



Exploring the research development trajectory and trends of green finance

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ABSTRACT

Green finance refers to a financial action of balancing ecological protection and economic growth simultaneously with the goal of mitigating climate change. Given the rapid development of green finance, many related concepts have also emerged, such as sustainable finance, carbon finance, and environmental finance, but the boundaries between them remain blurred, potentially limiting the development of green finance. To foster green finance development, this research adopts the bibliometric method of main path analysis (MPA) to examine the research development trajectory from 3712 green finance-related papers. Based on the findings, this study categorizes the knowledge trajectory of green finance into three phases and seven recent hot sub-fields. It also proposes future research directions, including government information disclosure, financial institutions' initiatives, and public engagement promotion, in order to provide a sustainable approach to facilitate green finance development.

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1. Introduction

With the increasing global focus on environmental issues, green finance activities aimed at combating climate change and improving ecological environments have become ever more critical (Taghizadeh-Hesary & Yoshino, 2019; Zhou, Tang, & Zhang, 2020). Nonetheless, the lack of a standardized definition for what constitutes “green” has led to confusion among stakeholders as the scope of green finance continues to broaden. As noted by Steuer and Tröger (2022), the concept of “green” leads to subjective interpretations, resulting in ambiguous standards for quality labels concerning green characteristics and even encompassing the scope of disclosing raw data. To address these challenges, this paper investigates the evolution of academic literature on green finance. Furthermore, it elucidates green finance's impact on various stakeholders. In this section, we provide a detailed overview of the current state of green finance.

From a global perspective, green finance reform is driven by

both international organizations and individual nations. International bodies focus on creating standardized guidelines to assist member countries in advancing green finance, thereby fostering cooperation and coordination. For instance, the 2015 Paris Agreement, adopted by the United Nations, aims to mitigate global greenhouse gas emissions by limiting the increase in global temperatures to below 2 Celsius this century (Falkner, 2016). In 2009, the United Nations launched the Sustainable Stock Exchanges initiative, which saw sixty-five exchanges worldwide commit to promoting sustainable principles in market transactions and enhancing Environmental, Social, and Governance (ESG) disclosures by listed companies, thereby sustaining their competitive advantage (Pham, Liu, & Chen, 2024). On a national level, both developed and developing countries have shown commitment to green finance. For example, France in 2016 enacted the Energy Transition Law, which established explicit green growth objectives and mandated that institutional investors disclose their actions related to climate change (Andriosopoulos & Silvestre, 2017). China also pioneered the development of a comprehensive green finance policy framework (Lv, Bian, Lee, & He, 2021).

As international regulations and national strategies evolve, so too does the concept of green finance (Dasgupta, 2001). Initially, early efforts focused primarily on conceptual discussions surrounding green finance, yet contemporary research has shifted towards the broader notion of sustainable finance (El Ghoul,

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Guedhami, Kwok, & Mishra, 2011; Steurer, 2010). Sustainable finance is an inclusive concept that integrates social, environmental, and economic dimensions, whereas green finance is primarily concerned with climate and environmental issues but does not encompass social and economic factors. The considerable overlap among these definitions and concepts can lead to confusion (Al-Sheryani & Nobanee, 2020; Gilchrist, Yu, & Zong, 2021; Ozili, 2022; Bhatnagar & Sharma, 2022). Furthermore, a universally accepted definition of green banking has yet to be established. As countries and regions develop their classification standards, discrepancies in definitions become increasingly pronounced (Park & Kim, 2020). Consequently, the green finance sector faces challenges such as inconsistent standards for defining green finance attributes, varying criteria for classifying green finance products, and the lack of standardized regulations for green finance operations (Zhu & Wang, 2017). These inconsistencies and ambiguities could potentially impede the green finance development.

In conclusion, green finance has garnered increasing attention globally as well as among various financial institutions and organizations. While the green finance literature covers a wide range of topics, there is still a lack of studies on the modeling, evolution, and integration of green finance concepts. To address the lack of clear definitions and distinctions between the various phases of research in green finance, this study discusses the following questions.

1. What are the development trajectories of green finance?
2. What are the future trends in the field of green finance?

To answer these research questions, this study employs a systematic review approach, called main path analysis (MPA), to trace the development trajectory of the green finance literature. More specifically, it examines the evolution concept of “green” in the financial domain by identifying its major development points and significant issues.

2. Literature review

The research field of green finance focuses on “how to raise funds for climate action effectively.” Since scholars interpret the definition and related concepts of green finance from different perspectives in each period, this literature review and discussion first introduce the basic concepts of green finance and its related terminology and then elaborate on the concept of “collective action under green finance.” Green finance is a subset of sustainable finance (Becchetti, Cordella, & Morone, 2022). According to the United Nations Environment Programme (UNEP), the widely accepted definition states that “the purpose of green finance is to increase the flow of funds from public, private, and non-profit sectors (including banks, microcredit, insurance, and investment) to achieve sustainable development priorities.” The goals of green finance include managing environmental risks, seizing opportunities to provide environmental benefits, and providing financial returns for investors or lenders. The research field of green finance, centered on financing, focuses on diverse research topics, such as green finance measures (e.g., green bonds, green banks, carbon finance), interactions among stakeholders including governments, citizens, financial institutions, emerging technologies and challenges and opportunities brought by innovation, and the responsibilities and roles of regulatory bodies in the green finance environment.

Adaptation costs serve as the foundation for conversations concerning the required investment levels for adjusting to climate change (Parry, 2009). This study examines the evolution of adaptation cost research since the 2000s and finds diverse trends in topics and calculations among different schools of thought. Early

scholars primarily focused on the costs of addressing climate crises (Narain, Margulis, & Essam, 2011; Donner, Kandlikar, & Webber, 2016). The World Bank's approach predicted a requirement of approximately US\$4–41 billion by 2030 (Smith et al., 2011). Another approach, exemplified by Raworth (2007), includes non-government-led adaptation interventions, with annual costs ranging from US\$0.8–33 billion. Additionally, previous research considered adaptation measures in sectors such as agriculture and fisheries, predicting a requirement of approximately US\$28–67 billion by 2030 (Stadelmann, Michaelowa, & Roberts, 2013; Herold & Johns, 2007).

The concept of adaptation costs at the national level requires clarification. First, countries must decide how to adapt to climate change, focusing on addressing current crises or goals to include preventive measures against potential future negative impacts (Pickering & Mitchell, 2017). Different national goals lead to varying calculations and results for adaptation costs. Second, government agencies should specify the adaptation measures and scope of activities that should be included in the calculation of adaptation costs. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines sustainable development as “a diverse process and approach to achieving sustainability.” According to the 1987 Brundtland Report, the concept of sustainability involves development that meets the needs of the present without compromising the ability of future generations to meet inherent needs.

Sustainable development issues have gained significant attention in recent years from countries and various organizations, leading to the development of internationally recognized norms and standards. For example, the United Nations Sustainable Development Goals (SDGs) were mentioned in the 2030 Agenda for Sustainable Development adopted by the United Nations General Assembly in 2015. These goals target all stakeholders, including businesses, investors, non-profit organizations, and countries, and offer new strategies for sustainable co-existence in areas such as economic growth, civil society, and environmental protection. Sustainable development, as the most inclusive concept, encompasses environmental, social, economic, and governance aspects. On the other hand, the subset of sustainable development known as green finance focuses on financing issues related to climate and other environmental conservation actions.

The review papers in the field of green finance research exhibit two methodologies. First, qualitative research with small sample sizes provides a subjective analysis of the field's development and relies on manual article selection. However, this approach lacks the comprehensive conceptual capture typically achieved through quantitative research. For example, Al-Sheryani and Nobanee (2020) analyzed 25 journal articles, and Akomea-Frimpong, Adeabah, Ofori, and Tenakwah (2022) primarily utilized qualitative analysis, focusing on products and determinants in the banking sector without considering all stakeholders in the broader market.

Second, quantitative analysis with large sample sizes collects papers on relevant topics through keyword searches. This method, however, fails to effectively elucidate the contextual connections between different articles and the temporal evolution of research themes. The field necessitates the use of diverse databases and advanced quantitative methods to analyze development trends comprehensively (Bhatnagar & Sharma, 2022; Mohanty, Nanda, Soubhari, Biswal, & Patnaik, 2023).

In light of this research gap, this paper adopts a mixed-methods approach, combining qualitative and quantitative analyses. Utilizing a large sample size, the main path analysis method is employed to ascertain the knowledge flow within the literature. This approach not only clearly defines the major research themes and directions over different periods, but also establishes the

interconnections between articles. Through qualitative text analysis, this paper delves deeper into the critical factors and focal points in the field, ultimately addressing the questions of why, when, and how the research trajectory of green finance has developed.

3. Research method

This study employs main path analysis (MPA) to trace the development of literature in the field of green finance. MPA, a method for bibliometric analysis, was first introduced by Hummon and Doreian (1989). This bibliometric technique elucidates the developmental trajectory of a research domain, while a literature review provides a comprehensive overview of the current state of research (Kamila & Jasrotia, 2023). Unlike traditional systematic reviews, MPA constructs the main development trajectory of a research field through the citation network structure (Yeh & Wang, 2024; Yu, Xiang, & Pan, 2024). The following sections detail the MPA methods used in this study, including the types of MPA employed and the data collection process.

3.1. Main path analysis

Main path analysis has been extensively utilized across various fields and involves two key steps. The first step is to compute the traversal counts for each citation link within the citation network to determine the significance of each link (Hummon & Doreian, 1989). Among the different algorithms available for calculating traversal counts, this study adopts the Search Path Link Count (SPLC) algorithm, as recommended by Liu, Lu, and Ho (2019). The rationale for this choice is to ensure that critical paths are not overlooked, as the SPLC algorithm identifies the most significant paths by examining both ends of the citation network (Gnekpe & Plantec, 2023; Huang, Liu, Ho, & Chou, 2022; Lu & Liu, 2016).

3.1.1. Key-Route main path analysis

To trace the evolution of the literature in green finance literature, this study employs Key-Route MPA. This approach involves selecting a critical path and examining its development by searching forward from its source and backward from its sink (Liu & Lu, 2012). The subsequent step entails identifying the primary citation contexts along the link with the highest traversal count. By searching from both ends of the path, this algorithm reduces the risk of overlooking significant citation contexts (Lu & Liu, 2016). Utilizing Key-Route MPA, this study identifies literature that outlines the principal directions of knowledge evolution within the field of green finance. The aim is to uncover distinct characteristics and conduct an in-depth analysis of the development trajectory of green finance research.

3.1.2. Multiple global main path analysis

Main paths can be divided into local main paths and global main paths. Local main paths search for links with the highest search path count (SPC) and repeatedly explore these links, while global main paths measure more comprehensively, seeking all potential paths with the highest traversal count. Lu and Liu (2016) suggest using multiple global main paths instead of a single global main path in order to obtain a richer and more complete development trajectory, thus aiding researchers in identifying popular topics in the field. This study employs multiple global MPA to identify recent important trends in green finance.

3.1.3. Data collection

For this study, data collection involved a two-step process. First, this study gathered literature and related citation data from the

Social Sciences Citation Index (SSCI) and the Science Citation Index Expanded (SCI-EXPANDED) databases on Web of Science (WOS). The search strategy primarily followed keywords related to “green finance.” These keywords included specialized terms such as “sustainable,” “environmental,” “carbon,” and “banking.” Table 1 presents the search strategy and keywords used in this research.

Second, academic papers collected based on the search strategy were examined individually to ensure that the data were relevant to the target field. Specifically, review papers are included in the database based on the research questions and objectives. Literature reviews are instrumental in understanding the current state, challenges, and research gaps in the field of green finance, providing essential background and theoretical foundations for main path analysis. However, it is important to recognize that review papers can introduce noise that may influence the final results, even to the extent of limiting the tracking of research trajectories. Although the integrator effect may increase the significance of documents that heavily reference others (Liu et al., 2019), considering a moderate number of review papers may be beneficial for researchers to clarify research developments. Therefore, without excluding review papers, this study identifies 29 important documents, of which only one is a review paper. Overall, this study concludes that the integrator effect did not have a significant impact; on the contrary, a small number of review papers did help clarify the development paths of green bonds and green loans (Gilchrist, Yu, & Zhong, 2021).

3.1.4. Data analysis

In accordance with the search strategy, this study's sample totals 1742 articles published between May 2011 and July 2024. The year 2011 was a significant turning point when green finance began to attract substantial international attention. In that year, UNEP highlighted the concept of a green economy in its report, “Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication.” The report emphasized the potential of a green economy to improve human well-being and social equity, while substantially mitigating environmental risks and addressing ecological scarcities. Motivated by initiatives from the United Nations, numerous countries, including the United States and the United Kingdom, have embarked on efforts to advance green finance as a pathway to achieving a green economy.

For data analysis, this study employs MPA to construct a citation network based on citation data from the Web of Science (WOS) database for articles related to green finance. By selecting key articles and identifying principal knowledge trajectories, this method facilitates an exploration of the research network within the field and an analysis of academic influence. This approach offers a comprehensive understanding of the flow of knowledge and the development trajectory within the domain of green finance.

4. Analysis

4.1. Evolution of green finance development through Key-Route MPA tracking

This section presents the outcomes of Key-Route MPA, highlighting the 29 most influential academic articles in the field of green finance, as illustrated in Fig. 1. In Fig. 1, each node represents an academic article, with the labels formatted to include the surname of the first author followed by the initials of the co-authors and the publication year. Additionally, arrows connect citing and cited articles, with the direction of the arrow indicating the flow of knowledge and the size of the arrow being proportional to the frequency of citation.

Table 1
Search strategy.

Database	Web Of Science (WOS)
Search strategy	TS=(("green financ*" OR "sustainab* financ*" OR "environ mental financ*" OR "climate financ*" OR "carbon financ*" OR "green banking"))
Document type	Article or Early Access or Review
Time span	May 2011 to July 2024

4.1.1. Phase 1: operating adaptation costs

The debate over adaptation costs and how to support developing countries in addressing climate change has intensified since 2009. Developed countries have committed to mobilizing at least US\$100 billion annually by 2020 to assist developing countries in tackling climate change. These commitments reflect the increasing recognition within the international community that effectively addressing global climate change requires providing more funding to developing countries. This funding aims to mitigate the growing share of global greenhouse gas emissions and support measures that enable developing countries to adapt to the increasingly evident impacts and changes of climate.

The literature from the first phase covers the period from 2011 to 2016 and focuses on adaptation costs and fundraising-related issues. Research in this phase primarily examines fundraising and assistance from a macroscopic perspective. For instance, it explores the estimation of adaptation costs from an international standpoint, examines how international coordination influences the equity of global financing, or investigates principles and practices of fundraising in developing countries. Additionally, it investigates decisions related to climate financing in developed countries from a national perspective.

This study is preliminarily divided into three evolutionary phases. The first phase involves comprehensive research on adaptation costs internationally. The second phase covers the utilization of assistance funds in developing countries. The third phase focuses on the allocation of assistance funds in developed countries and finally on the coordination between developed and developing countries.

Narain et al. (2011) studied climate change adaptation economics and provided updated and consistent estimates of adaptation costs for developing countries. The literature estimated by 2050 that the global cost for developing countries to adapt to a global warming of approximately 2 Celsius would range between US\$70 billion and US\$1 trillion annually from 2010 to 2050. Subsequently, Bowen (2011) discussed the principles for developing countries to raise funds for climate action. Pickering, Skovgaard, et al. (2015) investigated the internal dynamics of donor countries in climate financing decisions.

Some studies also focused on the connection and coordination between developed and developing countries. For instance, Pickering, Jotzo, and Wood (2015) examined how to achieve fair global climate financing under limited coordination and found that moderate coordination, combining nationally determined financing commitments with robust international review mechanisms, could alleviate the unfair distribution of funds and overall shortages. Donner et al. (2016) measured and tracked the flow of climate change adaptation assistance to developing countries in Oceania, investigating the distribution of climate adaptation funds between recipient and donor countries.

In summary, the research context of this phase primarily revolves around adaptation costs and climate assistance. The progression of research subjects moves from developing countries to developed countries and then focuses on the relationship between the two. Throughout this phase, the examination is conducted from a macroscopic perspective, considering both international and national levels.

4.1.2. Phase 2: mobilizing stakeholders

The literature in the second phase covers the period from 2016 to 2022, with a shift in focus from international organizations and national government agencies to exploring the roles and impacts of various stakeholders in green finance. During this phase, academic research perspectives have gradually moved from macroscopic analyses between countries or international organizations to meso-level research on the participation of the public and private sectors within a single country or industry. To achieve effective green financing, the literature in the second phase is classified into two evolving patterns: market-driven and politically driven approaches.

Studies advocating for market-driven approaches focus on analyzing stakeholders in green finance. These approaches aim to encourage more entities to take on sustainable development responsibilities by exploring strategic choices suitable for all parties, thereby enhancing the green finance market system. First, Tolliver, Keeley, and Managi (2019) primarily mentioned that green bonds can be used as a market-driven tool, and that they have attracted multiple stakeholders, including international financial institutions. These institutions provide financial support for sustainable projects worldwide through green bonds, promoting the sustainable development of the market. Second, Cui, Wang, and Wang (2020) argue that government support for green finance depends on government revenue and costs. Government reputation and social welfare are also crucial for government initiatives promoting green finance. Third, Batrancea et al. (2020) indicated that domestic credit in the financial sector contributes to green financing; however, the scale of domestic bank credit is insufficient to achieve green finance development goals. Therefore, governments should focus on designing sustainable fiscal and monetary policies to promote private-sector green financing.

Another portion of the literature focuses on China, primarily exploring the different policies adopted by developed and developing countries. By understanding the more mature developed countries in terms of green finance and green economic development, studies provide recommendations for government agencies on how to perform on the domestic and international stages. First, regarding domestic development, Yang, Su, and Yao (2021) focused on the impact of green finance and financial technology (fintech) on economic development in China and proposed three policy recommendations. Changes in scholarly interests across the three phases are primarily evident in the evolving focus on different participants in promoting the broader application and development of green finance through the optimization of policy frameworks. The differences in regional green finance development caused by China's regional policies are also a research focus. Most literature suggests that countries should undertake policy reforms by increasing multilateral oversight to promote green finance development.

Second, international factors affecting a country's green finance include commitments to multilateral agreements and international pressure among countries. For example, Cui and Huang (2018) found that the U.S. decision to withdraw from climate financing would significantly increase the burden on other donors. In the case of the EU, its contribution is expected to increase by nearly 14 percentage points. Therefore, besides focusing on domestic green

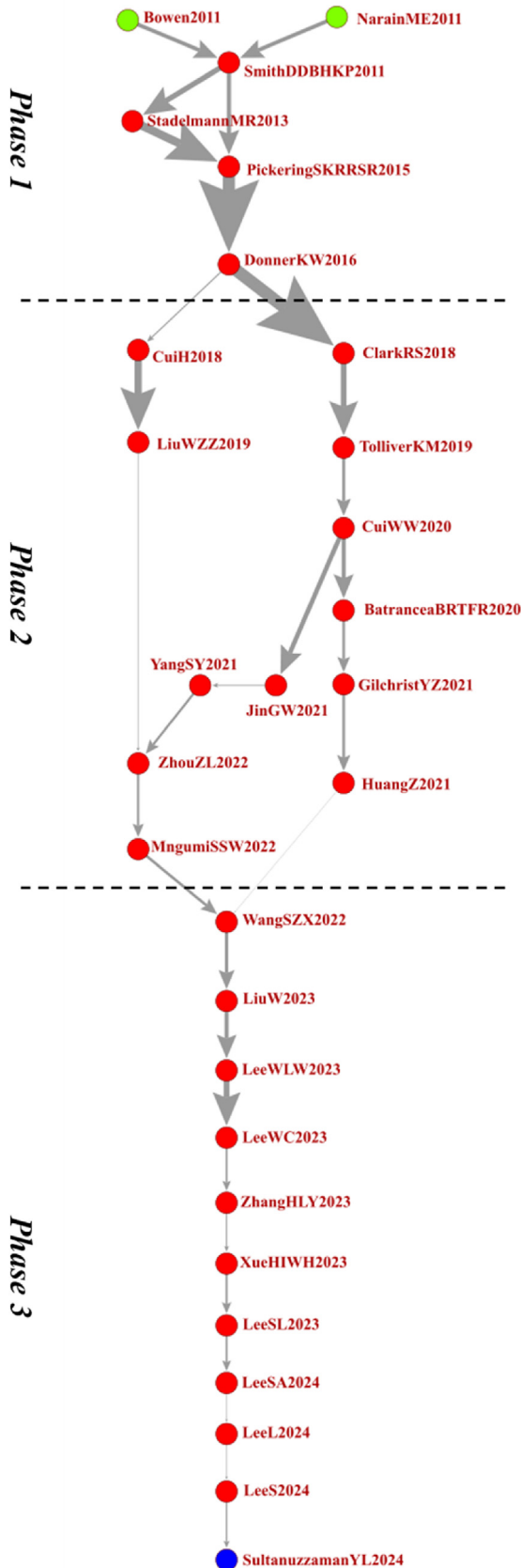


Fig. 1. Key-Route main paths of green finance.

finance implementation, governments also need to have a comprehensive understanding of the international financing situation.

In the second phase, this study identifies that the interactions and strategic choices between different stakeholders, both within the country and internationally, have a significant impact on green finance development. Therefore, whether it is motivating enterprises and financial sectors to participate in green financing in the market or how government organizations balance policy choices among political developments, public attitudes, and international organizations, these issues should all be considered important topics for its development.

4.1.3. Phase 3: initializing green banking

In the third phase, this study shifts from the previous macro- and meso-level perspectives to a micro-level perspective. The literature in this phase primarily focuses on the banking sector, emphasizing the establishment of green banks and green finance initiatives within both green banks and private commercial banks.

Green finance is a comprehensive concept, with green banking being one of its key components. Green banking prioritizes economic, social, and ecological factors to protect the climate and natural resources. It involves investing in environmental products and services to address climate change and preserve ecosystems. In this phase, initial studies mainly explore the impact of green finance on private commercial banks. For example, scholars aimed to understand bank executives' perspectives on various aspects of green finance and to identify the major challenges affecting the implementation of green finance in Bangladesh (Zheng, Siddik, Masukujjaman, Fatema, & Alam, 2021; Zheng, Siddik, Masukujjaman, & Fatema, 2021). The literature examined the dimensions of green finance and its impact on the sustainable development performance of financial institutions in developing economies. The results indicated that private commercial banks are the largest contributors to green finance, with their dimensions being linked to the economic, social, and environmental aspects of sustainable development goals. Subsequently, the literature began to cover the concept of green banking. For instance, Zhang, Wang, Zhong, Yang, and Siddik (2022) and Chen, Siddik, Zheng, Masukujjaman, and Bekhzod (2022) focused on determining the impact of green banking practices on the environmental performance of private commercial banks and analyzing the mediating effect of green financing sources on the relationship between green finance and the environmental performance of green banking activities and private commercial banks.

From 2023 to 2024, there has been a growing interest in the discussion of energy-related issues. Lee et al. (2023) evaluated the impact of green finance on China's energy transition, emphasizing that green finance can accelerate energy transition, particularly in regions with more advanced socioeconomic conditions. Xue et al. (2023) examined the role of green finance in alleviating energy poverty and validated the effectiveness of green finance policies. The study found that green finance significantly reduces energy poverty by restricting the development of energy-intensive industries, improving energy efficiency, and promoting energy structure adjustments. Lee, Wang, and Chang (2023) explored the impact of green finance on the development of renewable energy in China, discovering that green finance not only directly promotes renewable energy, but also indirectly supports it through driving research and development, enhancing market openness, and boosting economic growth.

In summary, this phase reveals the connections and mutual influences among concepts such as banks, green finance, and green banking. It also introduces discussions on the relationship between energy and green finance.

Changes in scholarly interests across the three phases are primarily evident in the evolving focus on different participants within green finance. MPA delineates the academic development of green finance into three dimensions: macro, meso, and micro. At the macro-level, the focus is on global perspectives and policy impacts. The meso-level examines stakeholder interactions and strategic dynamics, while the micro-level shifts to individual institutions and practices, emphasizing specific implementations and effects of green finance. Collectively, this study identifies a trend in green finance literature towards the establishment of a comprehensive green finance system or ecosystem, integrating contributions from governments, corporations, consumers, and other relevant stakeholders.

4.2. Recent trends

To provide insights into the practical trends of green finance, this study further employs Multiple Global MPA to conduct a detailed analysis of recent important trends in green finance. Multiple Global MPA is a method for tracing multiple pathways (Liu & Lu, 2012), helping researchers identify recent important subtopics within a domain. Through this method, this study identifies recent important trends in green finance literature and assesses different thematic branches in the trajectory of green finance research, focusing on the detailed development trajectories of each subtopic (Liu et al., 2012). The Multiple Global Main Path of green finance, as depicted in this research, reveals seven major branches and subdomains representing recent trends in development (see Fig. 2).

4.2.1. Sustainability Concepts and green finance standards

The concepts of sustainable finance and green finance largely overlap, with much research in this area focusing on the connection and impact of sustainability on finance. For instance, Ziolo et al. (2019) examined the relationship between finance, economics, environmental, and social development indicators from the perspective of sustainable development, particularly focusing on externalities. Ziolo, Bak, and Cheba (2021) conducted a study in OECD European countries on the connection between sustainable finance and Sustainable Development Goals (SDGs) and found that the more sustainable the financial model is, the better the achievement of SDGs, the closer connection between sustainable financial models and social sustainability. Furthermore,

environmental sustainability and economic sustainability appear to have a strong correlation.

Another aspect of research in this area revolves around standards and frameworks. For example, Nedopil et al. (2021) studied the nature of green finance standards and how to evolve in different participant-driven major economic systems. The research revealed that the evolution of green finance standards depends on economic governance types, environmental focal areas, and the involvement of participants within the government, intermediary institutions, and developing financial institutions. Migliorelli (2021) assessed existing frameworks and policy risks in sustainable finance. He believed that today's sustainable finance landscape is characterized by too many heterogeneous concepts, definitions, industries, and policy standards, which could hinder the smooth development of conceptual thinking supporting sustainable finance and pose specific risks that may damage the reputation of emerging markets. The literature in this stage proposes examining finance through the lens of sustainability and focuses on the establishment and evolution of standards between sustainable finance and green finance.

4.2.2. Green credit under green finance policy

Promoting technological innovation through green finance policy has become an important topic in the global green finance field in recent years, with green credit-related policies being a focus of much research. The introduction of green credit raises the threshold for corporate loans, making compliance with environmental standards, pollution control effects, and ecological protection important prerequisites for loan approval.

Research in this stage mainly focuses on green credit guidance policies implemented by the China government. Some studies examined the need for appropriate policy interventions to balance economic development and environmental improvement and protection, particularly for energy or emission-intensive enterprises. For example, Zhang, Wang, and Liu (2022) investigated China's green credit policy, which restricts loans to energy or emission-intensive enterprises, and found that this policy has a certain inhibitory effect on the performance of energy or emission-intensive companies and promotes green transformation and upgrading. Other studies presented diverse developmental contexts, conducting multidimensional in-depth explorations of green credit. Zhang, Xing, and Tripe (2021) noted that China's green credit policy has increased the loan quotas for environmentally friendly

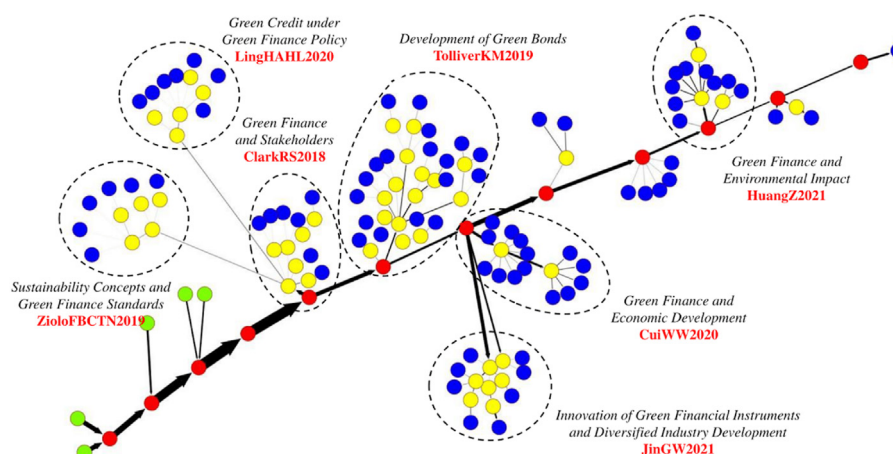


Fig. 2. Multiple global main path of green finance.

manufacturing enterprises, with observed differences in the policy's effects between small- and medium-size environmentally friendly manufacturing enterprises and larger ones. Small- and medium-size environmentally friendly manufacturing enterprises are more likely to obtain more loans than large ones. [Zhang, Hong, Li, and Li \(2021\)](#) discovered that green credit has a significantly negative impact on China's carbon dioxide emission intensity, indicating that the promotion of industrial structure upgrading, and technological innovation are two effective ways to reduce carbon dioxide emissions.

4.2.3. Green finance and stakeholders

As people are increasingly showing interest in expanding private investments to address persistent global socio-economic and environmental challenges, more private institutions, businesses, and banks are turning their attention to green finance issues, prompting academic involvement in researching various stakeholders in the field of green finance.

Regarding private investments, [Clark, Reed, and Sunderland \(2018\)](#) studied the pitfalls, progress, and potential of private financing, offering corresponding recommendations for government agencies and the research community to better incentivize private investment in developing and low-income countries. In research focusing on corporations as stakeholders, [Falcone and Sica \(2019\)](#) provided experimental evidence around opportunities and challenges related to green finance, using the case of an Italian biomaterial producer, with a focus on financial issues that may hinder investment decisions in green companies. These studies have indicated that green finance currently does not significantly benefit a company's profitability but provides opportunities for environmental sustainability innovation.

Scholars have discussed the role of government and policies in green finance, analyzing China's offshore wind power generation costs before and after the COVID-19 pandemic and the impact of green finance policies on the country's offshore wind power ([Tu, Mo, Liu, Gong, & Fan, 2021](#)). The research in this stage focuses on the impact of different stakeholders on green finance, including private investment, banks, businesses, and government. Green finance practitioners should consider the roles played by different stakeholders in the development of related services and formulate strategies for joint practices tailored to different roles.

4.2.4. Development of green bonds

Green bonds are increasingly utilized globally as a financing source for renewable energy development. Renowned for their risk mitigation features and attractiveness to institutional and socially responsible investors, green bonds have become increasingly prominent within climate change and sustainable financing frameworks. This has led to an extension of research into the innovative realm of green finance tools, with a growing number of studies delving into the impacts of green bonds on sustainability development and markets.

This study observes that some scholars focus on discussing the driving factors and development scenarios behind green bonds. For instance, [Tolliver et al. \(2019\)](#) found that many financial institutions lack clear, accurate, and transparent information regarding additional and non-additional environmental impacts, leading to challenges in establishing connections between sustainable development goals, nationally determined contributions, and the environmental outcomes guided by green bond financing tools. Some research has researched the driving factors behind the issuance volume of green bonds and discovered that nationally determined contributions and other macroeconomic and institutional factors are driving the growth of green bond issuance ([Tolliver et al., 2019, 2020](#)).

Another portion of the research has deeply investigated the varied development situations and solutions of green bonds in different regions and markets. Some research has aimed to explore various solutions for the development of Vietnam's green bond market, highlighting the existence of effective legal frameworks for green bond operation, national banks' monetary policies, and official interest rates on green bonds as significant accelerators for Vietnam to strengthen its green bond market ([Chucanhthu et al., 2020; Tu, Rasoulinezhad, & Sarker, 2020](#)). [Leitao, Ferreira, and Santibanez-Gonzalez \(2021\)](#) evaluated the non-linear impacts of green bonds, conventional bonds, and energy commodities on the behavior of the EU Emissions Trading System. [Fu and Ng \(2021\)](#) explored the effectiveness of green bonds in financing renewable energy assets and how to manage potential risks, particularly in emerging economies. The study revealed how China's issuance of green bonds focused on public and private sector involvement in domestic financial investment, supporting state-owned enterprises in obtaining financing for renewable energy projects and managing related risks. This theme primarily focuses on the development trends and driving factors of green bonds, as well as assessments and analyses of green bonds in different regions such as the European Union and emerging economies. It undoubtedly reminds practitioners to pay attention to the development status of green bonds in different economic entities.

4.2.5. Innovation of green financial instruments and diversified Industry Development

With the emergence of new research findings over time and technological advancements, the application scope and impact of green finance continue to expand, resulting in a diverse thematic development context in this phase of research. This study observes that some scholars focused on discussing green finance development in specific industries. For example, [Gholipour, Arjomandi, and Yam \(2022\)](#) presented the relationship between green real estate finance and carbon dioxide emissions in the construction industry. [Jin, Gao, and Wang \(2021\)](#) investigated how green finance facilitates the development of the Energy Conservation and Environmental Protection (ECEP) industry through credit provision. Such studies share three common characteristics. First, the literature acknowledges a significant negative correlation between green finance development and industry carbon dioxide emissions. Second, the results of these studies are more pronounced in developing countries compared to developed ones. Third, due to the focus on specific industries, a diverse range of research methods and data are employed. Among the research, the predominant trend is the use of company data rather than national/regional data to confirm the effectiveness of green finance policies.

The innovation of green financial instruments is one of the central themes in this phase of discussion, with related research mainly involving green funds, green bonds, and others. This study finds that some scholars have analyzed the effectiveness of different green financial instruments on green finance development. [Wang, Cai, and Elahi \(2021\)](#) found that debt-based green financial instruments are more effective than equity-based ones. [Zhang, Hong, Li, and Li \(2021\)](#) concluded that financing efficiency indicators based on energy efficiency standards positively correlate with equity financing and negatively correlate with debt financing and bond financing. In the green finance financing market, banks are seen as the most influential institutions providing credit services to various industries. This theme suggests that factors at both the national and corporate levels affect the financing efficiency of green finance and enhance the integrity of research topics on the diversified applications of green finance by focusing on specific industries. In the process of developing green finance, cooperation

between governments and enterprises is necessary to ensure a more stable and comprehensive development of green finance.

4.2.6. Green finance and economic development

This study finds that some literature has explored the significant role of financial technology (fintech) and regulatory agencies in promoting green finance development. Scholars on this research theme not only supported the viewpoint that green finance has a positive impact on the ecological environment and environmental sustainability but also proposed research results indicating the contribution of green finance to economic development. [Zhao, Wang, and Dong \(2022\)](#) presented comprehensive development of green finance to mitigate current energy poverty issues by accelerating technological innovation and optimizing industrial structures. Researchers confirmed that green finance positively affects the ecological environment, economic benefits, and economic structure, thereby comprehensively promoting high-quality economic development ([Yang et al., 2021](#)).

Scholars then delved into how various stakeholders accelerate the impact of green finance on the economy and the environment. This study finds that most literature has focused on analyzing the relationship between financial technology and green finance, suggesting that fintech accelerates the impact of green finance on the ecological environment and economic structure. [Muganyi, Yan, and Sun \(2021\)](#) stated that the integration of fintech helps reduce sulfur dioxide emissions and promotes environmental investment initiatives. However, some scholars pointed out that as the green finance system involves multiple stakeholders, the complexity of related systemic risks may increase. Therefore, scholars in this phase proposed research recommendations regarding regulatory agencies and control methods. Several studies suggested that countries should strengthen the integration of fintech development with green finance while establishing environmental disclosure frameworks to supervise local governments at enhancing green finance efficiency. Other research detailed regulatory methods targeting individual stakeholders to achieve governance objectives such as accelerating the development of green finance products and enhancing the capacity of financial institutions in green credit. This theme primarily describes the positive impact of green finance on economic development and the involvement of different stakeholders such as financial institutions, fintech, and regulatory agencies. Green finance practitioners should balance environmental protection and economic development and achieve inclusive growth through calibration between the two.

4.2.7. Green finance and environmental impact

The analysis conducted in this study reveals that certain literature, utilizing empirical research methods, corroborates the beneficial effects of green finance policies on the environment. [Huang and Zhang \(2021\)](#) concluded that the establishment of the Chinese State Council's Green Finance Reform and Innovation Pilot Zone in June 2017 reduced the degree of environmental pollution. [Chen and Chen \(2021\)](#) measured the level of green finance development in China from the perspectives of green credit, green securities, green investments, and green insurance and found that green finance helps reduce carbon emissions. [Zhang, Wang, and Liu \(2022\)](#) further concluded that green finance policies are implemented through the economic behavior of local enterprises and can control air pollution such as SO₂, NO₂, and PM_{2.5}.

The research methods in the literature of this phase tend to be consistent. Scholars generally used panel data from China's provinces as the observation objects and employed the difference-in-differences (DID) method to divide the research subjects into an experimental group affected by policies and a control group unaffected by policies to analyze the effectiveness of green finance

policies. The research results found that the effectiveness of policies in various provinces varies depending on differences in industrial structure, technological innovation, and financial investment levels. Additionally, compared to economically developed areas, the positive environmental effects of green finance policies are more pronounced in economically underdeveloped regions ([Zhang, Wang, & Liu, 2022](#)). Therefore, based on the research results indicating that green finance policies can bring about positive environmental effects, scholars in this theme suggested that countries should continue to expand investment in green finance reform, promote industrial structural upgrades and technological innovation, and enhance the regional capacity for green development.

5. Discussion

5.1. Collectivism in green finance

Collectivism is characterized by a focus on shared objectives, interchangeable interests, and commonalities among in-group members ([Triandis, 1995](#)). It emphasizes prioritizing collective interests over individual concerns through cooperation and joint efforts. In the context of green finance research, collectivism is manifested through the active participation and collaboration of multiple stakeholders. Research has indicated that the evolution of green finance involves different stages, ranging from macro-to meso-to micro-levels, with each stage involving the interaction and cooperation of various stakeholders. Through collective action, these stakeholders can collaboratively advance green finance development.

Through the Key-Route MPA of this study, the evolution of green finance research reveals three forms of collectivism, examining financing issues from different perspectives and collectively creating green finance through the involvement of various stakeholders. First, the literature's first stage focused on exploring climate aid issues between developed and developing countries from a macroscopic perspective. Calculating adaptation costs, the impact of government internal dynamics on climate finance decisions in developed countries and the utilization of aid funds in developing countries are all important topics facilitating international green finance.

In the second stage, studies approached the topic from a middle perspective, beginning to explore the influence of stakeholders within a single country or across different industries on green finance. Through multidimensional analysis involving public and private sectors, it promoted the comprehensive and diversified development of the green finance research field. This study finds that international multilateral agreements, government political orientations, domestic credit from the financial sector, and public concern about climate change are all key to promoting green finance development, aiming to encourage more stakeholders to take on sustainable development responsibilities to improve the green finance market system.

Finally, based on the research results of private commercial banks as a key component of green finance derived from the two aforementioned stages, recent research has focused on analyzing green banks from a micro-level perspective. This study reveals a bidirectional positive relationship between the social, economic, and environmental dimensions of green finance and the sustainable development performance of banks. Furthermore, this stage of literature provides several recommendations for how financial institutions can adjust operational strategies following a government's issuance of a green finance action plan. Challenges in implementing green products include insufficient client awareness of green banks, high investment costs, and difficulties in evaluating green projects as crucial factors. At the same time, the literature

Table 2
Data structure of green finance.

Dimension	Reference	Secondary Themes	Aggregated Dimensions
Macro	- Sharing the global climate finance effort fairly with limited coordination. (Pickering, Jotzo, & Wood, 2015)	International coordination positively influences the equity of global financing efforts.	Adaptation Costs
	- Measuring and tracking the flow of climate change adaptation aid to the developing world. (Donner et al., 2016)		
	- Raising climate finance to support developing country action: some economic considerations. (Bowen, 2011)	Principles and application of fundraising in developing countries.	
Meso	- Estimating costs of adaptation to climate change. (Narain et al., 2011)		Financing Strategies
	- Acting on climate finance pledges: Inter-agency dynamics and relationships with aid in contributor states. (Pickering, Jotzo, & Wood, 2015)	Climate financing decisions in developed countries.	
	- Can green financial development promote renewable energy investment efficiency? A consideration of bank credit. (He, Liu, Zhong, Wang, & Xia, 2019)	Strategic choices of multiple stakeholders under market-driven conditions.	
Micro	- An evolutionary analysis of green finance sustainability based on multi-agent game. (Cui et al., 2020)		Green Banks
	- Greening the financial system in USA, Canada and Brazil: A panel data analysis. (Batrancea et al., 2020)	How political forces influence green finance participation.	
	- What drives national support for multilateral climate finance? International and domestic influences on Australia's shifting stance. (Pickering & Mitchell, 2017)		
Micro	- Exploring the schemes for green climate fund financing: international lessons. (Cui & Huang, 2018)		Green Banks
	- Factors Affecting the Sustainability Performance of Financial Institutions in Bangladesh: The Role of Green Finance. (Zheng, Siddik, Masukujjaman, Fatema, et al., 2021)	The positive effects of green banks on environmental sustainability performance.	
	- Do Green Banking Activities Improve the Banks' Environmental Performance? The Mediating Effect of Green Financing. (Zhang, Wang, & Liu, 2022)		
Micro	- The Effect of Green Banking Practices on Banks' Environmental Performance and Green Financing: An Empirical Study. (Chen et al., 2022)		Green Banks
	- Green Finance Development in Bangladesh: The Role of Private Commercial Banks (PCBs). (Zheng, Siddik, Masukujjaman, Fatema, et al., 2021)	Challenges and benefits of green bank development in emerging economies.	

confirmed that participating in green finance effectively enhances bank competitiveness, reduces long-term costs and fees, and lifts customer reputation. Therefore, financial institutions and banks can refer to the research results of this study, analyzing the current development of green finance from macro-, meso-, and micro-level perspectives, exploring how to interact with diverse stakeholders in green finance, and further examining business strategy deployment based on the literature from the third stage.

In summary, this study contends that the involvement of stakeholders will facilitate the establishment of the entire green finance ecosystem, thereby significantly assisting in the overall development of the green finance industry. However, this paper suggests that the underlying interests behind stakeholders' involvement should be the focus of reflection for green finance service providers. How to ensure continuous engagement of stakeholders will become a key factor in green finance development. Research analysis indicates that challenges persist, particularly concerning the inadequate and ambiguously defined interests among various stakeholders regarding investment within the green finance sector. From a collectivist perspective, both industry and academia must recognize that collective action requires collective interests, as without interests, stakeholders cannot be compelled to invest. When green finance-related activities are viewed as collective endeavors, providing strategic choices suitable for various stakeholders to establish collective interests thus becomes indispensable for building the green finance ecosystem.

5.2. Data framework

This study adopts the grounded theory to delineate the data analysis process into four stages. In the first stage, a search strategy and direction are established through interviews with experts in the field of green finance, resulting in a database of green finance literature comprising 3712 articles from May 2011 to July 2021. In the second stage of analysis, this study initially examines textual data, cross-referencing data sources to identify similarities and differences and creating code labels for initial concepts. Concurrently, through an open coding process, these concepts are grouped

into primary categories. In the third stage of analysis, axial coding is employed to search for and identify relationships among primary concepts. This allows for linking between primary categories and grouping and synthesizing secondary themes with fewer instances. Finally, in the fourth stage, through selective coding, this study unifies all categories from axial coding around a core, comprehensively examining the aggregated dimensions constituting green finance: adaptation costs, financing strategies, and green banks. Table 2 illustrates our data framework, summarizing literature sources, secondary themes, and aggregate dimensions from macro-, meso-, and micro-level perspectives.

5.3. Future direction

Under Multiple Global MPA, this study reveals seven sub-domains of recent important trends. First, in the domain of Sustainability Concepts and Green Financing Standards, the linkages and impacts of sustainability on financing are explored, and standards and frameworks are used as the direction of the study. Second, in Green Credit under Green Financing Policies, scholars focused on how a government can realize corporate innovation and transformation through the implementation of green credit guidance policies. Third, as for Green Financing and Stakeholders, the impact of different stakeholders on green financing is the main focus, including the perspectives of private investment, banks, enterprises, the government, etc. Fourth, the Green Bond Development domain covers the development situation and drivers of green bonds, as well as the evaluation and analysis of green bonds in the European Union, emerging economies, and other regions. Fifth, Green Financing Innovations and Multi-Industry Development focuses on discussing the development of green financing in specific industries and examining innovative products such as green bonds and green funds. Sixth, Green Financing and Economic Development mainly describes the positive impact of green financing on economic development and explores the importance of fintech and regulators in green finance development. Lastly, Green Financing and Environmental Impacts affirms the positive environmental effects of green financing policies by examining the

study results. In this stage of research, it is observed that various stakeholders utilize different types of green financial products to assess the impacts on both the economy and the environment. This investigation aims to provide insights into how financial institutions or governmental bodies should proceed with the next phase of green finance initiatives.

This study uses a mixed-methods approach combining qualitative and quantitative analyses to introduce innovative aspects. This approach contrasts with typical research methods that either rely solely on large-sample keyword searches for quantitative studies or involve subjective, smaller-sample qualitative analyses. Uniquely, our research utilizes main path analysis to trace knowledge flows, defines major research themes across different periods, and establishes connections between studies. By examining the reasons, timing, and methodologies behind green finance development, this study addresses gaps in the literature, thereby offering a more comprehensive and in-depth understanding of the field.

Combining the findings from the Multiple Global MPA and Key-Route MPA studies and considering that financial institutions and the private sector are integral components of green finance, this study proposes the following recommendations based on the results. First, establishing awareness of participants' positioning, responsibilities, and interests within the green finance ecosystem is a key strategic approach to assist banks in participating in green finance and sustainable development. This study, based on a timeline analysis of significant research literature findings, can help banks realign current development strategies from macro-, meso-, and micro-level perspectives. Second, facing the growing number of green finance initiatives, commercial banks can analyze factors such as the development of multilateral agreements internationally, changes in government internal political orientations, and public attention to climate aid in order to understand the main reasons and appeals behind a government's new policy issuance and to establish banking operational strategies accordingly. Third, this study believes that constructing a green finance ecosystem is conducive to achieving economic, social, and environmental sustainability goals and an inevitable choice for the sustainable development of commercial banks. Therefore, this study puts forward an important perspective on green finance, stating that green initiatives should be based on the premise that stakeholders possess corresponding sustainable development profit models. It also provides academia, politics, and industries with some policy implications and directions for future green finance-related fields.

6. Conclusion

In summary, this study employs Key-Route MPA to delineate the evolution of green finance concepts and employs Multiple Global MPA to reveal future trends in green finance development. Through the application of Key-Route MPA, this study preliminarily categorizes green finance literature into three stages and examines issues such as operating adaptation costs, mobilizing stakeholders, and initializing green banking layouts from macro-, meso-, and micro-level perspectives. These three stages assist practitioners in conducting comprehensive analyses. To provide forward-looking insights, this study employs Multiple Global MPA to identify seven recent hot sub-domains within the green finance literature. By conducting detailed analyses of these sub-domains, stakeholders such as researchers, government agencies, and financial institutions are provided with focal points and directions for future research.

Green finance is an emerging research topic, thus offering significant potential for future development. Based on the findings of this study, future researchers could consider three dimensions: government information disclosure at the macro-level, financial

institutions' initiatives at the meso-level, and public engagement promotion at the micro-level.

Looking ahead, green finance presents substantial development potential with numerous areas still emerging. One major challenge is the lack of trust and collective interests within the green finance system, closely tied to collectivist principles that emphasize the need for collective action and participation. This assertion stems from Key-Route MPA, which shows a shift in scholarly focus toward stakeholder diversity in green finance. Notably, Cui et al. (2020) explored multi-agent systems, highlighting how stakeholder interactions affect green finance evolution. This study incorporates collectivism (Triandis, 1995) to analyze green finance development.

In green finance, collectivism implies collaboration among governments, financial institutions, businesses, and the public. Trust issues can undermine collective action, as stakeholders may doubt others' commitments, reducing investment and cooperation. Addressing this requires clear standards, enhanced transparency, and robust oversight. Future efforts should focus on creating a trust-based green finance system, leveraging practical experience and financial technology advancements to build a green digital asset exchange platform. Establishing national standards or participation mechanisms will be crucial in developing a green finance ecosystem with viable profit models for all participants.

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