"Mapping the evolution of green finance through bibliometric analysis"

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MAPPING THE EVOLUTION OF GREEN FINANCE THROUGH BIBLIOMETRIC ANALYSIS

Abstract

This bibliometric study seeks to analyze the intellectual structure and development of green finance research over a nearly 30-year period. Using Scopus data, a comprehensive analysis of 1,487 English-language publications on green finance was conducted. The scope of the analysis spans the years from 1997 to 2024. The analysis investigates numerous facets of green finance scholarship, such as publication and citation trends, influential works, authorship networks, geographic concentrations, conceptual links, and developmental phases. Since 2015, the number of publications and citations has increased significantly, indicating a significant rise in academic and industry interest. China is the leader in terms of research output and influence, demonstrating its dominance in the field. However, it is essential to note that other Asia-Pacific countries, such as Japan and Malaysia, have also made significant contributions to the field. Public policies, government initiatives, and the participation of the private sector are crucial to accelerating green investments and promoting sustainability, as evidenced by numerous citations to scholarly works on the subject. The study investigates a number of prospective future research avenues, including green bonds, green credit policies, green investment, green financial regulation, and green financial technology applications. Despite its heavy reliance on English-language Scopus sources, this quantitative longitudinal mapping provides valuable insights into the emergence and evolution of green finance as a significant multidisciplinary research field.

Keywords	green technology, green policy, emissions reduction, energy transition, environmental finance, sustainable finance, visualization
JEL Classification	Q01, Q50, Q56, G23

INTRODUCTION

As defined by the United Nations Environment Programme (UNDP, 2017), green finance encompasses the financial support and investment in projects that yield environmental benefits and contribute to the establishment of a sustainable economy. The major focus areas encompasses a range of essential topics such as renewable energy, energy efficiency, low-carbon transport, pollution prevention, climate adaptation, biodiversity conservation, and circular economy initiatives (UNDP, 2012). Diverse stakeholders in the financial system, such as investors, banks, corporations, regulators, stock exchanges, insurers, and fintech firms, are increasingly incorporating climate factors into their business strategies and decisions regarding capital allocation (Campiglio, 2016; Schoenmaker & Van Tilburg, 2016). The global momentum on green finance has experienced significant acceleration in recent years. As of 2022, more than 121 central banks and financial regulators have become members of the Network for Greening the Financial System (NGFS). The purpose of this network is to effectively handle climate-related risks and facilitate the allocation of funds for climate mitigation and adaptation (NGFS, 2023).

Over the past decades, many scholarly articles have been published, delving into various aspects of green finance. These articles span diverse disciplines, showcasing the extensive research conducted in this field. These include the intellectual landscape, influential works, regional differences, conceptual frameworks, interdisciplinary boundaries, and the evolutionary path of green finance scholarship (Bhatnagar & Sharma, 2022).

1. LITERATURE REVIEW

Green finance involves integrating environmental considerations into financial decision-making to encourage sustainable investments and activities while addressing environmental issues (Feng et al., 2023). It encompasses financial innovations, mechanisms, metrics, policies, and regulations that are designed to direct capital toward development pathways that are both low-carbon and climate-resilient.

The definition and conceptualization of green finance have undergone significant changes and developments from different perspectives over time. Weber (2014) described green finance as a combination of both public and private economic incentives aimed at promoting environmentally sustainable investments and developments. Feng et al. (2023) presented a comprehensive definition of innovation in financial instruments, services, metrics, and policies incorporating various facets. These innovations aim to direct funding toward climate change mitigation, adaptation, and environmental development objectives. Green finance is the practice of addressing climate and environmental hazards within the financial sector while facilitating capital allocation to environmentally sustainable sectors, according to the UNDP (2017).

Berrou et al. (2019) defined green finance as a collection of financial market solutions to achieve a balance between economic, environmental, and social factors to promote sustainable development. Green finance can be defined as the integration of various elements, including innovations, mechanisms, regulations, and policies. Its main objective is to encourage the redirection of financial resources toward environmentally friendly and economically sustainable activities. Additionally, green finance considers the risks and impacts associated with climate change.

Green finance's tools, implementation tactics, performance outcomes, and measuring methods have been extensively studied. Environmental studies, economics, finance, development studies, public policy, and management are covered (Wright & Nyberg, 2017). Green finance includes green bonds, sustainability-linked loans, carbon pricing, fintech applications, sustainability indices, climate risk regulations, central bank initiatives, and decarbonization-friendly financial policies (UNDP, 2017). Lichtenberger et al. (2022) examined how green bonds helped switch to renewable energy. Several green finance niche studies have used bibliometrics. Green bonds, fintech applications, and sustainable banking are included in these subdomains (Alsmadi et al., 2023; Lichtenberger et al., 2022). While valuable, these insights focus on certain areas rather than the entire environment. Research and practice developments in green finance are assessed qualitatively (Ameer & Othman, 2012; Liang & Renneboog, 2017). Although not bibliometrically validated, these findings highlight crucial topics and future approaches. Science-based quantitative mapping of green finance literature structure and evolution is limited.

Using bibliometrics, Luo et al. (2022) analyzed 3,786 sustainable finance scholarly papers from 2000 to 2021. The article analyzes sustainable finance research's main fields of study, trends, focal points, and key publications. Additionally, the report suggests future research and policy implications. The study also quantifies current scholarly works' transformational power using structural variation analysis. This method identifies novel and influential sustainable finance literature.

Bhatnagar and Sharma (2022) analyze sustainable finance literature, which combines social, environmental, and climate change into financial institutions' business strategies. Transdisciplinary publications and multidimensional concerns dominate sustainable finance research hubs, including the UK, China, the US, Switzerland, and Japan. Policies drive sustainable finance research,

which requires a fundamental reform in finance theory and epistemology to align financial system design with sustainability transition goals.

Based on the information provided, the objective of this study is to conduct a bibliometric analysis to examine global research trends in green finance spanning nearly three decades. The bibliometric study aims to offer insights into the emergence and development of the interdisciplinary domain of green finance scholarship by providing a quantitative longitudinal mapping of its intellectual structure and evolution. The analysis covers various aspects that have influenced the field of green finance, including pivotal moments, key contributors, research focal points, interdisciplinary boundaries, and promising future avenues.

2. METHODS

This study employs a rigorous bibliometric approach to quantitatively analyze patterns in the scholarly literature on green finance from 1994 to early 2024. Bibliometrics is the practice of using statistical analysis techniques to examine publications. Its purpose is to gain insights into the historical development, productivity patterns, and intellectual framework of a particular scientific field (Ellegaard & Wallin, 2015). Bibliometric reviews involve the use of publication and citation data analytics. This includes identifying patterns, uncovering networks and relationships, and tracking advancements in a specific research area over time (Moral-Muñoz et al., 2020). The use of quantitative techniques in bibliometric mapping provides researchers with valuable guidance when navigating the vast body of publications in emerging fields like green finance.

The scholarly publications analyzed in this bibliometric review were obtained systematically from the Scopus database. Scopus was chosen for its extensive coverage across various disciplines, encompassing over 90 million entries indexed from more than 100,000 peer-reviewed serials (Chadegani et al., 2013). The extensive collection of scholarly literature indexed by Scopus surpasses other databases, enhancing the reliability of bibliometric analysis.

The implemented advanced search query specifically included the following terms: ((TITLE-ABS-KEY ("green finance")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "bk") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "ar"))). The search strategy helped identify articles, reviews, or conference papers written in English. These sources focused on the terminology related to green finance, which can be found in the title.

Table 1. Type of publication for the 1,487 green finance research publications

ID	Document type	Number of Documents
1	Article	1,228
2	Book Chapter	107
3	Conference Paper	101
4	Review	37
5	Book	14
	Total	1,487

The initial search yielded 1,560 scholarly publications. However, after applying filters, a total of 1,487 documents were identified. Based on Table 1, there is a total of 1,487 research documents pertaining to the topic of "green finance," which have been classified into 5 distinct types. Most of the documents consist of articles, specifically 1,228 out of 1,487, accounting for approximately 82% of the total. This suggests that articles are the predominant document type utilized for research on this topic. The second largest share comprises book chapters, which account for approximately 7% or 107 documents. There is a relatively low number of conference papers and reviews, accounting for 101 (7%) and 37 (2%) documents, respectively. 14 books comprise less than 1% of the total.

The dataset that had undergone the cleaning process was subsequently loaded into the VOSviewer software application to carry out bibliometric analysis and provide visualizations of the networks and trends (Van Eck & Waltman, 2010). Co-authorship networks were constructed to examine and investigate the collaborative patterns among authors, institutions, nations, and journals (Chen et al., 2010). Leydesdorff and Rafols (2009) utilized co-occurrence techniques to examine the associations between commonly appearing keywords.

The researchers conducted overlay mapping to obtain a thorough understanding of the interdisciplinary nature of research in the domain of green finance (Waltman et al., 2010). Citation analysis provides useful insights into the scientific influence of publications, authors, journals, institutions, and nations (Chen et al., 2012). The researchers employed temporal algorithms to evaluate the temporal evolution of publishing and citation trends within the specified time frame (Chen et al., 2014).

Bibliometric analytic tools were utilized to construct a comprehensive depiction of the intellectual landscape and knowledge domains within the green finance research field over almost 30 years. The use of multivariate indicators facilitated the achievement of this outcome. Quantitative technique facilitated the impartial identification of the most influential contributors and works, employing data on publications and citations. The analysis of publication trends enables the identification of previous patterns of growth and the emergence of new priorities. Co-authorship and co-occurrence networks have played a crucial role in uncovering the underlying framework of relationships and interrelated themes that characterize the field. Nevertheless, it is crucial to recognize the constraints when exclusively relying on sources documented in the Scopus database (Mongeon & Paul-Hus, 2016) and the priority placed on English-language publications in this bibliometric analysis (Harzing & Alakangas, 2016). Hence, it is imperative to consider these constraints in interpreting the results, and one should avoid assuming that the study provides a fully comprehensive viewpoint. To increase the insights, further evaluations should be conducted by broadening the search scope to include new publishing databases. Furthermore, the examination of literature written in languages other than English can enhance one's comprehension of the subject matter (Archambault et al., 2006). Content analysis approaches with quantitative visualization would provide a significant supplementary method. The study's strength lies in its comprehensive and detailed bibliometric analysis of the scholarly knowledge landscape in green finance research for nearly 30 years (Kousha & Thelwall, 2007).

3. RESULTS AND DISCUSSION

3.1. Trends in research and production of green finance

The number of publications and citations on green finance has increased significantly over time, as shown in Table 2. Between 1997 and 2014, there was a notable dearth of publications, with an annual average of only 2 to 5 publications and fewer than 50 citations. This indicates a paucity of early research interest and influence. However, a notable increase in publication activity began in 2015, when five documents were published. This upward trend continued consistently in 2021, reaching a significant milestone of 182 documents. Citations also experienced a substantial increase beginning in 2016, with the number of citations rising from 423 in 2016 to a peak of 7,991 in 2022. In recent years, the number of publications has increased significantly. The number of publications rose from 182 in 2021 to 420 in 2022, surpassing 691 in the first half of 2023. This indicates a significant increase in green finance research interest and output. The number of citations has also remained high, with nearly 3,000 so far in the first half of 2023. The total number of publications to date is

Table 2. Publications and citations of research on green finance

ID	Year	Documents	Citations	ID	Year	Documents	Citations
1	1997	2	101	9	2017	11	177
2	2005	1	0	10	2018	31	835
3	2011	2	10	11	2019	46	1,794
4	2012	4	52	12	2020	79	1,986
5	2013	2	32	13	2021	182	5,438
6	2014	2	5	14	2022	420	7,991
7	2015	5	44	15	2023	691	2,901
8	2016	4	423	16	2024	5	0

1,487 documents, which have received an impressive total of 21,789 citations.

The publication and citation data plainly demonstrate exponential growth for both metrics over the past few years. This statement emphasizes the increasing significance of research in the field of green finance, which is garnering more interest from both academia and industry. The high number of citations indicates the substantial scholastic impact of the research. In the coming years, it is anticipated that the number of publications and citations pertaining to green finance will continue to increase rapidly if the current trends continue.

3.2. The most referenced green finance research papers

The top five most-cited green finance research papers provide valuable insights into the role of public policies, government initiatives, and private sector involvement in driving environmentally sustainable economic growth through green finance (Table 3). The top-ranked study by Zhang et al. (2021a), which has received 389 citations, investigates the relationship between public R&D expenditure and green economic growth in Belt and Road Initiative (BRI) countries. The findings of this study suggest that government policies have produced varying degrees of verdant growth. The second-ranked paper by C.-Chu. Lee and C.-Chi. Lee (2022) examines the relationship between green finance and green productivity in China. The study demonstrates that green finance has a significant positive impact on green productivity, particularly in provinces with high pollution levels and economic activity. This conclusion is supported by a significant number of citations, a total of 360. In a significant study by Taghizadeh-Hesary and Yoshino (2019), the authors attained a commendable third-place ranking with 349 citations. Their analysis centered on developing frameworks for enhancing private participation in green finance. In particular, they investigated the potential advantages of implementing green credit guarantees and tax incentives. In a study by Yu et al. (2021) that has received 346 citations, it was discovered that green finance policies have the potential to alleviate barriers to green innovation. However, it was also observed that private firms in

Table 3. The 20 most-cited papers in the field of green finance research

Rank	Research	Source title	Citations	DOI
1	Zhang et al. (2021a)	Energy Policy	389	10.1016/j.enpol.2021.112256
2	C.-Chu. Lee and C.-Chi. Lee (2022)	Energy Economics	360	10.1016/j.eneco.2022.105863
3	Taghizadeh-Hesary and Yoshino (2019)	Finance Research Letters	349	10.1016/j.frl.2019.04.016
4	Yu et al. (2021)	Energy Policy	346	10.1016/j.enpol.2021.112255
5	Wang and Zhi (2016)	Energy Procedia	265	10.1016/j.egypro.2016.12.053
6	Zhang et al. (2019)	Finance Research Letters	264	10.1016/j.frl.2019.02.003
7	Zhou et al. (2020)	Environmental Science and Pollution Research	237	10.1007/s11356-020-08383-2
8	He et al. (2019)	Renewable Energy	228	10.1016/j.renene.2019.05.059
9	Zhang et al. (2021b)	Journal of Environmental Management	208	10.1016/j.jenvman.2021.113159
10	Taghizadeh-Hesary and Yoshino (2020)	Energies	206	10.3390/en13040788
11	Irfan et al. (2022)	Technological Forecasting and Social Change	201	10.1016/j.techfore.2022.121882
12	Ren et al. (2020)	Journal of Cleaner Production	201	10.1016/j.jclepro.2020.122844
13	Tian et al. (2022)	Applied Energy	187	10.1016/j.apenergy.2021.118205
14	Saeed Meo and Karim (2022)	Borsa Istanbul Review	180	10.1016/j.bir.2021.03.002
15	Song et al. (2021)	Energy Policy	178	10.1016/j.enpol.2021.112267
16	Muganyi et al. (2021)	Environmental Science and Ecotechnology	174	10.1016/j.ese.2021.100107
17	Nawaz et al. (2021)	Environmental Science and Pollution Research	172	10.1007/s11356-020-10920-y
18	Rasoulinezhad and Taghizadeh-Hesary (2022)	Energy Efficiency	158	10.1007/s12053-022-10021-4
19	Lv et al. (2021)	Energy Economics	157	10.1016/j.eneco.2021.105476
20	C.-Chu. Lee et al. (2021)	North American Journal of Economics and Finance	150	10.1016/j.najef.2020.101309

China face challenges in accessing credits for such initiatives. This research finding positions the study as the 4th most influential in its field. The study conducted by Wang and Zhi (2016), which is ranked 5th and has received 265 citations, focuses on analyzing the green finance policies implemented in China's renewable energy sector with the aim of achieving ecological balance.

The top 20 papers covered a wider range of green finance topics but received fewer citations beyond the top 5. This suggests that the most cited studies had a much greater impact. The top five strategies emphasize the importance of balanced green finance to sustain economic growth while ensuring environmental sustainability.

3.3. Leading journals for research in green finance

Energy Economics is the journal with the most citations on green finance, with 1,336 citations from 42 documents, resulting in an exceptionally high 31.81 citations per document. It is followed by Journal of Cleaner Production (1,246 citations from 39 documents; 31.95 citations per document), Renewable Energy (1,478 citations from 64 documents; 23.09 citations per document), Resources Policy (1,343 citations from 79 documents; 17 citations per doc-

ument), and Environmental Science and Pollution Research (2,058 citations from 158 documents; 13.03 citations per document) (Table 4).

The top 5 journals account for 16.6% of total documents but 39.7% of total citations, with 6,461 citations from 382 documents. This implies they publish the most influential green finance research. These top journals publish research with a greater impact than the average of 8.95, as seen by the higher citation rates per document. The top 20 journals published 25.1% of documents but 55.1% of citations. Citation rates are high but lower than the top five, from 31.95 to 10.20 per document. Vital green finance research is concentrated in the top 5 journals. Energy Economics, Journal of Cleaner Production, Renewable Energy, Resources Policy, and Environmental Science and Pollution Research are the most common places where green finance studies are published. The analysis shows that a few famous publications publish green finance research with a much greater impact than the typical journal.

3.4. Most productive researchers in green finance

The author who has the highest number of publications on the topic of "green finance" is F. Taghizadeh-Hesary from Tokai University, Japan,

Table 4. Top 20 journals for research on green finance based on total citations

Rank	Source title	Documents	Citations	Citations per Document
1	Environmental Science and Pollution Research	158	2,058	13.03
2	Sustainability	114	1,557	13.66
3	Renewable Energy	64	1,478	23.09
4	Resources Policy	79	1,343	17.00
5	Energy Economics	42	1,336	31.81
6	Journal of Cleaner Production	39	1,246	31.95
7	Energy Policy	15	1,242	82.80
8	Finance Research Letters	17	805	47.35
9	Ecological Economics	8	533	66.63
10	Technological Forecasting and Social Change	9	492	54.67
11	Journal of Environmental Management	16	427	26.69
12	Energies	16	380	23.75
13	Economic Analysis and Policy	18	330	18.33
14	Global Finance Journal	7	293	41.86
15	International Journal of Environmental Research and Public Health	23	271	11.78
16	Borsa Istanbul Review	4	270	67.50
17	Energy Procedia	1	265	265.00
18	Frontiers in Environmental Science	39	252	6.46
19	Economic Research – Ekonomska Istrazivanja	21	237	11.29
20	China Finance Review International	7	219	31.29

Table 5. The top 20 researchers in the field of green finance

Rank	Author	Documents	Affiliation	Country
1	Taghizadeh-Hesary, F.	29	Tokai University	Japan
2	Sadiq, M.	10	Central South University	China
3	Lee, C.-Chu.	9	Nanchang University	China
4	Mohsin, M.	8	Taif University	Saudi Arabia
5	Siddik, A.B.	8	University of Science and Technology of China	China
6	Tang, D.	8	Nanjing University of Information Science & Technology	China
7	Wang, R.	8	Nanjing Xiaozhuang University	China
8	Yoshino, N.	8	Keio University	Japan
9	Zhang, D.	8	Capital University of Economics and Business	China
10	Chau, K.Y.	7	City University of Macau	China
11	Iqbal, W.	7	Shenzhen University	China
12	Rasoulinezhad, E.	7	Tehran University	Iran
13	Boamah, V.	6	Nanjing University of Information Science & Technology	China
14	Dong, K.	6	University of International Business and Economics	China
15	Ibrahim, R.L.	6	University of Lagos	Nigeria
16	Irfan, M.	6	Beijing Institute of Technology	China
17	Liu, Z.	6	Nanjing Normal University	China
18	Ng, A.W.	6	The Hong Kong Polytechnic University	China
19	Song, M.	6	Anhui University of Finance and Economics	China
20	Umar, M.	6	Lebanese American University	Lebanon

with a total of 29 documents. M. Sadiq from Central South University, China, is closely followed, as he possesses 10 documents (Table 5). The third most prolific author is C.-Chu. Lee from Nanchang University, China, with 9 documents. The next most published authors on this topic are M. Mohsin from Taif University, Saudi Arabia, and A. B. Siddik from the University of Science and Technology of China, with 8 documents each. In the top 5, the analysis observes D. Tang from Nanjing University of Information Science & Technology, China. Tang has published 8 documents on the topic of "green finance."

China-based universities produce 6 of the top 10 authors. After China, two Japanese, one Saudi, and one Iranian authors round out the top 10. This implies that Chinese scholars dominate leading publications on this field.

China leads the top 20 authors with 11 authors. However, Nigeria, Lebanon, Hong Kong, and Macau authors make the representation much more diverse. According to publishing data, Asia dominates "green finance" research. West countries are absent from the top rankings. The number of Chinese authors emphasizes China's focus on sustainability issues like green finance. Further analysis comparing research impact and citations would reveal how these highly published authors advance this topic.

3.5. Countries most influential in green finance research

China is the undisputed leader in terms of research output and its impact on green finance (Table 6). With an impressive count of 933 documents and an astounding 14,632 citations, China's dominance in this field is unquestionable. The significant lead observed here indicates China's swift growth in the realm of green finance and its aspiration to establish itself as a frontrunner in this domain. Pakistan, ranked second, has a mere 88 documents and 2,519 citations. Japan, Malaysia, and the UK complete the top 5, with each country having a range of 46-97 documents and 1,432-2,257 citations. While their productivity is commendable, it pales compared to China's output.

When analyzing the top 20 countries, China remains dominant. Five of the top twenty create 1,228 documents and 22,161 citations, while the other fifteen produce 848 and 10,491. China produces five times more research than second-place Pakistan, skewing productivity. East and Southeast Asian nations like Vietnam, Taiwan, Singapore, and Indonesia lead outside the top 5. The US, France, and Germany support this with 60-53 papers and 574-711 citations. The data show China's concentration on green finance research, a strategic aim shared by other Asia-Pacific governments. The pa-

Table 6. The top 20 countries in terms of citations for research output in green finance

Rank	Country	Documents	Citations	Rank	Country	Documents	Citations
1	China	933	14,632	11	Italy	35	660
2	Pakistan	88	2,519	12	France	42	608
3	Japan	46	2,257	13	Germany	53	574
4	Malaysia	66	2,021	14	Taiwan	28	549
5	The United Kingdom	97	1,432	15	Singapore	21	536
6	Vietnam	38	918	16	Turkey	30	525
7	Australia	45	917	17	Indonesia	26	496
8	The United Arab Emirates	20	726	18	Canada	20	349
9	The United States	60	711	19	Hong Kong	26	323
10	India	65	710	20	The Netherlands	14	313

per notes that Western nations continue to contribute significantly to research output and effect. China dominates green finance publications in Asia-Pacific in terms of output and influence.

3.6. Most significant affiliations in the study of green finance

Table 7 shows that Southwestern University of Finance and Economics is a leader in green finance research and influence. They produced 34 documents on this topic. The top Chinese university focusing on economics and finance is in Chengdu, a major economic hub. Southwestern's prominence shows China's focus on sustainable financing. The following Asian universities – Jiangsu University and Tokai University – have 29 and 27 documents, respectively. Anhui University of Finance and Economics and Zhongnan University of Economics and Law are among the top 5 Chinese universities with 22 and 21 publications, respectively. These Chinese colleges' popularity shows China's expanding involvement in global green finance research.

Chinese colleges dominate the top 20 affiliations, taking half of the places. The list expands to include universities in Vietnam, Singapore, Malaysia, and Uzbekistan. Japanese universities like Keio University are among the top 20. Oxford University and other Western universities are among the top 20. This shows global interest in sustainable finance. The top 20 is slightly more geographically diverse than the top 5, which focuses on China. China still dominates both lists. The number of top-20 articles reduces linearly without substantial drops. This shows that green finance research is widespread, although mostly in China and Asia. A deeper look at the 160 associations may reveal a wider global dispersion.

3.7. Keyword analysis in green finance research

The most common keyword (Table 8) in "green finance" studies is "Green Finance," 896 times. This statement concisely states the major topic under inquiry. The second most used keyword, "China,"

Table 7. The top 20 affiliations in terms of significant contributions

Rank	Affiliation	Documents	Rank	Affiliation	Documents
1	Southwestern University of Finance and Economics	34	11	University of Economics Ho Chi Minh City	18
2	Jiangsu University	29	12	Shenzhen University	17
3	Tokai University	27	13	Ocean University of China	16
4	Wuhan University	23	14	Nanjing University of Information Science & Technology	16
5	Anhui University of Finance and Economics	22	15	Nanjing Xiaozhuang College	16
6	Zhongnan University of Economics and Law	21	16	Fuzhou University of Foreign Studies and Trade	16
7	Qingdao University	21	17	University of International Business and Economics	15
8	Beijing Institute of Technology	19	18	Nanjing University of Aeronautics and Astronautics	15
9	Guizhou University of Finance and Economics	19	19	Central University of Finance and Economics	14
10	Capital University of Economics and Business	18	20	Xiamen University	14

Table 8. The top 20 keywords for researching green finance

Rank	Keyword	Occurrences	Rank	Keyword	Occurrences
1	Green Finance	896	11	Innovation	148
2	China	455	12	Carbon Emission	145
3	Finance	412	13	Climate Change	145
4	Sustainable Development	327	14	Carbon	143
5	Green Economy	289	15	Investment	139
6	Economic Development	219	16	Renewable Energy	115
7	Investments	215	17	Environmental Protection	110
8	Environmental Economics	170	18	Economic Growth	107
9	Sustainability	150	19	Panel Data	106
10	Alternative Energy	149	20	Carbon Dioxide	104

appears 455 times, highlighting China's importance in green finance research and development. "Finance" (412) and "Sustainable Development" (327) are the next most commonly referenced keywords, showing the link between green finance, general finance, and sustainability goals. The top 20 keywords include "Investments" (215), "Environmental Economics" (170), "Innovation" (148), "Carbon Emission" (145), and "Climate Change" (145). The top 20 keywords contain methodological terms like "Panel Data" (106), which may indicate research methodologies used in many publications.

In keyword frequency statistics, China, green finance, sustainable development, and environmental economics are prominent. The top five include high-level subjects, but the top 20 delve further into subtopics, techniques, and specific issues like carbon emissions and climate change.

3.8. Keyword co-occurrence network in green finance publications

Green finance research covers numerous topics that aim to foster economic growth while promoting environmental sustainability. Figure 1 presents an overview of four key clusters that categorize the main themes within this field. The first cluster, which is represented by the red color, focuses on research pertaining to green technology and productivity. The second cluster, represented by the green color, encompasses work about energy transition and reducing emissions. The third cluster, depicted in blue, centers around research on green policy and sustainable finance. Finally, the fourth cluster, which is depicted in yellow, pertains to research on sustainable finance and investment. Although diverse in their specific focus-

es, these four clusters collectively encompass the fundamental areas of scholarship that are shaping the expanding field of green finance.

Cluster 1 (red) addresses "Green Technology and Productivity." Key concepts in this cluster include "technological advancement," "invention," "manufacturing," "productivity," and "environmentally friendly technology." The keywords suggest researching how technology and innovation may boost productivity and efficiency while reducing environmental impact. Technology to boost sustainable economic productivity is studied.

Cluster 2 (green) covers "Energy Transition and Emissions Reduction." This cluster addresses climate change and carbon emissions by switching to renewable energy. It covers renewable energy, energy transition, carbon emissions, climate change, and fossil fuels. Energy policies, markets, and investments needed to shift from fossil fuels to solar and wind power and reduce greenhouse gas emissions to reach carbon neutrality are discussed.

Cluster 3 (blue) addresses "Green Policy and Sustainable Finance." In sustainable finance and environmental policy, this cluster covers "climate policy," "green finance," "carbon pricing," "sustainability policy," and "green innovation policy." Research should examine sustainable government policies, laws, and financial processes. Carbon pricing, green bonds, climate financing, and green technology subsidies are examined.

Cluster 4 (yellow) addresses "Sustainable Finance and Investment." This cluster explores "green finance," "sustainable finance," "ESG," "green bonds," "sustainable development," and "financial markets." Researchers study sustainable investing,
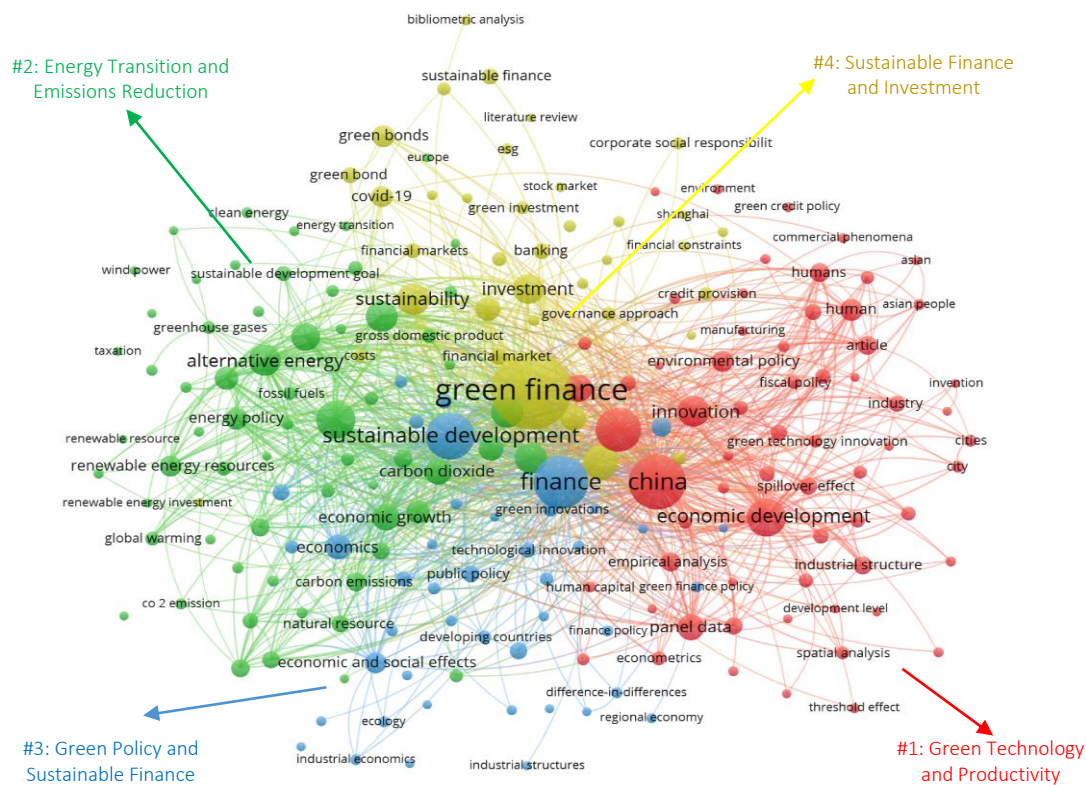
Figure 1. Network of co-occurrence of keywords in publications on green finance

green financing, and how financial institutions and businesses help transition to a low-carbon economy.

3.9. The future of green finance research trends

In the face of the pressing need to transition to a low-carbon economy, research on innovative green finance mechanisms has become increasingly crucial. Table 9 examines five potential areas that could significantly impact the future of scholarship in this emerging field. These areas include green bonds, which aim to direct private capital toward climate-aligned projects; green credit policies that provide incentives for sustainable investments; novel frameworks for analyzing and assessing the risks associated with green investments; regulatory measures aimed at aligning financial systems with climate objectives; and fintech innovations that have the potential to expedite the growth of climate finance. Although distinct, these potential research directions are fundamentally interlinked, providing valuable insights into the mobilization of finance for delivering climate solutions. This study aims to catalyze fresh perspectives and enquiry into the critical domain of green finance research by mapping its frontiers.

Research is currently exploring how green finance policies, regulation, technology, and investment practices can effectively direct capital toward climate solutions and the reduction of emissions. The current evidence suggests that progress has been made; however, it is crucial to emphasize the need for ongoing innovation in instruments, monitoring, and coordinated efforts.

CONCLUSION

The objective of this bibliometric study was to offer a thorough quantitative analysis of the intellectual framework and progression of research in green finance, spanning almost three decades. The main objectives were to investigate publication trends, influential works, authorship networks, geographic

Table 9. Five potential future research paths for green finance

Research Topic	Key Studies
Green bonds	Guo et al. (2023) analyzed how macroeconomic, policy, and firm-level variables affect Chinese green bond issuance and price. Green bond issuance is discouraged by economic policy uncertainty and stock market crashes but encouraged by government subsidies and reduced financing costs. Alharbi et al. (2023) showed that green bond issuance boosts renewable energy generation in 44 nations. Countries with carbon objectives and mature credit markets have a greater impact. Wang and Taghizadeh-Hesary (2023) proposed digital green bond platforms, issuer networks, carbon levies, and green economic stimulus to grow the global green bond market. Transparency requires standards.
Green credit	Liu et al. (2023) discovered that green credit policies in China effectively reduce the carbon intensity of corporations by reducing the carbon intensity of investments and enhancing environmental oversight. However, credit labeling does not reduce emissions directly. Cen (2023) demonstrated that green finance reforms in China reduce the risk of a stock price collapse for highly polluting firms by alleviating financing constraints and decreasing the stockpiling of negative news. This indicates that green credit can strengthen market stability. Dong et al. (2023) investigated the factors influencing the issuance of green credits in 30 Chinese provinces. Instability in economic policy and energy consumption discourage the issuance of green credit, while technology, environmental regulation, and government budgets encourage it.
Green investment	Wu et al. (2023) examined the influence of institutional investor networks on ESG investing in China. Shared preferences for ESG among interconnected investors increase low-carbon corporate innovation, moderated by regulation. Yang et al. (2023) found that China's institutional investors consider environmental factors more heavily when making decisions due to green finance policies. However, effects differ depending on investor horizons and the company's ownership structure. Zhang et al. (2023) demonstrated that in China, green credit and insurance inhibit the greening of the actual economy, while green investment promotes it. Policies for the virtual economy and the actual economy must be coordinated.
Green financial regulation	Ge et al. (2023) evaluated how China's green finance pilot zone reforms increased environmentally-biased technological progress by easing financing constraints and promoting industrial upgrading. Zhang and Ling (2023) used a natural experiment in China to demonstrate that the development of digital finance enhances environmental governance and reduces emissions, particularly in less developed regions. Shao and Huang (2023) examined the transition from direct intervention to market-based instruments in China's green finance policy blend over time. Interactions between government levels shaped the gradual implementation of reforms.
Green fintech	Chu et al. (2023) demonstrated that the expansion of digital finance in China decreases county-level carbon emissions by promoting green lending, innovation, and productivity. But digital divides can reduce the impact. Xu et al. (2023) discovered that increased financial technology promotes green finance and decreases China's industrial carbon intensity. In more developed regions, this effect is more pronounced. Song et al. (2023) demonstrated that financial technology development in China increases renewable energy adoption by alleviating capital constraints. There are significant spatial and temporal effects.

concentrations, conceptual linkages, and developmental phases that have influenced this emerging interdisciplinary field.

The results indicate a significant increase in publications and citations on green finance since 2015, suggesting a growing interest from both the academic and industry sectors. China has been identified as the unequivocal frontrunner regarding research output and impact. However, it is worth noting that other countries in the Asia-Pacific region, such as Japan and Malaysia, have also made noteworthy contributions in this regard. The analysis has identified highly cited seminal works that delve into the role of public policies, government initiatives, and private sector involvement in promoting green investments and environmental sustainability. Four key thematic clusters were identified through keyword co-occurrence network mapping. These clusters include green technology and productivity, energy transition and emissions reduction, green policy and sustainable finance, and sustainable finance and investment. Future research frontiers could explore green bonds, credit policies, risk frameworks, regulations, and financial technology applications.

This bibliometric study offers a thorough quantitative portrayal of the development of scholarship in green finance spanning almost three decades. The analysis offers insights into critical developments, influential publications and contributors, geographic concentrations, conceptual domains, and promising research directions that define this critical emerging field. However, it is essential to note that there

are constraints in this study as it heavily relies on English-language sources that have been documented in Scopus. Further studies that incorporate additional databases, languages, and qualitative content analysis have the potential to offer supplementary perspectives. Despite these limitations, the detailed longitudinal mapping of the green finance knowledge landscape conducted in this study provides valuable insights.

AUTHOR CONTRIBUTIONS

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