AN EXPLORATORY ANALYSIS OF GREEN FINANCE

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ABSTRACT

Objective: The objective of this study is to conduct an exploratory analysis of the scientific production in green finance using bibliometric methods to map its evolution and intellectual structure.

Theoretical Framework: This research is grounded in the principles of financial sustainability and climate change mitigation. The study highlights the importance of green finance in promoting environmental sustainability and economic growth.

Method: This research employs a bibliometric analysis of publications from 1997 to 2023. The descriptive analysis includes time series data, total journals and documents, annual growth rate, average age of documents, international co-authorship rate, and average number of co-authors per document. Data collection focused on five highly cited papers to assess their contributions and relevance.

Results and Discussion: The results indicate an exponential growth in publications since 2022, driven by increased awareness of financial sustainability and climate change. Clustering by coupling identified three main clusters: energy policy integration, technological development, and spatial coordination. These findings underscore the growing academic interest in green finance and the need for coordinated policies and investments.

Research Implications: This research provides insights into how green financing policies influence technological innovation, environmental sustainability, and economic growth. The implications emphasize the importance of international collaboration and new technologies.

Originality/Value: This study offers a comprehensive bibliometric analysis of green finance, underscoring its critical role in fostering a sustainable economy. The innovative approach and emerging trends identified contribute valuable foundations for future research and policies.

Keywords: Green Finance, Financial Sustainability, Climate Change, Environmental Sustainability.

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ANÁLISE EXPLORATÓRIA DA PRODUÇÃO CIENTÍFICA EM FINANÇAS VERDES

RESUMO

Objetivo: O objetivo deste estudo é realizar uma análise exploratória da produção científica em finanças verdes usando métodos bibliométricos para mapear sua evolução e estrutura intelectual.

Referencial Teórico: A pesquisa fundamenta-se nos princípios de sustentabilidade financeira e mitigação das mudanças climáticas. Destacam-se as teorias relacionadas às finanças verdes como um componente crítico na promoção da sustentabilidade ambiental e do crescimento econômico.

Método: A metodologia adotada inclui uma análise bibliométrica de publicações de 1997 a 2023. A análise descritiva abrange dados de séries temporais, total de revistas e documentos, taxa de crescimento anual, idade
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média dos documentos, taxa de coautoria internacional e número médio de coautores por documento. A coleta de
dados focou em cinco artigos altamente citados para avaliar suas contribuições e relevância.

Resultados e Discussão: Os resultados indicam um crescimento exponencial nas publicações desde 2022,
impulsionado pela maior conscientização sobre sustentabilidade financeira e a urgência das mudanças climáticas.
A técnica de agrupamento por acoplamento identificou três principais clusters: integração de políticas energéticas,
desenvolvimento tecnológico e coordenação espacial. Esses achados destacam o crescente interesse acadêmico em
finanças verdes e a necessidade de políticas coordenadas e investimentos direcionados.

Implicações da Pesquisa: A pesquisa oferece insights sobre como as políticas de financiamento verde influenciam
a inovação tecnológica, a sustentabilidade ambiental e o crescimento econômico. As implicações enfatizam a
importância da colaboração internacional e das novas tecnologias.

Originalidade/Valor: Este estudo oferece uma análise bibliométrica abrangente das finanças verdes, destacando
seu papel crítico na construção de uma economia sustentável. A abordagem inovadora e as tendências emergentes
identificadas contribuem com uma base valiosa para futuras pesquisas e políticas.


ANÁLISIS EXPLORATORIO DE LA PRODUCCIÓN CIENTÍFICA EN FINANZAS VERDES

RESUMEN

Objetivo: El objetivo de este estudio es realizar un análisis exploratorio de la producción científica en finanzas
verdes utilizando métodos bibliométricos para mapear su evolución y estructura intelectual.

Marco Teórico: Esta investigación se basa en los principios de sostenibilidad financiera y mitigación del cambio
climático. Destacan las teorías relacionadas con las finanzas verdes como un componente crítico en la promoción
de la sostenibilidad ambiental y el crecimiento económico.

Método: La metodología adoptada incluye un análisis bibliométrico de publicaciones desde 1997 hasta 2023. El
análisis descriptivo abarca datos de series temporales, total de revistas y documentos, tasa de crecimiento anual,
edad promedio de los documentos, tasa de coautoria internacional y número promedio de coautores por documento.
La recolección de datos se centró en cinco artículos altamente citados para evaluar sus contribuciones y relevancia.

Resultados y Discusión: Los resultados revelan un crecimiento exponencial en las publicaciones desde 2022,
impulsado por una mayor conciencia sobre la sostenibilidad financiera y la urgencia del cambio climático. La
técnica de agrupamiento por acoplamiento identificó tres principales grupos: integración de políticas energéticas,
desarrollo tecnológico y coordinación espacial. Estos hallazgos destacan el creciente interés académico en finanzas
verdes y la necesidad de políticas coordinadas e inversiones específicas.

Implicaciones de la investigación: La investigación ofrece información sobre cómo las políticas de
financiamiento verde influyen en la innovación tecnológica, la sostenibilidad ambiental y el crecimiento
económico. Las implicaciones subrayan la importancia de la colaboración internacional y las nuevas tecnologías.

Originalidad/Valor: Este estudio ofrece un análisis bibliométrico integral de las finanzas verdes, destacando su
papel crucial en la construcción de una economía sostenible. El enfoque innovador y las tendencias emergentes
identificadas contribuyen con una base valiosa para futuras investigaciones y políticas.

Palabras clave: Finanzas Verdes, Sostenibilidad Financiera, Innovación Tecnológica, Sostenibilidad Ambiental.

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1 INTRODUCTION

The evolution of green finance, from its origins to its current role as a crucial pillar of sustainable development, reflects a growing environmental awareness within the financial sector. This evolution can be explored in five key stages, with appropriate citations for a deeper understanding.

Initially, the concept of green finance began to take shape at the end of the 20th century, particularly after the 1992 Rio Conference, which highlighted the need to integrate economic development with environmental protection. This conference was a pivotal starting point for global recognition of the importance of financing that considers environmental criteria. While the term "green finance" was not yet widely used, the principles discussed during this event paved the way for its future formalization (Peng et al., 2018).

The Earth Summit, also known as Eco-92, held in Rio de Janeiro in 1992, was a decisive milestone for green finance. The conference underscored the importance of environmental sustainability and encouraged the development of financing mechanisms to support environmentally sustainable projects. This event helped raise awareness in the financial sectors about the need to invest in projects that not only promote economic growth but also protect the environment (Porfir'ev, 2016).

In this context, early green finance initiatives often focused on mitigating risks associated with environmental degradation and promoting investments in clean technologies. Although the adoption of such green financial practices was still limited, there was growing recognition that environmental health and economic well-being were interconnected. This led to the introduction of financial products such as green bonds and sustainable investment funds (Sachs et al., 2019).

Moreover, the 1990s witnessed the beginning of the inclusion of environmental, social, and governance (ESG) criteria in investment analysis, a crucial step for the subsequent development of green finance. These criteria began to be taken more seriously by investors and fund managers when evaluating the risks and opportunities associated with different investments (Berensmann & Lindenberg, 2016).

Therefore, the 1990s can be seen as a foundational period for green finance, establishing the groundwork for more robust and systematic growth in subsequent decades. The increasing awareness of the environmental impacts of economic activities and the need for financial approaches that integrated ecological and sustainable considerations were crucial for advancing the concept and practice of green finance globally.
From the 2000s to 2010, green finance began to gain momentum as a crucial component in sustainable development strategies and climate change mitigation efforts. This period was marked by significant advances in the implementation and recognition of financial practices aimed at sustainability.

In the early 2000s, the rise of green finance was driven by increasing global awareness of climate change and the need to finance projects that could mitigate its effects. This led to the development of new financial products, such as green bonds, which began to be adopted by financial institutions, governments, and companies as a means to raise funds for clean energy and energy efficiency projects (Berensmann & Lindenberg, 2016).

In 2007, the establishment of the Principles for Responsible Investment (PRI), supported by the United Nations, marked a turning point, solidifying the importance of responsible investment and the consideration of ESG criteria in portfolio management and investment decision-making. This movement helped promote a greater integration of environmental and social risks into financial analyses, contributing to the expansion of the green finance market (Porfir’ev, 2016).

Throughout the decade, green finance also started to be recognized not just as a tool for environmental mitigation but also as a potential catalyst for economic recovery. This was particularly evident during the 2008 financial crisis when renewable energy and energy efficiency projects began to be seen as stable and profitable investment opportunities in an otherwise volatile financial market (Zakari, 2022).

Thus, the 2000s to 2010 laid a solid foundation for green finance, leading to greater institutionalization and integration of these practices in global financial systems. This paved the way for even more systematic involvement of financial institutions in sustainable investments in subsequent years, highlighting the increasingly critical role of green finance in promoting economically and environmentally sustainable development.

From 2010 onwards, the development of green finance has been crucial in driving sustainable growth and addressing the challenges of climate change. This period is marked by a significant increase in the adoption of financing practices aimed at reducing environmental impact and promoting sustainability.

The Paris Agreement in 2015 marked a turning point, setting stringent carbon emission reduction targets for signatory countries. This expanded the need for green financing to meet these targets, resulting in a substantial increase in the issuance of green bonds and the development of other green financial tools for renewable energy projects, energy efficiency, and other sustainable initiatives (Sachs et al., 2019).
Since then, the integration of green finance policies in major world economies and emerging markets has accelerated. Banks, financial institutions, and governments have begun implementing policies that favor green investments over fossil fuel investments. These policies are often complemented by tax incentives and subsidies aimed at reducing the perceived risk of green investments and attracting more private capital to the sector (Berensmann & Lindenberg, 2016).

A notable example of the impact of green finance is the transformation of China's energy sector. Green finance policies introduced in the country have significantly encouraged the adoption of clean and renewable technologies. Studies show that these policies have not only improved environmental quality but also stimulated technological innovation, highlighting the synergy between green financial development and technological progress (Zeng et al., 2022).

In summary, the period from 2010 onwards has demonstrated the transformative potential of green finance, not only as a response to environmental concerns but also as a catalyst for sustainable economic development. The policies and practices that emerged during this period continue to shape global financial strategies and have the potential to steer the world economy toward a more sustainable future.

Given this context, this paper conducts an exploratory analysis of the scientific production on green finance using bibliometric methods. Specifically, it performs a descriptive data analysis, examines the five most globally cited works—assuming they are the most influential on the subject—and evaluates clustering by coupling to identify the intellectual structure of the field under analysis.

2 DATA AND METHOD

Data collection for this exploratory study on green finance was conducted using the SciVerse Scopus database. The process involved the following steps:

- **Defining Search Terms**: The term “green finance” was used to search within the abstracts, titles, and keywords of the papers;

- **Filtering by Document Type**: To ensure data relevance and quality, the search was limited to papers published in academic journals, excluding conference papers, books, book chapters, etc;

- **Temporal Filter**: Data from the year 2024 were excluded, considering that the year is still ongoing and the data may not be complete. After completing these steps, the data were collected in a CSV file for use with the Bibliometrix package available for
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RStudio.

Bibliometrix is an open-source tool that enables comprehensive bibliometric analyses, from data collection to result visualization. It is especially useful for scientific mapping, integrating various analysis techniques into a recommended workflow. As it is programmed in \( R \), it is flexible and can be quickly updated and integrated with other statistical packages (Aria & Cuccurullo, 2017).

The application of Bibliometrix is not limited to a specific field. For instance, it has been used to analyze the literature on graphene, a rapidly growing field in nanotechnology, demonstrating its applicability across diverse scientific areas (Derviş, 2019).

Initially, a comprehensive description of the data was performed, including a time series analysis of publications, the total number of journals, documents, and researchers, the annual growth rate of scientific production, the average age of documents, the international co-authorship rate, and the average number of co-authors per document.

Next, an analysis of the five most globally cited papers on green finance was conducted, examining their main contributions, impact, and relevance to the field's evolution, as well as their influence on other studies and practices in the area. This is relevant because these papers often contain fundamental and innovative contributions that have shaped the field of green finance. They offer valuable insights and have established theoretical and methodological foundations for subsequent research. Highly cited papers differ significantly from “ordinary” papers in terms of authorship and international collaboration. Most of these papers represent significant contributions that are widely recognized and used by other researchers (Aksnes, 2003). Additionally, for new researchers, these papers serve as essential starting points, providing a comprehensive and in-depth view of the most important developments on a topic (Lai, 2020).

Finally, a clustering by coupling analysis was conducted. This technique, used in bibliometric analysis, combines bibliographic coupling and citation coupling information to identify clusters of related scientific documents. This technique is particularly useful for mapping and understanding the intellectual structure of a research field. Hybrid clustering methods, based on bibliographic coupling and text mining, are effective in detecting and analyzing emerging topics across various scientific disciplines (Gläser et al., 2017).
3 RESULTS AND DISCUSSIONS

The time series, spanning from 1997 to 2023, illustrates the extent of scientific production on green finance over more than two decades. This trend is also depicted in Figure 1, which shows the evolution of research on green finance throughout this period. This timeframe allows us to observe trends and developments in this field, highlighting the continuous growth and increasing interest over the years.

Figure 1

_Evolution of Green Finance Research._

![Graph showing the evolution of green finance research from 1997 to 2023.]

Source: compiled by the authors

From 1997 to 2010, the production of academic papers on green finance was limited, with only 2 papers published in 1997 and a sporadic number of publications in subsequent years. This can be attributed to several factors. During this period, awareness of financial sustainability and climate change was still emerging. Green finance research was not a priority on the global academic and policy agenda. One study notes that during this time, most financial institutions and governments had not yet fully integrated environmental considerations into their financial practices and policies (Ben Ghoul, 2019). Additionally, the necessary infrastructure to support green finance research and incentive policies were in their early stages. Financial sustainability initiatives only began gaining traction later, with the implementation of more robust policies. Studies indicate that the lack of clear guidelines and an adequate
regulatory framework was a significant barrier to advancing green finance research and practices during the 1990s and early 2000s (Mol, 2017).

From 2011 onwards, there was a gradual increase in the number of published papers on green finance, reflecting greater awareness and interest in the field. This increase can be explained by various factors, including adherence to international agreements and the establishment of green funds and policies.

The adoption of international agreements, such as the Paris Agreement in 2015, encouraged countries to invest in sustainable financial solutions to combat climate change. The agreement set clear commitments to limit global warming to well below 2 degrees Celsius, necessitating substantial investments in sustainable technologies and projects. Its implementation also depends on the decarbonization of global economies, involving fundamental shifts in the financial world towards what is known as “green finance” (Berensmann & Lindenberg, 2016).

Governments and financial institutions began creating specific funds and policies to support green projects, boosting scientific production in the area. For example, the growth of the green bond market was substantial after 2015, with funds allocated to renewable energy projects, clean water initiatives, low-carbon transportation, and more. This increase in green bond issuance was crucial for financing investments related to the Paris Agreement and the United Nations Sustainable Development Goals (SDGs) (Tolliver et al., 2019).

The exponential growth in scientific production on green finance from 2022 and 2023, with 364 and 736 papers published respectively, can be attributed to several key factors. The growing urgency to address the climate crisis drove demand for sustainable financial solutions. The academic community and policymakers recognized the critical need for research to inform and guide practical and policy decisions. The COVID-19 pandemic highlighted the interconnectedness of public health, the economy, and the environment, leading to renewed focus on sustainable and resilient financial practices. According to Khudyakova (Khudyakova, 2023), the pandemic exposed vulnerabilities in financial systems and underscored the importance of green finance in building resilience against future crises.

The adoption of new technologies, such as artificial intelligence and blockchain, applied to green finance, significantly expanded opportunities for research and innovation. These technologies allow for greater efficiency and transparency in green financial operations and facilitate the creation of new sustainable financial products (Trukhachev & Dzhikiya, 2023).
Therefore, these combined factors explain the surge in publications on green finance in 2022 and 2023, reflecting a global response to climate challenges, technological advancements, and lessons learned during the COVID-19 pandemic.

The evolution of green finance research reflects a trajectory of growing awareness and urgency regarding financial sustainability and climate change. The transition from limited initial interest to an explosion of publications in recent years underscores the critical importance of green finance on the global academic and policy agenda. This exponential growth, especially after 2022, can be attributed to a combination of robust international policies, technological advancements, and the pressing need to address the climate crisis through innovative and sustainable financial solutions.

Next, we describe the dataset analyzed, which is summarized in Table 1.

**Table 1**

*Descriptive Summary of the Data*

<table>
<thead>
<tr>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Series</td>
<td>1997 to 2023</td>
</tr>
<tr>
<td>Total Number of Journals</td>
<td>353</td>
</tr>
<tr>
<td>Total Number of Documents</td>
<td>1,358</td>
</tr>
<tr>
<td>Annual Growth Rate of Document Production (%)</td>
<td>25.51</td>
</tr>
<tr>
<td>Average Age of Documents</td>
<td>1.9</td>
</tr>
<tr>
<td>Total Number of Researchers</td>
<td>3,489</td>
</tr>
<tr>
<td>Co-authors per Document</td>
<td>3.2</td>
</tr>
<tr>
<td>International Co-authorship Rate (%)</td>
<td>29.46</td>
</tr>
</tbody>
</table>

Source: compiled by the authors

A total of 353 journals and 1,358 published documents were identified. The annual growth rate of document production is 25.51%, indicating a rapid increase in the number of published studies each year. This accelerated growth suggests that green finance is becoming an increasingly important and urgent field of study as environmental and sustainability issues gain global prominence. The average age of the documents, 1.9 years, indicates that research in green finance is relatively recent and up-to-date. This implies that many of the findings and insights are contemporary, reflecting the latest trends and challenges faced by the field. Recent studies are crucial for maintaining the relevance and applicability of the proposed solutions.

The total number of researchers involved is 3,489, demonstrating broad participation from the academic community. Collaboration among a large number of researchers indicates a diversity of perspectives and expertise, which is essential for addressing the complex issues related to green finance.
The average number of co-authors per document, 3.2, suggests a high level of collaboration among researchers. Co-authorship is common in complex and interdisciplinary fields like green finance, where the integration of various knowledge and skills is fundamental to quality research. The international co-authorship rate of 29.46% reflects the global nature of environmental challenges and the need for collaborative solutions. International collaboration is crucial for sharing knowledge, resources, and experiences, promoting significant and innovative advancements in green finance.

The results of this descriptive analysis highlight the growing importance of green finance in academic literature and the dynamics of its evolution. The rapid expansion and global collaboration indicate that green finance is a vital research area for addressing contemporary environmental challenges. The high growth rate and the relevance of recent publications show that researchers are actively responding to the urgent needs of developing sustainable financial solutions.

Next, we move to the analysis of the five most globally cited papers from the sample, aiming to examine their main contributions to the scientific field. The results are presented in Table 2.

**Table 2**

*Five Most Global Cited Papers*

<table>
<thead>
<tr>
<th>Paper</th>
<th>Doi</th>
<th>Citations</th>
</tr>
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</table>

Source: compiled by the authors
The study “How Green Finance Affects Green Total Factor Productivity? Evidence from China” investigates the impact of green finance on green total factor productivity (GTFP) in China, emphasizing its role in the country's green economic transformation. This paper, the most cited globally in our sample with 501 citations, employs a model accounting for unexpected outputs to calculate GTFP across 30 Chinese provinces from 2006 to 2020. Additionally, the study disaggregates GTFP into changes in green technical efficiency (EC) and green technical change (TC) to explore the internal mechanisms of this impact in detail (Lee & Lee, 2022).

The main findings indicate that green finance significantly enhances green total factor productivity (GTFP), primarily by promoting green technical change (TC). The technological transaction market activity and improved financial development are identified as powerful channels for this enhancement. It is crucial to stimulate technological transaction market activity and elevate financial development levels to maximize the benefits of green finance (Lee & Lee, 2022).

The impact of green finance is consistent across various regions in China, including coastal, inland, eastern, central, and western areas. However, in the western regions, where financial development is less advanced and natural resources are more abundant, the impact of green finance is less significant. These findings are useful for improving related policies and promoting sustainable economic development and green transformation in China. The study concludes that green finance plays a crucial role in enhancing green total factor productivity (GTFP) in China. Through channels such as technological transactions and financial development, green finance stimulates green technical innovation, improving the country’s economic efficiency and sustainability (Lee & Lee, 2022).

The study “Demand for green finance: Resolving financing constraints on green innovation in China” examines the effects of financing constraints on promoting green innovations using a sample of listed companies in China from 2001 to 2017. This paper, cited 493 times, explores how green finance policies can address the financing constraints faced by companies to promote green innovations (Yu et al., 2021).

Using data from Chinese listed companies between 2001 and 2017, the authors analyzed the relationship between financial constraints and green innovation capacity, focusing on both private and state-owned enterprises. The main findings reveal that financial constraints significantly hinder green innovation, especially in private companies. While green finance policies are generally effective, green credits are less accessible to private firms, which face greater financial difficulties. The study recommends greater government support for these firms.
and better dissemination of information about green credits by financial institutions and companies (Yu et al., 2021).

The study “Public spending and green economic growth in BRI region: mediating role of green finance” investigates the relationship between public spending on research and development (R&D) and green economic growth in the Belt and Road Initiative (BRI) region, highlighting the mediating role of green finance. This paper, the third most cited globally in our sample with 475 citations, uses panel data from BRI member countries from 2008 to 2018, applying the generalized method of moments (GMM) and data envelopment analysis (DEA) to assess this relationship (Zhang et al., 2021).

The study aimed to understand how public spending on R&D and green technology development influences sustainable economic growth in the BRI region and how green finance mediates this relationship. The main findings indicate that green economic growth indicators fluctuated due to inconsistent government policies. Public spending on human resources and green energy technology R&D is essential for promoting sustainable green economies by boosting production and technology. However, the effects of public R&D investments and green finance vary between high and low per capita GDP countries, being more pronounced in high GDP per capita countries. The study concludes that public spending on R&D and green technology development are crucial for promoting green economic growth in the BRI region. Green finance acts as an important mediator, amplifying the positive effects of public investments. The effectiveness of these policies varies across countries, highlighting the need for tailored policy approaches to the economic and technological specificities of each region (Zhang et al., 2021).

The study “The way to induce private participation in green finance and investment” by Taghizadeh-Hesary and Yoshino (2019) explores ways to increase private participation in green finance and investment. It is the fourth most cited paper globally in our sample, with 430 citations. The paper proposes two applied frameworks supported by theoretical models, including the establishment of green credit guarantee schemes (GCGSs) and the return of a portion of tax revenue generated by the spillover effect of green energy supply to investors. These frameworks aim to reduce the risk of green finance and increase the rate of return on green energy projects (Taghizadeh-Hesary & Yoshino, 2019).

Additionally, the study highlights the technical development of distributed ledger technologies, which offer the opportunity to increase transparency in green finance and investments. Implementing these schemes can significantly reduce the risks associated with green investments and enhance the returns on these projects, making them more attractive to
private investors. The authors conclude that by implementing these frameworks, it is possible to induce greater private participation in green finance and investments, thereby promoting sustainable economic growth and the adoption of green technologies (Taghizadeh-Hesary & Yoshino, 2019).

The study “A bibliometric analysis on green finance: Current status, development, and future directions” by Dayong Zhang, Zhiwei Zhang, and Shunsuke Managi (2019), the fifth most cited paper globally in our sample with 339 citations, provides a comprehensive review of recent advances in green finance research. Using a bibliometric approach, the paper maps the current state of knowledge, development trends, and future directions of green finance research (Zhang et al., 2019).

The analysis reveals emerging trends such as socially responsible investments, climate finance, and the development of green financial instruments like green bonds. The research highlights the need to integrate environmental considerations into traditional financial models. The study also suggests that future research should focus on defining and scoping green finance, given the lack of clear consensus among researchers. Additionally, there is a need to evaluate the impact of green finance policies in different economic and regional contexts (Zhang et al., 2019).

The five most cited papers provide a comprehensive and multifaceted view of green finance research, underscoring the importance of green policies and investments for promoting sustainable development. They illustrate how green finance can mitigate financing constraints, stimulate innovation and economic efficiency, and integrate environmental considerations into traditional financial models. Furthermore, the studies emphasize the need for region-specific policy approaches to maximize the benefits of green finance.

These papers establish a solid foundation for future research and policies, offering valuable insights for academics, policymakers, and professionals interested in promoting sustainable economic growth and the adoption of green technologies.

To further deepen the understanding of the evolution and intellectual structure of the field of green finance, the next part of our analysis will use the clustering by coupling technique. This approach will identify and map the main clusters of related scientific documents, revealing how different research areas are interconnected and evolving over time. Through this analysis, it will be possible to identify the key themes, authors, and institutions shaping the field of green finance, providing a detailed view of collaboration dynamics and emerging trends. The results are presented in Figure 2.
The clustering by coupling analysis of documents on green finance reveals the intellectual structure and interconnections within the research field. Focusing on the most cited papers grouped in Cluster 1, we observe a high Normalized Local Citation Score (NLCS), indicating their importance and influence. Key papers and authors in Cluster 1 include “LEE C-C, 2022, ENERGY ECON” with an NLCS of 501, “IRFAN M, 2022, TECHNOL FORECAST SOC CHANGE” with an NLCS of 311, and “ZHANG D, 2021, ENERGY POLICY” with an NLCS of 475. These papers explore the impact of green finance policies on sustainable economic development, emphasizing the need for robust regulatory frameworks to encourage investments in clean technologies. Lee (Lee & Lee, 2022) highlights how public policies can mobilize financial resources to support emerging green technologies. Irfan (Irfan et al., 2022) focuses on technological forecasting and social change, exploring how green finance can accelerate the adoption of sustainable technologies, underscoring the importance of targeted investments and favorable policies. Zhang (Zhang et al., 2021) investigates energy policies and their role in promoting green finance, emphasizing how public policies can mobilize financial resources for emerging green technologies.

The research in Cluster 1 reveals several important trends, including the integration of green finance and sustainable technologies, social impact forecasting, and energy policies and sustainability. The concentration of studies around integrating green finance with technological development and energy policies shows a clear research trend aimed at addressing global sustainability challenges through innovative financial solutions. The analysis of Cluster 1
reveals that research in green finance is strongly focused on integrating sustainable technologies, forecasting social impacts, and developing energy policies. These studies provide a solid foundation for future research and policies, highlighting the importance of effective regulatory frameworks and targeted investments to promote sustainable economic development. The high citation of the papers in this cluster underscores their ongoing influence and relevance in the field of green finance.

Cluster 2 is primarily centered on topics related to the regional impact of green finance, technological innovation, and the coordination between green urbanization and green finance. Key papers and authors in Cluster 2 include “Green financing as a condition for sustainable economic growth” by Semenova et al. (Semenova et al., 2020), “Does green finance support to reduce the investment sensitivity of environmental firms?” by Habib et al. (Habib et al., 2023), and “Coupling coordination and spatiotemporal dynamic evolution between green urbanization and green finance: A case study in China” by Dong et al. (Dong et al., 2021). These papers explore different aspects of green finance, from evaluating the impact of green finance on sustainable economic growth to the coordination between green urbanization and green finance.

These papers in Cluster 2 are highly cited, reflecting their importance and influence in the green finance field. The high NLCS of these papers indicates that they are widely recognized and used as a foundation for subsequent research. The concentration of studies around integrating green finance with technological development and energy policies shows a clear research trend aimed at addressing global sustainability challenges through innovative financial solutions. The analysis of Cluster 2 reveals that research in green finance is strongly focused on impact evaluation, spatial and temporal coordination, and the implementation of sustainable investment practices.

Cluster 3 is primarily focused on topics related to the relationship between green finance development and environmental sustainability, as well as technological innovation and energy policy. Key papers and authors in Cluster 3 include “Emerging Research Trends in Green Finance: A Bibliometric Overview” by Mohanty et al. (Mohanty et al., 2023), “Green finance development and environmental sustainability: A panel data Analysis” by Khan et al. (Khan et al., 2022), and “Discovering research trends and opportunities of green finance and energy policy: A data-driven scientometric Analysis” by Wang et al. (Wang et al., 2021). These papers explore different aspects of green finance, from evaluating the impact of green finance on economic development and environmental quality to the coordination between energy policies and green finance.
These papers in Cluster 3 are highly cited, reflecting their importance and influence in the green finance field. The high NLCS of these papers indicates that they are widely recognized and used as a foundation for subsequent research. The concentration of studies around integrating green finance with technological development and energy policies shows a clear research trend aimed at addressing global sustainability challenges through innovative financial solutions. The analysis of Cluster 3 reveals that research in green finance is strongly focused on the relationship between financial development and environmental sustainability, technological innovation, and energy policy.

The clustering by coupling analysis of documents on green finance revealed three main clusters, each centered on different aspects of green finance research. These three clusters provide a comprehensive view of green finance research, highlighting the importance of coordinated policies, technological innovation, and targeted investments in promoting economic and environmental sustainability.

4 CONCLUSION

This study provided a comprehensive exploratory analysis of the scientific production in green finance, utilizing bibliometric methods to map the field's evolution and intellectual structure. The descriptive analysis of the data revealed an exponential growth in green finance publications, especially from 2022 onward, reflecting the growing global awareness of the importance of financial sustainability and the urgency of addressing climate change.

The evaluation of the five most globally cited papers highlighted significant contributions that have shaped the field of green finance. These papers provided valuable insights into how green finance policies can influence technological innovation, promote environmental sustainability, and stimulate economic growth. The recognition of these works underscores the relevance and impact of green finance research in academia and public policy formulation.

The clustering by coupling technique allowed for the identification and mapping of major clusters of related scientific documents, revealing how different research areas are interconnected and evolving over time. This analysis showed that green finance research is focused on topics such as the integration of energy policies, technological development, and spatial coordination to promote sustainability. The concentration of studies in these areas indicates a clear trend toward addressing global sustainability challenges through innovative financial solutions.
The findings of this study not only highlight the growing importance of green finance in academic literature but also emphasize the need for coordinated policies and targeted investments to promote economic and environmental sustainability. International collaboration and the application of new technologies are essential for advancing research and implementing sustainable financial practices.

In conclusion, this work contributes to a deeper understanding of the evolution and emerging trends in green finance, providing a solid foundation for future research and policy development. The continued expansion and relevance of green finance demonstrate its critical role in building a sustainable and environmentally conscious economic future. The findings of this study can guide researchers, policymakers, and professionals interested in promoting financial solutions that support global sustainable development.

REFERENCES


An Exploratory Analysis Of Green Finance


Sachs, J. D., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2019). Why is green finance important?


