

# Green Finance Research: A Scientometrics Review

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**Abstract:** In recent years, green finance has attracted extensive attention in various fields all over the world. This study selected 739 high-quality references collected from the core database of Web of Science from 1990 to 2019, and conducted a comprehensive scientometrics review by using CiteSpace. The results show that: (1) the collaborative relationship between countries is relatively weak, and the representation of developing countries in the global research network is still insufficient. (2) subdivided themes can be summarized as: international green financing policies based on the macro framework, green financial instruments, bilateral donor behavior and political choices, etc. Among them, green financial instruments has become a hot pot in recent years. (3) cost reduction, corporate social responsibility, green investment and innovation, energy consumption control, and renewable energy issues have attracted academic attention in recent years, the improvement of environment in developing countries and carbon market have also become hot topics.

## 1. Introduction

With the rapid development of the global economy since the 21st century, the energy consumption of the world has already overloaded, which leads to a sharp increase in pollution emissions, global warming, ecological environment deterioration and other issues. Therefore, green finance began to rise as a powerful management method for alleviating this situation.

Green finance is also known as environmental finance, sustainability finance or carbon finance. The concept originated in the western developed countries in the 1970s. In 1974, the federal republic of Germany established the world's first policy-based environmental protection bank, named after the "eco-bank", which provides preferential loans for environmental projects that the general banks are unwilling to accept. Since then, the research on green finance has been carried out in the academic circles around the world.

There is a considerable amount of literature published on green finance. However, these studies tends to focus on a single aspect. Therefore, in order to clarify the trend of the research on green finance and explore the correlation between different topics and research directions, this study aims to obtain a complete knowledge map of green finance by reviewing the existing literature. Therefore, our research will have the following objectives:

- (1) describe the current status of green finance research based on the number of papers published.
- (2) analyze the cooperation network, identify the main contributors and cooperative relationships
- (3) cluster the topics so as to find out the high-quality literatures influencing the research and summarize the subdivision research direction
- (4) draw the knowledge pattern of the field from the perspective of keywords to find research hot spots, frontiers and trends

## 2. Materials and Methodology

### 2.1 Data acquisition

In the process of searching data, we should pay attention to balance the accuracy rates and recall rates. Simple retrieval strategy is beneficial to improve the recall rate, but will lead to a lower

accuracy rate. This paper collects data according to the following screening strategies:

(1) For data sources, we selected SCIE and SSCI from the WOS core database.

(2) To cover as many articles as possible of green finance, we set the search word "green financ\*" or "carbon financ\*" or "sustainable financ\*" or "environmental financ\*" or "climate financ\*" add "green bond", "green credit", "green fund", "green insurance" and "green investment" as supplements.

(3) Since the articles are more academic, the literature type is set to "Article".

(4) After a rough search, the first relevant article appeared after 1990, so the time span is set as "1990-2019".

(5) Sources of subject words include title, abstract, keyword, and full text. The data is saved in the format of "record full contents and references". The file format is "plain text".

To test the validity of the results, we randomly selected 200 articles and manually screened their relevance to the topic. The results show that 98% of them are closely related to the theme, which indicates that the retrieval strategy is effective. After filtering and removing the overlapping data, we obtained a total of 739 pieces of data.

## 2.2 Citespace

At present, knowledge mapping tools in academia mainly include CiteSpace, VOSviewer, SPSS, etc. Data processing in this study is based on CiteSpace developed by Chaomei Mei. In this study, different network node types were selected and divided by one year. Then we apply the default cosine algorithm to calculate the correlation strength, select the top 50 items of data with the highest frequency in each time partition, and use the path seeking network algorithm (PFNET) in the clipping method. Meanwhile, we allow slicing and merging networks to generate co-occurrence graphs in turn for visual analysis.

## 3. Results

### 3.1 Annual variations of publications

As can be seen in figure 1, by analyzing the annual variations of publications, we find that the number is closely related to the occurrence of international events. Therefore, we divide it into the following three stages:

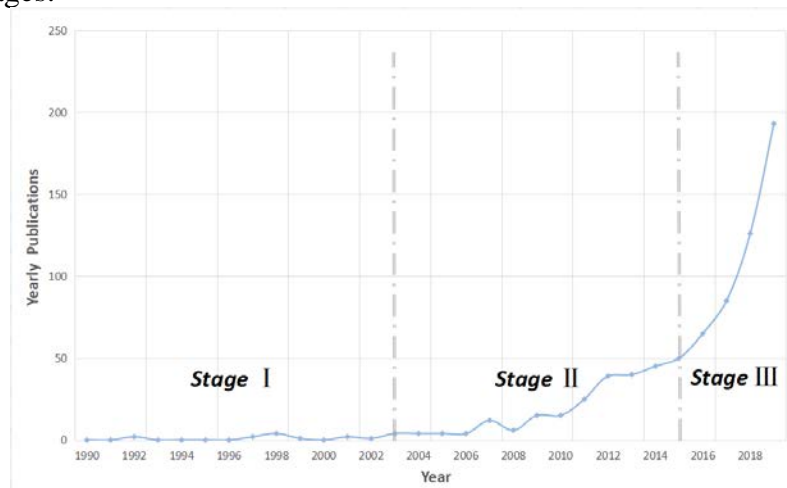


Figure 1 Annual Variations of Publications of Green Finance

#### 3.1.1 Initial research period (1990-2003)

The concept of sustainable development was first put forward at the first United Nations Conference on the human environment. Then, at the 1997 United Nations Climate Change Conference in Kyoto, Japan, the *Kyoto Protocol* identified three market mechanisms for reducing greenhouse gas emissions, leading to the establishment of a carbon trading market. We can see that the number of articles published in 1998 increased slightly. In 2003, research entered a new phase

with the establishment of the equator principles by 10 international Banks, which emphasized the integration of environmental, social and corporate development goals.

### 3.1.2 Basic research period (2003-2015)

It can be found that the quantity has been increasing year by year since 2009, which is closely related to the United Nations Climate Change Conference held in Copenhagen in 2009. In 2010, the establishment of the green climate fund (GCF) has provided an official channel for international funding to prepare for environmental solutions. Clearer definitions and accurate data sources have further promoted the scientific research activities of the academic community.

### 3.1.3 Extended research period (2015-2019)

In 2015, 194 signatories signed the *Paris Agreement*, which ushered in a new era of research on green finance. Subsequently, developed countries are taking the lead in energy conservation and emission reduction, and developing countries are supporting to mitigate climate change while enhancing technology and building capacity. Since then, the idea of combining environmental governance with economic development has been widely recognized by all countries, and the passion of green finance research continues to rise.

## 3.2 Cooperation network analysis

Table1 Quantity and centrality of publications by countries

Rank	Frequency	Centrality	Author	Year
1	177	0.29	USA	2003
2	115	0.15	China	2010
3	114	0.15	England	2007
4	75	0	Germany	2011
5	45	0.55	Switzerland	2011
6	34	0.57	Canada	2011
7	33	0.22	Australia	2014
8	27	0.42	Italy	2016

As can be seen from the table 1, although the United States published the most articles, the average year was relatively early. In contrast, Australia and Italy published less than 50 articles, but the average year of publication was 2014 and 2016 respectively, indicating that these two countries have made great contributions to the research in recent years.

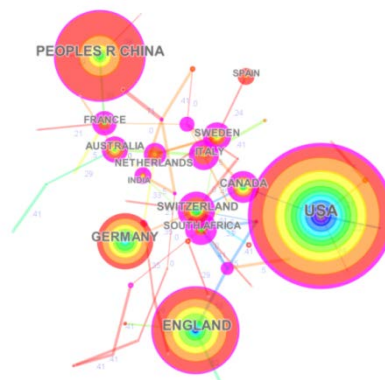


Figure 2 National Cooperation Network of Green Finance

Figure 2 gives us a view of the cooperation among countries, which suggests that cross-border links were more frequent but less intense during the study. It is also found that China has been paying more attention to environmental problems in the economy in recent years and gradually participating in the green finance research in the world. From the perspective of cooperation intensity, the United States has carried out cooperation with more countries. However, there is a low cooperation intensity. In comparison, Switzerland has a higher cooperation intensity with other

countries. In addition, China and the UK have relatively sparse network structure, which indicates that they have few cooperative relations with other countries, but their important role in field research cannot be ignored.

### 3.3 Literature co-citation analysis

In this part of the research, we cluster the research topics and read the representative literature in the group closely to summarize the focus of the topic research. Over a period of 30 years, we extracted 19,170 valid references cited in 739 articles and visualized them as figure 3.

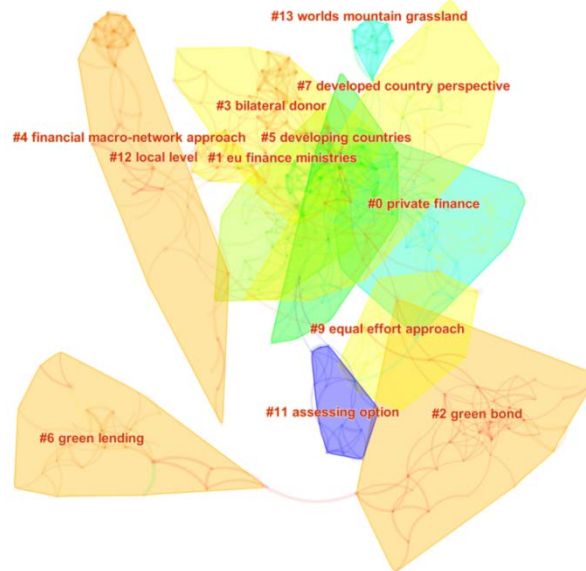


Figure 3 Literature Clustering of Green Finance

The keyword of cluster 0 is "Private Finance". Many scholars have pointed to the crucial role of private finance in achieving low-carbon development and tackling climate change. However, there is still more research on public climate finance than on private climate-related finance[1]. Other scholars have studied typical areas of Africa and found that the implementation of climate aid increases the flow of private funds to some extent, which in turn increases private financing[2]. In addition, it is worth mentioning that some scholars have analyzed private financing from an ethical perspective. Stadelmann, M discussed private financing from a political perspective and found that although it played a key role in achieving low-carbon development, the current lack of clear definition of "private financing" makes it difficult to verify statistical data and hinders further research[1].

The keyword of cluster 2 is "Green Bond", which is a relatively new group with high research value. Bachelet, M. J compared green bonds with brown bonds and found that issuer reputation and green third-party certification could not only reduce information asymmetry, but also make financing more convenient[3]. Some scholars have concluded that the average financing scale of highly rated green bonds is obviously lower in recent years[4], but the green bond market is expanding rapidly in recent years. In particular, spending on renewable energy, clean water, low-carbon transport and other SDG-related investment categories is on the rise[5]. Some other scholars investigated the special properties of green bonds from macro and micro perspectives[6]: Investors' environmental preference has little impact on bond prices[7], but this does not mean that investors are unwilling to support the further expansion of the green bond market.

Related to the keywords for cluster 2 is cluster 6, called "Green Lending". As a supplement, Park, S. K studied the regulation of green bonds and found that there was no reasonable government regulatory agency. However, the private governance mechanism is decentralized due to its lack of legitimacy, accountability and consistency[8]. Some scholars discussed the environmental information disclosure system in the process of green credit, and found that it did not send a valuable signal to the government, and failed to help the bank to carry out effective risk management[9]. In addition, in terms of risk management in green lending, Hu and m. Z discussed

the role of environmental credit risk management (ECRM) in bank risk control and analyzed the relevant influencing factors[10].Cui, y. J studies that green loans can not only reduce Banks' non-performing loan ratio, but also help improve Banks' financial performance and environmental performance[11].

The keyword of 4th cluster is "Financial Macro-network Approach". Some scholars have built new models based on existing problems, such as Mielke, j. and g. a. Steudle analyzed the impact of the green quantitative easing program on finance and global warming based on stock - current fund ecological macroeconomic model[12].By establishing a macro model, Reboredo, j. C found that the spill-over effect of fixed income market price of enterprises and Treasury had a great impact on green bonds, while the market price of stocks and energy had little impact on them[13].Monasterolo, I, developed a climate stress test for a portfolio of loans for energy infrastructure projects based on the Chinese market. He found that coal and oil projects had a significant negative impact on green financing in China[14]. Mielke, j. and g. a. Steudle also discussed the investment equilibrium problem from the perspective of game theory[15].Some other scholars put forward some shortcomings based on the existing models and improved them[16-17].

There are other clusters worth mentioning. Cluster 3 mentioned "Bilateral donors". This cluster discusses the financing scale, donation preference and political appeal of donor behavior, taking the trust between developing and developed countries into account. Through clustering and intensive reading of the literature, it is found that the above clusters can be summarized into the following topics: international green financing policies based on the macro framework, green financial instruments, behavior and political choices of bilateral donors, policy analysis based on developing and developed countries, *etc.*

### 3.4 Keyword co-occurrence analysis

Generally speaking, high-frequency keywords tend to represent the hot topics in the research field, while burst keywords can be used as the research guide for analysis in the new era. Figure 4 is a co-occurrence timeline view of keywords.



Figure 4 Co-Occurrence Timeline View of Keywords of Green Finance

The first keyword appears in 2006.To facilitate a comprehensive analysis, we divided it into three sections: 2006-2010,2011-2014,2015-2019.The first two intervals belong to the basic research period, and the third interval belongs to the extended research period.

From 2006 to 2010, research begins to focus on the environmental governance of developing countries represented by parts of Africa. At the same time, with the continuous deterioration of the global ecological environment, how to maintain sustainable development is a problem worthy of careful consideration in this region. Policy and health were also mentioned in the interval. Based on the above analysis, the better development of green finance cannot be achieved without the

direction and timing of the government's decision-making. It is also worth mentioning that official development assistance (ODA) has made great contributions to the research on the sources of green finance funds in developing countries.

In 2012, two positions have emerged to deal with the problem of environmental deterioration: mitigating the degree of climate deterioration or adapting to climate warming. In this area, the study is divided into several general directions. Some scholars focus on environmental aspects such as climate policy formulation, biodiversity conservation, ecosystem services, and innovative management. Other scholars also conducted a deeper analysis on the motivation, incentive, scale and preference of investment behavior from the perspective of finance. They also discussed feedback on the financial and performance management brought about by green fund. In addition, carbon market also received the attention of the academic community in this section.

The signing of the Paris Agreement has greatly promoted the research process and stimulated many new topics of green finance. In 2015, scholars began to discuss environmental governance from another Angle -- how to reduce costs (such as utilizing scale effect effectively). Some scholars have also conducted academic research on excessive carbon dioxide emissions, energy consumption control and efficient use of renewable energy in the new period. Corporate social responsibility has been on the horizon of scholars since 2015. Later, some scholars combined it with sustainable supply chain finance. In addition, political economy are gradually added to green finance research, including the sources of green investment, debt management and control, as well as the frequent use of green financial instruments (such as green bonds and green credit) in the new period.

#### **4. Conclusion**

From the perspective of national cooperation, the United States has the earliest research on green finance, Australia and Italy have also begun to increase their contributions. In addition, developing countries are still under-represented in the global research network. In general, it is necessary to adjust the research direction and integrate the research resources to further strengthen the cooperation among countries in the future.

It is found that the research on green financial instruments (such as green bonds and green insurance) has become an upward tendency in recent years and has great potential. In addition, public policies, funds and resources are the "engines" supporting the development of green finance. In the future, researchers can maintain the balance between risks and benefits by setting up a macro research framework and choosing the way to drive financial supply and demand.

Through keywords analysis, we found that in the first five years of the basic research period, the research mainly focused on environmental governance in developing countries, national policies and human health issues. In the last four years, two different attitudes began to emerge in the international community, which triggered academic discussions on a series of issues. In addition, some scholars have conducted in-depth studies from the environmental view and the financial view. Carbon market related issues has also become a hot topic. In extended research period, scholars gradually took the factors of political economy into account and conducted academic research on excessive carbon dioxide emissions, control of energy consumption and efficient use of renewable energy.

After searching, we find that there are few systematic reviews of green finance and most of them are qualitative analysis. This study adopts the bibliometrics method to present the overall situation of green finance, hoping to help scholars broaden their research direction. At the same time, this paper is expected to provide some new ideas for basic research and valuable references for policy formulation.

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