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Navigating the Green Finance Landscape: A Comprehensive Bibliometric Exploration of Current Trends, Evolution, and Prospects

Dr. Noor Ulain Rizvi[*1], Adil[*2], Dr. Cheshta Kapuria[*3], Thahani Iqbal[*4], Sakshi Malik[*5]
Affiliations: [*1]Faculty, Curtin University (Dubai), [*2]Regional Credit Leader, Trane Technologies, [*3] Assistant Manager- Invest India, [*4] Faculty, Manipal Academy of Higher Education (Dubai), [*5]Assistant Professor, Jindal Global Business School, O.P. Jindal Global University

Abstract
Climate change and sustainability have become global focal points, exemplified by the 2015 Paris Agreement. This has led to the emergence of "green finance," a term often intertwined with climate finance. Distinguishing between the two can be challenging, but both focus on financial mechanisms for addressing climate change and sustainability.
This paper employs bibliometric analysis to provide insights into academic research on green finance. We find that green finance research is predominantly led by scholars from developed economies, with publications primarily appearing in policy and environmental journals rather than mainstream economics or finance journals. Our analysis suggests three future research directions: a finance-centric approach, research from developing countries' perspectives, and anticipation of emerging challenges in this policy-driven field. This study contributes to understanding the conceptual nuances and emerging trends in green finance research.
Keywords: Green finance, sustainability, bibliometric analysis, climate finance

Introduction
Climate change and sustainability have been a focal point internationally. World leaders found common ground on this issue, as evidenced by the 2015 Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC). While member nations have united to combat the pressing challenge of greenhouse gas (GHG) emissions, a significant hurdle lies in securing the necessary financing for climate change mitigation and sustainability efforts. Tackling this problem demands substantial investments, with estimates indicating that a staggering $53 trillion in energy-related investments will be required by 2035 to uphold the Paris Agreement's 2°C temperature target (International Energy Agency (IEA), 2014).
Ji and Zhang (2019) highlight the pivotal role of financial development in advancing China's renewable energy sector. In 2010, the Green Climate Fund (GCF) was established by 194 countries with the aim of providing financial assistance to developing nations for GHG emissions reduction and climate change adaptation. Consequently, the term "green finance" has become increasingly prevalent in the discourse of international organizations and national governments, as evidenced in reports such as those by the International Finance Corporation (IFC, 2017). These discussions have also captured the attention of

scholars and academics. However, it's important to note that green finance remains somewhat ambiguously defined and often conflated with climate finance.

Distinguishing between green finance and climate finance can be challenging. According to the IFC (2017), green finance is described as "*financing of investments that provide environmental benefits*", while climate finance, as defined by the UNFCCC, involves "*local, national or transnational financing-drawn from public, private and alternative sources of financing-that seeks to support mitigation and adaption actions that will address climate change*". Despite these subtle distinctions in definitions, both terms revolve around financial mechanisms for addressing climate change and promoting sustainability.

The significance of green finance is evident through the extensive discussions among international organizations and governments, which have sparked growing interest among academic researchers. For instance, Zhang (2018) highlight the importance of carbon finance within the broader framework of green finance.

This paper attempts to summarize recent literature, with the primary goal of providing an overarching perspective on academic research in this field. The paper aims to develop a clearer understanding of conceptual nuances and, more importantly, provide the emerging trends for future research.

Methodology

In this research, bibliometric analysis approach, pioneered by Pritchard (Pritchard, 1969), which has gained widespread popularity for aiding quantitative analysis in comprehending the literature is used. Given the absence of a precise conceptual definition for green finance, we focused our keyword search on three terms: green finance, climate finance, and carbon finance. Additionally, we incorporated several closely related keywords such as green financing, climate financing, carbon financing, green investment, and green bond to ensure comprehensive coverage of relevant literature.

To ensure a consistent and comprehensive dataset, we established specific criteria for identifying relevant research. Firstly, all candidate papers needed to be part of the Web of Science core collection. Secondly, we selected papers classified as articles and indexed in one of the following indices: Science citation index-expanded (SCIE), Social science citation index (SSCI), Arts & Humanities citation index (A&HCI), and Emerging source citation index (ESCI). Our effective sample spanned from 2001 to 2023. Thirdly, we meticulously reviewed all titles and abstracts to exclude any articles that were not pertinent to our study. In total, our sample encompassed 395 papers. A clear upward trend in publications over the sample period is observed. Notably, there was a significant surge in relevant publications after 2015, contrasting with the relatively gradual and steady growth observed prior to that year. This spike in publications post-2015 indicates a substantial increase in academic interest in green finance following the signing of the 2015 Paris Agreement.

Results

The bibliometric analysis centers on four primary areas, with the objective of addressing the following inquiries:

Journal Publications: We will identify the journals where these papers have been published, shedding light on the academic outlets that have contributed to the discourse on green finance.

Author Origins: We will investigate the countries of origin of the authors, providing insights into the geographical distribution of scholarly contributions in this field.

Keyword Analysis: We will conduct a thorough examination of the key interests expressed in these studies through keyword analysis. This analysis will reveal the most prevalent and significant themes within the literature.

Citation Patterns: We will explore how these papers have been cited in the broader academic literature, allowing us to understand the influence and impact of these contributions in the field of green finance.

a) Journal Distribution

Table 1 exhibits a collection of journals based on the number of publications (with more than six relevant papers per journal) in our sample. Interestingly, while finance is a central element of green finance, the primary journals publishing related works are those focusing on environmental and climate change topics. Surprisingly, no major finance journal made it to the list. However, upon closer examination of papers published in finance journals, we did identify a few relevant ones. From 1997 till 2017, there were no 'finance' journals, publishing about green finance. Only after 2018, the author's found one publication in Emerging Markets Finance (by He and Liu, 2018) and three papers in each Finance Research Letters (Taghizadeh-Hesary and Yoshino, 2019; Zhang et. al., 2019) and Finance: Theory and Practice (Steblyanskaya *et. al.*, 2019; Miroshnichenko and Mostovaya, 2019). In 2022, China Finance Review International published four relevant papers in its special issue titled, 'Green and Energy Efficiency Finance'. Finance Research Letters published 13 papers related to green finance in its Volume 56, published in September 2023. While we observe that this topic has picked up acceptance in the last 3 years, however none of the publications come from prestigious finance journal, this evidence aligns with the findings of Diaz-Rainey et al. (2017) and Zhang et al. (2019), suggesting that mainstream finance journals tend to overlook climate change issues.

Table 1: Journal distributions (with more than six relevant papers per journal between 1997-2023)

Journal name	**No. of papers**	**Journal name**	**No. of papers**
Environmental Science and Pollution Research	156	Climate Policy	10
Sustainability (Switzerland)	112	Economic Change and Restructuring	10
Resources Policy	82	Frontiers in Energy Research	10
Renewable Energy	64	Business Strategy and the Environment	9
Energy Economics	45	Emerging Markets Finance and Trade	9
Frontiers in Environmental Science	39	Energy and Environment	9
Journal of Cleaner Production	37	International Journal of Energy Economics and Policy	9
International Journal of Environmental Research and Public Health	23	Technological Forecasting and Social Change	9
Economic Research-Ekonomska Istrazivanja	21	Ecological Economics	8
Economic Analysis and Policy	19	International Review of Financial Analysis	8

Finance Research Letters	19	China Finance Review International	7
Journal of Environmental Management	16	Corporate Social Responsibility and Environmental Management	7
Energies	15	Global Finance Journal	7
Energy Policy	15	International Review of Economics and Finance	7
Environment, Development and Sustainability	13	Finance: Theory and Practice	6
Journal of Sustainable Finance and Investment	13	Frontiers in Public Health	6
PLoS ONE	13		

Notably, three significant economics journals featured on this list: Ecological Economics, Energy Economics, and Environmental & Resource Economics, all of which are specialized in environmental and resource economics. It's evident that green finance has yet to capture the attention of mainstream economics and finance journals, despite its acknowledged significance and the pressing need for comprehensive policy and regulatory tools. There is much work to be done to propel this rapidly evolving subject into the forefront of mainstream economic and financial research, bridging the significant gap in the existing literature.

Two key factors support our assertions here. Firstly, investment in green and climate projects has seen substantial growth in recent years, with a strong upward trajectory. For instance, global green bond issuance reached a historic high of $155.5 billion in 2017, signaling a significant demand for academic research in this domain. Secondly, more researchers from a diverse range of academic backgrounds are taking interest in this field, even though an increase in publications may not be immediately apparent. Notable events associated with mainstream finance journals in recent years, such as the 2018 RFS Climate Finance Initiative in London, are likely to yield relevant outputs. The scarcity of existing research also implies the potential for high-impact, groundbreaking research in this field. Overall, we are optimistic in asserting that an opportunity exists in this arena.

b) Authors' Countries of Origin

It's also worthwhile to explore where the enthusiasm for green finance research primarily originates. We can gain insights into this by examining the countries of origin of the authors. The primary contributors to the recent rapid progress in this field hail from the United States, Europe, and a select few other developed countries. The prominence of U.S.-based researchers in this domain is not surprising, given the presence of influential international organizations like the World Bank and the United Nations on U.S. soil, which can encourage and facilitate relevant research. For years, Europe has been a fervent advocate for global cooperation on climate change, and its world-leading carbon trading market (EU ETS) has attracted significant attention from academic researchers studying green energy issues. It's evident that researchers from the United States and England have taken the lead in this field, while studies from other regions have followed and emerged later.

China and India stand out as the only two emerging economies. Given the size of these two countries and their contributions to global greenhouse gas emissions, their active involvement in these discussions is crucial. The imbalance in the distribution of origins between developed and developing countries suggests that developed nations continue to dominate discussions on green finance. In international climate negotiations, developing countries have been playing an increasingly vital role, which is one of the main reasons why achieving a universal agreement has proven challenging (Costantini *et al.,* 2016). While developed countries are primarily the source of funding, efficient green financing and investment are challenging to attain without active cooperation from developing nations. Therefore, it is imperative to conduct further investigations and gain a deeper understanding of the status quo in developing economies. While the dominance of developed economies in academic research may not change significantly in the short term, issues pertaining to developing countries should be a primary focus for future research directions.

c) Keywords Analysis

Table 2 presents a compilation of the top ten keywords found in the literature. Climate Finance, Climate Change, and Policy emerge as the three primary focal points within the literature. It's evident that the objective of developing green finance is closely tied to addressing climate change, making it a profoundly policy-relevant subject.

Table 2: List of top Keywords with frequency

Keywords	**Frequency**
Climate finance	85
Climate change	74
Policy	57
Adaption	42
Country	31
Carbon Finance	29
China	28
Emission	22

Alongside the core issues, several keywords have garnered significant attention. For instance, Management is ranked tenth, indicating a concern about how green finance is administered, whether by a government or within a market. Another pertinent keyword, Governance, is also visibly important suggesting that effective governance is a critical aspect of green finance. Researchers are also keen on understanding the Impact of green finance, how it can contribute to sustainability and development (as reflected in the keyword Growth). Given China's pivotal role in green finance, it's unsurprising that it emerges as a prominent research focus. While Market, Finance, and Investment didn't make the top list, they were significant, underscoring the need to approach green finance topics from financial perspectives.

Keyword analysis serves as a valuable tool for clarifying the conceptual underpinnings of green finance. It's evident that green finance is intricately linked to climate change and is primarily driven by policy considerations. The central theme revolves around financing or investing in climate adaptation, highlighting the need for contributions from not only environmental economists and scientists but also economists and financial experts.

d) Citation Analysis

Papers in the realm of green finance tend to receive robust citation rates. On average, the sample of 395 papers receive an average of 9 citations each. The most highly cited paper, Heinkel *et al.* (2001), has been cited 1454 times. Table 3 provides a list of the top most cited papers in our sample, exhibiting the diverse array of sources contributing to the interdisciplinary nature of this subject.

Table3: Top most cited papers

Journal name	Author	Year of publication	Title	Citation
Journal of Financial and Quantitative Analysis	Heinkel et al.	2001	The effect of green investment on corporate behavior	1454
Philosophical Transactions of the Royal Society B-Biological Sciences	Ebeling and Yasue	2008	Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits	355
PLOS One (2012)	Jeuland and Pattanayak	2012	Benefits and Costs of Improved Cookstoves: Assessing the Implications of Variability in Health, Forest and Climate Impacts	312
Marine Pollution Bulletin	Macreadie et al.	2014	Quantifying and modelling the carbon sequestration capacity of seagrass meadows - A critical assessment	281
Energy Policy	Lewis	2010	The evolving role of carbon finance in promoting renewable energy development in China	214
European Journal of Operation Research	Ballestero et al.	2012	Socially Responsible Investment: A multicriteria approach to portfolio selection combining ethical and financial objectives	196
Trends in Ecology & Evolution	Brodie et al.	2012	Climate change and tropical biodiversity: a new focus	172
Proceedings of the National Academy of Sciences	Palm et al.	2010	Identifying potential synergies and trade-offs for meeting food security and climate change objectives in sub-Saharan Africa	166
Environmental Science & Policy	Stringer et al.	2012	Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands	160

Furthermore, we delved into the sources of references cited by these papers and it is evident that the references predominantly come from scientific, climate change, and environmental journals. Although a few economics journals (e.g., American Economic Review, Ecological Economics) exert influence on this research, mainstream finance journals appear to have a limited role. This citation analysis underscores that while green finance carries the name of finance, its current studies seldom rely on mainstream finance journals. It highlights the necessity of introducing techniques and models from mainstream finance research to better understand green finance issues.

Conclusion

This study employs bibliometric analysis to examine the current state and trends in academic research on green finance. Through an assessment of 395 relevant publications, along with ranking analysis and visual aids, we gain insights into this interdisciplinary field, covering policies, investments, and governance related to climate adaptation financing.

Our analysis reveals that green finance research is primarily led by scholars from developed economies, with publications often found in policy and environmental journals rather than mainstream economics or finance journals. Despite its growing importance, green finance remains underrepresented in these mainstream publications.

This disparity presents three key avenues for future research:

Emphasizing a finance-centric approach, exploring topics like green bonds, risk management, and governance within mainstream finance journals. Expanding research from the perspectives of developing countries to align diverse policy objectives and promote international collaboration. Acknowledging that green finance is policy-driven, researchers should anticipate emerging challenges and issues influenced by evolving global economic and political landscapes.

Comprehensive reviews of existing literature in this field are lacking, making it crucial to explore and compare our bibliometric analysis results.

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