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Review

The Evolution of Green Taxation Research: A Bibliometric Analysis of Knowledge Structures, Thematic Trends, and Emerging Research Frontiers

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Abstract

Green taxation has evolved from a fiscal instrument for correcting environmental externalities into a strategic policy mechanism for promoting sustainable development and supporting the transition toward low-carbon economies. As research on this topic has expanded, the literature has become increasingly fragmented, characterized by diverse research streams, limited interdisciplinary integration, and an incomplete understanding of its intellectual and conceptual development. This study provides a comprehensive bibliometric analysis of green taxation research to examine its scientific evolution, map its knowledge structure, and identify emerging research frontiers and knowledge gaps. Conceptually, the literature on green taxation extends beyond conventional Pigouvian foundations to encompass ecological, institutional, and broader heterodox perspectives. The analysis is based on 2952 publications indexed in the Scopus database between 1990 and 2025. Biblioshiny (Bibliometrix in R) and VOSviewer were employed to examine publication trends, co-citation networks, keyword co-occurrence, and international scientific collaboration. The results reveal sustained growth in scientific production, reaching its highest level in 2024, and a heterogeneous research landscape structured around major themes, including the double dividend, innovation for sustainable development, environmental policy related to pollution and welfare, circular economy and sustainability transitions, as well as green investment linked to technological change. Scientific output remains highly concentrated in a limited number of countries, with China emerging as the leading contributor, while international collaboration remains comparatively limited. The analysis also highlights significant geographical disparities, particularly the underrepresentation of Africa and the MENA region, and reveals that the field remains only partially integrated despite its rapid expansion. These findings provide an integrated understanding of the evolution of green taxation research and identify key priorities for future empirical and comparative studies to support more effective and inclusive environmental fiscal policies.

Keywords: green taxation; environmental taxation; bibliometric analysis; Scopus; Biblioshiny; VOSviewer

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1. Introduction

Environmental degradation and climate change have emerged as some of the major challenges of the twenty-first century, threatening ecosystem integrity, economic resilience, and societal well-being. Population growth, industrial expansion, and rising energy demand continue to exert increasing pressure on natural resources while accelerating greenhouse gas emissions (Khatun, 2009). Among these emissions, carbon dioxide (CO_2) remains the primary anthropogenic greenhouse gas responsible for global warming and its far-reaching environmental, economic, and social consequences (Lin & Jia, 2018). In response to these challenges, governments and international organizations have progressively strengthened the implementation of public policy instruments aimed at reducing emissions and accelerating the transition toward sustainable, low-carbon development (H. Li & Peng, 2020). Within this context, green taxation has emerged as a key pillar of environmental fiscal policy, relying on environmental taxes designed to encourage more sustainable patterns of production and consumption while contributing to climate change mitigation objectives (Bashir et al., 2020; Soufiene et al., 2025). Despite its growing importance in both public policy frameworks and academic debates, questions remain regarding its conceptual and theoretical foundations as well as its practical effectiveness, highlighting the complex and multidimensional nature of environmental fiscal policy.

Green taxation refers to the set of fiscal levies introduced to protect the natural environment (Mpofu, 2022). However, the literature provides no universally accepted definition of the concept, as its interpretation varies across institutional contexts and analytical perspectives (Mpofu, 2022). The terms green taxation and environmental taxation are frequently used interchangeably, alongside other expressions such as climate taxes, ecological taxes, and eco-taxes (Mpofu, 2022). This category includes, among others, taxes on carbon, energy, pollution, transport, and natural resources, whose design and implementation vary according to the public policy objectives pursued and the institutional contexts in which they operate (Mpofu, 2022).

This terminological diversity reflects the multidisciplinary nature of green taxation. Economic perspectives primarily emphasize the use of taxation to encourage more environmentally responsible behavior, whereas legal and institutional perspectives highlight the importance of regulatory frameworks and the implementation of the polluter-pays principle (Borrego & Carreira, 2020). Environmental and sustainability-oriented perspectives, in turn, examine its contribution to reducing pollutant emissions and supporting more sustainable development pathways (Lai et al., 2020). Green taxation therefore encompasses economic, environmental, legal, institutional, and political dimensions that have often been examined separately, potentially limiting the development of an integrated understanding of the research field.

The theoretical foundations of green taxation have progressively expanded beyond the traditional Pigouvian framework as environmental policy has increasingly been understood as extending beyond the correction of market failures alone. Within environmental economics, environmental taxation has traditionally been justified as a market-based instrument for internalizing negative externalities by incorporating environmental costs into market prices (Pigou, 1920; Borrego & Carreira, 2020). Although this rationale remains the conventional economic foundation of environmental taxation, it no longer fully captures the diversity of theoretical perspectives employed to analyze environmental policy.

This evolution is particularly reflected in ecological economics, which challenges the neoclassical foundations of environmental policy by emphasizing the complexity of ecological systems, fundamental uncertainty, and value pluralism, while rejecting approaches that reduce environmental problems solely to price-based market mechanisms (Spash, 2013). From this perspective, Douai et al. (2012) argue that debates on environmental taxation

have been primarily structured by the interaction between neoclassical economics and ecological economics, while emphasizing that heterodox approaches remain comparatively underrepresented despite their potential to enrich the analysis of environmental policy.

Old Institutional Economics adds an institutional dimension to this theoretical broadening by emphasizing the role of institutions, culture, and evolutionary processes in shaping economic behavior (Langlois, 1989). This institutional perspective provides a transition toward the French Regulation School, which situates economic processes within historically specific institutional configurations (Boyer & Saillard, 2005). Applied to environmental policy, this perspective leads Lipietz (2002) to emphasize the role of political authority and institutional compromises in the implementation of environmental policy instruments, while Zuindeau (2007) examines the relevance of key concepts from regulation theory for analyzing the relationships between economic and environmental dynamics.

Post-Keynesian economics further broadens this theoretical discussion by emphasizing that economic decisions are made under conditions of fundamental uncertainty rather than fully calculable risk (Davidson, 1991). In the context of environmental policy, this distinction raises the question of the extent to which future environmental damages can be regarded as fully quantifiable risks and, consequently, the degree of precision that can be associated with determining optimal environmental tax rates. Beyond uncertainty, environmental policy outcomes must also be considered in relation to broader macroeconomic processes, particularly those associated with finance, investment, technological change, and distributional dynamics (Pollitt, 2019). Dafermos and Nikolaidi (2019), meanwhile, examine the environmental and macroeconomic effects of green fiscal policies and show that a policy mix combining carbon taxation, green subsidies, and green public investment can produce better outcomes than implementing these policies in isolation.

Complementing these perspectives, Söderholm (2020) emphasizes the challenges associated with sustainable technological change and with the development and adoption of the technologies required for the transition toward a green economy. From a broader political-economy perspective, Kus and Jackson (2025) argue that addressing climate change requires reconsidering fundamental concepts concerning the state, markets, economic growth, and distributional conflicts, while conceptualizing the state as an actor actively involved in shaping green transitions. Together, these contributions broaden the discussion beyond environmental taxation considered in isolation by situating environmental policy within wider processes of technological and institutional transformation.

Taken as a whole, these perspectives broaden the understanding of green taxation beyond the conventional correction of environmental externalities by drawing attention to ecological constraints, institutional configurations, fundamental uncertainty, technological change, distributional dynamics, and the broader policy environment within which environmental taxes are implemented. Green taxation can therefore be understood not only through its price-correction function but also in relation to the broader conditions that shape its environmental and socioeconomic outcomes.

The broadening of the theoretical foundations of green taxation has been accompanied by substantial diversification in empirical research. Existing studies show that the effects of environmental taxation depend not only on the existence or level of the tax but also on its design and implementation. In particular, the use of tax revenues and revenue-recycling mechanisms influences the distributional effects of reforms, while accompanying or compensatory measures can mitigate their socioeconomic consequences, although these design choices may involve trade-offs with environmental effectiveness objectives (Metcalf, 1998; Wang et al., 2016). Distributional consequences therefore constitute an important dimension in assessing the sustainability of environmental tax policies, alongside their environmental effectiveness.

This growing body of research is also characterized by considerable methodological and contextual heterogeneity. Studies examine different forms of environmental taxation and employ diverse indicators, databases, analytical approaches, and geographical settings, thereby limiting the systematic comparability of their findings. Although this diversity has deepened the understanding of green taxation, it has also contributed to the fragmentation of the research field, making it more difficult to identify relationships among its different research streams and to trace their evolution over time.

The development trajectories of environmental taxation display substantial disparities across national contexts. Developed economies have progressively consolidated their environmental taxation systems, while developing countries have undertaken similar initiatives through differentiated approaches reflecting their levels of development and the progress of their fiscal reforms (Tan et al., 2022). However, these different contexts have not received equivalent attention in the literature. Environmental taxation remains comparatively understudied in Africa, despite the significant environmental and developmental challenges facing the region (Mpofu, 2022). This uneven geographical coverage limits the understanding of green taxation across diverse economic and institutional contexts, thereby highlighting a persistent gap in the existing literature.

In response to this fragmentation, and consistent with recent methodological developments in the literature review, bibliometric analysis has emerged as a robust framework for systematically examining large bodies of scientific literature (Jalal et al., 2025). It provides a quantitative, transparent, and reproducible approach for evaluating publication trends, identifying influential contributors, and examining the intellectual, conceptual, and social structure of a research field through citation analysis, co-authorship mapping, and keyword co-occurrence networks, while also enabling the identification of emerging research themes (Chipunza & Ntsalaze, 2025; Öztürk et al., 2024; Donthu et al., 2021; Khatib et al., 2022). Compared with traditional narrative reviews, bibliometric analysis offers a more systematic and data-driven overview of scientific development, thereby reducing subjectivity and strengthening analytical rigor (Öztürk et al., 2024).

The bibliometric literature on green taxation has expanded considerably over the past decade, reflecting growing scholarly interest in the field. However, existing studies differ substantially in their temporal coverage, database selection, search strategies, and science-mapping techniques, resulting in complementary yet partial representations of its development. While these studies have provided valuable insights into different dimensions of the literature, including scientific performance, collaboration structures, intellectual foundations, and thematic dynamics, their integration within a common analytical framework remains limited. Consequently, it remains difficult to assess collectively how these different dimensions have contributed to structuring and shaping the evolution of green taxation research. Against this background, Table 1 provides a critical comparison of the principal bibliometric studies, highlighting their respective contributions and the remaining limitations that the present research seeks to address.

Building on this comparative assessment, the present study adopts a unified science-mapping framework designed to provide a multidimensional understanding of the development of green taxation research. By combining citation analysis, author-, reference-, and source-level co-citation, co-authorship analysis, and keyword co-occurrence, the study examines the field from complementary intellectual, social, and thematic perspectives. Particular attention is devoted to the systematic interpretation of thematic clusters and their interrelationships, allowing the analysis to move beyond their descriptive identification toward a clearer understanding of how major research streams are connected and how emerging directions are shaping the field.

Table 1. Comparative overview of bibliometric studies on green taxation research.

Reference	Period	Corpus & Database	Science-Mapping Methods	Scientific Contribution	Distinctive Feature/ Remaining Gap
(Zhang et al., 2016)	1989–2014	1224 WoS	Performance analysis; collaboration; citation; keyword co-occurrence	Mapped the development and major research patterns of carbon-taxation research	Restricted to carbon taxation; no broader green-taxation perspective
(Bashir et al., 2021)	1999–2019	476 WoS	Performance analysis; collaboration; co-citation; thematic analysis	Identified major knowledge domains and thematic organization of environmental taxation	Did not integrate the intellectual, social and conceptual dimensions within a unified framework
(Nobanee & Ullah, 2023)	2015–2022	1502 Scopus	Descriptive analysis; citation; author co-citation; co-authorship; keyword co-occurrence	Mapped the contemporary research landscape of green taxation	Short time span limited assessment of long-term evolution
(Patel & Jhalani, 2024)	2001–2022	590 Scopus	Performance analysis; citation; collaboration; keyword co-occurrence	Identified publication trends, collaboration patterns, and major research hotspots	Thematic relationships were not systematically interpreted
(Apriantoro & Maulana, 2025)	1969–2023	1272 Scopus	Performance analysis; citation; conceptual structure; keyword co-occurrence	Mapped the conceptual structure of environmental taxation	Conceptual domains were mapped but not critically interpreted
(Mubarok, 2026)	1990–2025	398 Scopus	Performance analysis; thematic evolution; conceptual structure	Traced the thematic and conceptual evolution of green-taxation research	Emphasized thematic and conceptual developments, with limited attention to intellectual and social structures
Present study	1990–2025	2952 Scopus	Scientific production; citation; author, reference & source co-citation; co-authorship analysis; keyword co-occurrence	Provides an integrated reconstruction of the intellectual, social and thematic architecture of green-taxation research	Integrates three-level co-citation, collaboration and systematic thematic interpretation within a unified science-mapping framework to provide a multidimensional understanding of the field's evolution

Against this background, the study addresses the following research questions:

RQ1: How has the green taxation literature evolved in terms of scientific production, collaboration patterns, and influential research contributions?

RQ2: What are the intellectual foundations and knowledge structure of green taxation research?

RQ3: How has the conceptual structure of green taxation research evolved, and what are the major thematic developments and emerging research directions?

The remainder of this article is organized as follows. Section 2 presents the materials and methods, including data collection procedures and bibliometric techniques. Section 3 reports the results concerning scientific production, influential research contributions, intellectual foundations, collaboration structures, and thematic developments. Section 4 discusses the main findings, their theoretical implications, the study's limitations, and directions for future research. Section 5 concludes the study.

2. Materials and Methods

2.1. Data Source and Search Methodology

Scientific data were retrieved from the Elsevier Scopus database, one of the largest and most widely used multidisciplinary databases for bibliometric research (Sweileh, 2018). Compared with Web of Science, Scopus provides broader journal coverage, indexes a larger number of publications (Falagas et al., 2008), and generally provides a higher average number of citations per article, making it particularly suitable for large-scale bibliometric analyses (Kulkarni et al., 2009).

To ensure transparency and reproducibility, a structured query was formulated using TITLE-ABS-KEY, which simultaneously searches document titles, abstracts, and keywords, to capture the main terms used to designate green taxation, including "green tax", "environmental tax*", "ecological tax*", and "eco tax*", complemented by "Pigouvian tax*" in recognition of its established theoretical grounding in this research field (Borrego & Carreira, 2020):

TITLE-ABS-KEY ("green tax*" OR "environmental tax*" OR "ecological tax*" OR "eco tax*" OR "Pigouvian tax*").

The query was performed on 1 August 2025. The Boolean operator OR was employed to include synonymous and closely related concepts used within the literature. This search strategy was intended to maximize coverage while maintaining relevance and precision in document retrieval.

2.2. Data Screening and Workflow

The inclusion criteria covered four dimensions: publication period, document type, language, and subject area. Accordingly, the analysis was restricted to journal articles published between 1990 and 2025, written in English, and classified under Environmental Science; Economics, Econometrics and Finance; Social Sciences; and Business, Management and Accounting. Records falling outside the specified period, document types other than journal articles (e.g., conference papers, book chapters, books, reviews, and editorials), non-English publications, and records classified outside the selected subject areas were excluded. No restrictions were imposed on source titles, authors, affiliations, or keywords.

A structured screening procedure was applied sequentially to the initial search results, as illustrated in Figure 1. The search initially retrieved 4655 documents. Applying the publication-period criterion excluded 26 documents published outside the 1990–2025 period, leaving 4629 records. The document-type criterion was then applied, excluding 749 records other than journal articles and reducing the dataset to 3880 publications. The language criterion subsequently excluded 168 non-English publications, leaving 3712 records. Finally, the subject-area criterion excluded 760 publications classified outside Environmental Science; Economics, Econometrics and Finance; Social Sciences; and Business,

Management and Accounting, resulting in a final corpus of 2952 publications. This final dataset was used for all subsequent bibliometric analyses.

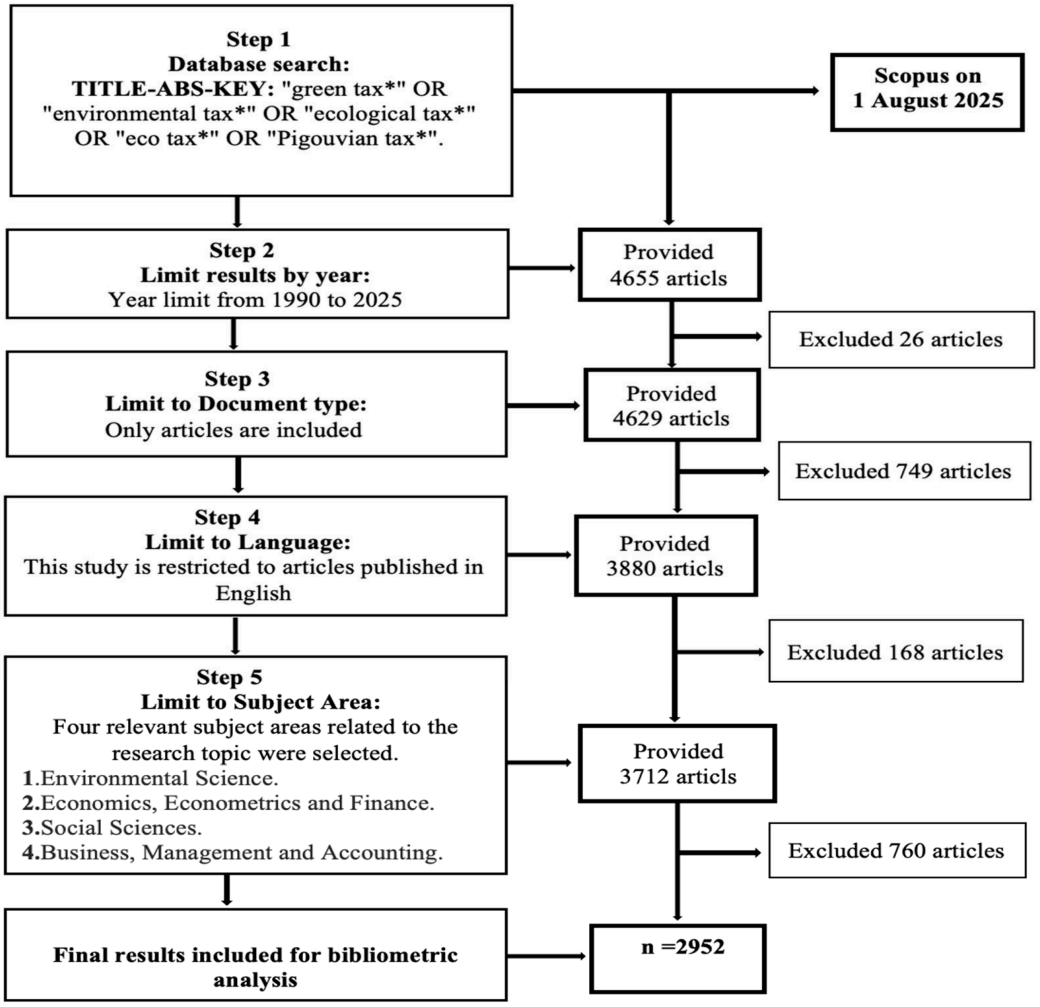


Figure 1. Research strategy flow diagram. Source: Authors' elaboration.

2.3. Bibliometric Analysis and Tools

The final dataset was analyzed using Biblioshiny (Bibliometrix version 5.1.0) in R (version 4.5.1) (Aria & Cuccurullo, 2017) and VOSviewer (version 1.6.20) (van Eck & Waltman, 2010), two complementary software tools widely employed in bibliometric research.

Biblioshiny was primarily used for descriptive and performance analyses, including annual scientific production, most relevant sources, authors, institutions, countries, citation indicators, and thematic analyses. Its statistical capabilities facilitate comprehensive science mapping and performance evaluation (Dervis, 2019).

VOSviewer was employed to construct and visualize bibliometric networks. Specifically, it was used to analyze co-authorship networks, citation relationships, co-citation structures, and keyword co-occurrence patterns (Jindal et al., 2025). The software applies the Visualization of Similarities (VOS) mapping technique and enables the identification of clusters representing related research themes and intellectual structures (van Eck & Waltman, 2008).

The analytical process followed a structured sequence. First, descriptive analyses were conducted to examine the evolution of scientific production and research performance. Second, citation analysis and author-, reference-, and source-level co-citation analyses were performed to examine the intellectual structure and identify the knowledge foundations

of green taxation research. Third, co-authorship analyses at the author and country levels were conducted to examine the social structure and patterns of scientific collaboration. Finally, keyword co-occurrence and thematic analyses were used to explore the thematic structure, its evolution, and emerging research directions within the field.

For analyses conducted using VOSviewer, the networks were constructed using the full counting method and normalized using the association-strength method. Where clustering was applicable, clusters were generated using the VOSviewer clustering algorithm with a resolution parameter of 1.00 and a minimum cluster size of one. Specific thresholds and selection criteria applied to each analysis are reported in the corresponding analytical sections.

3. Results

3.1. Evolution of Scientific Production in Green Taxation Research

As illustrated in Figure 2, research on green taxation has experienced sustained growth in scientific production between 1990 and 2025. While the period from 1990 to 2016 was characterized by relatively moderate progress, a marked acceleration in publication activity has been observed since 2017. This evolution has occurred alongside the progressive diffusion of environmental taxation frameworks across both developed and developing economies, with their specific forms varying according to countries' levels of development and the progress of their tax reforms (Tan et al., 2022). Environmental taxation has also diversified across different forms, including emission, energy, carbon, and sulphur taxes (Tan et al., 2022). Furthermore, the strengthening of international climate commitments following the Paris Agreement (United Nations Framework Convention on Climate Change, 2015), together with the expansion of carbon pricing mechanisms worldwide, has contributed to increasing attention toward green taxation as an instrument for combating climate change and supporting sustainable development objectives (H. Li & Peng, 2020).

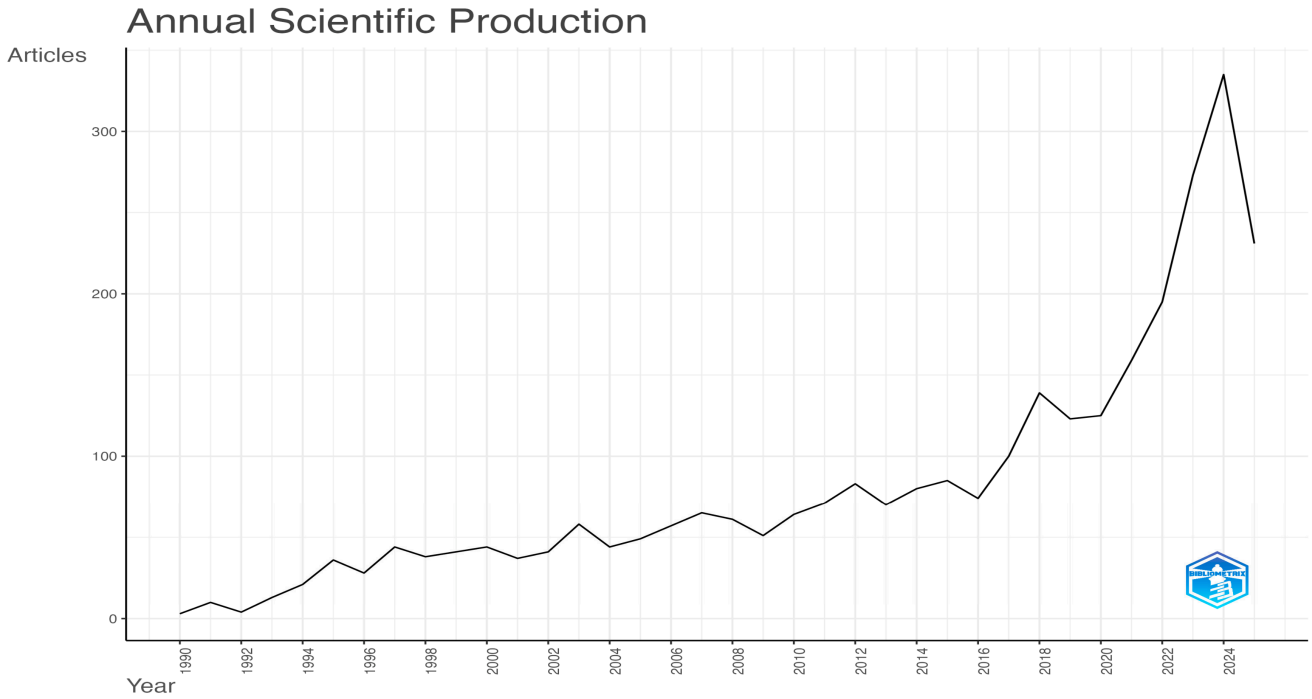


Figure 2. Annual publication trends from 1990 to 2025. Source: Author's elaboration using Scopus data collection and the Biblioshiny interface.

As a result, green taxation has progressively emerged as an increasingly structured field of research within broader debates on environmental governance, low-carbon transitions, and sustainable development. These findings are consistent with those of Patel and Jhalani (2024), who likewise reported a significant increase in environmental taxation publications after 2017. The decline observed in 2025 should, however, be interpreted with caution, as data collection was conducted on 1 August 2025 and therefore does not account for publications that may be indexed during the remaining months of the year.

3.2. Intellectual Structure of Green Taxation Research

3.2.1. Citation Analysis

Citation analysis is widely used to assess the scientific influence and visibility of publications by examining the frequency with which they are cited in subsequent studies (Kumar et al., 2020). As illustrated in Figure 3, the resulting citation network highlights the most influential publications in green taxation research. Following an assessment of alternative citation thresholds, a minimum threshold of 35 citations was retained to balance the coverage of influential publications with network interpretability, resulting in a network of 354 publications. Each node represents a publication, with its size proportional to the number of citations received. To complement the network visualization, Table 2 presents the ten most-cited publications identified using Biblioshiny, together with their total citation counts (TC) and average citations per year (TC/year).

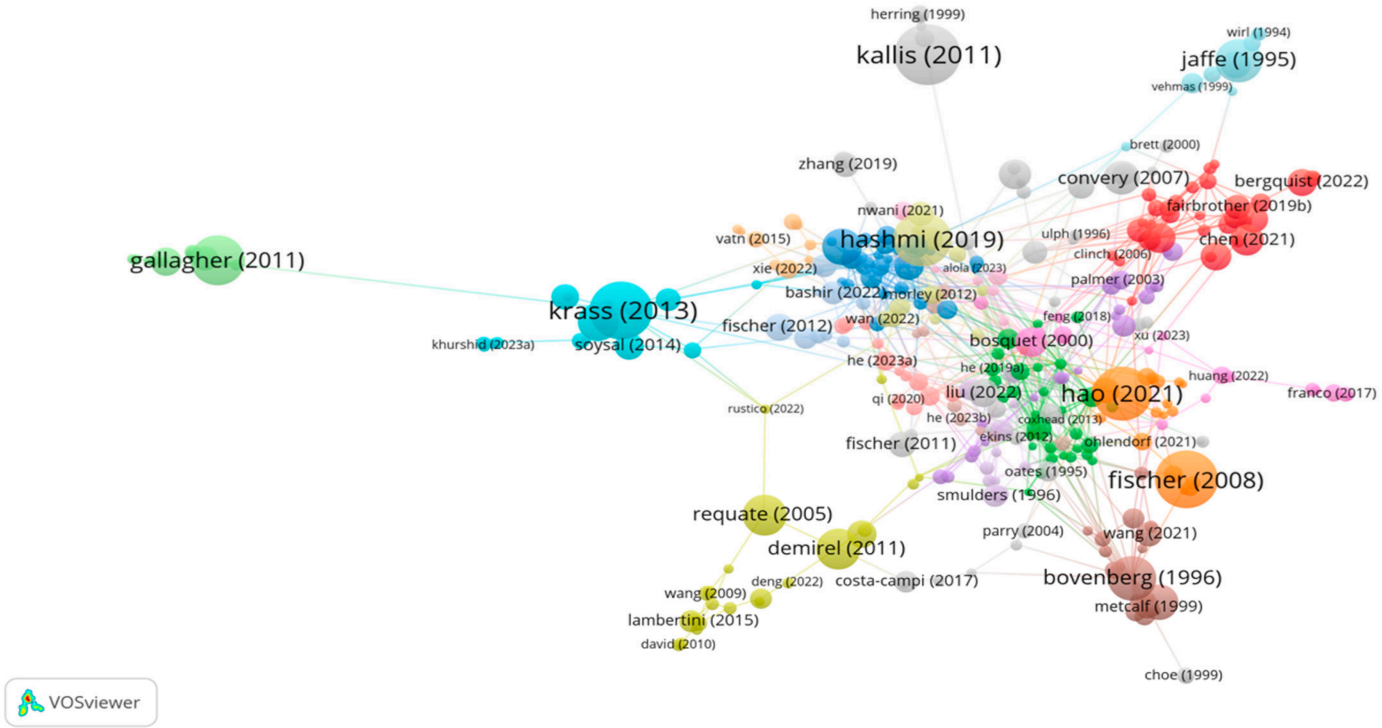


Figure 3. Citation Network of Influential Publications in Green Taxation Research Using VOSviewer.

The citation network shows that scientific influence is concentrated among a limited number of highly cited publications. Goulder (1995) records the highest cumulative citation impact, with 765 citations, followed by Kallis (2011) with 719 citations, Krass et al. (2013) with 690 citations, and Fischer and Newell (2008) with 672 citations. Their prominence reflects the influence of several established research strands within the corpus, encompassing environmental taxation and the double-dividend debate, degrowth, and the relationship between environmental taxation and green technology choices, as well as environmental and technological policies for climate change mitigation. Rather than converging around a

single theoretical orientation, these highly cited contributions indicate that the development of green taxation research has drawn upon distinct yet interconnected environmental, economic, and technological perspectives.

Table 2. Top 10 cited articles, sourced from Biblioshiny (Bibliometrix Package for R).

R	Authors	Title	Journal	TC	TC/Year
1	(Goulder, 1995)	Environmental Taxation and the Double Dividend: A Reader's Guide	*International tax and public finance*	765	24.68
2	(Kallis, 2011)	In defence of degrowth	*Ecological Economics*	719	47.93
3	(Krass et al., 2013)	Environmental taxes and the choice of green technology	*Production and Operations Management*	690	53.08
4	(Fischer & Newell, 2008)	Environmental and technology policies for climate mitigation	*Journal of Environmental Economics and Management*	672	37.33
5	(Hashmi & Alam, 2019)	Dynamic relationship among environmental regulation, innovation, CO_2 emissions, population, and economic growth in OECD countries: A panel investigation	*Journal of Cleaner Production*	610	87.14
6	(Hao et al., 2021)	Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is?	*Science of the Total Environment*	608	121.60
7	(Gallagher & Muehlegger, 2011)	Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology	*Journal of Environmental Economics and Management*	538	35.87
8	(Gössling et al., 2005)	The eco-efficiency of tourism	*Ecological Economics*	482	22.95
9	(Bovenberg & Goulder, 1996)	American Economic Association Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses	*The American Economic Review*	451	15.03
10	(Jaffe & Stavins, 1995)	Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion	*Journal of Environmental Economics and Management*	437	13.70

R = Rank; TC = Total Citations; TC/Year = Total Citations per Year.

The citation structure also highlights the growing visibility of more recent contributions, particularly Hashmi and Alam (2019), with 610 citations, and Hao et al. (2021), with 608 citations. Their prominence reflects growing scholarly interest in the interactions between environmental regulation, innovation, CO_2 emissions, and economic growth, as well as between environmental taxation, renewable energy, human capital, and green growth. This development becomes particularly apparent when citation impact is considered on an annual basis: Hao et al. (2021) records the highest citation rate among the ten most-cited publications, with 121.60 citations per year, followed by Hashmi and Alam (2019) with 87.14, compared with 24.68 for Goulder (1995). Thus, while earlier contributions retain substantial cumulative influence, more recent studies are gaining scholarly visibility at a comparatively faster rate, reflecting the expanding scope of the literature toward more diverse environmental and sustainability-related issues.

3.2.2. Co-Citation Analysis

Co-citation refers to the frequency with which two documents or authors are cited together in subsequent publications (Small, 1973; Tunger & Eulerich, 2018). A high co-citation frequency suggests an intellectual or thematic proximity between publications, making this method a valuable tool for identifying conceptual similarities among studies that share a common theme, theoretical framework, methodological approach, or disciplinary field (Kumar et al., 2020).

Author Co-Citation Analysis

Figure 4 presents the author co-citation network underlying the intellectual structure of green taxation research. A minimum threshold of 150 citations was retained, with 114 cited authors meeting this criterion and forming three main co-citation clusters, with an overall Total Link Strength (TLS) of 423,589. This threshold was selected to capture the most recurrent intellectual influences while preserving network interpretability; lower thresholds produced increasingly dense networks, whereas higher thresholds resulted in a more restrictive representation of the cited-author structure.

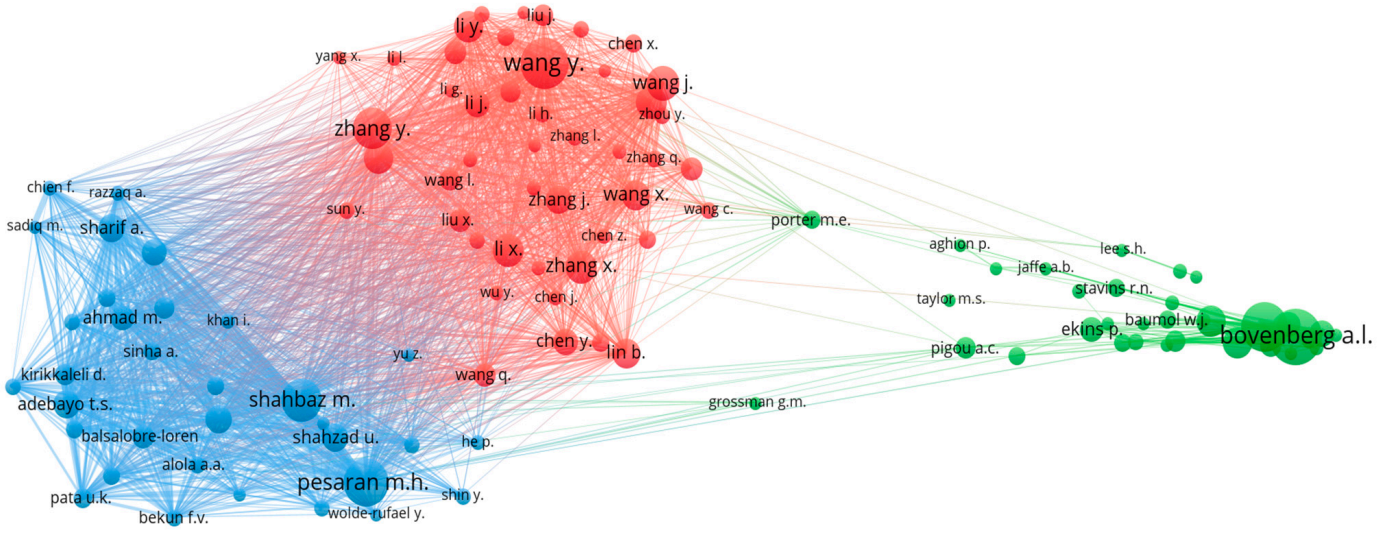


Figure 4. Author co-citation network in green taxation research using VOSviewer.

The red cluster, the largest and most densely connected component of the network, is dominated by Wang Y., with 705 citations (C) and a Total Link Strength (TLS) of 20,959, followed by Zhang Y. (C = 549; TLS = 16,899), Wang J. (C = 445; TLS = 11,911), Li X. (C = 440; TLS = 13,412), and Zhang X. (C = 425; TLS = 12,939). Their citation and connectivity levels indicate a substantial presence within the co-citation network. No systematic manual standardization or disambiguation was applied to abbreviated author labels when individual identities could not be reliably established from the cited reference records. Accordingly, ambiguous labels were retained in their original form and interpreted cautiously, without assigning specific research orientations where individual identities could not be reliably established.

The blue cluster reflects the interplay between methodological and empirical dimensions, as evidenced by Pesaran M.H. (C = 657; TLS = 22,673), Shahbaz M. (C = 574; TLS = 22,188), and Ozturk I. (C = 365; TLS = 15,879). Their co-citation relationships connect advances in panel-data econometrics with a broader empirical literature examining environmental taxation in relation to energy consumption, carbon emissions, economic activity, technological development, and environmental sustainability. Rather than representing a research stream exclusively devoted to green taxation, this configuration illustrates how the

field draws on econometric approaches alongside broader perspectives from environmental and energy economics.

The green cluster is more directly associated with the theoretical and public-finance foundations of environmental taxation. Bovenberg A.L. (C = 777; TLS = 9204) occupies a prominent position, with the underlying literature addressing environmental taxation, environmental tax reform, the double-dividend debate, and their implications for employment, welfare, and distribution. This component thus establishes a more direct connection with tax-specific theoretical debates, complementing the broader methodological and empirical influences identified elsewhere in the network.

Overall, the author co-citation network identifies the principal scholarly communities underlying the intellectual structure of green taxation research and highlights the theoretical, methodological, and empirical influences that have contributed to its development.

Reference Co-Citation Analysis

The reference co-citation network of the green taxation literature is presented in Figure 5. Applying a minimum threshold of 15 citations resulted in the inclusion of 67 references, allowing the analysis to focus on sufficiently recurrent works to identify the principal components of the intellectual structure while maintaining adequate coverage of the corpus diversity. The network comprises 665 links, with an overall Total Link Strength (TLS) of 1317.

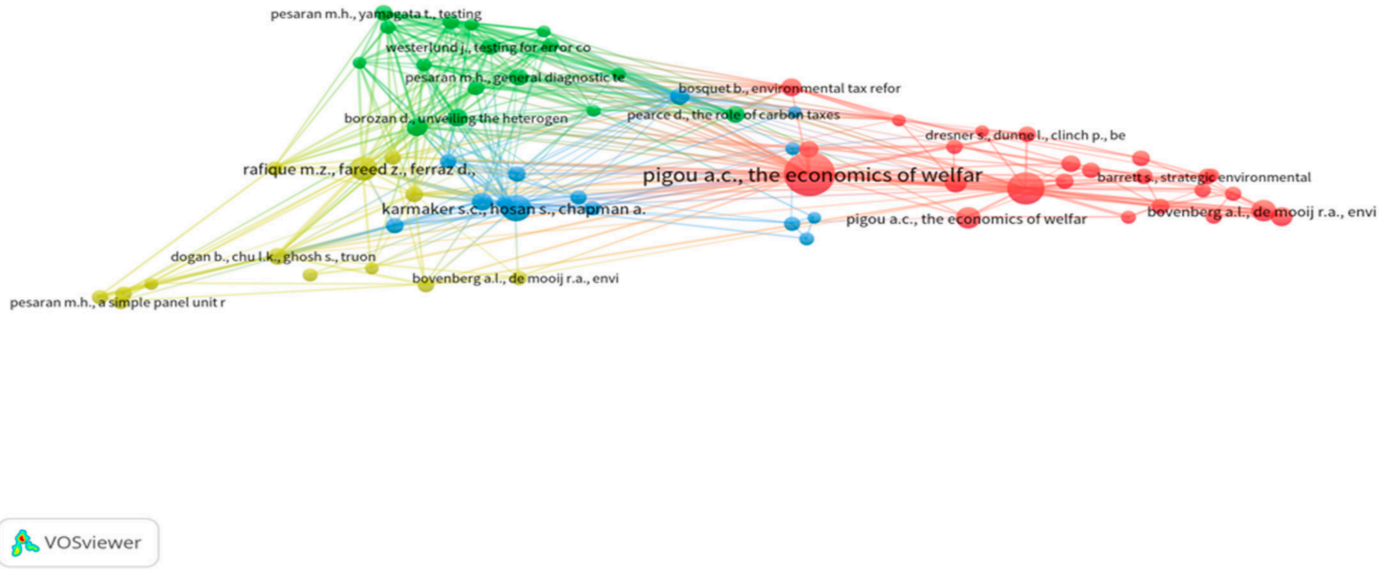


Figure 5. Reference co-citation network in green taxation research using VOSviewer.

The red cluster is primarily structured around Pigou (1920), The Economics of Welfare, reflecting the Pigouvian tradition of corrective taxation and externality internalization as one of the theoretical foundations informing the study of environmental taxation. The green cluster is organized notably around Borozan (2019), Unveiling the Heterogeneous Effect of Energy Taxes and Income on Residential Energy Consumption, and represents an empirical strand concerned with the relationship between energy taxation and household energy consumption. The blue cluster is notably associated with Karmaker et al. (2021), The Role of Environmental Taxes on Technological Innovation, highlighting a research orientation linking environmental fiscal instruments to technological innovation dynamics.

Finally, the yellow cluster includes Rafique et al. (2022), Exploring the Heterogeneous Impacts of Environmental Taxes on Environmental Footprints: An Empirical Assessment

from Developed Economies, associating this component of the network with the assessment of the environmental effects of taxation.

Taken together, these clusters reveal a differentiated intellectual structure that connects the theoretical tradition of externality correction with empirical strands addressing energy consumption, technological innovation, and environmental outcomes. They should, however, be interpreted as complementary sets of co-cited references rather than as successive stages in the evolution of the field, as the observed structure primarily reflects intellectual proximities among the works cited within the literature.

Source Co-Citation Analysis

Figure 6 presents the source co-citation network within the field. A minimum threshold of five citations was retained to ensure sufficiently broad coverage of the journal-based intellectual structure without excessively increasing network density or compromising the readability of the co-citation map. Applying this threshold resulted in 1000 journals connected through 99,853 links, with an overall Total Link Strength (TLS) of 1,295,139 and identified seven major clusters.

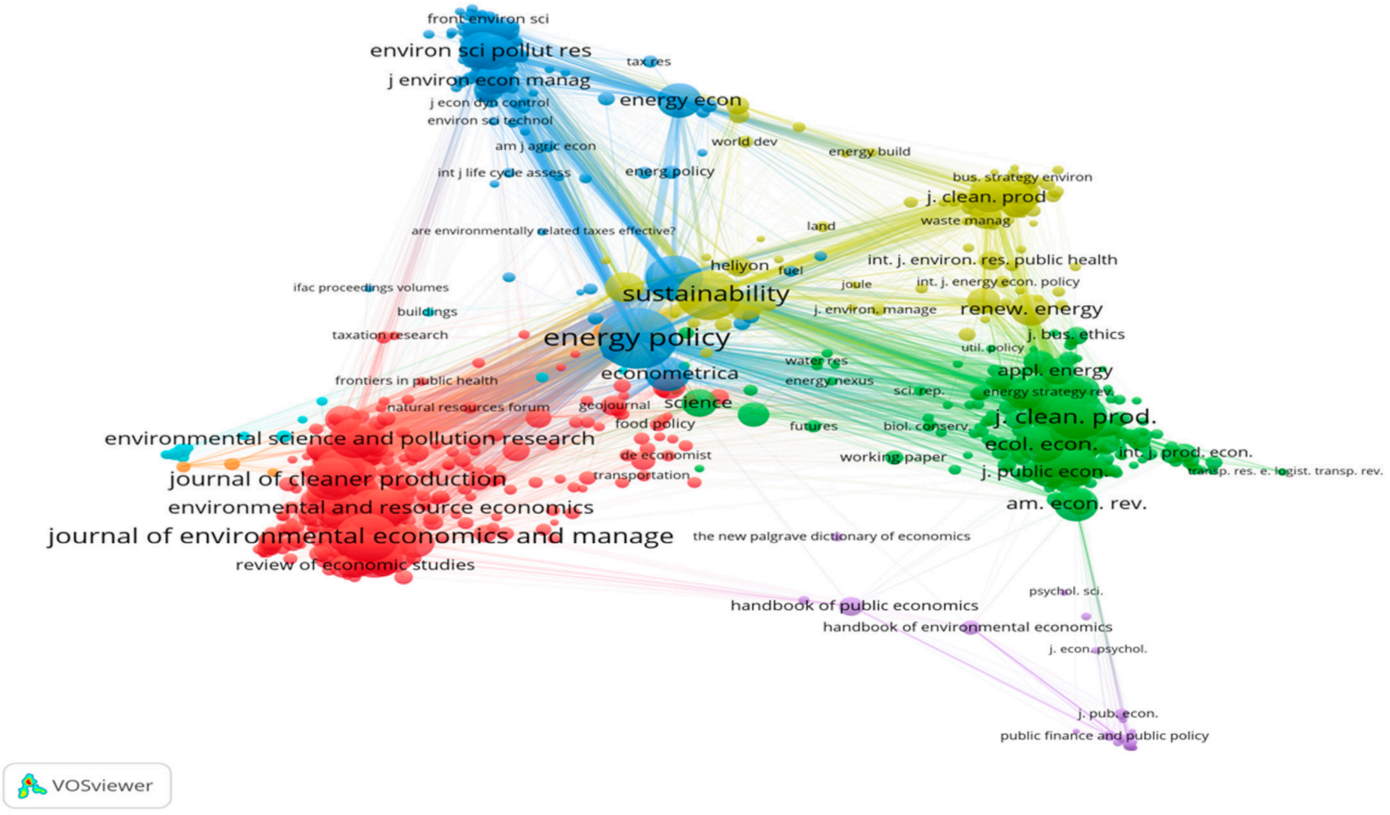


Figure 6. Source co-citation network in green taxation research using VOSviewer.

Several journals occupy prominent positions within the co-citation network, notably *Energy Policy* (TC = 2590; TLS = 91,141), Journal of Cleaner Production (TC = 2554; TLS = 51,764), Journal of Environmental Economics and Management (TC = 2284; TLS = 33,999), Ecological Economics (TC = 1866; TLS = 25,705), Environmental Science and Pollution Research (TC = 1801; TLS = 33,253), Energy Economics (TC = 1459; TLS = 27,154), and Sustainability (TC = 1415; TLS = 60,521). Their citation and connectivity profiles show that the principal nodes of the network are associated with journals in environmental economics, energy policy, and sustainability studies.

The cluster configuration highlights the thematic and disciplinary breadth of the field, while co-citation relationships among journals from different research domains reveal the convergence of multiple research traditions in shaping the intellectual foundations of green taxation.

3.3. Social Structure of Green Taxation Research

Co-authorship analysis examines the social structure of a research field by highlighting collaborative relationships among authors and countries (Acedo et al., 2006). As scientific theories and research methodologies have become increasingly complex, collaborative research has expanded considerably (Acedo et al., 2006). According to Hassan et al. (2020), co-authorship enhances scientific productivity and facilitates the generation of new knowledge. Moreover, publications involving larger research teams tend to receive more citations, suggesting a positive association between collaboration intensity and scientific impact (Tahamtan et al., 2016).

3.3.1. Author Co-Authorship Analysis

The author co-authorship network presented in Figure 7 was constructed by applying a minimum threshold of three publications per author, thereby focusing the analysis on contributors with sufficiently recurrent publication activity to characterize the main patterns of collaboration. This criterion retained 29 authors, distributed across seven clusters and connected through 39 links, with an overall Total Link Strength (TLS) of 52.

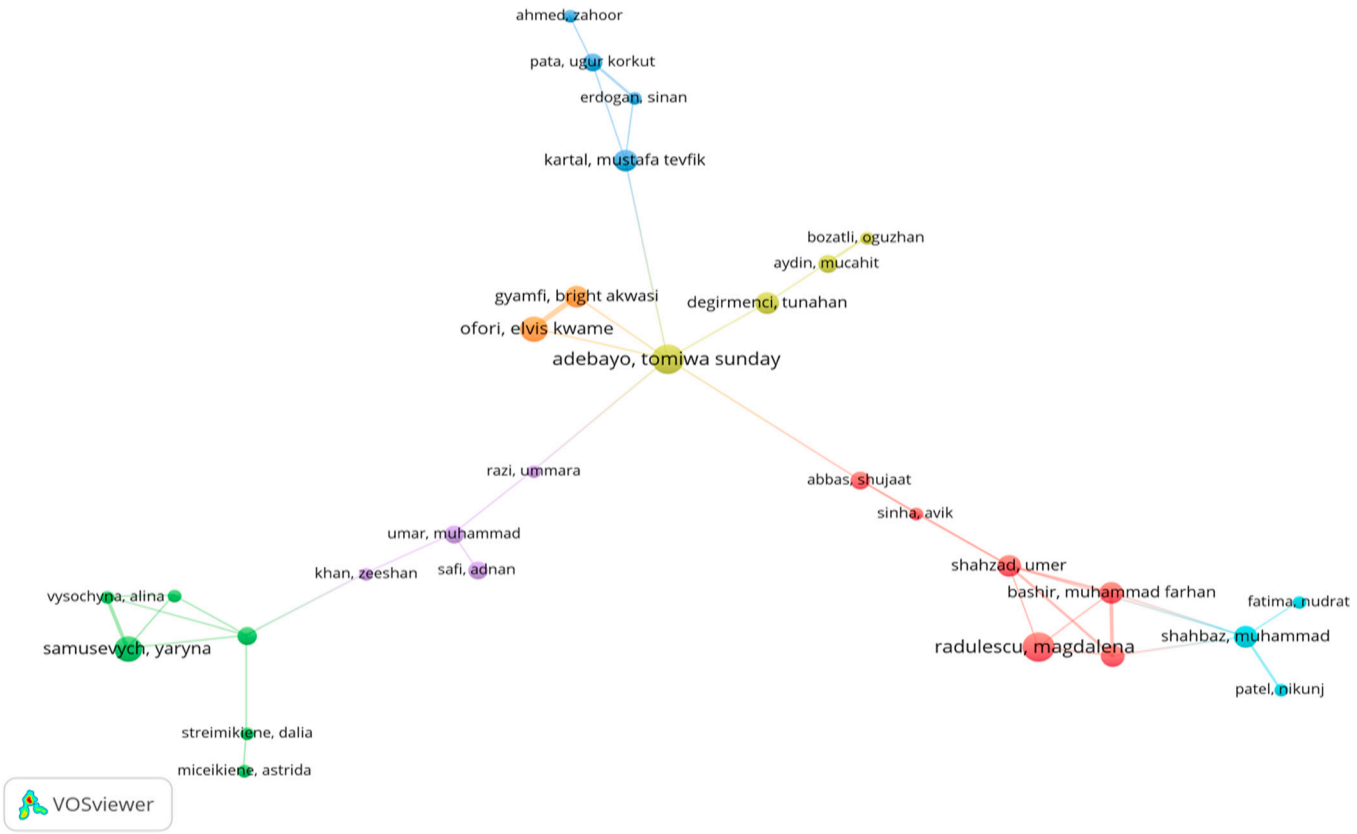


Figure 7. Author Co-authorship Network in green taxation research using VOSviewer.

The network structure reveals a relatively fragmented pattern of collaboration, characterized by several small author communities and limited interconnection among their members. Among the most highly connected authors, Adebayo Tomiwa Sunday records 6 links and a TLS of 6, Shahbaz Muhammad 5 links and a TLS of 6, and Umar Muhammad

3 links and a TLS of 3. These indicators show that Adebayo Tomiwa Sunday exhibits the broadest connectivity among these authors, while his overall link strength is identical to that of Shahbaz Muhammad despite having a larger number of connections.

This pattern indicates that the breadth of collaboration and its overall strength are not necessarily distributed proportionally among the principal contributors.

At the network level, the limited interconnection among clusters indicates that co-authorship relationships remain primarily concentrated within distinct author communities, with fewer connections across different groups. The observed structure therefore points to a relatively fragmented collaboration network rather than a highly interconnected system of co-authorship across the field.

3.3.2. Country Co-Authorship Analysis

The country co-authorship network presented in Figure 8 was constructed by applying a minimum threshold of five documents per country. This threshold was selected to focus the analysis on countries contributing recurrently to green taxation research while maintaining sufficiently broad coverage of the international collaboration network. A total of 68 countries met this criterion, forming seven clusters connected through 579 links, with an overall Total Link Strength (TLS) of 1546.

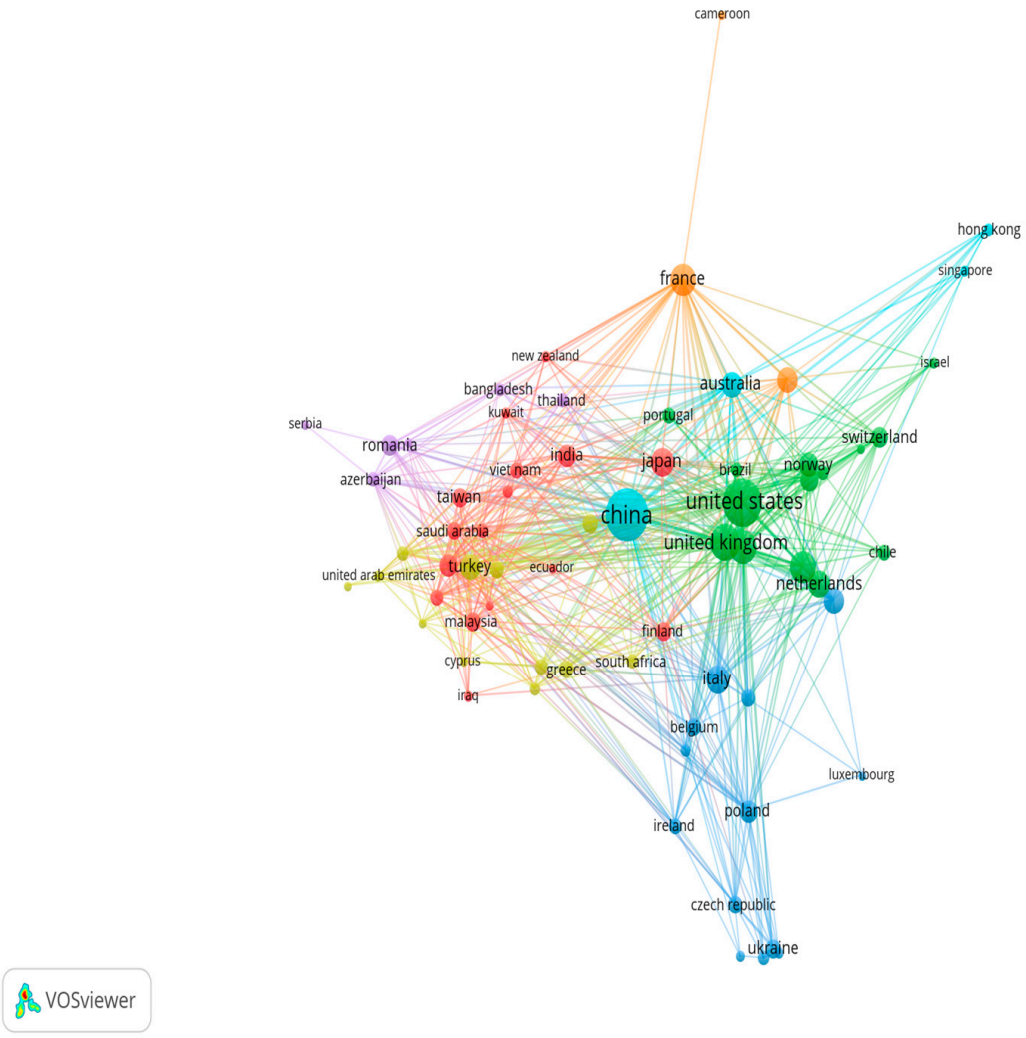


Figure 8. Country Co-authorship Network in green taxation research using VOSviewer.

The resulting structure reveals an uneven distribution of the intensity of international collaboration. China records the highest TLS (394; 601 documents), followed by the United States (TLS = 279; 464 documents) and the United Kingdom (TLS = 200; 247 documents). Germany (TLS = 134; 192 documents), France (TLS = 124; 157 documents), Italy (TLS = 92; 125 documents), Australia (TLS = 84; 93 documents), Spain (TLS = 66; 161 documents), Canada (TLS = 64; 91 documents), and Japan (TLS = 44; 129 documents) complete the group of countries exhibiting the highest levels of collaborative connectivity.

Figure 9 extends this analysis by distinguishing between Single Country Publications (SCP) and Multiple Country Publications (MCP). SCP accounts for 72.9% of publications in China, 74.0% in the United States, and 70.8% in the United Kingdom, indicating that the scientific output of these three leading contributors is predominantly produced at the national level. In contrast, Poland (MCP = 37.9%), Canada (37.5%), and Turkey (37.2%) exhibit relatively higher shares of internationally co-authored publications despite their lower publication volumes.

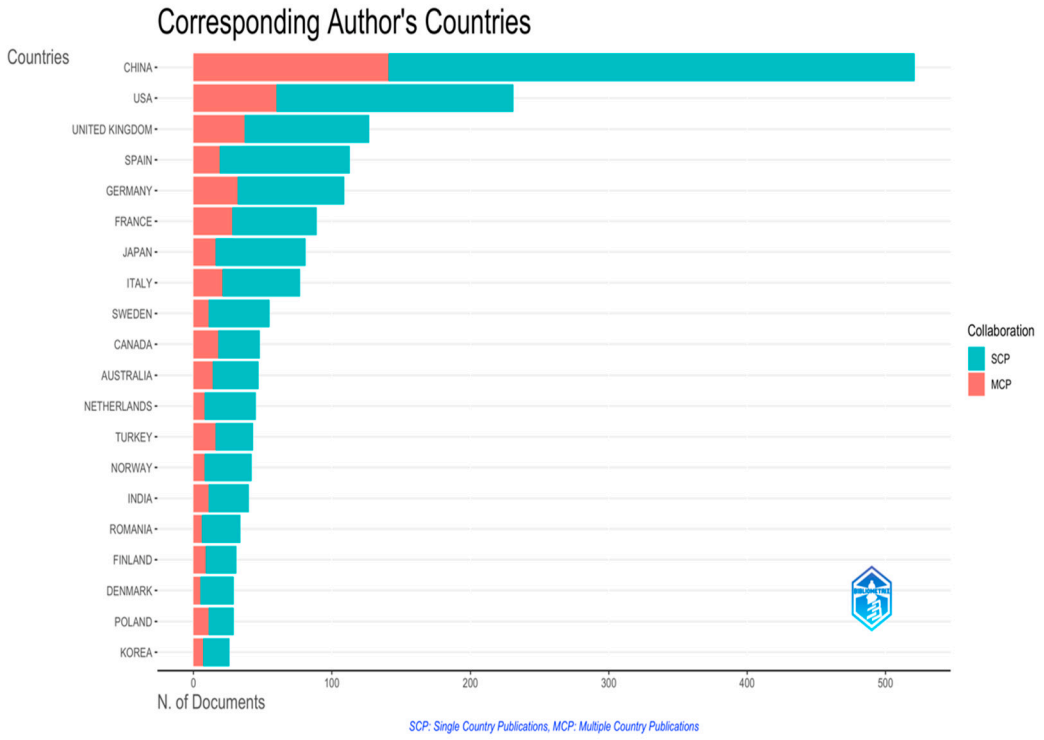


Figure 9. Leading Publishing Countries by SCP and MCP. Source: Biblioshiny (Bibliometrix Package of R).

Overall, these indicators reveal a distinction between scientific productivity, collaborative link strength, and the relative degree of internationalization, with high publication output or strong network connectivity not necessarily corresponding to a higher proportion of internationally co-authored publications.

3.4. Thematic Structure of Green Taxation Research

Keyword analysis provides an overview of the main themes and research trends that characterise a scientific field (Duan, 2023). In the present study, a total of 6134 author keywords were identified and analysed to examine the conceptual structure of green taxation research.

Figure 10 presents the word cloud and provides a visual overview of the most frequently occurring keywords in the field. The prominence of concepts related to environmental taxation indicates that the literature is organised around a well-defined conceptual

core rooted in environmental fiscal instruments and their economic rationale. Beyond this conceptual foundation, the diversity of recurrent keywords indicates that the research agenda has progressively expanded to encompass broader issues related to climate and environmental governance, sustainable development, energy transition, and the economic implications of environmental fiscal policies. This thematic configuration suggests that green taxation research has moved beyond its initial concern with the correction of environmental externalities and has evolved into a multidimensional field of scientific inquiry.



Figure 10. Word cloud of authors' keywords. Source: Biblioshiny (Bibliometrix Package of R).

Co-occurrence (or co-word) analysis is based on the assumption that the keywords selected by authors accurately reflect the content of scientific publications (Comerio & Strozzi, 2019). It examines the simultaneous occurrence of two or more keywords within the same publication to uncover the connections among research topics and identify patterns of thematic association within the field (Kent Baker et al., 2020).

The thematic structure of green taxation research was examined through author-keyword co-occurrence analysis. A minimum threshold of 15 occurrences per keyword was applied to retain sufficiently recurrent terms for identifying the main thematic relationships within the literature while limiting the influence of infrequently used keywords. Of the keywords identified in the dataset, 83 met this threshold, forming five clusters connected through 941 links, with an overall Total Link Strength (TLS) of 1907.

As shown in Figure 11, the co-occurrence network is organized around a strongly connected core of taxation-related concepts and their associations with environmental policy, climate change, sustainable development, regulation, innovation, and economic growth. The most frequent keywords are environmental taxes (302 occurrences), environmental tax (287), environmental taxation (158), environmental policy (121), carbon tax (89), climate change (82), sustainable development (78), environmental regulation (69), environmental tax reform (69), and economic growth (68). Their prominence indicates that the literature is structured around environmental taxation as its central conceptual domain, while its connections with policy, climate, sustainability, regulation, and economic themes reveal the broader thematic directions through which the field has developed.

The clustering structure further differentiates the network into five clusters, whose constituent keywords and occurrence frequencies are reported in Table 3. To establish a transparent correspondence between the network structure and its thematic interpretation,

each cluster was labeled according to the relative prominence and conceptual relationships of its constituent keywords, rather than on the basis of predefined thematic categories. The reported occurrence frequencies therefore provide a quantitative basis for identifying the most prominent terms within each cluster and support the subsequent interpretation of its thematic orientation.

Table 3. Thematic clusters identified in the authors' keyword co-occurrence network.

Number	Number of Items	Color	Keywords
1	27	red	Carbon pricing (16), carbon tax (89), carbon taxes (16), climate change (82), climate policy (36), computable general equilibrium (15), distributional effects (15), double dividend (61), endogenous growth (17), energy efficiency (28), energy tax (18), environmental tax reform (69), environmental taxation (158), environmental taxes and subsidies (17), externalities (55), externality (15), fiscal policy (16), general equilibrium (18), global warming (19), green tax reform (24), h23 (16), optimal taxation (29), Pigouvian tax (60), Pigouvian taxation (25), Pigouvian taxes (39).
2	19	green	Carbon emissions (32), China (50), CO_2 emissions (36), ecological footprint (23), economic growth (68), energy transition (15), environmental protection tax (39), environmental sustainability (28), environmental tax (287), environmental taxes (302), financial development (17), green finance (21), green growth (19), green innovation (47), green taxes (23), natural resources (18), OECD (16), renewable energy (65), technological innovation (21).
3	17	bleu	Emission tax (20), emissions (17), energy (23), environment (57), environmental policy (121), environmental pollution (26), environmental quality (32), green taxation (33), international trade (24), pollution (58), regulation (17), subsidies (16), tax (23), tax policy (16), taxation (48), taxes (28), welfare (20).
4	12	yellow	Circular economy (34), ecological tax reform (22), environmental protection (28), Europe (20), European Union (25), greenhouse gas emissions (18), innovation (19), panel data (17), recycling (15), sustainability (51), sustainable development (78), sustainable development goals (16).
5	8	purple	Air pollution (23), environmental protection tax law (16), environmental regulation (69), evolutionary game (15), green investment (15), green tax (44), green technology innovation (18), Porter hypothesis (16).

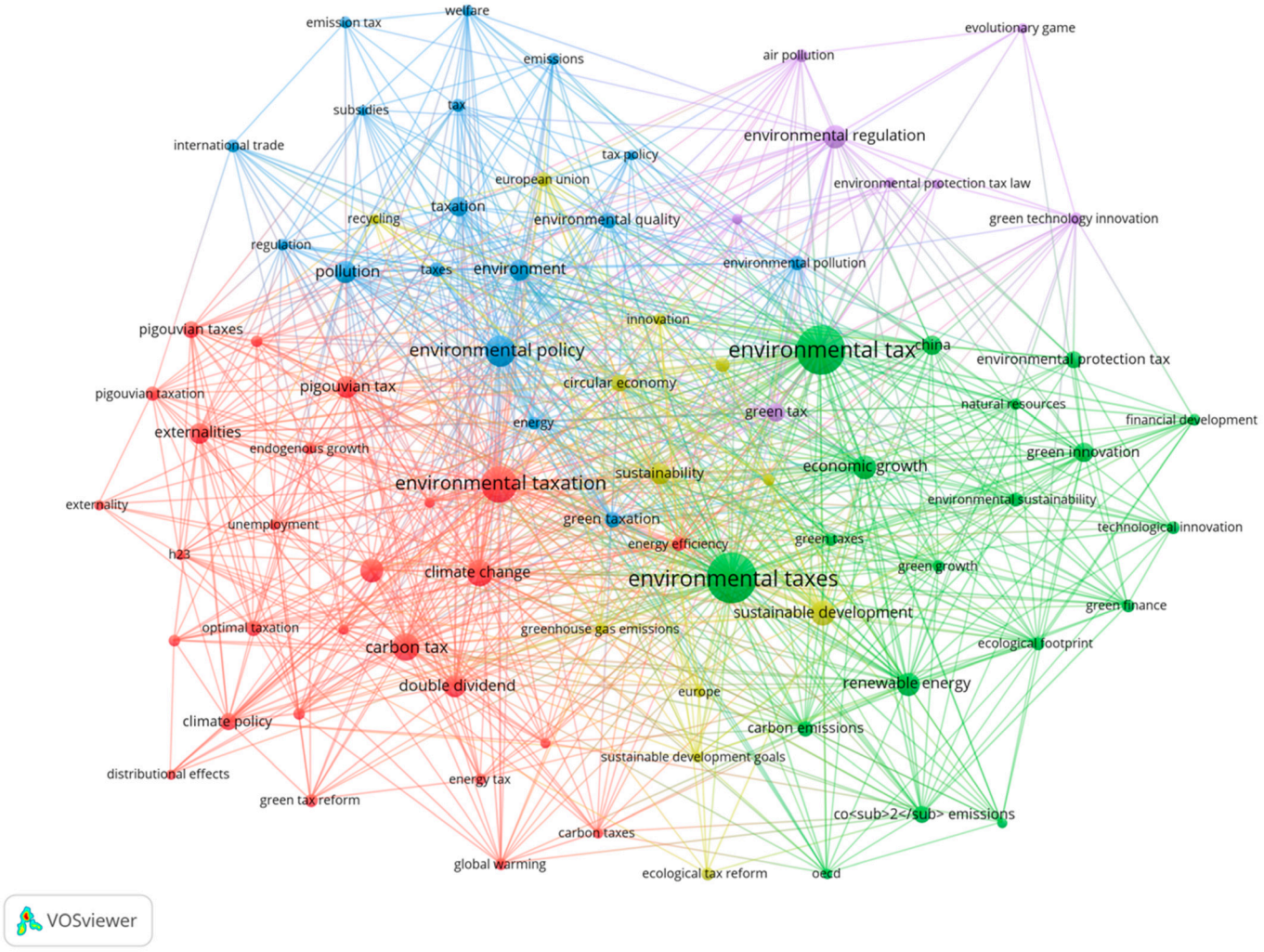


Figure 11. Co-occurrence network of authors' keywords in green taxation research using VOSviewer.

Cluster 1 (red color): Environmental Taxation and the Double Dividend

The convergence of environmental taxation, environmental tax reform, double dividend, Pigouvian tax, and externalities, together with related concepts such as optimal taxation and fiscal policy, identifies Cluster 1 as a research stream concerned with the economic foundations and fiscal design of environmental taxation.

This foundational strand of the literature focuses on the economic efficiency of environmental fiscal instruments, with particular emphasis on the double-dividend hypothesis, optimal environmental taxation, and revenue-recycling mechanisms (Goulder, 1995; De Mooij & Bovenberg, 1998; Freire-González, 2018). It examines how environmental taxes can simultaneously internalize environmental externalities, improve environmental quality, and generate economic gains through appropriate fiscal reforms, while highlighting the importance of complementary fiscal and innovation policies in enhancing policy effectiveness (De Mooij & Bovenberg, 1998; Fischer & Newell, 2008).

Taken together, this body of literature provides an analytical foundation for green taxation research by conceptualizing environmental taxation as a policy instrument capable of reconciling environmental and economic objectives.

Cluster 2 (green color): Environmental Taxation, Innovation, and Sustainable Development

The association of taxation-related terms with environmental sustainability, economic growth, renewable energy, green innovation, and technological innovation provides the empirical basis for the thematic orientation of Cluster 2.

This research stream reflects the growing attention devoted to the dynamic dimensions of environmental fiscal instruments, particularly their relationship with technological change and sustainable development trajectories. The literature examines the role of environmental fiscal instruments in fostering green innovation, enhancing resource productivity and environmental performance, and supporting the energy transition and green growth (Hashmi & Alam, 2019; Moutinho et al., 2017; G. Li & Masui, 2019).

Collectively, these contributions indicate a broader conceptualization of environmental taxation that extends beyond the correction of environmental externalities to encompass its role in the transition toward a low-carbon economy and the pursuit of environmental and economic objectives.

Cluster 3 (blue color): Environmental Tax Policy, Pollution, and Welfare

This cluster is structured around environmental policy, pollution, environmental quality, and green taxation, alongside emission tax, regulation, subsidies, welfare, and international trade. Their thematic proximity delineates a research area in which environmental taxation is examined in relation to pollution control and environmental quality, while also incorporating policy and welfare considerations.

Within this configuration, emission tax, regulation, and subsidies point to the design and interaction of environmental policy measures, whereas welfare and international trade introduce economic and cross-border dimensions. This interpretation is consistent with Wesseh and Lin (2018), who examine optimal carbon taxation in relation to welfare, environmental pollution, and energy supply, and with Matsukawa (2012), who analyzes emission taxes and subsidies in relation to environmental quality and social welfare. Kruse-Andersen and Sørensen (2022) further examine energy taxation and subsidies in the context of international trade and carbon leakage.

Overall, this thematic stream reflects an integrated policy perspective in which environmental taxation is examined within the broader framework of environmental and economic policy.

Cluster 4 (yellow color): Circular Economy and Sustainability Transitions

The co-occurrence of circular economy, ecological tax reform, recycling, sustainability, sustainable development, and sustainable development goals, together with Europe and the European Union, delineates the thematic orientation of this cluster and its distinctly European dimension.

This research stream highlights the growing convergence between environmental taxation, the circular economy, and sustainability objectives within the European context. It reflects the evolution of research toward a more integrated conception of public policy, in which environmental tax reforms are increasingly viewed as policy instruments that promote resource-use efficiency, facilitate the transition toward more circular production models, and contribute to reducing greenhouse gas emissions (Busu & Trica, 2019). Related research also emphasizes the importance of integrating environmental, economic, and social dimensions into the design of fiscal policies in order to simultaneously support environmental sustainability and economic growth (Hysa et al., 2020). The growing interest in methodological frameworks for analyzing the interactions among different circular economy indicators reflects an increasingly systemic approach to evaluating ecological transition policies (Tantau et al., 2018).

This research reflects the progressive integration of green taxation into a broader framework of sustainability-oriented transformation.

Cluster 5 (purple color): Green Investment, Technological Change, and the Porter Hypothesis

The combination of environmental regulation, green tax, green investment, green technology innovation, and the Porter hypothesis gives Cluster 5 a distinct firm-level orientation, linking environmental fiscal and regulatory measures to corporate investment and technological responses.

Particular attention is devoted to green investment decisions, technological upgrading, and competitive adaptation. Rather than focusing on the macroeconomic objectives of environmental fiscal policy, this literature examines the behavioral mechanisms through which environmental taxes influence corporate strategies and innovation incentives. The prominence of the Porter hypothesis reflects growing interest in the conditions under which well-designed environmental regulations can enhance firms' productivity and competitiveness while encouraging cleaner production processes (Qiu et al., 2018). This interpretation is further supported by empirical evidence from Chinese firms showing that environmental tax reforms can stimulate corporate environmental investment, particularly among heavily polluting firms and state-owned enterprises, thereby improving both environmental and economic performance (Liu et al., 2022; Cheng et al., 2022).

This body of research reflects a shift toward a more micro-level understanding of green taxation, with increasing attention to corporate responses.

4. Discussion

4.1. Key Findings and Knowledge Gap Analysis

The findings of this study provide an updated perspective on the evolution of green taxation research, revealing substantial growth and progressive diversification over the period examined. The marked increase in scientific output after 2017 indicates growing scholarly interest in this topic, accompanied by an expansion of the research agenda toward climate change, sustainable development, technological innovation, and ecological transition. This evolution reflects a progressive broadening of the literature beyond the traditional economic foundations of environmental taxation toward a wider range of environmental, technological, and sustainability-related concerns.

The intellectual and thematic structures nevertheless show that this diversification has not displaced the field's established foundations in environmental economics. The double-dividend hypothesis, together with concerns related to economic efficiency and fiscal design, remains central to the mapped literature. At the same time, thematic orientations have expanded toward green innovation, energy transition, the circular economy, and sustainable development. The coexistence of these orientations therefore points to an evolution through broadening rather than rupture: established economic approaches continue to structure the field, while new environmental, technological, and sustainability-related perspectives have progressively become integrated into it. This configuration highlights the increasingly multidisciplinary character of the research while suggesting scope for greater integration across these different perspectives.

A first comparatively less visible dimension concerns distributional effects. Distributional effects appear within the research stream associated with environmental taxation and the double dividend, while welfare is represented in the stream linking environmental taxation to pollution control and environmental policy. Their presence indicates that the economic and social implications of green taxation are already incorporated into the literature; however, their lower prominence in the co-occurrence network suggests that they remain less central than the main environmental and economic themes identified. This

configuration points to scope for more systematic investigation of the interactions among green taxation, income distribution, revenue recycling, welfare, employment, and economic activity. Such research could provide a more nuanced understanding of the mechanisms through which environmental fiscal instruments may generate differentiated effects across social groups and sectors, without presupposing the direction or magnitude of these effects.

A second comparatively less consolidated dimension concerns institutional factors. Although environmental policy and environmental regulation occupy prominent positions within the co-occurrence structure, explicitly institutional concepts do not appear among the recurrent keywords retained in the network. This distinction indicates that policy instruments and regulatory frameworks are widely represented in the field, whereas the institutional conditions under which green taxation policies are designed, implemented, and adjusted remain less explicitly articulated within the thematic structure. This observation points to the need for greater attention to governance arrangements, regulatory capacity, and implementation conditions, particularly to better understand how institutional environments interact with the economic, environmental, and technological dimensions of green taxation.

The geographical dimension reveals a further imbalance. Scientific production and international collaboration are concentrated among a relatively limited number of highly productive and interconnected countries, with China occupying a particularly prominent position, while the United States and the United Kingdom also hold central positions within the international research network. Developing economies, by contrast, remain less represented in the mapped literature. This configuration results in a comparatively narrower representation of the economic, institutional, and policy contexts in which green taxation is studied. It therefore underscores the value of strengthening comparative research across different levels of development to examine the extent to which research priorities, institutional arrangements, and distributional concerns vary across national contexts.

These different dimensions should not, however, be considered in isolation. Their interconnections constitute an important avenue for further development of the field. Greater geographical diversity could, for example, broaden the analysis of institutional configurations and distributional effects associated with green taxation policies, while more systematic integration of these dimensions could better account for the heterogeneity of national contexts. Future research could therefore adopt comparative and context-sensitive approaches that jointly examine the economic, institutional, distributional, and environmental dimensions of green taxation. Such an orientation could move beyond a predominant focus on environmental effects and economic efficiency toward a more nuanced understanding of the conditions under which green taxation instruments are designed, implemented, and studied.

Overall, the findings reveal substantial expansion in green taxation research and progressive diversification of its orientations, without a departure from its established foundations in environmental economics. The mapping of the field's intellectual, thematic, and collaborative structures thus portrays a research domain that remains anchored in established traditions while progressively incorporating new environmental, technological, and social concerns. It also highlights distributional, institutional, and geographical dimensions that remain comparatively less developed and offer important avenues for further research. Importantly, these bibliometric findings characterize the structure, evolution, and thematic priorities of the literature; they do not, in themselves, provide direct evidence of the effectiveness or ineffectiveness of green taxation as a policy instrument.

4.2. Limitations and Future Directions

Despite its contributions and findings, this study has certain methodological limitations. First, the dataset was constructed exclusively from the Scopus database and therefore depends on the search strategy, keyword selection, and inclusion criteria adopted during the data collection process. Although considerable effort was devoted to developing a comprehensive search query, some relevant publications may not have been captured. In addition, the identification and interpretation of thematic structures may be influenced by the clustering parameters and network configuration adopted in the bibliometric analysis. Furthermore, future research could extend the analysis of green taxation to institutional contexts that remain underexplored, particularly in Africa and the MENA region, where scientific production remains relatively limited. Comparative studies across countries with different environmental taxation systems would also provide a better understanding of how institutional contexts shape the development and implementation of green taxation policies.

5. Conclusions

This study provides an integrated bibliometric assessment of the evolution of green taxation research by examining the intellectual, collaborative, and thematic structures that have shaped its development over the period under study. The findings reveal sustained growth in scientific production and increasing diversification of research orientations, while showing that the field remains anchored in its established foundations in environmental economics. Established economic concerns now coexist with environmental, technological, and sustainability-related perspectives, reflecting the progressive expansion of the field's research agenda.

The different levels of bibliometric analysis provide a coherent representation of this evolution. The intellectual structure identifies the foundations underpinning the literature, the collaborative structure reveals the organization of scientific interactions, while the thematic structure captures transformations in its principal research orientations. Considered jointly, these dimensions elucidate the relationships among the field's knowledge base, scientific networks, and thematic dynamics, thereby providing a multidimensional understanding of its development.

Complementing the patterns identified through bibliometric mapping, the theoretical literature also highlights the relevance of ecological constraints, institutional configurations, fundamental uncertainty, and distributional dynamics for understanding green taxation.

This integrated perspective therefore provides a reference framework for situating the accumulated body of knowledge and better understanding the trajectories that have shaped the scientific development of the field.

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