissions is used, and these generally fall into three categories: Scope 1 emissions (direct emissions from a company's own operations), Scope 2 emissions (indirect emissions from purchased electricity, heat, etc.), and Scope 3 emissions (all other indirect emissions in the value chain). Due to data limitations, most of the macro-level studies have focused on Scope 1 and Scope 2 emissions, and firm-level research has recently started to incorporate Scope 3 emissions. Carbon intensity is the amount of greenhouse gases released per unit of GDP or value added, and it is frequently used to show the carbon efficiency of economic development. An index that shows this is a typical indicator of energy efficiency; generally speaking, it refers to the amount of energy required to produce a unit of output and is closely related to the development of green finance.

4. Methodological approaches to assessing the dual effects of green finance

In recent years, the ecological footprint has been used as an all-encompassing measure of the environment. Ecological Footprint measures the demand for ecological resources in a certain area by converting all ecological services into a common unit and is thus a more comprehensive index of environmental pressure than a single carbon indicator.

At the top of the list are the International Energy Agency, the Global Carbon Project, relevant environmental statistics in China, etc. The main problems in the empirical research are inconsistent data definitions, accounting errors and missing Scope 3 emissions data.

Measurement of growth performance has moved from a single indicator to several. The old studies have mainly used the rate of increase in GDP, and its advantages are a stable definition and easy-to-obtain data. However, GDP alone cannot indicate whether the growth is "green". Therefore, people have gradually been demanding a high-quality development.

Green total factor productivity incorporates energy consumption and environmental pollution into the productivity accounting system, and at present, it is one of the most commonly used indicators of green growth. GTFP is generally estimated using data envelopment analysis, and the slacks-based measure (SBM) model proposed by Tone, or stochastic frontier analysis, is used with CO₂ emissions as an undesirable output [7].

Green innovation output is also a representative form of green growth, and it is often shown by green patent applications or the application of green technology. Hu, Guanghua, Wang, Xinyi and Wang, Yudong used Chinese city-level data to find that green finance can promote green technological innovation by easing financing constraints and encouraging investment in

environmentally friendly technologies [8]. Social indicators of green development are gradually being added to the assessment criteria, such as employment creation and improvements in the living standards of residents.

When conducting research to promote the reduction of emissions and economic development simultaneously, it is not clear whether the two are in harmony or conflict. The above are the existing approaches.

Dual-objective regression estimates green finance coefficients separately for environmental and growth indicators in the same model, and judges synergy (coefficients in the same direction) or trade-off (coefficients in opposite directions) based on the sign of the coefficients. This way is simple and intuitive, but it cannot quantify the degree of trade-off.

Research on Mediation Models of Green Finance, Emission Reduction and Economic Development (via technological innovation), etc. If the mediator affects both end results in the same way, it is a supplement.

Data Envelopment Analysis is often applied to multiple-objective efficiency assessment. Researchers build an all-encompassing system of green finance inputs, pollution emissions (undesirable outputs), and economic growth (desirable outputs) to determine the "dual-effect efficiency" of green finance. Coupling coordination models measure the level of coordination in the development of the green finance system and economic growth system.

Marginal Abatement Cost and Green Premium approach the problem from a price perspective. Marginal abatement cost is the economic cost of reducing emissions by one unit; the green premium is the cost difference between clean and traditional technology. The above indices can quantify the specific trade-off between emission reduction and economic growth.

Methodological Differences are not the only reasons for the disparate results. Institutional Differences may also account for the disunity in the empirical evidence. Nguyen and others have determined that the environmental impact of green finance is affected by institutional quality, and better results have been achieved in areas with good governance and regulation [9]. Therefore, when studying the two sides of the effect of green finance, variations in institutional quality and differences in research methods should be considered.

In short, there is no single framework for combined assessment of the two sides, and the results obtained by different means are not the same; thus, careful consideration must be given when interpreting the research outcomes.

5. Review of mechanisms: why do "emission reduction-growth" dual effects occur

The old theory of financial development and economic growth believes that a good financial system can promote the allocation of resources to high-return, low-risk projects [10]. Environmental finance adds the goal of ecological improvement directly to the investment decisions in this model. In addition to the expected commercial returns on liquidity, ecological finance also considers environmental factors to allocate funds for green development and excludes high-polluting production facilities.

The first and most open connection between green finance and the goals of the environment and the economy is resource allocation. Through different loan structures and personalised interest rates, the cost of capital for ecological initiatives has been reduced, and at the same time, carbon-intensive activities have been penalized; thus, asset flows have successfully shifted to sustainable operations. Therefore, these funds will be directed towards curbing the expansion of polluting production modes to reduce overall emissions and simultaneously supporting investment in clean industries to create new paths for economic development. Sachs and others believe that the primary aim of ecological

financing is to shift funds for necessary-but-non-revenue-generating investments toward environmentally sustainable development and thereby improve the efficiency of capital utilisation overall [11]. Reduce the credit risk of eco-projects to promote development in sustainable power and low-emission industries under the dual objectives of environmental protection and economic benefits through green finance.

Scholarly research has provided varying degrees of support for the above objectives of green finance. Although a large number of papers have shown that the ecological and economic benefits are favourable, many scholars believe that such advantages depend on the current regulatory system. Nguyen and his co-authors have demonstrated in their study that a good institutional system can enhance the ecological benefits of green finance; otherwise, due to weak governance and lax supervision, the policies will not be effectively implemented [9]. Due to the above reasons, the same financial plan may have different outcomes in different areas or countries.

Only one is the reason for the difference. Delmas and Burbano believe that, due to greenwashing, many environmental benefits promised by ecological finance will not be realised [2]. An organisation may be motivated to overstate the long-term benefits of its business to obtain favourable green credit; however, it fails to implement corresponding reductions in its environmental impact. Therefore, an increase in the scale of green investments is insufficient to achieve the goal of carbon reduction.

The start of the low-carbon transition is relatively noisy in the data. If the credit channel for the older, high-emission enterprise is suddenly cut off, there will be a considerable economic loss. This generally takes the form of reduced corporate investment, an increase in insolvency, and temporary unemployment, as the new green sector has not yet been able to absorb the displaced labour and capital.

The above observations are consistent with the economic model of asset distribution, and given the considerable time lag for capital reallocation, industrial modernisation and efficiency improvements have not yet been realised. Jiang and Li show that digital solutions reduce information asymmetry to improve the efficiency of asset allocation by optimising production factors [12]. Therefore, the technological integration of green finance can help promote the smooth flow of funds for high-efficiency, environmentally friendly development projects.

Development of technology is supporting the double benefits of green finance. Based on Porter's theory, the company will have to develop new kinds of production methods under this constraint [13]. Technological Optimisation will reduce the company's compliance costs and achieve emission reductions in the long run.

Field evidence shows that the new form of modernisation is also a transmission channel. Lee and Lee have studied that environmental finance boosts green total factor productivity by motivating creative engineering and eco-friendly production [4]. Similarly, Hu, Wang and Wang have shown that green R&D investment will increase due to loosened credit policies and a reduction in credit constraints [8]. Based on the above analysis, new technologies will help link the incentive system to the development goals for a longer period.

Address the problem of innovation externalities at the same time. As the public benefits of the new generation of green technology are generally large, but the profit margin for private enterprises is relatively small, there is a lack of incentive to invest in research and development. Therefore, the financial incentives should work together with the all-encompassing environmental and industrial regulatory system.

Climate risk is now a known danger to the financial system, and although it has once been considered an environmental problem, is no longer so. Given the risk to assets from natural disasters

and the risk of asset impairment due to changes in regulations, the bank has revised the potential losses.

The Risk-Pricing Channel Changes Corporate Investment Decisions in Two Ways. First, detailed risk assessment raises the cost of borrowing for high-emission projects. Secondly, the people's bank has set up a favourable interest rate for low-carbon projects to help reduce pollution and promote green development of the economy.

Support for this structural channel has been expanding rapidly in recent years. Du and his colleagues have found that the new ecological-friendly financial system is actively promoting investment in green innovation by lowering financing costs and boosting R&D investment [14]. Zheng and others have also shown that environmental finance has promoted renewable power engineering in a sample of 64 countries, and the results have been relatively stronger in wealthy countries [15]. The above group studies show that, at present, most environmental funds for green development are provided in the form of technology.

However, the extended long-term macro trend will not be changed by this initial short-term fluctuation. As liquid funds are drawn away from the environmentally damaged and low-efficiency areas of the economy, an organised industrial upgrading path for wealth creation has gradually been formed. The development of the alternative-energy industry and the construction of an ecological-service-networked clean-technology-enterprise will create jobs and stimulate the economy. Gradually, the above basic structural changes will strengthen the economy's stability and promote continuous development. Therefore, the results of industrial restructuring should be viewed as a dynamic story of change, and the immediate benefits often do not extend to long-term financial and environmental gains.

6. Conclusion

Systematic review of the interaction between green finance and carbon reduction and economic growth. Based on the analysis of both empirical results and theoretical systems, the specific conditions and limits of this connection are shown below.

In short, the above studies have shown that financial incentives can help achieve environmental goals and economic development simultaneously. Market mechanisms such as green credit, green bonds and ESG-driven investment have been introduced to direct funds towards environmentally friendly projects away from high-carbon industries.

The following are the reasons for the above phenomena. Channels of capital allocation reduce the financing costs of green projects and promote green technological innovation to enhance firm productivity.

Field observations are still very varied because of different empirical indicators, data repositories and methodological arrangements. Different studies use different particular metrics to assess the adoption level and sustainable development of eco-finance, and this difference in evaluation criteria is one reason for the contradictory results in the literature.

The present study provides new references for scholars to explore how the various pieces of evidence relate to environmental and macroeconomic changes in the path of green asset flows. Based on the above data, a good system of green finance can help achieve the goals of reducing carbon emissions and promoting the construction of a green economy simultaneously.

There are some defects in the above synthesis, however. Most of the available research focuses on the immediate empirical dynamics and uses very different evaluation indicators; thus, the conclusions of these papers may not be easily compared. There is also a widespread problem of false

environmental marketing; thus, the actual ecological benefits of green finance are difficult to confirm.

In the future, more standardised evaluation indicators and an increase in the size of large-scale datasets will be needed for research. Other firm-level factors or changes in the cross-country comparison system could be the reason for this result; further research is needed.

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