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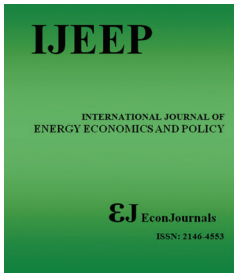

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How Sustainable is Environmental Economics? A Review of Research Trends and Implications

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ABSTRACT

Embarking on a comprehensive review of the Environmental Economics literature, we employed a bibliometric approach to gather 6,118 articles published between 1993 and 2023 from Scopus-indexed journals. Utilizing a suite of software tools, including RStudio, VOSviewer, and Excel, we conducted a thorough examination of data to identify the leading contributors in the realm of Environmental Economics, categorized by nations, institutions, sources, documents, and authors. This study unveiled a significant upward trend in publications, particularly since 2017. This underscores the expanding applications of Environmental Economics across a multitude of domains, encompassing Sustainability, Environmental Footprints, Carbon Emissions, Climate Impact, Navigating Environmental Governance, Policies for Sustainable Futures, Economic Approaches, and Environmental Sustainability. Interestingly, China, the United States, and the United Kingdom emerged as the predominant contributors to the subject's literature. These findings offer valuable insights for stakeholders, particularly in illustrating how environmental economics could influence their decision-making processes.

Keywords: Environmental, Economics, Sustainability, Bibliometric Analysis, Trends, Research Gaps
JEL Classifications: N10, N50, N70

1. INTRODUCTION

Environmental Economics, firmly rooted in microeconomic principles, delves into the intricate relationship between economic systems and the environment. It tackles pressing challenges like environmental degradation and resource depletion, employing economic tools to quantify the negative externalities arising from human activities (Setyari, 2021; Shoeb et al., 2022). The discipline advocates for market-based solutions, regulatory frameworks, and incentives to harmonize economic development with environmental conservation (Torras and Boyce, 1998). As societies grapple with escalating ecological concerns, Environmental Economics, informed by studies on the environmental Kuznets curve and scientometric analyses, becomes increasingly crucial for shaping policies that balance economic growth with ecological integrity (Taqi et al., 2021; Stern, 2004).

Sustainability in Environmental Economics seamlessly integrates economic progress with environmental preservation, drawing upon the foundational principles of microeconomics (Setyari, 2021). This interdisciplinary field tackles the pressing challenges of environmental degradation and resource depletion (Stern, 2004), emphasizing practical strategies for safeguarding long-term ecological health (Taqi et al., 2021). Market-based solutions, regulatory frameworks, and incentives lie at the heart of this approach, enabling a delicate balance between economic development and environmental stewardship (Torras and Boyce, 1998). As global concerns over environmental sustainability intensify, Sustainability in Environmental Economics emerges as a crucial guide for formulating conscientious policy decisions (Alvarez et al., 2021).

Reconciling economic development with sustainability poses a critical challenge in Environmental Economics, as global

economies strive for growth while grappling with environmental degradation and resource depletion (Illge and Schwarze, 2009; Common, 2017). This imperative necessitates a thorough understanding of the intricate relationship between economic activities and ecological well-being (Vatn, 2020). While market-based solutions, regulatory frameworks, and incentives hold promise, their effectiveness remains uncertain (Ahmed et al., 2022). Moving beyond theoretical discussions, addressing this challenge requires rigorous empirical investigations and innovative policy formulations to foster a sustainable coexistence between economic progress and environmental preservation (Khan et al., 2022; Daniela-Abigail et al., 2022; Ahmed et al., 2022). Urgent policy formulation is crucial not only to mitigate environmental threats but also to promote enduring economic prosperity within ecological constraints. This study employs a bibliometric approach to assess the field of Environmental Economics, addressing its historical disorganization. The research questions guiding this study are:

- How has academic research on Environmental Economics evolved between 1993 and 2023?
- What are the notable publication volumes, citation patterns, and prominent contributors in the field of Environmental Economics, as revealed by bibliometric analysis?
- What gaps exist in the current literature on sustainability Environmental Economics, and how might these gaps influence future research efforts?

Encompassing a broad range of Environmental Economics topics, the study employed an in-depth bibliometric analysis of 6,118 articles published in Scopus-indexed journals between 1993 and 2023. This thorough exploration utilized investigative techniques such as citation analysis, co-citation analysis, co-authorship analysis, trend analysis, and keyword occurrence analysis. Our exploration focused on four key research streams: (1) Sustainability and Environmental Economics; (2) deciphering environmental footprints: Unraveling the dynamics of carbon emissions and climate impact; (3) navigating environmental Governance: Assessing policies for sustainable futures; (4) Evaluating economic approaches for environmental sustainability. Among the noteworthy studies within this research landscape are Ruiz-Real et al.'s (2018) global analysis of the circular economy and the environment, Sarkodie and Strezov's (2019) meta-analysis on the environmental Kuznets curve hypothesis, and Babl et al.'s (2014) examination of clean technologies in German economic literature. Other significant contributions encompass research on environmental taxes (Bashir et al., 2021), circular economy (Goyal et al., 2021; Castillo-Vergara et al., 2018), business economics (Bonilla et al., 2015), Economics in Latin America (Bonilla et al., 2015), environmental sustainability (Sneegas et al., 2021), and green bonds (Alsmadi et al., 2023). Additional studies explore topics such as the sustainable biofuel economy (Hasan et al., 2023) and the low-carbon economy (Wang et al., 2022).

The remainder of this research is structured as follows: Section 2 delves into the data and methodology employed in this investigation. Section 3 meticulously scrutinizes the findings unearthed through this bibliometric analysis. Finally, Section 4 encapsulates the conclusion of this study, summarizing the key takeaways and highlighting the implications for future research in Environmental Economics.

2. METHODOLOGICAL DESIGN

2.1. Data Gathering

2.1.1. Origins of data collection

Our decision to primarily utilize the Scopus database for data collection was informed by several factors, as supported by previous research works (Aldieri et al., 2019; Ecim and Maroun, 2023; Rahman et al., 2022). Firstly, Scopus stands as one of the most comprehensive repositories of peer-reviewed academic literature, encompassing a vast array of disciplines. Secondly, its widespread recognition and availability make it a preferred choice for researchers seeking to access reputable publications in the field of Economics. Thirdly, Scopus offers users extensive search functionalities and a suite of bibliometric analysis tools, including the ability to customize bibliographical data exports to suit specific requirements. Finally, for the scope of our investigation, Scopus provided a substantial collection of relevant papers, surpassing alternatives such as the Web of Science (WOS).

2.1.2. Strategy for keyword selection and refinement process

To guarantee the accuracy of the keyword selection process, we employed a two-pronged approach. In the initial phase, we meticulously reviewed online dictionaries and glossaries specifically dedicated to Environmental Economics to identify the most relevant and frequently used keywords. Subsequently, we embarked on a two-step Scopus search strategy to delve into the terminology of Environmental Economics in a more comprehensive manner. Initially, we employed the Scopus keyword tool for an exploratory search. This enabled us to refine our final query while adhering to the character limitations of the Scopus search bar. Subsequently, in the second stage, we meticulously assessed the precision of each term, thereby validating the reliability of our search outcomes.

This two-part approach ensured that our keyword selection process was both comprehensive and accurate, capturing the breadth of Environmental Economics terminology while maintaining precision. We were able to discover the most relevant terms that successfully captured the core of our study by combining the knowledge of specialist dictionaries and glossaries with the immense resources of Scopus.

Upon formulating the research question, the study embarked on a search strategy employing both TITLE and KEYWORD criteria, as detailed in Table 1. We restricted the results to include only papers and reviews from English publications on the topic of Environmental Economics, yielding 27,968 publications. Despite having a large preliminary dataset, we implemented various online adjustments. Initially, we limited the timeframe of the publications and evaluations to 1993-2023. This decision was based on the observation that, prior to 1993, the volume of research in sustainable environmental economics within the broader field of environmental economics was limited, often confined to single digits (Alvarez et al., 2021). Additionally, we eliminated non-Economics journals by employing Scopus Q1 and

Q2 article screening criteria. Subsequently, each publication was meticulously examined for its relevance to the subject matter. We also implemented manual screening procedures to exclude publications deemed irrelevant.

Employing specialized bibliometric techniques, the data was meticulously prepared for subsequent analysis. The inclusion and exclusion criteria were determined by the explicit relevance of the topic within the chosen literature domain. Following the rigorous screening procedure, 6,118 articles and reviews were selected for further bibliometric and content analysis. Additional information regarding this selection is provided in the subsequent step. This selection encompasses all pertinent papers and reviews on environmental economics published in Scopus Q1 and Q2 economics journals.

Finally, the decision to study environmental economics stems from a thorough examination of the intersection between economic concepts and environmental challenges. This highlights the increasing prominence of environmental factors in economic discussions, which emerged in the mid-twentieth century. Pioneering scholars like Kenneth Boulding played a pivotal role in the establishment of this field, and by the 1990s, it had firmly established itself as a distinct academic discipline, as evidenced by Geoghegan et al. (1997). The selection of keywords underscores the significance of economic analysis in comprehending and addressing environmental issues.

2.2. Study Approach and Tools

Pritchard's pioneering bibliometric technique, first proposed in 1969, continues to serve as a valuable tool for uncovering and interpreting article networks through comprehensive citation analysis. As highlighted by Alvarez et al. in 2021, this methodology, in conjunction with scientometric methodologies, has found widespread application in prior research endeavors.

Table 1: Final data collection query

No.	Search query	Findings
#1	Final query: (TITLE ["sustainable environmental economics" OR "environmental sustainability" OR "ecological economics" OR "green economy" OR "sustainability" OR "environmental policy" OR "natural resource economics" OR "climate change economics"]) OR KEY ("sustainable environmental economics" OR "environmental sustainability" OR "ecological economics" OR "green economy" OR "sustainability" OR "environmental policy" OR "natural resource economics" OR "climate change economics") AND (LIMIT-TO [DOCTYPE, "article"] OR LIMIT-TO [DOCTYPE, "review"]) AND (LIMIT-TO [SUBJAREA, "Economics"]) AND (LIMIT-TO [LANGUAGE, "English"]) AND (LIMIT-TO [SRCTYPE, "journal"])	27,968
Constrained online to English, journals, articles, and reviews in the domains of economics and finance		
#2	Limiting the inquiry to papers published between 1993 and 2023 and removing journals with Scopus rankings below Q1 and Q2, as of 2023.	21,177
#3	For full analysis, publications outside the domain of economics are being excluded, and manual screening is being used.	6,118

As underscored by Aladayleh et al. in 2023 and Alqudah et al. in 2023, its utility lies in its ability to yield precise and reproducible findings, providing readers with a comprehensive understanding of intellectual breakthroughs within a specific field. Bibliometrics has been employed to analyze the research output of nations, universities, and individual scholars (Weingart, 2005), as well as journals, themes, and emerging topics (Qudah et al., 2023; Momani et al., 2023). When combined with content analysis, this approach facilitates the synthesis of contributions to a particular field of study.

This investigation employed a three-pronged methodological approach. Firstly, a performance analysis was conducted to identify the most prominent scientific contributors within the literature. Secondly, a citation analysis enabled a detailed examination of the performance of various scientific field players, including publications, authors, and nations. Finally, VOSviewer and RStudio (biblioshiny) were utilized for network analysis, encompassing keyword co-occurrence, factorial analysis, trend analysis, co-authorship networks, and bibliographical coupling. According to Van Eck and Waltman (2017, 2010), VOSviewer enhanced our understanding of leading contributors, while RStudio, equipped with the BibliometriX package, provided a graphical interface for conducting bibliometric tests (Van Eck and Waltman, 2010, 2011, 2013, 2017; Waltman et al., 2010).

3. FINDINGS AND DISCUSSION

3.1. Overview and Evaluation of Performance

Table 2 provides essential details of the Scopus database encompassing the period from 1993 to 2023. This comprehensive

Table 2: Key data for scopus database

Description	Findings
Primary data overview	
Time range	1993:2023
Sources (Journals, Books, etc.)	208
Total publications	6118
Annual growth rate %	14.25
Average age of publications	10.1
Average citations per document	46.34
References cited	254311
Publication overview	
Keywords plus (ID)	14703
Author's keywords (DE)	12320
Authors	
Total authors	10660
Authors of single-authored documents	1091
Collaborative authors	
Single-authored documents	1344
Co-authors per document	2.74
International co-authorships %	28.23
Publication types	
Article	5797
Conference paper	73
Editorial	10
Erratum	2
Letter	1
Note	35
Retracted	1
Review	143
Short survey	56

database comprises 208 sources, including both journals and books, housing a total of 6,118 publications. Exhibiting an annual growth rate of 14.25%, the database reflects a dynamic and continuously evolving scholarly landscape. The publications, with an average age of 10.1 years, garner an average of 46.34 citations each. The extensive content is enriched by 25,431 references, and the significance of keywords is emphasized by 14,703 instances of "Keywords Plus" and 12,320 instances of "Author's Keywords." The authorship landscape involves 10,660 individuals, with 1,091 contributing to single-authored documents. Collaborative efforts yield an average of 2.74 co-authors per document, with an international co-authorship rate of 28.23%. The diversity of publication types, encompassing articles, conference papers, editorials, errata, letters, notes, retractions, reviews, and short surveys, highlights the abundant and multifaceted scholarly contributions within the database.

Figure 1 illustrates the trajectory of environmental economics literature from 1993 to 2023, shedding light on the annual publication counts in conjunction with a polynomial trend line. The data uncovers fluctuations, characterized by a notable peak of 599 publications in 2023 and intermittent downturns, particularly in 2006, 2015, and 1994. The polynomial trend line values suggest periods conducive to consolidation (lower values) and exploration (higher values). Peaks, exemplified in 2017, 2010, and 1994, denote prime moments for advancement and discovery. Conversely, troughs, evident in 2005 and 2015, signal intervals for consolidation and focused research within the field of environmental economics (Geoghegan et al., 1997).

Figure 2 illustrates countries that exert significant influence in the realm of environmental economics literature. Notably, the United States, China, and the United Kingdom stand out as the most prolific and influential contributors in this field. The evaluation process entailed assigning each author's affiliation to a single country, with particular attention given to instances where multiple authors collaborated on a research article pertaining to a specific country, ensuring that each contribution was attributed to that nation. Furthermore, consideration was given to comparable authors to enhance the representation of nations' productivity. This approach aims to provide a more comprehensive overview of each country's contribution to the field of environmental economics.

Figure 3 details the production of countries in environmental economics based on corresponding authors, distinguishing between single Country Publications (SCP) and Multiple Country Publishing (MCP). The United States takes the lead with 1824 articles, showcasing both its significant overall output and collaborative research endeavors. China and the United Kingdom follow, each exhibiting distinct SCP and MCP patterns. The "MCP ratio" provides insights into collaborative tendencies, where higher ratios indicate a greater prevalence of multiple-nation publishing. Peaks in MCP ratios, exemplified by Spain, suggest opportune moments for growth, emphasizing collaborative exploration. Conversely, lower ratios, as evident in Canada, may indicate times to consolidate and focus research efforts.

Figure 4 offers an overview of authors' productivity in environmental economics, placing the spotlight on the top

Figure 1: Environmental economics literature growth

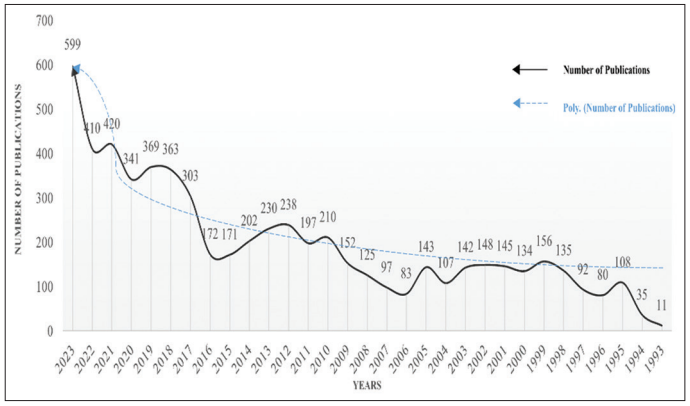
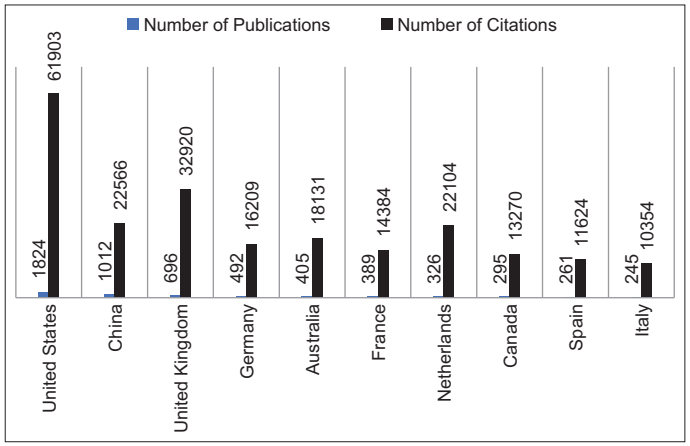


Figure 2: Countries with the highest productivity and impact



contributors over time. Each circle represents an author's annual publication frequency, with larger circles indicating a higher number of articles. The intensity of the circle corresponds to the citations per year, with darker shades indicating a more substantial impact. Renowned authors like Hanley N, Li J, and Wang Y consistently contribute significantly, showcasing diverse patterns across the years. This visual representation facilitates the identification of periods conducive for consolidation (settle), highlighting intervals of sustained productivity, and phases opportune for advancement (climb), underscoring periods of heightened impact and exploration.

3.2. Citation Analysis

Table 3 and Figure 5 showcase the most frequently cited articles within the document collection. Notably, Grossman and Krueger's (1995) seminal research on "Economic growth and the environment" stands out with the highest number of citations, reaching a staggering 5105. The substantial citation count since its publication in 1995 underscores its remarkable performance as a review article. This notable achievement can be attributed, at least in part, to the esteemed reputation and high impact factor of the journal in which it was published, the Quarterly Journal of Economics, boasting an impact factor of 13.7.

Table 3 highlights pivotal publications that have profoundly influenced the field of environmental economics. Grossman and Krueger's (1995) groundbreaking work on "Economic growth

Figure 3: Country output according to corresponding authors, MCP denotes cases of multiple country publishing while SCP denotes single-country publications

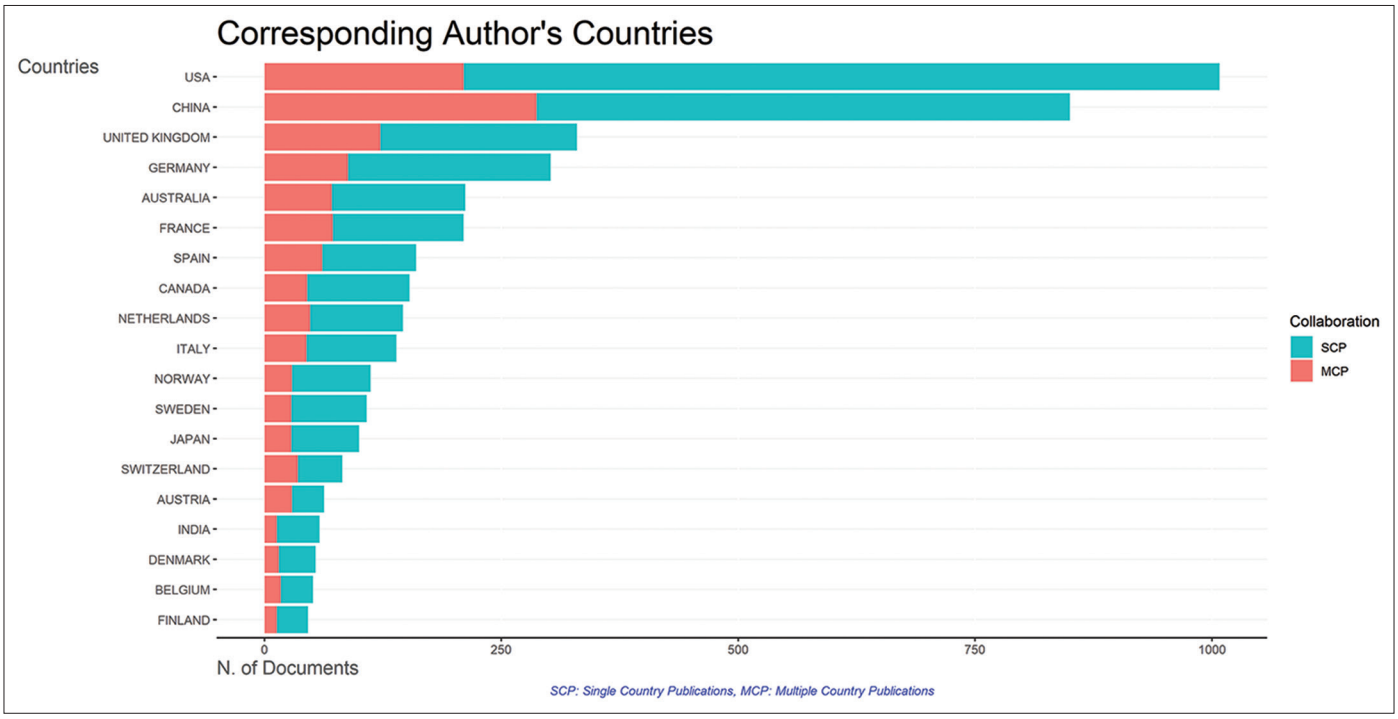
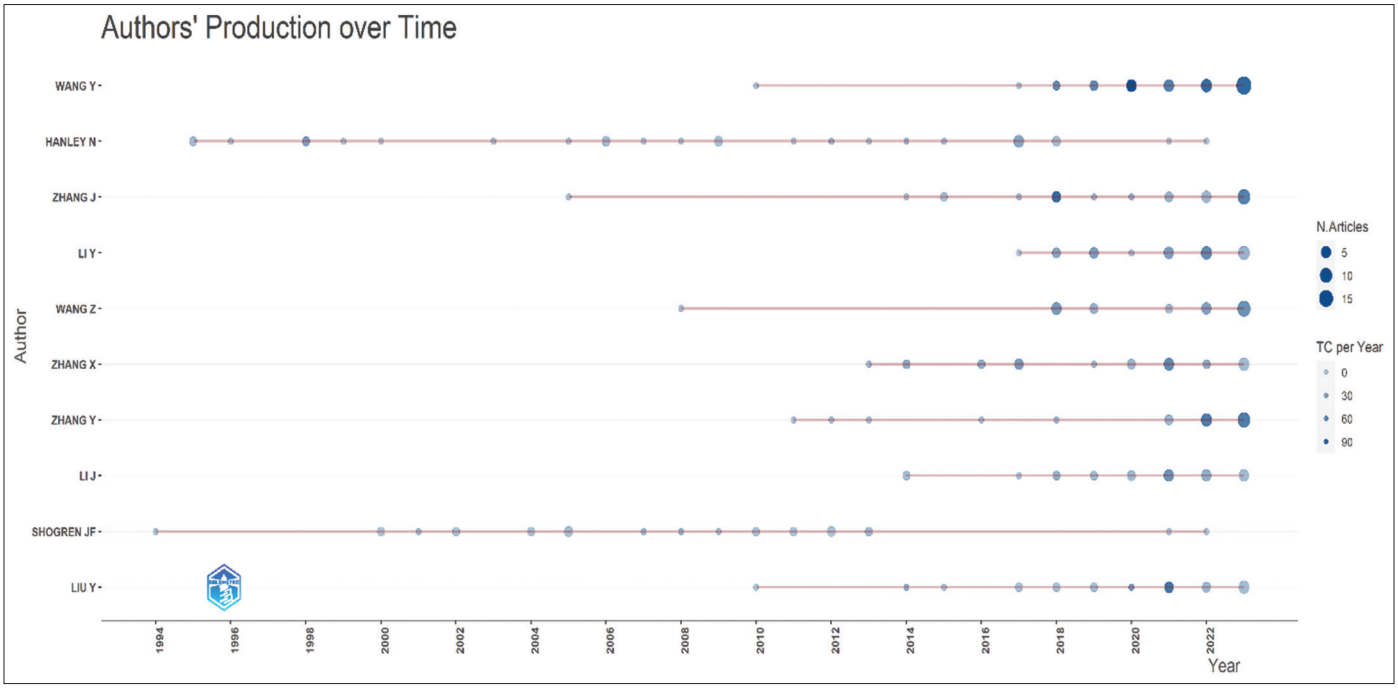


Figure 4: Comparing the top authors' publication and citation rates over time



Source: A larger circle indicates a higher number of articles published by the author in a particular year, while a darker circle signifies a greater number of citations per year

and the environment" stands out with a remarkable 5105 citations, underscoring its enduring significance as a review article. Dinda's (2004) comprehensive survey on the "Environmental Kuznets Curve hypothesis" and Stern's (2004) critical evaluation of "The Rise and Fall of the Environmental Kuznets Curve" follow closely with 2319 and 2212 citations, respectively. Korhonen et al. (2018) insightful examination of the "Circular Economy" concept garners 1747 citations, establishing its prominence in the field. Engel et al. (2008) overview of "Designing payments for environmental services" accumulates 1583 citations, highlighting its practical contributions. Boyd and Banzhaf's (2007) foundational work on "Ecosystem services" receives 1452 citations, emphasizing the need for standardized environmental accounting units. Zhang and Cheng's (2009) study on "Energy consumption, carbon

Table 3: Top cited publications on the environmental economics

Authors	Author (s) ID	Title	Year	Source title	ISSN	Impact factor	Volume	Issue	Page start	Page end	Page count	Citations	Affiliations	Countries	Publisher
Grossman and Krueger	7102260431; 7102925200	Economic growth and the environment	1995	Quarterly Journal of Economics	335533	13.7	110	2	353	377	24	5105	Princeton University	United States	Oxford Academic
Dinda	6603967092	Environmental Kuznets Curve hypothesis: A survey	2004	Ecological Economics	9218009	7	49	4	431	455	24	2319	Indian Statistical Institute	India	Elsevier B.V.
Stern	7202386508	The rise and fall of the environmental Kuznets curve	2004	World Development	0305750X	6.9	32	8	1419	1439	20	2212	Rensselaer Polytechnic Institute	United States	Elsevier B.V.
Korhonen et al.	56208450800; 6603787397; 7103321612	Circular Economy: The concept and its limitations	2018	Ecological Economics	9218009	7	143	1	37	46	9	1747	KTH Royal Institute of Technology	Finland	Elsevier B.V.
Engel et al.	8670489200; 6603659235; 7003871913	Designing payments for environmental services in theory and practice: An overview of the issues	2008	Ecological Economics	9218009	7	65	4	663	674	11	1583	Institute for Environmental Decisions	Switzerland	Elsevier B.V.
Boyd and Banzhaf's	7402669171; 6603516059	What are ecosystem services? The need for standardized environmental accounting units	2007	Ecological Economics	9218009	7	63	1	616	626	10	1452	Georgia State University	United States	Elsevier B.V.
Zhang and Cheng	14829812400; 26654712600	Energy consumption, carbon emissions, and economic growth in China	2009	Ecological Economics	9218009	7	68	10	2706	2712	6	1103	North China Electric Power University	China	Elsevier B.V.
Zhang et al.	57196273500; 7102538614; 6701709530; 7005975406; 6701694147	Ecosystem services and dis-services to agriculture	2007	Ecological Economics	9218009	7	64	2	253	260	7	1054	Michigan State University	United States	Elsevier B.V.

(Contd...)

emissions, and economic growth in China” generates 1103 citations, delving into the intricate relationship between economic development, energy use, and environmental impact. Zhang et al. (2007) investigation into “Ecosystem services and dis-services to agriculture” earns 1054 citations, providing valuable insights into the complex interactions between agriculture and ecosystems. Brunnermeier and Cohen’s (2003) analysis of “Determinants of environmental innovation” accrues 975 citations, shedding light on the factors influencing environmental innovation. Finally, Torras and Boyce’s (1998) reassessment of the “Income, inequality, and pollution” paradigm adds 870 citations, offering a nuanced perspective on the environmental Kuznets curve. These seminal publications collectively shape the discourse in environmental economics, opening avenues for future research to address emerging challenges and gaps in the field.

As environmental concerns intensify, the field of environmental economics plays a critical role in shaping sustainable solutions. Table 3 highlights the significant contributions of environmental economics to date. However, to ensure continued growth and relevance, the field must address several crucial research gaps.

One key area is the integration of behavioral economics into environmental studies. By understanding the psychological factors that influence human behavior, environmental economists can design more effective policies that align with individual decision-making processes. For instance, insights from behavioral economics can inform the design of nudges, incentives, and social norms to promote environmentally friendly choices.

Another critical research gap lies in assessing the long-term sustainability of circular economy practices. The circular economy aims to reduce waste and resource consumption by emphasizing reuse, repair, and recycling. While the concept holds promise, rigorous economic analysis is needed to evaluate the long-term viability of circular economy models and identify potential barriers to implementation.

Furthermore, environmental economics must explore the intersectionality of environmental issues. Environmental degradation often intersects with social and economic inequalities, exacerbating existing vulnerabilities. Research in this area can shed light on the complex interactions between environmental and social factors, informing policy interventions that address both environmental protection and social justice goals.

Emerging technologies also present promising research frontiers for environmental economics. From renewable energy sources to carbon capture and storage, technological advancements offer potential solutions to environmental challenges. Economic analysis can guide the development and adoption of these technologies, ensuring their efficiency and widespread implementation.

International collaborations play a crucial role in addressing global environmental problems. Research should focus on evaluating the effectiveness of international environmental agreements and identifying opportunities for strengthened cooperation. By understanding the economic dimensions of international

Table 3: ***(Continued)***

Authors	Author (s) ID	Title	Year	Source title	ISSN	Impact factor	Volume	Issue	Page start	Page end	Page count	Citations	Affiliations	Countries	Publisher
Brunnermeier and Cohen	6507239222; 55190212100	Determinants of environmental innovation in US manufacturing industries	2003	Journal of Environmental Economics and Management	950696	4.6	45	2	278	293	15	975	Princeton University	United States	Academic Press Inc.
Torras and Boyce	6602718841; 7201747318	Income, inequality, and pollution: A reassessment of the environmental Kuznets curve	1998	Ecological Economics	9218009	7	25	2	147	160	13	870	University of New Hampshire	United States	Elsevier B.V.

environmental governance, researchers can contribute to the development of more effective global environmental policies.

Finally, a deeper understanding of the economic implications of biodiversity loss is essential. Biodiversity loss not only threatens ecosystems but also carries significant economic costs, affecting human health, food security, and ecosystem services. Research in this area can quantify the economic value of biodiversity and inform policies that protect and restore biodiversity.

Tackling these research gaps will enrich the field of environmental economics, providing theoretical depth and practical insights for sustainable and equitable environmental policymaking. Through tackling the forthcoming obstacles and prospects, environmental economics may maintain its crucial function in molding a future characterized by greater sustainability.

3.3. Visualization of Networks

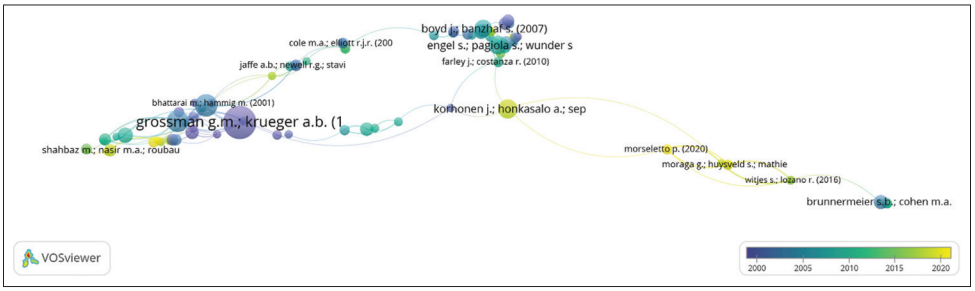
This section delves into the patterns of reference citation and co-authorship among scholars. Figure 6 illustrates the co-citation patterns for the sources, with a greater distance between sources indicating lesser interconnectedness and a shorter distance signifying stronger interconnectedness. Our analysis of 208 sources uncovered only 38 links, demonstrating a notable level of connectedness among journals. This observation aligns with our previous finding of high citation rates within this subject area.

Figure 7 illustrates the co-authorship patterns within the literature. Analysis of data from 764 authors revealed only 28 links, indicating a relatively low level of collaboration among researchers. This paucity of co-authorship underscores the need for greater involvement of research institutions in this field.

3.3.1. Analysis of keywords and cartography

Employing VOSviewer software for keyword analysis, we validated our initial selections and identified distinct clusters within the literature. The yellow cluster, as depicted in Figure 8, encompasses critical areas such as environmental economics, ecosystem services, contingent value, decision-making, willingness to pay, and other pertinent economic terminology.

Figure 5: Citation analysis of publications



Source: Illustrates a citation analysis of publications, offering insights into the frequency and impact of citations, providing a snapshot of scholarly influence and engagement

Figure 6: Co-citation patterns of 38 highly cited journals (out of 208) within the evaluated studies. The size of each node corresponds to the number of citations it has received, while the connecting lines represent the presence of citations between journals. The distance between nodes reflects the frequency with which journals are cited together

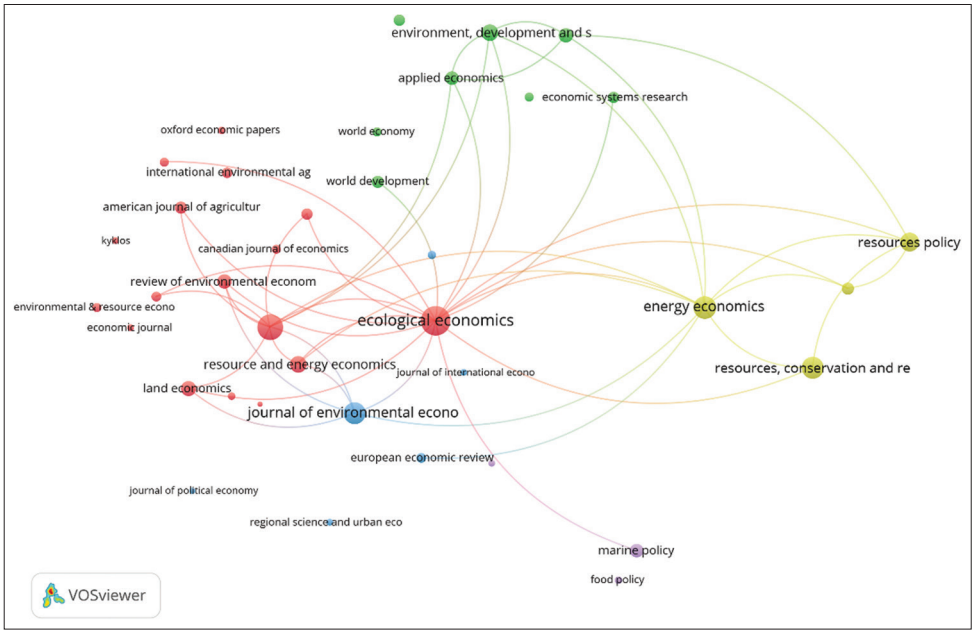


Figure 7: Co-authorship patterns among the most cited researchers. Co-authorship trends among highly cited scholars are depicted, with co-authors being those who cooperate on scientific research articles

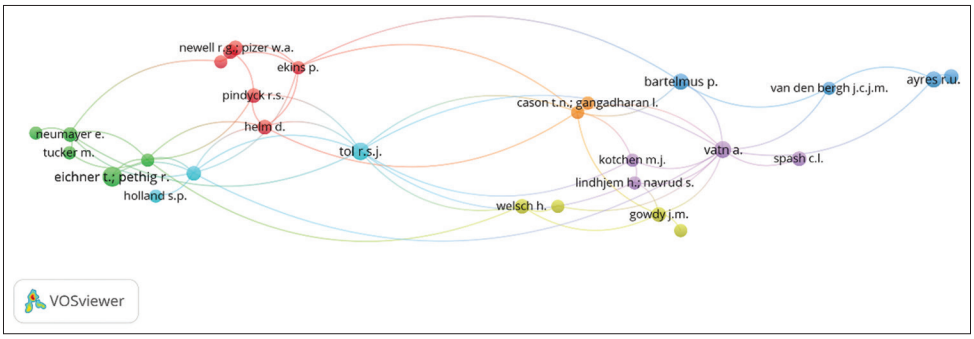
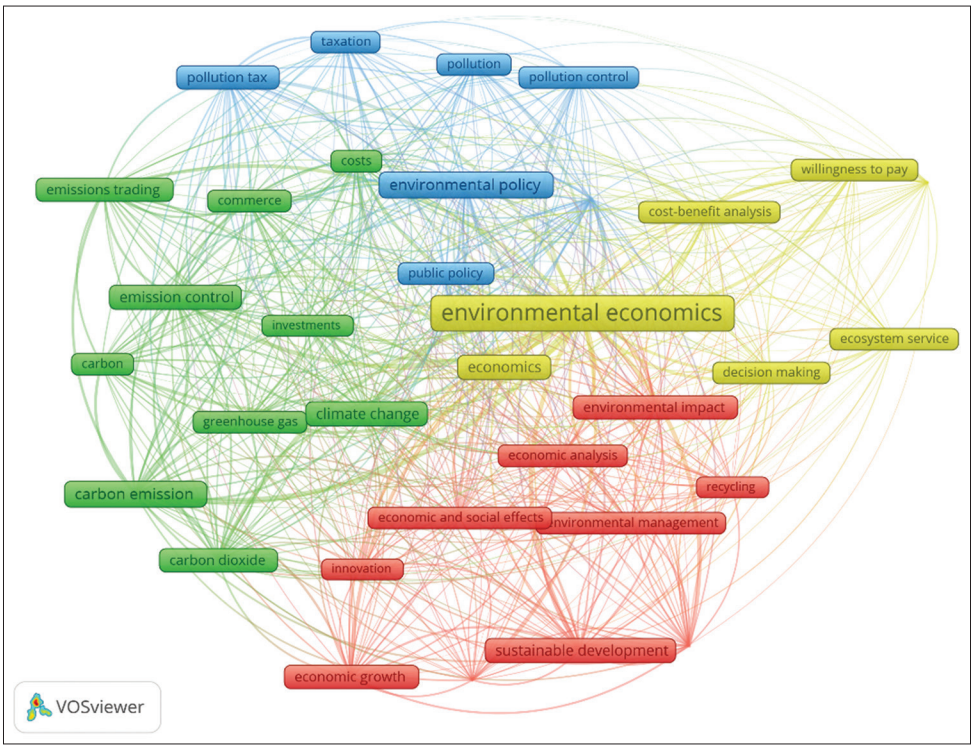


Figure 8: Keyword co-occurrence. KCNs, or keyword co-occurrence networks, are an effective method for examining the connections between terms in a text corpus. Keyword co-occurrences are analyzed for frequency and closeness, and this allows KCNs to uncover hidden patterns and linkages in the data



These concepts intertwine with economic concerns including climate change, pollution management, carbon, public policy, and pollution taxes. This interconnection underscores the application of these concepts and techniques in tasks such as time series prediction and clustering, aligning with the objectives of environmental economics. Algorithmic trading, on the other hand, forms a distinct cluster, with research in this domain commencing considerably earlier than in other areas, as evidenced in Table 4.

Figure 9 highlights the most recent study subjects, where the yellow hue indicates recently studied regions. This reflects a contemporary emphasis on carbon emissions and trade in the economics domain. The graphic underscores the escalating significance of environmental economics in today's world.

As depicted in Figure 10, we constructed a three-field plot restricting the analysis to 20 sources. Journals are positioned to the left, countries in the center, and keywords to the right in this layout. This graph reveals that the United States, China, and the United Kingdom have emerged as the leading nations in this sector. Regarding sources, Ecological Economics was the most widely read journal in this field.

3.4. Bibliographic Coupling and Content Analysis

The stream subjects, derived from keyword co-occurrence, effectively capture the thematic patterns within each cluster. Stream 2, aptly encapsulates the focus on sustainable practices and climate change mitigation strategies. Stream 3, highlights the interplay between environmental policy formulation and its economic ramifications. Stream 4, underscores the significance of economic tools and decision-making frameworks in addressing environmental challenges. These concise titles serve as succinct summaries of the predominant themes within each cluster, offering a streamlined understanding of the content and focus of the respective streams.

Table 4: The most often used occurring keywords

Keywords		Cluster color	Total link strength	Occurrences
1	Environmental economics	Yellow	14969	6118
2	Carbon emission	Green	4226	996
3	Environmental policy	Blue	3626	948
4	Sustainable development	Red	2335	807
5	Sustainability	Red	2393	737
6	Emission control	Green	3326	705
7	Climate change	Green	2665	674
8	Economics	Yellow	2816	654
9	Environmental protection	Blue	2446	602
10	Carbon dioxide	Green	2737	595

Figure 9: Visualizing Keyword Overlap. "This visual representation employs a keyword overlay, where node size denotes the frequency of occurrence and connecting curves indicate co-occurrence. A shorter distance between nodes implies a higher frequency of co-occurrence between the two terms

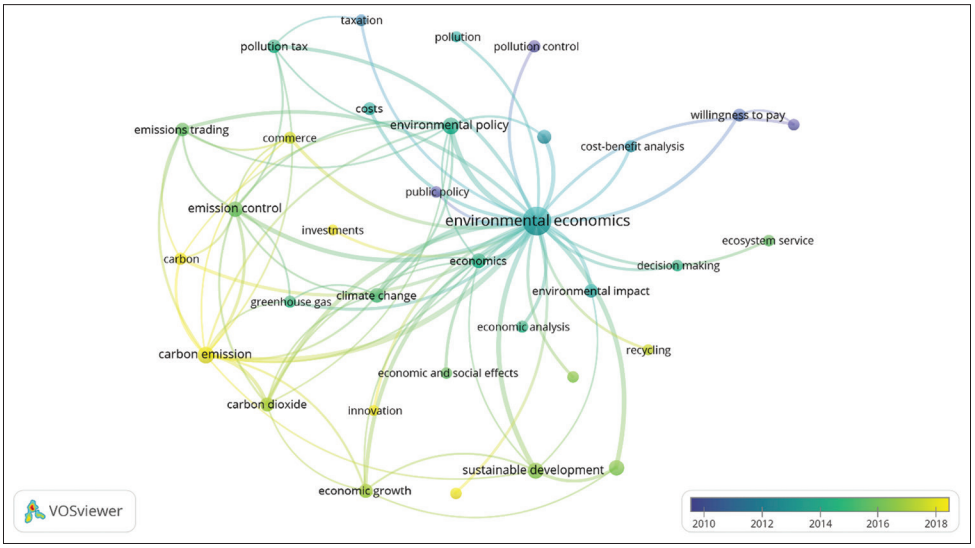
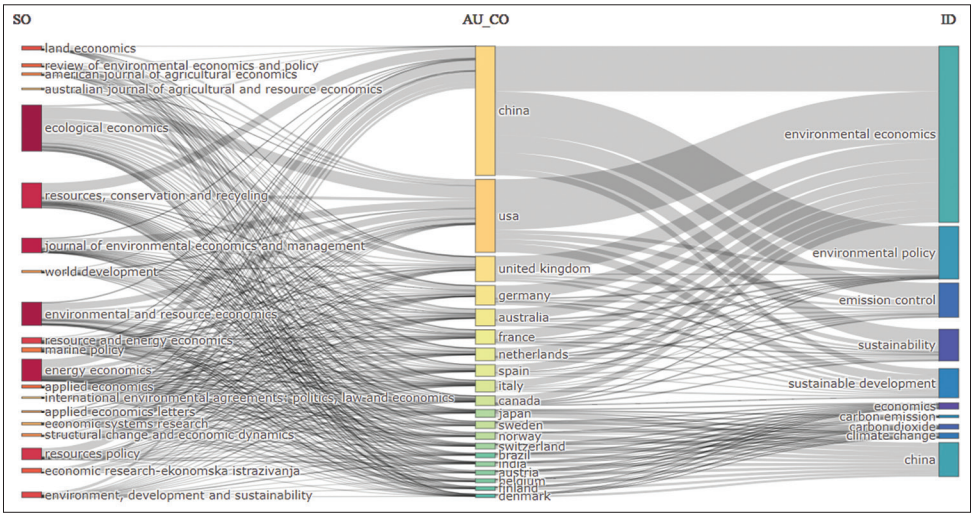


Figure 10: Trilateral Visualization: Unravelling Connections across Journal, Country, and Keyword



Source: The purpose of this illustration is to highlight the relative contributions of each nation by elucidating the relationships between journals, countries, and keywords. The keywords correspond to specific publications and subjects, providing a comprehensive understanding of the intricate linkages prevalent in this academic landscape

3.4.1. Research stream 1: Sustainability and environmental economics

Stream 1 delves into the intricate interplay of economic factors and environmental concerns, encompassing a wide range of keywords such as economic analysis, sustainability, and environmental impact. It reflects a comprehensive exploration of the relationship between economic development and ecological well-being.

Sustainability, the cornerstone of environmental economics, seeks to harmonize economic growth with environmental stewardship. This Stream's emphasis on economic analysis and sustainability echoes the paradigm shift towards circular economies (Korhonen et al., 2018) and the pursuit of innovative solutions for environmental management (Engel et al., 2008). Grossman and Krueger's (1995) seminal work on the link between economic growth and the environment provides a foundation for understanding the crucial role of economic activities in shaping sustainability narratives.

The implications of environmental economics extend to research examining the environmental Kuznets curve (Dinda, 2004; Stern, 2004). This stream's focus on economic and social effects underscores the dynamic relationship between economic growth and environmental impact. Innovations in environmental accounting (Boyd and Banzhaf, 2007; Petrenko, 2021) and the multifaceted concept of ecosystem services (Zhang et al., 2007) exemplify the evolving dialogue on integrating environmental considerations into economic frameworks.

Current research trends within this stream reveal a burgeoning interest in the green economy and environmental accounting methodologies (Alsmadi and Alzoubi, 2022; Shoeb et al., 2022). Additionally, studies exploring the relationship between renewable energy consumption and economic growth (Al-Kasasbeh et al., 2023; Wahyudi and Palupi, 2023) highlight the evolving landscape of environmental economics. The scientometric analysis by Taqi et al. (2021) and empirical studies assessing the environmental Kuznets curve hypothesis (Mougenot et al., 2022; Setyari, 2021) emphasize the diverse avenues of exploration within this dynamic field.

The findings within this stream underscore the imperative of integrating environmental considerations into economic frameworks for sustainability. Noteworthy contributions include Brunnermeier and Cohen's (2003) insights into the determinants of environmental innovation and Torras and Boyce's (1998) reassessment of the environmental Kuznets curve. Recent studies, such as Jadoon et al.'s (2022) exploration of the relationship between environmental degradation, economic growth, and energy consumption, and Al-Kasasbeh et al.'s (2023) empirical evidence on the nexus between renewable energy consumption and economic growth in Jordan, contribute to the evolving discourse on environmental economics.

3.4.2. Research stream 2: Deciphering environmental footprints: Unraveling the dynamics of carbon Emissions and climate impact

Stream 2 delves into the environmental repercussions of human activities, encompassing keywords such as carbon, emissions trading, and greenhouse gas. It unravels the multifaceted challenges posed by carbon emissions, offering insights into the intricate interplay between commerce, costs, and emission control strategies in the face of escalating climate change concerns.

Within the realm of environmental economics, the focus on carbon-related keywords reflects a critical juncture in addressing sustainability challenges. The surge in carbon dioxide and greenhouse gas discussions signifies a pivotal shift towards understanding and mitigating climate change impacts. Environmental economists, as illuminated by Grossman and Krueger (1995), are tasked with unraveling the intricate connection between economic growth and the escalating environmental challenges posed by carbon emissions.

The implications of this stream extend beyond the economic realm, delving into the very fabric of environmental sustainability. Carbon emissions, emissions trading, and emission control mechanisms underscore the urgency for innovative solutions. Insights from Stern (2004) on the rise and fall of the environmental Kuznets curve add depth to the discourse, highlighting the need for dynamic strategies in mitigating the environmental impact of economic activities (Wahyudi, 2019).

Current research trends within this stream unveil a growing interest in emissions trading mechanisms and their effectiveness in curbing carbon emissions (Rojas et al., 2022; Alsmadi and Alzoubi, 2022; Sertoglu, et al. 2021). The exploration of investments and costs related to emission control reflects an evolving discourse on the economic dimensions of sustainable practices. As demonstrated by recent studies (Wahyudi and Palupi, 2023; Azra et al., 2023), the interplay between carbon-related keywords and financial institutions' efficiency becomes a focal point in contemporary research.

The findings within this stream shed light on the intricate dynamics of carbon-related challenges and the evolving strategies to mitigate climate change impacts. Insights from Boyd and Banzhaf (2007) regarding ecosystem services and Zhang and Cheng (2009) exploration of the relationship between energy consumption, carbon emissions, and economic growth contribute significantly to the ongoing discourse. Recent studies, such as those by Jadoon et al. (2022) and Al-Kasasbeh et al. (2023), provide empirical evidence on the nexus between environmental degradation, economic growth, and the pivotal role of renewable energy consumption.

3.4.3. Research stream 3: Navigating environmental governance: Assessing policies for sustainable futures

Stream 3 is dedicated to the intricate web of environmental policies and protection strategies, encompassing keywords such as environmental policy, pollution control, and taxation. It delves into the dynamic landscape of public policies aimed at curbing pollution and fostering environmental protection on a global scale.

Environmental economics plays a pivotal role in shaping and evaluating policies that address contemporary ecological challenges. Within this stream, the emphasis on environmental policy, pollution control, and taxation reflects the integral role of economic frameworks in designing and implementing strategies for sustainable environmental protection. Grossman and Krueger's (1995) insights into the relationship between economic growth and environmental concerns provide a foundational understanding for researchers navigating the complexities of environmental economics.

The implications of this stream extend beyond theoretical constructs, delving into the tangible impact of environmental

policies on pollution reduction and sustainable practices. Stern's (2004) exploration of the rise and fall of the environmental Kuznets curve becomes particularly relevant, offering valuable insights into the evolving dynamics of policies aimed at mitigating pollution and fostering environmental protection.

Current research trends within this stream reveal a growing interest in innovative pollution control mechanisms and the integration of taxation strategies for environmental sustainability. Recent studies, such as those by Rojas et al. (2022) and Alsmadi and Alzoubi (2022), showcase the expanding discourse on economic strategies to promote green economy frameworks. The exploration of ecosystem services and taxation's role in environmental protection, as suggested by Boyd and Banzhaf (2007), stands at the forefront of contemporary research.

The findings within Stream 3 offer a nuanced understanding of the intricate relationship between environmental policies, pollution control, and taxation. Insights from Lacheheb et al.'s (2015) investigation of the environmental Kuznets curve in Algeria contribute significantly to the ongoing discourse on the effectiveness of policy measures in diverse socio-economic contexts. As global attention increasingly shifts towards environmental sustainability, recent studies by Al-Kasasbeh et al. (2023) and Wahyudi and Palupi (2023) provide empirical evidence on the nexus between renewable energy consumption, economic growth, and the implications for policy formulation.

3.4.4. Research stream 4: Evaluating economic approaches for environmental sustainability

Stream 4 navigates the intricate realm of environmental economics, exploring vital concepts such as contingent valuation, cost-benefit analysis, and decision making. With a strong emphasis on the economic dimension, particularly in terms of willingness to pay, this stream investigates the nuanced intersections of economics and environmental conservation.

At the heart of environmental economics lies the pursuit of sustainable solutions to contemporary challenges. In Stream 4, the focus on contingent valuation, cost-benefit analysis, and decision-making underscores the integral role of economic methodologies in shaping environmental policies. Grossman and Krueger's (1995) exploration of economic growth's relationship with the environment serves as a foundational backdrop for understanding the economic dynamics within environmental sustainability.

The implications derived from this stream extend beyond theoretical constructs, offering insights into the practical applications of economic tools for environmental conservation. Cost-benefit analysis and contingent valuation emerge as pivotal instruments, providing decision-makers with frameworks to assess the economic viability of environmental initiatives. Stern's (2004) insights into the rise and fall of the environmental Kuznets curve become particularly relevant, offering a critical perspective on the economic aspects of environmental policy (Siddiqui, et al. 2023).

Recent trends within this stream highlight a growing interest in understanding the economic value of ecosystem services and the willingness of individuals to pay for environmental conservation. Boyd and Banzhaf's (2007) exploration of ecosystem services become a cornerstone for current research trends, emphasizing the need for standardized environmental accounting units. Additionally, the evolving discourse on the economic dimensions of environmental accounting, as showcased by Shoeb et al. (2022), mirrors the field's dynamic nature.

The findings within Stream 4 illuminate the intricate relationship between economic tools and environmental sustainability. Insights from Torras and Boyce's (1998) reassessment of the environmental Kuznets curve contribute significantly to understanding the interplay between income, inequality, and pollution. Recent empirical studies by Al-Kasasbeh et al. (2023) and Wahyudi and Palupi (2023) shed light on the nexus between renewable energy consumption, economic growth, and the role of economic decision-making in shaping environmental outcomes.

3.5. Statistical Distribution by Countries

Figure 11 (VOSviewer) and Figure 12 (RStudio) illustrate co-authorship patterns among countries, revealing robust research collaborations between the United States, China, and the United Kingdom. These three countries form a strong nucleus of international research collaboration in the field of environmental economics. Evidence also suggests collaboration between China and Australia, with scholars from the United Kingdom involved. This pattern of co-authorship reflects the global nature of environmental challenges and the need for international cooperation in addressing them. The United States, China, and the United Kingdom are all major economic powers with significant environmental impacts. By collaborating on research, these countries can share knowledge and expertise to develop more effective solutions to environmental problems.

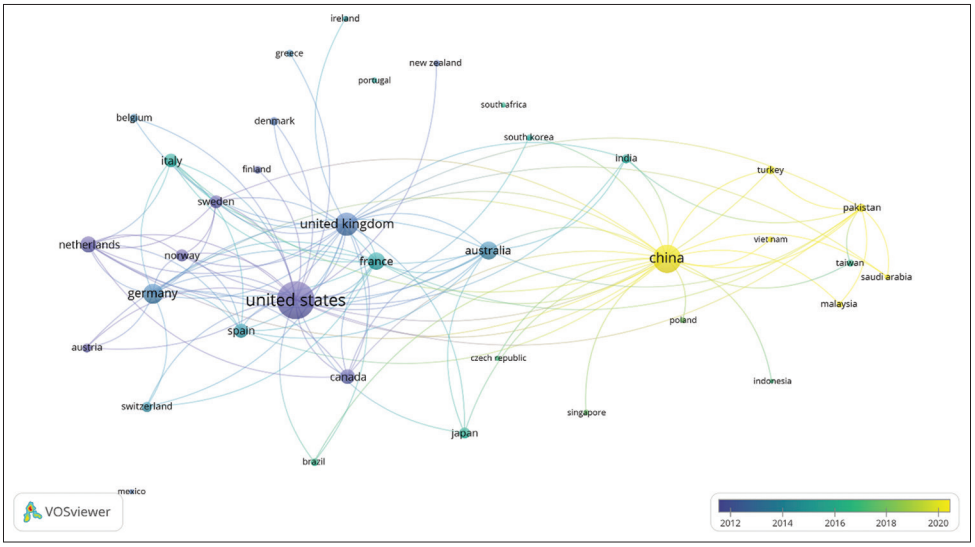
The collaboration between China and Australia is particularly noteworthy, as these two countries have very different political and economic systems. This suggests that there is a strong global commitment to addressing environmental challenges, even among countries with different backgrounds. Overall, the co-authorship patterns in Figure 11 suggest that the field of environmental economics is becoming increasingly internationalized. This is a positive trend, as it will help to ensure that the best minds from around the world are working together to address the most pressing environmental challenges of our time (Aladayleh et al., 2023).

3.6. Major Insights and Sustainability Contributions Unveiled by the Literature Streams

A thorough examination of four distinct literature streams reveals significant insights and contributions at the intersection of environmental economics and sustainability.

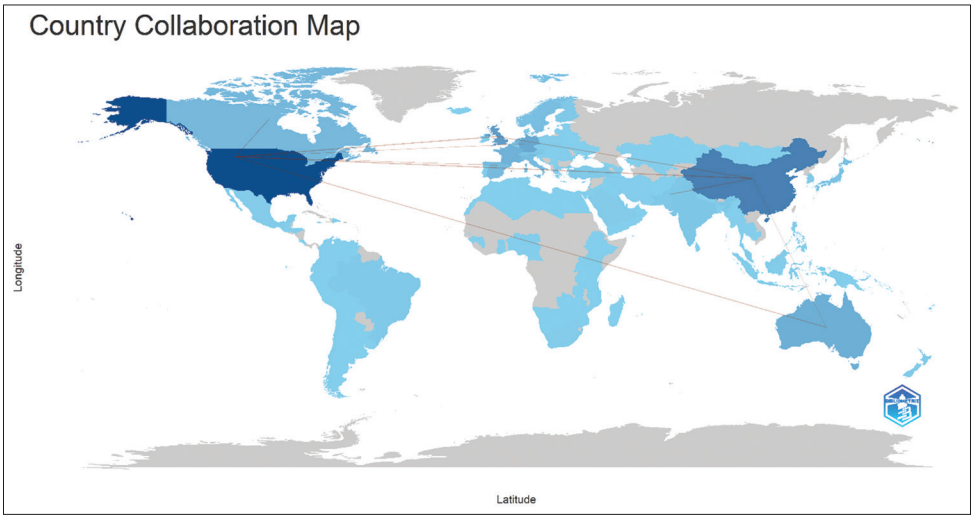
Stream 1 places a strong emphasis on sustainability and economic analysis, reflecting a paradigm shift towards circular economies and innovative environmental management solutions. Key contributions include foundational works by Grossman and Krueger (1995), which shape narratives on the link between economic growth and environmental sustainability.

Figure 11: Statistical distribution map



Source: Displays a statistical distribution map, visually representing the geographical spread or dispersion of data points across a specific area or region

Figure 12: World collaboration and production map



Source: Illustrates global collaboration and production dynamics, showcasing interconnected networks fostering innovation and productivity worldwide. The map visually represents the collaborative landscape on a global scale

Stream 2 delves into the dynamics of carbon emissions and climate impact, offering crucial insights into mitigating climate change challenges. Contributions by Boyd and Banzhaf on ecosystem services and studies on the nexus between renewable energy consumption and economic growth underscore the evolving discourse.

Stream 3 navigates environmental governance, shedding light on policies and strategies for pollution control and taxation. Noteworthy contributions include insights from Stern on the environmental Kuznets curve and recent studies providing empirical evidence on the relationship between renewable energy consumption, economic growth, and policy implications.

Finally, Stream 4 evaluates economic approaches for environmental sustainability, emphasizing tools like contingent valuation and cost-benefit analysis. Major insights encompass the economic dimensions of environmental conservation, with contributions from Torras and Boyce (1998) on the interplay between income, inequality, and pollution. Recent empirical studies provide critical perspectives on renewable energy consumption, economic growth, and economic decision-making in shaping environmental outcomes. Collectively, these streams contribute significantly to advancing our understanding of the intricate relationships between economics and environmental sustainability.

3.7. Emerging Avenues: Future Research Trends in Environmental Economics

As the landscape of environmental economics continues to evolve, several promising avenues for future research emerge from the comprehensive exploration of distinct literature streams.

One compelling trajectory involves advancing the understanding of circular economies, building upon the paradigm shift highlighted in Stream 1 (Korhonen et al., 2018). Investigating the practical implications and implementation challenges of circular economy principles in diverse socio-economic contexts could offer valuable insights. Additionally, the burgeoning interest in the green economy, evident in recent studies (Alsmadi and Alzoubi, 2022; Shoeb et al., 2022), suggests a need for deeper exploration into the economic mechanisms that drive sustainable practices and their potential global impact. Future research could delve into the nuanced interactions between economic policies, technological innovations, and consumer behavior shaping the trajectory of the green economy.

Furthermore, the pressing issue of climate change, as highlighted in Stream 2, opens avenues for research on the effectiveness of emissions trading mechanisms and innovative strategies for curbing carbon emissions. Exploring the economic dimensions of climate change mitigation, particularly in terms of investments and costs related to emission control, offers a fertile ground for scholars and policymakers alike. Understanding how financial institutions' efficiency influences the success of emission control initiatives could be a key focus in this regard. Future research may unravel the evolving dynamics of international collaborations in addressing climate change, building on the patterns of co-authorship identified in Figure 11.

In the realm of environmental governance and policies (Stream 3), the evolving landscape calls for research that assesses the practical outcomes of diverse pollution control mechanisms and taxation strategies. Investigating the effectiveness of green economy frameworks, as showcased in recent studies (Rojas et al., 2022; Alsmadi and Alzoubi, 2022), provides a platform for shaping future policies. Exploring how ecosystem services contribute to environmental protection and the potential integration of such services into policy frameworks could be a transformative area of study. Additionally, research may delve into the socio-economic implications of taxation policies on environmental protection, considering factors like income distribution and economic equity.

Lastly, Stream 4 invites future research to delve deeper into the economic tools and methodologies that underpin environmental sustainability. Exploring the evolving landscape of contingent valuation, cost-benefit analysis, and decision-making in the context of environmental conservation offers opportunities for methodological advancements. Understanding the economic value of ecosystem services, as highlighted by Boyd and Banzhaf (2007), could be further refined, emphasizing the need for standardized environmental accounting units. Future studies might also scrutinize the role of economic decision-making in shaping environmental outcomes, considering the changing dynamics of renewable energy consumption and its impact on economic growth.

3.8. Bridging the Gap: Practical and Theoretical Ramifications of Environmental Economics

Environmental economics, with its distinct research streams, sheds light on the intricate connection between economic activities and ecological well-being. The first stream emphasizes integrating environmental considerations into economic frameworks for sustainability, aligning with global efforts for circular economies and innovative solutions. Seminal works like Grossman and Krueger's (1995) exploration of the environment's impact on economic growth lay a foundation, while contemporary studies on the green economy and renewable energy showcase evolving perspectives.

The second stream focuses on carbon emissions and climate impact, emphasizing the urgency of addressing sustainability challenges. Understanding emissions trading mechanisms and economic dimensions of emission control, as explored by Boyd and Banzhaf (2007), contributes to a nuanced approach to mitigating climate change impacts.

In the third stream, environmental governance takes center stage, highlighting the role of policies in shaping sustainable futures. Innovative pollution control mechanisms and taxation strategies reflect a dynamic discourse on economic approaches to promote green economy frameworks, enriched by exploring ecosystem services and policy effectiveness in diverse socio-economic contexts.

The fourth stream prioritizes the economic dimension, emphasizing tools like contingent valuation and cost-benefit analysis for environmental conservation. Insights from Torras and Boyce (1998) on the environmental Kuznets curve and trends in understanding the economic value of ecosystem services underscore the critical role economic methodologies play in shaping environmental policies.

As theory meets practice in environmental economics, these streams collectively contribute to a holistic framework for addressing contemporary environmental challenges. The synthesis of theoretical insights and empirical evidence informs academic discourse and offers practical guidance for policymakers, businesses, and individuals navigating the complex intersection of economics and environmental stewardship. Ultimately, these streams underscore the integral role of environmental economics in forging a sustainable and resilient future for our planet.

4. CONCLUSION

Employing a bibliometric technique, this study delved into the realm of environmental economics, scrutinizing 6,118 papers published between 1993 and 2023 in Q1 and Q2 economics journals indexed in the Scopus database. The data unveiled a remarkable upward trend in publication volume, commencing in 2017. Key study themes encompassed Sustainability, Environmental Footprints, Carbon Emissions, Climate Impact, Navigating Environmental Governance, Policies for Sustainable Futures, Economic Approaches, and Environmental Sustainability. China, the United States, and the United Kingdom emerged as the foremost contributors to the literature.

The study emphasizes the growing prominence of environmental economics in addressing current environmental concerns. The

rising publication trend signifies an escalating interest in the subject, while the diversity of study topics reflects the intricate nature of environmental challenges. The substantial contributions from China, the United States, and the United Kingdom highlight the global scope of environmental economics research.

It is noteworthy that the study did not compare the efficacy of various sustainable environmental economic techniques. Future research should focus on evaluating the performance of different sustainable environmental economic techniques to identify the most effective approaches for tackling environmental challenges.

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