Bilal Ali Ibraheem Al Nsour

Periodical Part

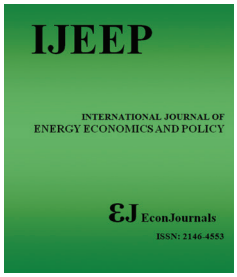
Systematic and bibliometric reviews of environmental economics in the energy sector : key trends, influential studies, and future research directions

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: In: International Journal of Energy Economics and Policy Systematic and bibliometric reviews of environmental economics in the energy sector : key trends, influential studies, and future research directions 15 (2025).
https://www.econjournals.com/index.php/ijeep/article/download/18095/8563/42153.
doi:10.32479/ijeep.18095.

This Version is available at:
http://hdl.handle.net/11159/708506



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(2), 140-156.

Systematic and Bibliometric Reviews of Environmental Economics in the Energy Sector: Key Trends, Influential Studies, and Future Research Directions

Bilal Ali Ibraheem Al Nsour*

Department of Management, Faculty of Business, Al-Balqa Applied University, Salt, Jordan. *Email: drbilalnsour6@gmail.com

Received: 19 September 2024 **Accepted:** 13 January 2025 **DOI:** https://doi.org/10.32479/ijeep.18095

ABSTRACT

This study analyzes the trends, influential contributions, and research directions in environmental economics within the energy sector from 2004 to 2024. Employing a bibliometric and systematic literature review approach, it examines 237 articles, identifying key themes such as renewable energy adoption, sustainable development, and energy efficiency. The analysis highlights the growing focus on regulatory impacts, financing renewable energy, and addressing challenges like energy poverty. Major contributors and journals in the field, as well as citation trends, are explored, with a particular emphasis on top articles and influential authors. Emerging research clusters include energy policy frameworks, the role of renewable resources, and the integration of green technologies. The study provides insights into the evolving research landscape, emphasizing the importance of policy coherence, innovation, and global collaboration in addressing environmental sustainability. It suggests future research opportunities in scaling green technologies, fintech's role in sustainability, and the development of regulatory frameworks for equitable energy transitions.

Keywords: Environmental Economics, Energy Policy, Renewable Energy, Sustainable Development, Bibliometrics.
JEL Classifications: Q40, Q52, Q58

1. INTRODUCTION

Intersecting forces such as technological innovation, policy development, and market dynamics shape the dynamic and multifaceted field of environmental economics within the energy sector (Shahbaz et al., 2020; Papadis and Tsatsaronis, 2020). The integration of sustainability principles within energy transitions has garnered significant scholarly attention, leading to the proliferation of studies exploring various dimensions of this field. Key focus areas include assessing the economic implications of renewable energy adoption, analyzing carbon pricing mechanisms, evaluating emissions reduction policies, and examining the socio-environmental impacts of energy production and consumption (Al-Shetwi, 2022; Guo et al., 2014; Nepal et al., 2021; Akpan and Akpan, 2012). These investigations have underscored the critical importance of addressing the economic, social, and environmental challenges inherent in energy systems, particularly in the context of achieving global climate targets and sustainable development goals (Markandya et al., 2016; Mastini et al., 2021). Despite the breadth of research in this domain, existing literature often remains fragmented, with studies focusing narrowly on specific themes or regions. For instance, while numerous studies have analyzed the benefits of renewable energy adoption, there is limited integration of findings across diverse geographical and policy contexts. Similarly, despite extensive exploration of carbon pricing mechanisms and emissions trading systems, their comparative effectiveness in various economic and regulatory settings has not received enough attention (Hájek et al., 2019; Liu et al., 2018). This fragmentation highlights the need for a comprehensive synthesis of the existing literature to identify overarching trends, unresolved challenges, and emerging research directions.

This paper aims to address these gaps by conducting a rigorous bibliometric and systematic literature review (SLR) on environmental economics in the energy sector. Unlike conventional reviews that focus on limited datasets or specific subfields, this study adopts a holistic approach, synthesizing an extensive body of literature across multiple years and scholarly sources. By analyzing 237 peer-reviewed articles published between 2004 and November 2024, the study provides a nuanced understanding of research trends and identifies unexplored areas within the field. The regulation and economic dynamics of energy markets form the core focus of this paper, which seeks to illuminate key issues at the intersection of environmental economics and energy policy (Ćetković and Buzogány, 2016; Corbet et al., 2021). The study employs a mixed methodology, combining qualitative and quantitative approaches to ensure a robust and comprehensive analysis (Chen et al., 2021; Wang et al., 2014). The study employs bibliometric analysis tools like VOSviewer and the Bibliometrix R package, renowned for their ability to conduct detailed and systematic analyses of academic literature (Bozkurt and Akan, 2014; Enevoldsen et al., 2007). VOSviewer was used to map influential authors, journals, research clusters, and country-specific contributions, while Bibliometrix facilitated trend topic analyses and phrase co-occurrence analyses. These tools enabled the identification of core themes and emerging research directions in the field, providing a comprehensive overview of the intellectual structure and evolution of environmental economics in the energy sector. Two main research questions shape the paper:

a) What are the prominent themes in environmental economics within the energy sector, and how are they characterized?
b) What are the emerging directions for future research in this field?

To address these questions, a detailed research plan was devised, incorporating carefully crafted research questions, the selection of relevant databases and search terms, and stringent screening criteria to ensure the inclusion of high-quality academic publications (Dritsaki and Dritsaki, 2014; García-Martos et al., 2013). The bibliometric analysis identified several prominent themes, including renewable energy integration, carbon pricing mechanisms, energy market liberalization, and the socio-economic impacts of energy transitions. A systematic review further explored these themes, synthesizing insights from diverse studies to provide a cohesive understanding of the field.

One of the key findings of this study is the identification of emerging research directions in environmental economics within the energy sector. Some interesting topics to look into further in the future are how adding renewable energy to national grids affects the economy, how well carbon pricing and emissions trading systems work, how to find new ways to pay for green energy projects, and the social and economic effects of energy transitions in developing economies (Guo et al., 2014; Duran and Saqib, 2024; Eyraud et al., 2013; Farhani and Rejeb, 2012). Further investigation has identified the interplay between energy policies and sustainable development goals as a critical area, particularly in aligning energy strategies with global climate and development targets (Markandya et al., 2016; Mastini et al., 2021). By surpassing traditional narrative reviews, this paper establishes a new standard in environmental economics research, combining the precision of bibliometric methods with the depth of systematic reviews. This hybrid methodology delivers an unbiased synthesis of the literature, capturing broad research trends while avoiding the limitations of narrow focus or subjective interpretation (Ibrahiem, 2020; Shahbaz et al., 2016). The use of advanced bibliometric tools, such as VOSviewer and Bibliometrix, ensures the reliability and validity of the analysis, providing stakeholders and policymakers with actionable insights for fostering sustainable development.

The findings of this study have significant policy implications. For instance, the economic impacts of renewable energy adoption underscore the need for supportive policy frameworks that incentivize investment in clean energy technologies while addressing potential market distortions. Similarly, the analysis of carbon pricing mechanisms highlights the importance of designing equitable and effective policies that balance economic efficiency with environmental objectives. The study also emphasizes the need for targeted interventions to address the socio-economic challenges of energy transitions in developing economies, including issues related to energy access, affordability, and employment (Farhani and Rejeb, 2012; Akpan and Akpan, 2012). Six sections organize the paper. Section 2 outlines the research methodology, detailing the selection criteria, data sources, and analytical tools used in the study. Section 3 presents the results of the bibliometric analysis, highlighting key trends, influential contributors, and research clusters. Section 4 discusses thematic clusters and key findings, providing an in-depth analysis of the core themes identified in the literature. Section 5 identifies new research opportunities, offering insights into emerging directions and unresolved challenges in the field. Finally, Section 6 concludes with policy implications and recommendations for future studies, emphasizing the importance of interdisciplinary collaboration and innovative approaches to addressing the complex challenges of environmental economics in the energy sector.

2. METHODOLOGY

This study utilizes a combined methodology of bibliometric analysis and systematic literature review (SLR) to explore the concept of "value relevance" in environmental economics within the energy sector. The frameworks established by Janssens et al. (2008), Raan (2008), Caputo et al. (2021), and Momani et al. (2023) inspire the methodology. This approach enables a comprehensive understanding by merging quantitative insights and qualitative assessments, mitigating biases, and enhancing scientific rigor (Pritchard, 1969; Gómez-Núñez et al., 2016; Pizzi et al., 2020, 2021; Oliveira et al., 2023). Recent research has also shown that bibliometric analyses are becoming more important for finding trends and insights in many areas, including leadership trends (Abu Orabi et al., 2024), creative accounting (ALShanti et al., 2024), green economics (Alqudah et al., 2024) etc. The research begins with an SLR following established protocols (Moher et al., 2015; Caputo et al., 2018; Qudah et al., 2023; Mancini et al., 2021). This ensures a structured and replicable process, aligned with Petticrew and Roberts' (2008) guidelines. The protocol includes defining research questions, selecting databases, identifying keywords, and

applying criteria for study inclusion. Recent bibliometric reviews, such as Qudah et al. (2023) on Islamic finance and Aladayleh et al. (2023) on COVID-19's impact on sustainability, have highlighted the effectiveness of such systematic approaches in generating actionable insights. Key initial steps included:

1. The formulation of research questions addressing trends in environmental economics and the energy sector shaped the study's direction.
2. Relevant academic databases were selected to ensure effective retrieval of studies. Similar approaches have been used in reviewing the evolution of IT auditing practices (Al Karabsheh et al., 2024) and algorithmic finance (Qudah et al., 2024).
3. Criteria such as publication stage and language were applied to filter studies. This method aligns with strategies in bibliometric reviews on sustainability in cryptocurrencies (Alqudah et al., 2023).
4. A rigorous evaluation process ensured that only relevant studies addressing the research focus were included, following practices outlined by Abu Anzeh et al. (2024).

The subsequent bibliometric analysis delves deeper into the intellectual landscape of the field. This method employs quantitative measures such as publication counts and citation frequencies to identify influential works and emerging trends (Santos et al., 2017; Touijrat et al., 2021; Momani et al., 2023). By visualizing the evolution of research domains through science maps, the analysis mirrors the methods used in studies of COVID-19 and project risk management (Al Qudah et al., 2023) and FinTech's role in social responsibility (AlQudah et al., 2024). Steps in this phase included:

1. Metrics like citation frequencies and authorship networks were employed to analyze the field, reflecting practices in studies on digital technologies in business education (Masa'deh et al., 2024).
2. Core themes were identified using common keywords, similar to the approaches of Qabajeh et al. (2024) in auditing research.
3. Emerging trends and research gaps were identified, enabling the study to suggest areas for future investigation, as highlighted in reviews of marketing strategies and information systems (Abu Anzeh et al., 2024).

This integrated approach combines bibliometric analysis and SLR to evaluate trends, influential studies, and future research directions, contributing to the broader discourse on environmental economics in the energy sector.

2.1. Phase One: Systematic Literature Review (SLR)

The first phase of our research focused on systematically reviewing the literature to address specific research questions that would guide the study of environmental economics within the energy sector. These research questions were formulated as follows: a) What are the key themes that characterize relevant research in the field of environmental economics in the energy sector? b) How do these themes differentiate from each other, and what are the trends in research evolution within the domain of environmental economics in the energy sector?

To ensure that the dataset was comprehensive and representative, we carefully selected relevant papers from the Scopus database, which is known for its extensive coverage. Scopus is considered a superior choice over other databases, such as Web of Science (WoS), for conducting detailed literature reviews (Janssens et al., 2008; Raan, 2008; Caputo et al., 2021; Yang et al., 2023). This database offers broader search results and better facilitates data collection and analysis. A Python script utilizing the pybliometrics. scopus library was employed to automate the search process within Scopus, ensuring efficient and accurate data retrieval. The search query included a range of terms related to environmental economics, energy sector policies, market regulation, and sustainability development (see the search query below).

All = ((“Environmental Economics” AND “Energy Sector” OR “Energy Policy” OR “Renewable Energy” OR “Carbon Emissions” OR “Energy Efficiency” OR “Sustainable Development” OR “Energy Markets”) AND (“Regulation” OR “Policy” OR “Market Efficiency” OR “Monetary Policy” OR “Energy Transition” OR “Environmental Impact” OR “Economic Development” OR “Climate Change” OR “Energy Security” OR “Renewable Technologies”))

This study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring transparency and reproducibility throughout the review process (Thakur et al., 2023). The PRISMA framework was instrumental in ensuring that the research followed clear stages, including identification, screening, eligibility assessment, and inclusion of relevant studies (Helbach et al., 2023; Cala et al., 2023). By adhering to the PRISMA standards, we minimized bias and increased the reliability of our findings, ensuring a comprehensive and objective analysis of the literature on environmental economics in the energy sector. To enhance the dataset's relevance, rigorous filters were applied during the search. These filters focused on key subject areas such as “Environmental Economics,” “Energy Markets,” and “Energy Policy,” as well as document types (articles), publication stages (final), source types (journals), and language (English). One of the most cited papers in the sample investigated the economic implications of carbon pricing, making it a critical contribution to understanding regulatory measures within the energy sector. This study incorporated a robust mix of bibliometric and systematic review methodologies to extract key insights from the body of work.

The final analysis examined 237 journal articles published between 2004 and 2024. This range captures a significant period of growth and transformation in environmental economics in the energy sector, particularly with the rise of renewable energy policies and the increasing importance of regulatory frameworks addressing climate change. The search process ensured that only peer-reviewed journal articles in English, published up to November 2024, were included. This approach guaranteed that the study reflects the most current trends and scholarly contributions. The initial search identified 351 articles. A two-level screening process was then employed (Lamboglia et al., 2021; Tranfield et al., 2003), in which authors independently evaluated titles, abstracts, and full articles (if needed) for relevance. Disagreements were resolved through regular discussions. Articles that were irrelevant to the field (73), outside the scope of the review (8), book chapters (14),

duplicates (6), and articles lacking abstracts (13) were excluded. This rigorous screening process resulted in a final dataset of 237 relevant journal articles, as outlined in Figure 1.

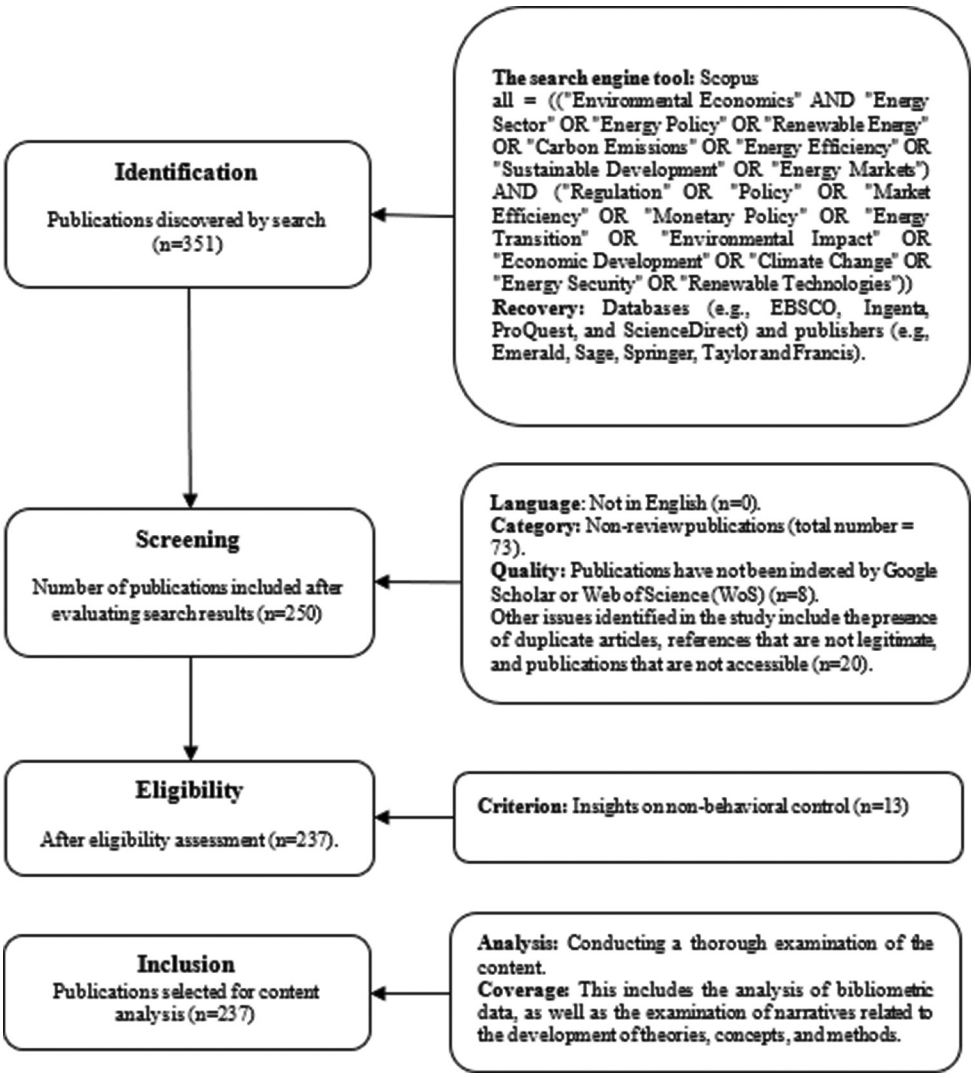
2.2. Phase Second: Bibliometric Analysis

Bibliometric studies begin with a critical initial phase: performance analysis (Donthu et al., 2021, p.287). This widely recognized and essential step lays the groundwork for subsequent analyses (Abbas et al., 2022; Caputo et al., 2018; Saxena and Kumar, 2023). Its objective is to evaluate the research field's performance across various components, including authors, countries, and journals. To achieve this, performance analysis employs various indicators, primarily derived from bibliographical citations, to generate descriptive statistics (Dol et al., 2024). This comprehensive overview provides valuable insights into the field's research volume and impact (Sharifi et al., 2023; Singh et al., 2023; Yang et al., 2023). To explore the development of valuable research on cryptocurrency adoption and its associated regulatory challenges, the study examined the distribution of articles over time. It also evaluated their impact through citation analysis and citations per year (CPY) analyses (Massaro et al., 2016). Citation analysis, a frequently used bibliometric technique, involves compiling lists of the most cited papers or authors, offering insights into research prominence and productivity (Farooq, 2024). This approach rests on the assumption that scholars typically cite influential works relevant to their research (Singh et al., 2023; Otitolaiye and Abd Aziz, 2024).

Following this methodology, the study identified the most influential journals, authors, and corresponding countries (Caputo et al., 2018; Lamboglia et al., 2021; Aladayleh et al., 2023). The VOSviewer software, renowned for its utility in bibliometric analysis, facilitated this process (van Eck and Waltman, 2010; 2011; 2013; 2017; Waltman et al., 2010; Wong, 2018). VOSviewer enables the objective and user-friendly visualization of significant publications, authors, journals, research groups, and countries within the field (van Eck and Waltman, 2010; 2011; 2013; 2017; Waltman et al., 2010). The main part of the bibliometric analysis was science mapping, which used first- and second-generation relational indicators to look at the structure and organization of research on how people use cryptocurrencies and the problems that come with them (Massaro et al., 2016; Wong, 2018). This analysis encompassed two primary techniques: keyword co-occurrence and trend topic analyses.

Keyword co-occurrence analysis, a form of content analysis, examined the keywords within articles to delineate the field's

Figure 1: PRISMA review protocol flowchart for publications selection



conceptual landscape. It identified key thematic clusters by analyzing how frequently specific keywords appeared together in articles. Frequent co-occurrences indicate stronger connections and a higher likelihood of articles sharing the same research theme (Afeltra et al., 2022; Lamboglia et al., 2021). Unlike other bibliometric tools linking documents through citations or co-authorship, this method uses the actual content of papers to establish a similarity measure and identify thematic clusters (ALShanti et al., 2024). By examining the frequency of authors' keyword usage over time and distinguishing between terms commonly used in the past and those more recently, trend topic analysis aimed to identify new research directions (Abbas et al., 2022). The R package Bibliometrix facilitated these analyses (Alqudah et al., 2023; ALShanti et al., 2024). This software enables comprehensive bibliometric studies by categorizing various elements as sources, authors, records, and conceptual, social, and intellectual structures. It used clustering algorithms like "walktrap" and "leading eigenvalues" to make network graphs that showed how bibliographic metadata appeared together (Aria and Cuccurullo, 2017).

Bibliometrix software played a crucial role in visualizing the relationships between keywords. Aria and Cuccurullo (2017) and ALShanti et al. (2024) used the leading eigenvalues algorithm to create a co-occurrence network map for the keyword co-occurrence analysis. This map visually depicts clusters of keywords corresponding to specific research themes, represented by distinct colors. We used the same software for trend topic analysis. Here, we produced a scatter plot with axes representing time and topic (Aria and Cuccurullo, 2017; Gerged et al., 2023; ALShanti et al., 2024). This facilitated the identification of the reference year for each topic by analyzing the median of its keyword occurrences throughout the studied period.

Before the science mapping studies, we carefully normalized the set of raw keywords with a thesaurus (ALShanti et al., 2024; Laila et al., 2021). This process eliminated duplicates, standardized spelling variations, and merged synonyms to ensure data accuracy. Bibliometrix then automated the assignment of articles to thematic clusters with a specific probability level. We classified articles with a high probability (0.8 or above) as highly likely to belong to a specific cluster and those with a moderate probability (between 0.4 and 0.8) as likely. To ensure the reliability of these classifications, manual content analysis complemented the automation process. Researchers distributed articles with a probability below 0.8 for independent reading and analysis of titles, abstracts, and keywords. Panel meetings and discussions addressed any disagreements or uncertainties, guaranteeing accurate cluster attribution (Van Eck and Waltman, 2014; Waltman and van Eck, 2013). We held a final meeting to review and reach consensus on the final cluster formation. The study conducted a critical review of the most relevant contributions within each cluster, deeming formal reliability checks unnecessary due to the step-by-step agreement achieved. This review aimed to discuss key insights and complement the bibliometric analysis outcomes. It also served to highlight emerging research directions and suggest opportunities for future research endeavors.

3. RESULTS

3.1. Descriptive Data

This section serves as a technique for summarizing and interpreting data, uncovering patterns, trends, and valuable insights. In the context of research on the energy sector's environmental economics, this method provides several key benefits. First, it illustrates the rapid expansion of academic focus in this area. Second, it enables the identification of critical topics and influential studies that are shaping the field. Lastly, it sheds light on the contributions from various authors and journals, offering a comprehensive view of the research landscape. This is achieved by examining publication counts, citation frequencies, and the global distribution of research outputs.

3.2. Articles Data

Research on environmental economics in the energy sector has experienced significant growth, with publications rising from just 2 in 2004 to 27 in 2023 as shown in figure 2. This increase reflects growing interest in addressing the complexities of environmental economics in energy systems. Early studies focused on market behavior and public policy, while recent research has expanded to explore sustainable energy use and renewable energy financing. The economic impact of energy policies, particularly in terms of regulation and market behavior, is becoming a critical focus. Notably, the number of citations per article peaked in 2013 at 93.5, with an average citation count of 39.67 across all documents. However, in recent years, citation rates have declined, with 2024 showing an average of 3.86 citations per paper. The overall growth in publications, averaging an annual growth rate of 14.31%, indicates increasing recognition of environmental economics within the energy sector. Collaboration is common, with 37.13% of papers involving international co-authorship. Of the 237 total documents, 226 are articles and 11 are reviews, underscoring the ongoing expansion of research in this field.

A significant study in the field of environmental economics, "Public-private partnerships investment in energy as a new determinant of CO2 emissions: the role of technological innovations in China" by Shahbaz et al. (2020), stands as the most cited article on Scopus as of November 1, 2024, with 431 citations (Table 1). This emphasizes the growing interest in understanding how investments in energy, particularly through public-private partnerships, can influence CO2 emissions and the role of technological innovations in addressing environmental challenges. In the context of the energy sector, there is ongoing debate regarding the best approaches for addressing environmental issues. Advocates for stricter regulations argue that enhanced rules are necessary to mitigate risks such as environmental degradation and ensure market stability, while others believe that more relaxed regulation can foster innovation and facilitate growth in the energy sector. Experts unanimously agree that the energy sector will experience heightened regulatory scrutiny in the future due to the need for enhanced environmental protection, improved energy efficiency, and overall stability (Shahbaz et al., 2016; Papadis and Tsatsaronis, 2020; Ulucak, 2020; Al-Shetwi, 2022).

The article with the highest average annual citations, Al-Shetwi (2022), which has garnered an impressive 94.00 citations/year

(Table 2), likely reflects the increasing attention given to sustainable energy practices and their integration into power sectors. This research addresses trends, environmental impacts, and challenges in renewable energy, a topic of significant relevance to current policy discussions and energy sector transformations. The growing importance of sustainable energy in the context of global environmental policies and the energy transition may account for the high citation rate (Shahbaz et al., 2020). The article's focus on technological innovations and their role in promoting green energy solutions aligns with broader efforts to mitigate environmental impacts through improved energy strategies (Papadis and Tsatsaronis, 2020). Moreover, the widespread interest in these themes, compounded by calls for decarbonization, has likely contributed to the article's prominent citation rate (Ulucak, 2020). This paper's comprehensive analysis of renewable energy integration into the power sector and its connection to global sustainability trends positions it as a key reference in ongoing discussions about the future of the energy sector and its regulatory challenges.

3.3. Authors and Journals Data

Table 3 outlines the top ten authors in the field based on their citation rates. This analysis considers the number of published

Table 1: The top ten articles with the highest citation counts on Scopus as of November, 2024

#	Reference	Article	# Citation
1	Shahbaz et al. (2020)	Public-private partnerships investment in energy as new determinant of CO2 emissions: The role of technological innovations in China.	431
2	Papadis and Tsatsaronis (2020)	Challenges in the decarbonization of the energy sector.	408
3	Shahbaz et al. (2016)	Financial development and environmental quality: the way forward.	378
4	Ulucak (2020)	How do environmental technologies affect green growth? Evidence from BRICS economies.	328
5	Al-Shetwi (2022)	Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges.	282
6	Eyraud et al. (2013)	Green investment: Trends and determinants.	253
7	Zafar et al. (2019)	The impact of globalization and financial development on environmental quality: Evidence from selected countries in the Organization for Economic Co-operation and Development (OECD).	220
8	Lee et al. (2017)	Water-energy nexus for urban water systems: A comparative review on energy intensity and environmental impacts in relation to global water risks.	205
9	Mastini et al. (2021)	A green new deal without growth?.	190
10	Guo et al. (2014)	Exploring the impacts of a carbon tax on the Chinese economy using a CGE model with a detailed disaggregation of energy sectors.	189

Table 2: The ten articles with the highest number of citations per year (CY) as of November 2024

#	Reference	Article	# Citation
1	Al-Shetwi (2022)	Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges	94.00
2	Shahbaz et al. (2020)	Public-private partnerships investment in energy as new determinant of CO_2 emissions: The role of technological innovations in China	86.20
3	Papadis and Tsatsaronis (2020)	Challenges in the decarbonization of the energy sector	81.60
4	Ulucak (2020)	How do environmental technologies affect green growth? Evidence from BRICS economies	65.60
5	Mastini et al. (2021)	A green new deal without growth?	47.50
6	Shahbaz et al. (2016)	Financial development and environmental quality: the way forward	42.00
7	Jin et al. (2021)	The financing efficiency of listed energy conservation and environmental protection firms: Evidence and implications for green finance in China	41.00
8	Sethi et al. (2024)	Do green finance, green technology innovation, and institutional quality help achieve environmental sustainability? Evidence from the developing economies	37.00
9	Zafar et al. (2019)	The impact of globalization and financial development on environmental quality: Evidence from selected countries in the Organization for Economic Co-operation and Development (OECD)	36.67
10	Fahmy (2022)	The rise in investors' awareness of climate risks after the Paris Agreement and the clean energy-oil-technology prices nexus	36.67

Table 3: The top ten authors who have achieved the highest citation rates

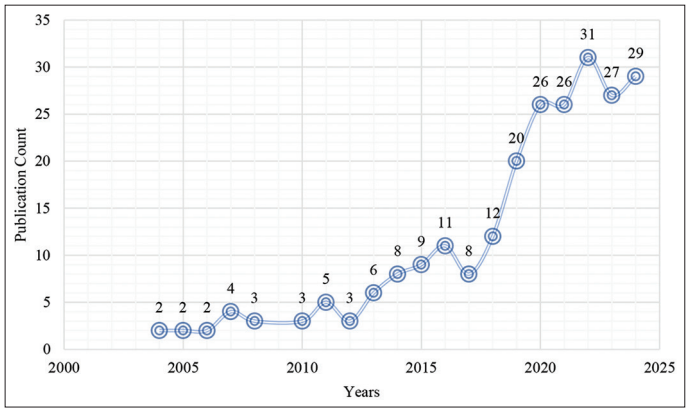
#	Author	h_index	g_index	m_index	# Citation	# Article	Citation Points	Year
1	Bekun Fv	4	4	0.8	127	4	31.75	2020
2	Alola Aa	3	3	0.75	92	3	30.67	2021
3	Huang G	3	3	0.429	154	3	51.33	2018
4	Liu L	3	3	0.429	163	3	54.33	2018
5	Paltsev S	3	3	0.429	111	3	37.00	2018
6	Wang H	3	3	0.375	235	3	78.33	2017
7	Ahmad N	2	2	0.222	470	2	235.00	2016
8	Andersen Ms	2	2	0.095	144	2	72.00	2004
9	Baetz B	2	2	0.286	139	2	69.50	2018
10	Bretschger L	2	2	0.143	48	2	24.00	2011

The citation points represent the average number of citations per year for each author

articles, total citations, and citation points per author. In 2020, Bekun Fv stands out with 127 citations across four articles, achieving a citation rate of 31.75. In 2021, Alola Aa published three articles, garnering 92 citations with a rate of 30.67. Huang G and Liu L, both with three publications in 2018, have earned citation rates of 51.33 and 54.33, respectively, reflecting strong scholarly influence. Wang H, with 235 citations from three articles published in 2017, achieved the highest citation rate at 78.33. Ahmad N, who published two articles in 2016, has received 470 citations, resulting in a citation rate of 235.00. Other notable authors include Andersen Ms, Baetz B, and Bretschger L, each contributing significantly to the field, with citation rates ranging from 24.00 to 72.00. These statistics provide a comprehensive view of the academic impact of these authors, highlighting their contributions to environmental economics and energy sector research.

Table 4 shows the ten most-cited journals in the field of energy economics. This analysis considers citation counts, the number of articles published, the average normalized impact per article, and SJR rankings. Among the top journals, *Energy Policy* and *Environmental Science and Pollution Research* stand out with 1470 and 793 citations, respectively, and both hold Q1 SJR rankings. These journals have significantly contributed to the literature, with high average normalized impact values of 81.67 and 41.74, respectively. *Climate Policy* and *Energy Economics* follow closely with notable citation counts of 449 and 1120, respectively, and average normalized impacts of 37.42 and 70.00. Additionally, journals like *Applied Energy* and *Science of the Total Environment* continue to publish impactful research, with average normalized impacts of 87.25 and 97.25, respectively, and both maintaining Q1 SJR rankings. These findings illustrate the prominent role of journals in shaping research trends and policy discussions in the energy sector.

Figure 2: Publishing count



3.4. Developed and Developing Countries

Research output in the energy sector, particularly in environmental economics, is notably higher in developed countries such as the USA, Germany, and the United Kingdom as shown in table 5. For instance, the USA leads with 711 citations from 39 articles, averaging 39.5 citations per article, while Germany follows with 575 citations across just 6 articles, achieving an average of 95.8 citations per article. These figures highlight the extensive research activity in developed economies, where environmental policies and regulations are often more established and have a well-established body of literature. In contrast, developing countries show less research output, although there are signs of emerging interest. China leads among developing economies with 1893 citations from 40 articles, averaging 40.3 citations per article. Turkey and Pakistan also demonstrate growing research, with 526 and 499 citations, respectively, reflecting an increasing focus on environmental economics. The citation averages for countries like Pakistan (124.8) and Saudi Arabia (146.5) suggest a high impact per publication. These trends underscore the disparity in research output between developed and developing countries, driven by differences in economic development and regulatory maturity. However, the rising citation impact in developing nations indicates a growing global engagement with environmental economic research, particularly in energy-related topics.

The Trump administration championed the "America First" policy, which marked a shift in US foreign policy by prioritizing domestic interests over global engagement (Figure 3). This approach led to increased trade tensions, particularly with China, and a withdrawal from international agreements like the Paris Climate Accord. Although this policy sought to strengthen American industry and decrease dependence on foreign trade, it also paved the way for China to fill the void. China's rapid economic growth and strategic investments, particularly through initiatives like the Belt and Road Initiative, have significantly enhanced its global influence. This rise has led to increased competition with the US in various sectors, including technology, manufacturing, and infrastructure. The strategic rivalry between the two superpowers has reshaped the global geopolitical landscape, with implications for trade,

Table 4: The ten journals that have received the highest number of citations

Element	h_index	g_index	m_index	# Citation	# Article	Average Norm. Impact	Year	SJR ranking
Energy Policy	15	18	0.714	1470	18	81.67	2004	Q1
Environmental Science and Pollution Research	14	19	1.75	793	19	41.74	2017	Q1
Climate Policy	11	12	0.524	449	12	37.42	2004	Q1
Energy Economics	11	16	0.611	1120	16	70.00	2007	Q1
Sustainability	10	17	0.909	313	17	18.41	2014	Q1
Applied Energy	8	8	0.667	698	8	87.25	2013	Q1
Science of the Total Environment	8	8	1	778	8	97.25	2017	Q1
Energy	7	13	0.636	810	13	62.31	2014	Q1
Ecological Economics	4	4	0.333	287	4	71.75	2013	Q1
Energy and Environment	4	5	0.235	166	5	33.20	2008	Q2

The top ten most-cited journals, showcasing their impact through citation counts, h-index, normalized impact, and SJR rankings, emphasizing their academic influence

technology, and security. As China continues to assert itself on the world stage, the dynamics of the US-China relationship will shape the course of global affairs in the coming years.

3.5. Keyword Co-occurrence Data

Figure 3 illustrates a network map derived from a keyword co-occurrence analysis, as outlined by Lamboglia et al. (2021). This map visually represents keywords as circles, with lines connecting them to show how frequently they co-appear in the analyzed studies. The size of each circle reflects the keyword's relative importance, with larger circles indicating more frequent usage, based on the methodology by Aria and Cuccurullo (2017). The thickness of the connecting lines signifies the strength of the relationship between keywords, based on their frequency of occurrence together. The placement of the circles on the map indicates their thematic connections, with closely positioned circles suggesting a stronger relationship. Additionally, keywords sharing the same color are grouped into thematic clusters, providing a clear visual representation of interrelated research areas in the field.

A co-occurrence network map was developed to illustrate the connections between commonly used keywords in the research, following the approach outlined by Lamboglia et al. (2021). To enhance clarity, isolated nodes—keywords with no connections to others—were removed. This resulted in a network map featuring 45 keywords, grouped into three thematic clusters (Figure 4).

Figure 3: Network map of country analysis based on bibliographic data from the Scopus database

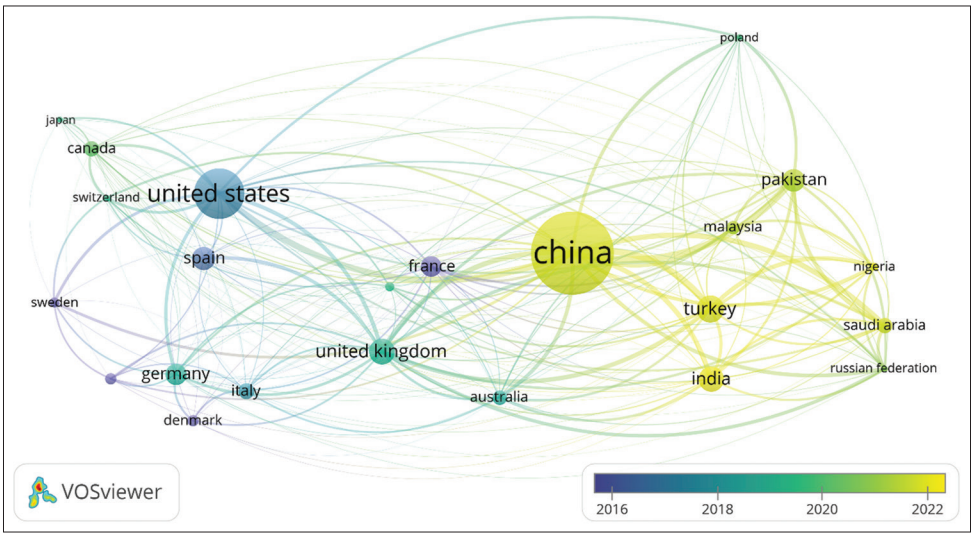
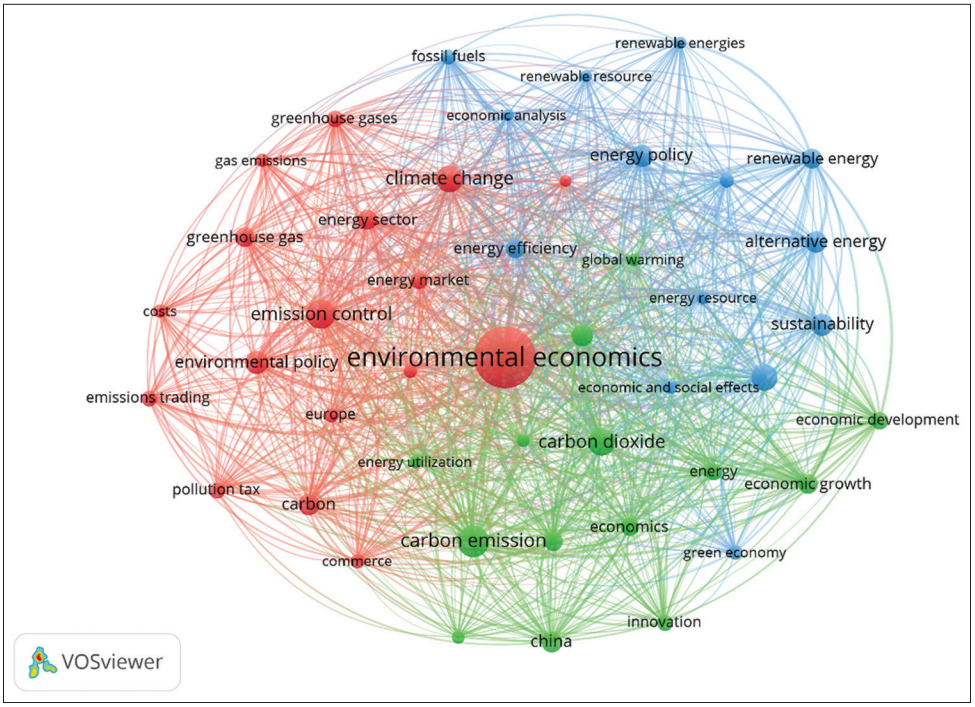


Figure 4: Network map of keyword co-occurrence analysis based on bibliographic data from the Scopus database



Crafting compelling titles using relevant keywords is essential for attracting attention to key research areas and effectively conveying the focus of research clusters. A well-designed title should reflect the core of the research, its scope, and its potential implications. For example, the title "Environmental Economics and Climate Change: Navigating Emissions and Policy" for the Red Cluster succinctly captures the cluster's emphasis on environmental economics, climate change, and emissions control. In the Green Cluster, "Economic Growth and Carbon Emissions: A Global Perspective on China and Innovation" reflects the cluster's exploration of the economic dynamics surrounding carbon emissions and growth, with a focus on China's role. The Blue Cluster's title, "Energy Policy and Sustainability: The Role of Renewable Resources in a Changing Energy Market," highlights its focus on energy resources, policy, and sustainability. These titles effectively summarize the clusters' key themes and objectives by employing clear, concise language relevant to the research focus.

Figure 5 shows visualization analysis reveals a surge in research activity at the intersection of environmental economics and energy policy between 2018 and 2020. The prominent clusters highlight key themes: climate change mitigation through policies like carbon pricing and renewable energy subsidies, the integration of renewable energy sources into the grid, energy efficiency measures to reduce consumption, sustainable development goals for equitable energy access, and the economic valuation of environmental externalities. These trends underscore the growing importance of sustainable energy solutions and the need for informed policymaking to balance economic growth with environmental protection.

3.6. Trend Topics Data

Figure 6 presents the results of a trend topic analysis, focusing on keywords that have appeared frequently in environmental economics research between 2004 and 2024. The analysis highlights keywords that appeared at least five times annually, with a maximum of three keywords considered per year. Data extracted from the Scopus dataset was analyzed using a scatter plot, where each bubble represents a keyword, with its size indicating the frequency of occurrence. The grey bars represent the first and third quartiles of the distribution, showing the longevity of scholarly interest in each topic. Over the years, several key trends emerge. From 2004 to 2016, topics like *carbon dioxide*, *climate change*, and *emission control* gradually gained prominence. The keyword *environmental economics* saw significant growth in frequency, with notable peaks in 2017 and 2020, reflecting a growing body of research in this area. Keywords such as *carbon emissions*, *sustainable development*, and *economic development* also experienced consistent increases in focus, particularly after 2018. By 2024, *China* emerged as a focal point in the context of global environmental policy and economic growth. The increasing frequency of topics like *carbon*, *sustainability*, and *environmental policy* underscores the growing importance of climate-related discussions in the field. This analysis highlights the key themes that have shaped environmental economics research over the past two decades, providing a comprehensive view of evolving academic interests.

4. DISCUSSION AND EMERGING RESEARCH DIRECTIONS

This section, derived from the common keyword and trend topic analyses, highlights key findings from the most influential papers in each thematic cluster identified in the keyword analysis (Figure 4). These clusters were formed by grouping frequently occurring keywords. By integrating insights from both the trend topic analysis and a content review of the most significant papers within each cluster, we can uncover emerging research trends and potential opportunities for future investigations. This method helps us grasp the current research landscape in each

Figure 5: Visualization map of keyword co-occurrence analysis based on bibliographic data from the Scopus database

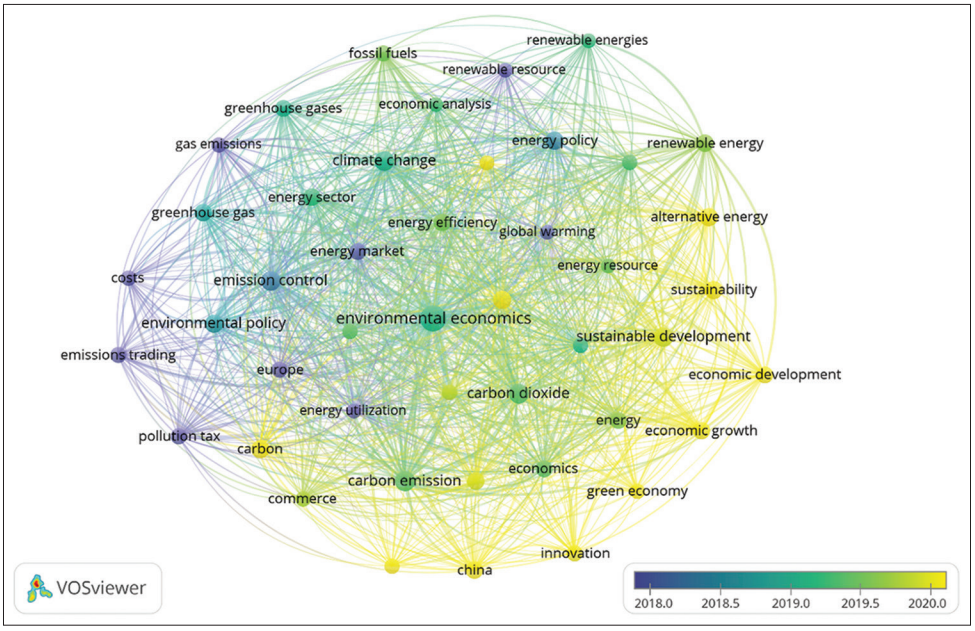
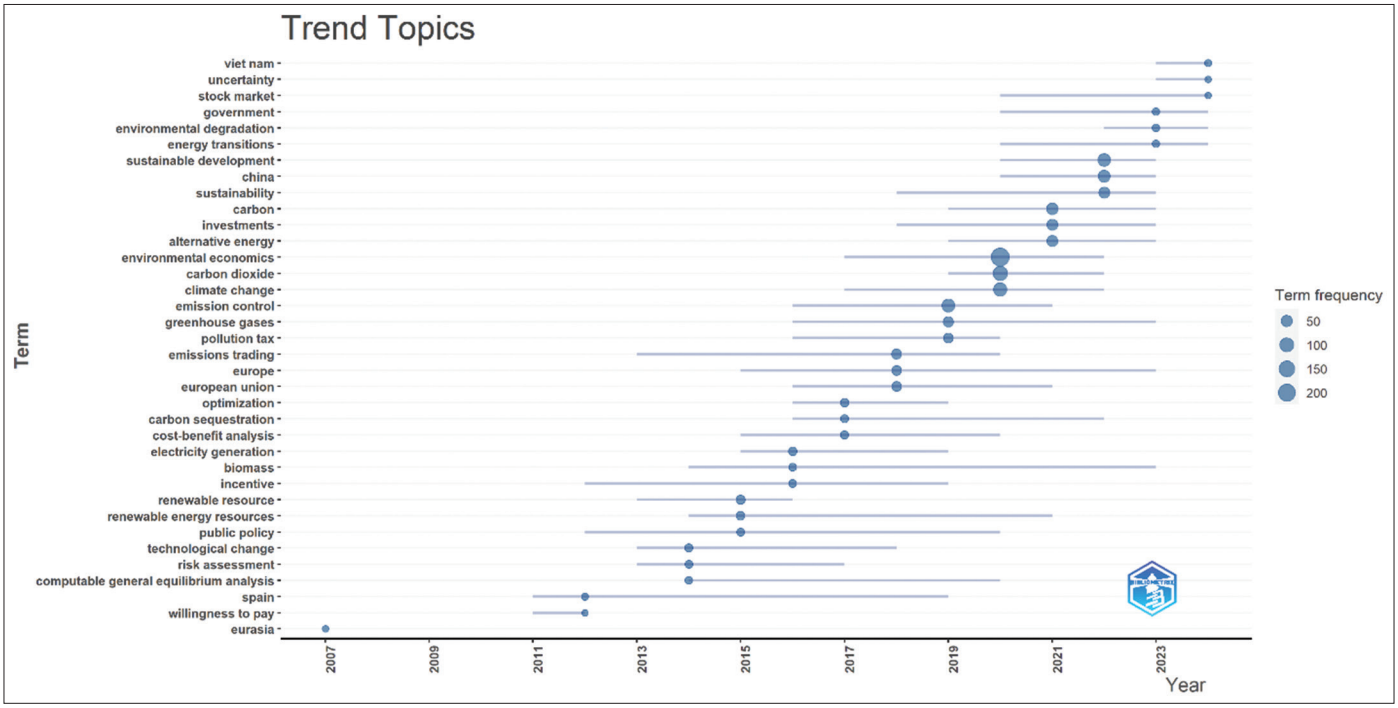


Figure 6: Examination of Key Topics Based on Bibliographic Data from the Scopus Dataset



thematic area while also identifying promising directions for further exploration.

Table 6 offers a synopsis of the main keywords, relevant publications, and prospective study questions resulting from new areas of inquiry within every cluster.

In our study, we used a co-occurrence network map (Figure 4) to visually illustrate the connections between frequently occurring keywords. Drawing on this approach, our network map identified three distinct thematic clusters, each representing a major area of research focus. These clusters are outlined as follows:

4.1. Red Cluster: "Environmental Economics and Climate Change: Navigating Emissions and Policy"

The Red Cluster investigates the intersection of environmental economics, climate change, and sustainable development within the financial landscape, examining both developed and developing countries. This topic is particularly significant due to the rapid growth of the environmental finance and green technology sectors, which are expected to reach substantial values in the coming years, creating both opportunities and challenges. In developed countries, the emphasis is on sophisticated green financial instruments and the adoption of advanced technologies to achieve net-zero emissions targets (Shahbaz et al., 2020; Eyraud et al., 2013; Ahmed et al., 2022). In contrast, developing countries face challenges in accessing finance for green technologies, requiring supportive regulatory frameworks to promote sustainable development (Zafar et al., 2019; Ulucak, 2020). This cluster covers research on a range of topics, including emissions regulation, renewable energy adoption, and the implications of financial innovations for sustainable development (Papadis and Tsatsaronis, 2020; Jin et al., 2021). Emissions regulation emerges as a central theme within this cluster, given its relevance to sectors that often rely on carbon markets or green technologies (Guo et al., 2014; Ibrahiem, 2020). The importance of regulation lies in its ability to ensure environmental protection, compliance with climate policies, and the promotion of sustainable practices, which ultimately fosters trust and confidence in green financial markets (Shahbaz et al., 2016). By examining emerging trends and key contributions within the cluster, researchers can uncover new directions for future studies (Lee et al., 2017). While some literature suggests that regulatory measures can enhance environmental integrity and climate policy compliance, debates remain about their potential to hinder economic growth, making this an essential area for exploration (Mastini et al., 2021).

In developed countries, the focus is often on more mature markets for green bonds, carbon trading, and advanced climate policies. These countries typically have well-established regulatory frameworks and financial systems to support environmental economics and emission reductions (Chen et al., 2021; Hájek et al., 2019). Researchers from these nations explore strategies to deepen green finance markets and create incentives for businesses to adopt sustainable practices (Hassan et al., 2022). In developing countries, however, the challenges are more complex, as they may lack the infrastructure or financial resources needed to implement large-scale sustainability initiatives (Nepal et al., 2021; Dritsaki and Dritsaki, 2014). The literature in the Red Cluster also explores the adoption of green technologies, such as renewable energy sources, and their implications for sustainable development, particularly in developing countries (Al-Shetwi, 2022; Fahmy, 2022). Researchers investigate the challenges and opportunities of adopting clean technologies in various sectors, as well as their potential to support climate change mitigation and achieve global sustainability targets (Markandya et al., 2016; Ibrahiem, 2020). Moreover, studies within this cluster examine the role of financial instruments in promoting sustainable investments and addressing socio-economic challenges, with a focus on policy lessons and best

Table 5: Most cited authors from developed and developing countries

Developed Countries	# Citation	# Article	Average Norm. Impact	Developing Countries	# Citation	# Article	Average Norm. Impact
USA	711	39	39.5	China	1893	40	40.3
Germany	575	6	95.8	Turkey	526	10	52.6
United Kingdom	261	9	29	Pakistan	499	4	124.8
Netherlands	231	6	38.5	Saudi Arabia	293	2	146.5
Australia	182	8	22.8	Bangladesh	117	2	58.5
Ireland	175	2	87.5	India	107	5	21.4
Canada	160	3	53.3	Egypt	141	2	70.5
Sweden	65	4	16.2	Mexico	131	3	43.7
Switzerland	128	4	32	Nigeria	62	1	62
Finland	16	1	16	Brazil	58	2	29

The table compares citation counts, article numbers, and average normalized impact between developed and developing countries, highlighting differences in research productivity and influence

Table 6: List of research clusters

Cluster	Topic	Key Areas of Focus	Challenges	Opportunities	Policy Implications	Key References
Red Cluster	Environmental Economics and Climate Change: Navigating Emissions and Policy	• Emissions regulation • Green financial instruments • Renewable energy adoption • Green technology adoption • Financial innovations	• Limited access to green finance in developing countries • Regulatory barriers • Economic growth hindrances	• Green finance sector growth • Technological innovations in both developed and developing countries • Carbon markets for green businesses	• Need for strong regulatory frameworks to ensure environmental protection • Support for green finance markets to promote sustainable development	Shahbaz et al., 2020; Eyraud et al., 2013; Zafar et al., 2019; Papadis and Tsatsaronis, 2020; Guo et al., 2014
Green Cluster	Economic Growth and Carbon Emissions: A Global Perspective on China and Innovation	• Economic growth versus carbon emissions • Innovation in green technologies • Sustainable economic growth • Role of fintech in carbon emission reduction	• Technological access issues in developing countries • Infrastructure limitations • Financial constraints	• Green technology adoption can foster sustainable growth Innovation in clean technologies offers opportunities for leapfrogging outdated systems	• Innovation can drive green economic growth in both developed and developing countries • Policies must balance economic growth with sustainability	Shahbaz et al., 2020; Papadis and Tsatsaronis, 2020; Chen et al., 2021; Ibrahiem, 2020; Enevoldsen et al., 2007
Blue Cluster	Energy Policy and Sustainability: The Role of Renewable Resources in a Changing Energy Market	• Renewable energy adoption • Legislative frameworks • Integration of renewable technologies • Energy poverty alleviation	• Infrastructure investment for renewable energy • Scalability challenges • Technology deployment hurdles	• Renewable energy systems can enhance efficiency and sustainability • Energy storage solutions for grid reliability	• The role of renewable energy in long-term sustainability • Investment in clean energy technologies is key to reducing carbon footprints	Shahbaz et al., 2016; Eyraud et al., 2013; Lee et al., 2017

practices from emerging markets (Zafar et al., 2019; Chen and Nie, 2016). Scholars analyze the contribution of environmental economics to sustainable development goals, focusing on how financial innovations can help countries transition to low-carbon economies (Dell'Anna, 2021; Duran and Saqib, 2024).

The cluster further investigates the impact of emission-reduction platforms and carbon markets on sustainable development in developing countries. Scholars explore how these platforms can facilitate access to finance for green businesses and promote environmental justice, thereby supporting climate resilience and poverty reduction (Corbet et al., 2021; Bozkurt and Akan, 2014). The literature also examines the role of regulatory frameworks in shaping the adoption of green technologies and practices within high-risk contexts, assessing their implications for global sustainability (Papadis and Tsatsaronis, 2020; Alege et al., 2016). Researchers evaluate the advantages and disadvantages of integrating carbon markets into national financial systems, considering factors such as regulatory frameworks, economic impacts, and environmental outcomes (Tian et al., 2021; Wang et al., 2014). Studies also analyze the factors influencing the adoption of environmental technologies and emission-reduction strategies

across various industries, including energy, transportation, and agriculture (Liu et al., 2018; Markandya et al., 2016). In this way, the Red Cluster emphasizes the importance of strong environmental policies, innovative technologies, and long-term strategies to foster equitable growth and support the global transition to a sustainable, low-carbon economy (Ibrahim et al., 2024; Shahbaz et al., 2016). By advancing knowledge in this critical area, researchers can contribute to the development of policies and strategies that drive environmental sustainability and support climate change mitigation efforts, particularly in the context of both developed and developing countries (Shahbaz et al., 2016; Mastini et al., 2021).

4.2. Green Cluster: "Economic Growth and Carbon Emissions: A Global Perspective on China and Innovation"

The relationship between economic growth and carbon emissions is a critical area of study, particularly in the context of China's role in global sustainability efforts, as well as the contrasting dynamics in developed and developing countries. As China continues to emerge as one of the world's largest economies, its economic growth inextricably links to carbon emissions, making this topic especially pertinent (Shahbaz et al., 2020). The economic boom has made China a focal point in global discussions about balancing development with environmental sustainability (Papadis and Tsatsaronis, 2020). This cluster delves into the relationship between economic growth and carbon emissions, exploring the role of innovation in mitigating environmental impact (Shahbaz et al., 2016). The issue becomes even more complex when considering the varying conditions in developed and developing countries. While developed countries often have more resources to adopt cleaner technologies and implement stringent regulations (Ulucak, 2020), developing nations face more significant barriers such as limited technological access and financial constraints (Al-Shetwi, 2022). The growing investment in green technologies in both regions highlights the potential for innovative solutions, such as renewable energy sources and energy-efficient technologies, to reduce carbon emissions while fostering sustainable economic growth (Eyraud et al., 2013). Regulatory frameworks play a key role in guiding these efforts, with differing challenges across the economic spectrum. In developed nations, these regulations often emphasize stricter environmental standards, whereas developing countries must balance economic growth with the adoption of cleaner technologies and resource-efficient practices (Zafar et al., 2019).

The literature within this cluster emphasizes the necessity of innovation to reduce carbon emissions while sustaining economic growth. For example, China's rapid industrialization has prompted a surge in emissions, but its government has made strides to incorporate green policies and technological innovations (Lee et al., 2017). In developed countries, the focus often lies on fostering innovation through research and development (RandD) in renewable energy, green manufacturing, and other low-emission technologies (Mastini et al., 2021). In contrast, developing countries, while adopting innovation, often face challenges such as inadequate infrastructure and financial limitations (Guo et al., 2014). This discrepancy in capabilities highlights the need for tailored approaches that address the unique challenges in each region (Jin et al., 2021). Moreover, studies suggest that China's role as an emerging global leader in green technology could influence the broader international landscape, offering valuable lessons for other developing economies (García-Martos et al., 2013). On a global scale, the adoption of sustainable practices and technologies is crucial for reducing the environmental footprint of industrial and economic growth, particularly in countries that are still in the process of industrialization (Hájek et al., 2019).

The economic implications of these developments are also significant. In developed countries, the shift to greener technologies can create new industries and markets, fostering long-term economic growth (Dell'Anna, 2021). However, the transition also presents risks, such as job displacement in traditional industries (Ibrahiem, 2020). In developing nations, innovation in green technologies can serve as a pathway to leapfrog outdated, polluting technologies, offering a potential advantage in fostering sustainable growth (Chen et al., 2021). Studies also explore how innovation can address economic disparities, especially in the context of carbon emissions (Enevoldsen et al., 2007). Green technologies, when accessible and affordable, can reduce emissions and provide economic opportunities, such as job creation in the clean energy sector (Markandya et al., 2016). However, further research is necessary to effectively scale these technologies in low-income regions, where limited access to resources and infrastructure may hinder their widespread adoption (Fahmy, 2022).

The intersection of fintech ecosystems and innovation presents an additional avenue for addressing carbon emissions. Both developed and developing nations are increasingly exploring fintech innovations as a means to support environmental sustainability (Corbet et al., 2021). Digital technologies can streamline economic activities to enhance energy efficiency and reduce waste, contributing to lower carbon footprints (Liu et al., 2018). Moreover, fintech has the potential to drive financial inclusion, allowing developing countries to tap into green investment opportunities (Ćetković and Buzogány, 2016). These innovations offer cost-effective solutions to mitigate carbon emissions, especially in regions where traditional solutions are economically unfeasible (Hassan et al., 2022). The relationship between economic growth and carbon emissions is complex, with innovation serving as a key driver in addressing sustainability challenges across different economies. In China, significant strides in green technology offer a potential model for other developing nations seeking to balance growth with environmental responsibility (Nepal et al., 2021). However, the challenges faced by developed and developing countries are distinct, and policy frameworks must account for these differences to foster global sustainability (Wang et al., 2014). By promoting innovation, sustainable practices, and economic policies tailored to the unique needs of each country, we can work toward a future where both economic growth and carbon emissions are managed effectively, contributing to a healthier and more prosperous global economy (Oparaocha and Dutta, 2011).

4.3. Blue Cluster: "Energy Policy and Sustainability: The Role of Renewable Resources in a Changing Energy Market"

Energy policy plays a critical role in fostering innovation while maintaining the integrity of the energy market and

protecting consumers. With the renewable energy sector growing exponentially, understanding the legal and regulatory frameworks governing these resources is essential for mitigating risks and ensuring the stability of energy markets (Shahbaz et al., 2020). By drawing on evidence from both trending topics and an analysis of the most relevant contributions within the sector, we can identify emerging research trends and potential opportunities for future studies. This approach allows us to understand the current state of research within each thematic area and pinpoint promising avenues for further exploration (Papadis and Tsatsaronis, 2020). Legislative frameworks significantly influence the potential for a global transition to clean energy, and as renewable energy solutions evolve, their integration into various market sectors necessitates ongoing analysis of policy implications and their effects on economic growth (Sadorsky, 2014).

The research within this sector highlights the transformative potential of renewable energy technologies across various industries, including electricity generation, transportation, and heating systems. Researchers are exploring how renewable solutions can enhance efficiency, reduce emissions, and build resilience in energy systems, paving the way for more inclusive and sustainable development (Shahbaz et al., 2016). This potential becomes increasingly important as more businesses and governments look to renewable energy for solutions to longstanding challenges in their operations. In developed countries, there is a strong focus on advancing technological innovations and integrating renewables into existing infrastructure, with an emphasis on reducing dependency on fossil fuels and meeting carbon neutrality targets (Ulucak, 2020). In developing countries, however, renewable energy adoption can address critical issues such as energy poverty, improving access to reliable and affordable energy, and reducing the environmental impact of traditional energy sources (Al-Shetwi, 2022). Studies also examine the impact of renewable energy adoption on economic development and energy access in these regions (Eyraud et al., 2013). By leveraging renewable energy technologies, researchers aim to address challenges related to energy scarcity, infrastructure development, and environmental protection (Zafar et al., 2019).

The literature also explores the environmental and economic implications of renewable resource utilization, particularly the challenges of integrating these technologies into existing infrastructure. Researchers are analyzing the efficiency, scalability, and sustainability of renewable energy systems, as well as the potential of energy storage solutions to enhance grid reliability and mitigate environmental impacts (Lee et al., 2017). In both developed and developing countries, the integration of renewable energy requires significant investment in infrastructure, policy development, and technology deployment (Mastini et al., 2021). Furthermore, the increasing cost-effectiveness of renewable technologies has highlighted their potential for long-term energy sustainability, making them viable options even in markets traditionally dependent on fossil fuels. As scrutiny over environmental sustainability intensifies, these factors will play a critical role in shaping the future of energy policy (Guo et al., 2014). Overall, the research findings underscore the transformative potential of renewable resources in reshaping energy systems, reducing carbon footprints, and fostering sustainable development (Jin et al., 2021). By analyzing emerging trends and identifying research gaps, scholars can contribute to the advancement of knowledge in this rapidly evolving field, driving positive social, economic, and environmental outcomes globally (García-Martos et al., 2013; Bihari et al., 2016).

Through this integrated approach to energy policy and research, stakeholders can better navigate the challenges posed by renewable energy adoption, ensuring a balanced and effective transition to cleaner, more sustainable energy systems. The findings from current literature provide valuable insights into the path forward, emphasizing the need for careful policy design, technological advancement, and international cooperation to unlock the full potential of renewable resources (Sorrell et al., 2018). As nations pursue ambitious climate goals, the role of renewable energy in mitigating climate change and achieving sustainable development becomes ever more urgent, demanding concerted global action (Kumbaroglu et al., 2011).

5. CONCLUSIONS

This study breaks new ground in the field of environmental economics by combining two powerful research methods. Bibliometric analysis, a quantitative approach, employs statistical methods to scrutinize large datasets of scholarly publications. Systematic literature review (SLR), a qualitative approach, meticulously reviews and analyzes relevant literature. Previous reviews in this area have typically relied on more traditional narrative methods or have focused on specific niches within the broader environmental economics landscape. This paper presents a unique contribution by offering a comprehensive and objective overview of the entire body of knowledge across various research streams in the energy sector. This will serve as a valuable foundation for new researchers aiming to make fresh contributions to the field. To achieve this goal, the study established a robust research protocol based on best practices for systematic literature reviews. The study also employed various bibliometric tools, such as VosViewer and Bibliometrix software, to perform analyses that map the field's performance and knowledge structure. The bibliometric analysis was complemented by a manual content analysis of important articles. This allowed for a more in-depth discussion of key findings within each research cluster and the discovery of possible gaps in current knowledge.

This study investigated the relevance of environmental economics in the energy sector by examining 237 journal articles published throughout the research period. The findings reveal a significant rise in research impact, with the number of articles growing from just 2 in 2004 to 29 in 2024. A key turning point came in 2022, following the widespread adoption of energy sector regulations by many countries. Additionally, recent years have seen a growing emphasis on the importance of non-financial information in sustainable energy decision-making. The analysis reveals that a few top journals, including Energy Policy and Environmental Science and Pollution Research, dominate the debate over relevance. Notably, Energy Policy accounts for nearly a third of all citations, likely due to the contributions of influential scholars

like Shahbaz et al. (2020), and Lee et al. (2017). The study's central contribution lies in identifying the six main thematic clusters that represent the primary knowledge pathways in value-relevant research. These clusters were identified through keyword analysis: (1) Red Cluster: "Energy Policy and Sustainability: The Role of Renewable Resources in a Changing Energy Market," (2) Green Cluster: "Decarbonization and Sustainable Finance in Renewable Energy," (3) Blue Cluster: "Energy Efficiency and Technological Innovations in Renewable Energy," (4) Yellow Cluster: "Global Policy Integration for Sustainable Energy Financing," (5) Purple Cluster: "Social Dimensions of Energy Transitions and Equity," and (6) Light Blue Cluster: "Economic Impact of Renewable Energy on Local Economies."

While there is a wealth of research on energy policy within the Red Cluster, a significant gap remains in understanding the specific regulatory challenges related to integrating renewable energy systems across diverse geopolitical contexts. Future research could investigate the intricacies of the regulatory frameworks governing renewable energy integration, addressing issues such as international cooperation, investment incentives, and market access barriers. Although the technological advancements in the Green Cluster have received considerable attention, research remains limited regarding the development of comprehensive frameworks for assessing and mitigating the environmental impacts of renewable energy technologies. Future studies could investigate energy-efficient production techniques, sustainable infrastructure, and innovative energy storage solutions to improve grid reliability and resilience.

While the transformative potential of renewable energy is a major focus within the Blue Cluster, a research gap exists regarding the socio-economic implications of energy transitions for marginalized communities in developing countries. Future research could explore how renewable energy solutions can empower underserved groups, enhance financial inclusion, and contribute to poverty alleviation and sustainable development in these regions. Furthermore, this study offers practical insights for policymakers, regulators, and industry stakeholders involved in energy sustainability. By identifying key thematic clusters and research gaps, stakeholders can prioritize areas for further investigation and policy development. For example, regulators can focus on refining frameworks for energy finance, creating incentives for green investments, and mitigating the social inequalities that often arise from energy transitions. Industry players, on the other hand, can leverage emerging trends such as energy storage innovations and decentralized renewable models to enhance sustainability and innovation strategies, fostering a more robust regulatory environment conducive to sustainable growth and development.

Building on the identified research gaps, policymakers should prioritize initiatives aimed at enhancing regulatory clarity, fostering innovation, and promoting sustainable practices in the energy sector. Regulators need to engage in proactive dialogue with industry stakeholders to develop adaptive regulatory frameworks that balance innovation with environmental sustainability. Policymakers can help the energy sector remain legitimate and successful in the long run by creating an environment that supports responsible innovation while also protecting consumer interests and promoting economic stability. In both developed and developing countries, regulators should focus on improving policy frameworks to facilitate the adoption of renewable technologies while ensuring equitable access to clean energy solutions.

To address the complex issues emerging in this dynamic field, new researchers should adopt interdisciplinary methods and foster networks for collaborative efforts. Staying attuned to new trends and regulatory developments will allow researchers to identify specific areas of study, contributing to the evolution of a rapidly changing field. By collaborating with industry stakeholders and policymakers, researchers can enhance the relevance and impact of their findings, ultimately driving positive change in the global energy transition and sustainability efforts. Future research could also focus on the scaling of green technologies, the role of fintech in sustainable energy financing, and the development of regulatory frameworks that balance economic growth with environmental responsibility. Through these efforts, scholars can contribute to a more effective and sustainable future in the energy sector.

REFERENCES

Abbas, A., Siddique, N., Gulzar, A., Khan, U.A., Khan, M.A., Mahmood, K. (2022), Characterizing elite scholars of library and information science: A bibliometric analysis. Journal of Information Management and Practices (JIMP), 2(2), 1-20.

Abu Anzeh, A.Y., Basel Abushaweesh, Q., Alfayez, M., AlQudah, M.Z. (2024), Mapping the future information systems and marketing strategy-a bibliometric analysis of emerging trends. EDPACS, 69(10), 1-29.

Abu Orabi, T., Almasarweh, M.S., Qteishat, M.K., Qudah, H.A., AlQudah, M.Z. (2024), Mapping leadership and organizational commitment trends: A bibliometric review. Administrative Sciences, 14(8), 171.

Afeltra, G., Alerasoul, A., Usman, B. (2022), Board of directors and corporate social reporting: A systematic literature network analysis. Accounting in Europe, 19(1), 48-77.

Ahmed, Z., Cary, M., Ali, S., Murshed, M., Ullah, H., Mahmood, H. (2022), Moving toward a green revolution in Japan: symmetric and asymmetric relationships among clean energy technology development investments, economic growth, and CO_2 emissions. Energy andEnvironment, 33(7), 1417-1440.

Akpan, G.E., Akpan, U.F. (2012), Electricity consumption, carbon emissions and economic growth in Nigeria. International Journal of Energy Economics and Policy, 2(4), 292-306.

Al Karabsheh, F.I., Abuorabi, Y.K., Abdul Kareem Abu Shaqra, K.T., AlQudah, M.Z. (2024), Quantifying the evolution of it audit and control practices: A bibliometric approach. EDPACS, 69(8), 1-20.

Al Qudah, S.M.A., Bargues, J.L.F., Gisbert, P.F. (2023), The effect of COVID-19 on the research trends on project risk management and achievement of sustainable development goals. Journal of the Knowledge Economy, 15, 1-19.

Aladayleh, K.J., Al Qudah, S.M.A., Bargues, J.L.F., Gisbert, P.F. (2023), Global trends of the research on COVID-19 risks effect in sustainable facility management fields: A bibliometric analysis. Engineering Management in Production and Services, 15(1), 12-28.

Alege, P.O., Adediran, O.S., Ogundipe, A.A. (2016), Pollutant emissions, energy consumption and economic growth in Nigeria. International Journal of Energy Economics and Policy, 6(2), 202-207.

Alqudah, H., Al Qudah, M.Z., Abu Huson, Y., Lutfi, A., Alrawad, M.,

Almaiah, M.A. (2024), A decade of green economic literature: An analysis-based bibliometric. International Journal of Energy Economics and Policy, 14(3), 497-511.
Alqudah, M., Ferruz, L., Martín, E., Qudah, H., Hamdan, F. (2023), The sustainability of investing in cryptocurrencies: A bibliometric analysis of research trends. International Journal of Financial Studies, 11(3), 93.
AlQudah, M.Z., Samara, H., Qudah, H., Nazzal, R., Yousef Bani Hani, L., Radwan, R.A., Alrahamneh, S. (2024), Financial technology's role in advancing social responsibility: A bibliometric review of research progress and future opportunities. International Journal of Law and Management, 66(5), 1-12.
ALShanti, A.M., Al-Azab, H.A.H., Humeedat, M.M., AlQudah, M.Z. (2024), Exploring the evolution of creative accounting and external auditors: Bibliometric analysis. Cogent Business and Management, 11(1), 2300500.
Al-Shetwi, A.Q. (2022), Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges. Science of The Total Environment, 822, 153645.
Aria, M., Cuccurullo, C. (2017), Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959-975.
Bozkurt, C., Akan, Y. (2014), Economic growth, CO_2 emissions and energy consumption: The Turkish case. International Journal of Energy Economics and Policy, 4(3), 484-494.
Cala, A., Maturana-Cordoba, A., Soto-Verjel, J. (2023), Exploring the pretreatments' influence on pressure reverse osmosis: PRISMA review. Renewable and Sustainable Energy Reviews, 188, 113866.
Caputo, A., Marzi, G., Pellegrini, M.M., Rialti, R. (2018), Conflict management in family businesses: A bibliometric analysis and systematic literature review. International Journal of Conflict Management, 29(4), 519-542.
Caputo, A., Pizzi, S., Pellegrini, M.M., Dabić, M. (2021), Digitalization and business models: Where are we going? A science map of the field. Journal of Business Research, 123, 489-501.
Ćetković, S., Buzogány, A. (2016), Varieties of capitalism and clean energy transitions in the European Union: When renewable energy hits different economic logics. Climate Policy, 16(5), 642-657.
Chen, C., Hu, Y., Karuppiah, M., Kumar, P.M. (2021), Artificial intelligence on economic evaluation of energy efficiency and renewable energy technologies. Sustainable Energy Technologies and Assessments, 47, 101358.
Chen, Z.Y., Nie, P.Y. (2016), Effects of carbon tax on social welfare: A case study of China. Applied Energy, 183, 1607-1615.
Corbet, S., Lucey, B., Yarovaya, L. (2021), Bitcoin-energy markets interrelationships-New evidence. Resources Policy, 70, 101916.
Dell'Anna, F. (2021), Green jobs and energy efficiency as strategies for economic growth and the reduction of environmental impacts. Energy Policy, 149, 112031.
Dol, J., Dennis, C.L., Campbell-Yeo, M., Leahy-Warren, P. (2024), Bibliometric analysis of published articles on perinatal depression from 1920 to 2020. Birth, 51(1), 28-38.
Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W.M. (2021), How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285-296.
Dritsaki, C., Dritsaki, M. (2014), Causal relationship between energy consumption, economic growth and CO_2 emissions: A dynamic panel data approach. International Journal of Energy Economics and Policy, 4(2), 125-136.
Duran, I.A., Saqib, N. (2024), Load capacity factor and environmental quality: Unveiling the role of economic growth, green innovations, and environmental policies in G20 economies. International Journal of Energy Economics and Policy, 14(6), 287-294.
Enevoldsen, M.K., Ryelund, A.V., Andersen, M.S. (2007), Decoupling of industrial energy consumption and CO_2-emissions in energy-intensive industries in Scandinavia. Energy Economics, 29(4), 665-692.
Eyraud, L., Clements, B., Wane, A. (2013), Green investment: Trends and determinants. Energy Policy, 60, 852-865.
Fahmy, H. (2022), The rise in investors' awareness of climate risks after the Paris agreement and the clean energy-oil-technology prices nexus. Energy Economics, 106, 105738.
Farhani, S., Rejeb, J.B. (2012), Energy consumption, economic growth and CO_2 emissions: Evidence from panel data for MENA region. International Journal of Energy Economics and Policy, 2(2), 71-81.
Farooq, M., Wahid, A., Zahra, N., Hafeez, M. B., & Siddique, K. H. (2024), Recent advances in plant drought tolerance. Journal of Plant Growth Regulation, 1-33.
García-Martos, C., Rodríguez, J., Sánchez, M.J. (2013), Modelling and forecasting fossil fuels, CO_2 and electricity prices and their volatilities. Applied Energy, 101, 363-375.
Gerged, A.M., Arslan, H.M., Abbas, A., Chen, S., Manzoor, S. (2023), A bibliometric review of corporate environmental disclosure literature. Journal of Accounting Literature, 46, 214-237.
Gómez-Núñez, A.J., Vargas-Quesada, B., De Moya-Anegón, F. (2016), Updating the SCI mago journal and country rank classification: A new approach using Ward's clustering and alternative combination of citation measures. Journal of the Association for Information Science and Technology, 67(1), 178-190.
Guo, Z., Zhang, X., Zheng, Y., Rao, R. (2014), Exploring the impacts of a carbon tax on the Chinese economy using a CGE model with a detailed disaggregation of energy sectors. Energy Economics, 45, 455-462.
Hájek, M., Zimmermannová, J., Helman, K., Rozenský, L. (2019), Analysis of carbon tax efficiency in energy industries of selected EU countries. Energy Policy, 134, 110955.
Hassan, T., Song, H., Khan, Y., Kirikkaleli, D. (2022), Energy efficiency a source of low carbon energy sources? Evidence from 16 high-income OECD economies. Energy, 243, 123063.
Helbach, J., Hoffmann, F., Pieper, D., Allers, K. (2023), Reporting according to the preferred reporting items for systematic reviews and meta-analyses for abstracts (PRISMA-A) depends on abstract length. Journal of Clinical Epidemiology, 154, 167-177.
Ibrahiem, D.M. (2020), Do technological innovations and financial development improve environmental quality in Egypt? Environmental Science and Pollution Research, 27(10), 10869-10881.
Ibrahim, A., Almasria, N.A., Almaqtari, F.A., Al-Kasasbeh, O., Alhatabatb, Z., Ershaid, D. (2024), The impact of green finance, fintech and digital economy on environmental sustainability: Evidence from advanced panel techniques. International Journal of Energy Economics and Policy, 14(6), 621-627.
Janssens, F., Glänzel, W., De Moor, B. (2008), A hybrid mapping of information science. Scientometrics, 75(3), 607-631.
Jin, Y., Gao, X., Wang, M. (2021), The financing efficiency of listed energy conservation and environmental protection firms: Evidence and implications for green finance in China. Energy Policy, 153, 112254.
Kumbaroğlu, G. (2011), A sectoral decomposition analysis of Turkish CO2 emissions over 1990–2007. Energy, 36(5), 2419-2433.
Laila, N., Rusydiana, A.S., Irfany, M.I., Imron, H.R., Srisusilawati, P., Taqi, M. (2021), Energy economics in Islamic countries: A bibliometric review. International Journal of Energy Economics and Policy, 11(2), 88-95.
Lamboglia, R., Lavorato, D., Scornavacca, E., Za, S. (2021), Exploring the relationship between audit and technology. A bibliometric analysis. Meditari Accountancy Research, 29(5), 1233-1260.
Lee, M., Keller, A.A., Chiang, P.C., Den, W., Wang, H., Hou, C.H., Yan, J.

(2017), Water-energy nexus for urban water systems: A comparative review on energy intensity and environmental impacts in relation to global water risks. Applied Energy, 205, 589-601.
Liu, L., Huang, C.Z., Huang, G., Baetz, B., Pittendrigh, S.M. (2018), How a carbon tax will affect an emission-intensive economy: A case study of the Province of Saskatchewan, Canada. Energy, 159, 817-826.
Markandya, A., Arto, I., González-Eguino, M., Román, M.V. (2016), Towards a green energy economy? Tracking the employment effects of low-carbon technologies in the European Union. Applied Energy, 179, 1342-1350.
Masa'deh, R.E., AlQudah, M.Z., Shatnawi, A., Samara, H., Ghasawneh, D., Al-Majali, R.T., Al-Rahamneh, A. (2024), Digital Technologies in Business Education: A Hybrid Literature Review from the Web of Science Database. United Kingdom: Emerald Publishing.
Massaro, M., Dumay, J., Guthrie, J. (2016), On the shoulders of giants: Undertaking a structured literature review in accounting. Accounting, Auditing and Accountability Journal, 29(5), 767-801.
Mastini, R., Kallis, G., Hickel, J. (2021), A green new deal without growth? Ecological Economics, 179, 106832.
Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L.A., Prisma-P Group. (2015), Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews, 4, 1.
Momani, M.A.K.A., Alharahasheh, K.A., Alqudah, M. (2023), Digital learning in sciences education: A literature review. Cogent Education, 10(2), 2277007.
Nepal, R., Paija, N., Tyagi, B., Harvie, C. (2021), Energy security, economic growth and environmental sustainability in India: Does FDI and trade openness play a role? Journal of Environmental Management, 281, 111886.
Oliveira, W., Hamari, J., Shi, L., Toda, A.M., Rodrigues, L., Palomino, P.T., Isotani, S. (2023), Tailored gamification in education: A literature review and future agenda. Education and Information Technologies, 28(1), 373-406.
Oparaocha, S., Dutta, S. (2011), Gender and energy for sustainable development. Current Opinion in Environmental Sustainability, 3(4), 265-271.
Otitolaiye, V.O., Abd Aziz, F.S. (2024), Bibliometric analysis of safety management system research (2001-2021), Journal of Safety Research, 88, 111-124.
Papadis, E., Tsatsaronis, G. (2020), Challenges in the decarbonization of the energy sector. Energy, 205, 118025.
Petticrew, M., Roberts, H. (2008), Systematic Reviews in the Social Sciences: A Practical Guide. John Wiley and Sons.
Pizzi, S., Caputo, A., Corvino, A., Venturelli, A. (2020), Management research and the UN sustainable development goals (SDGs): A bibliometric investigation and systematic review. Journal of Cleaner Production, 276, 124033.
Pizzi, S., Venturelli, A., Variale, M., Macario, G.P. (2021), Assessing the impacts of digital transformation on internal auditing: A bibliometric analysis. Technology in Society, 67, 101738.
Pritchard, A. (1969), Statistical bibliography or bibliometrics. Journal of Documentation, 25, 348.
Qabajeh, M., Qubbaja, A., Jebreel, M., Zakaria AlQudah, M., Salim Faiq Alkhatib, F. (2024), Trends and patterns in coso-related auditing research: A bibliometric study. EDPACS, 69(10), 30-53.
Qudah, H., Baqila, B.K.A., Albadienah, J.M.O., AlQudah, M.Z., Al Qudah, S., Alrahamneh, S., Ababne, A., Qudah, I. (2024), Using bibliometrics to understand algorithmic finance. Journal of Applied Economics, 27(1), 2389497.
Qudah, H., Malahim, S., Airout, R., Alomari, M., Hamour, A.A., Alqudah, M. (2023), Islamic finance in the era of financial technology: A bibliometric review of future trends. International Journal of Financial Studies, 11(2), 76.
Qudah, H., Malahim, S., Airout, R., AlQudah, M.Z., Al-Zoubi, W.K., Huson, Y.A., Zyadat, A. (2024), Unlocking the ESG value of sustainable investments in cryptocurrency: A bibliometric review of research trends. Technology Analysis and Strategic Management, 2024, 1-15.
Raan, A.F.V. (2008), Scaling rules in the science system: Influence of field-specific citation characteristics on the impact of research groups. Journal of the American Society for Information Science and Technology, 59(4), 565-576.
Sadorsky, P. (2014), The effect of urbanization on CO_2 emissions in emerging economies. Energy economics, 41, 147-153.
Santos, C., Mehrsai, A., Barros, A.C., Araújo, M., Ares, E. (2017), Towards Industry 4.0: An overview of European strategic roadmaps. Procedia Manufacturing, 13, 972-979.
Saxena, C., Kumar, P. (2023), Bibliometric Analysis of Journal of Money Laundering Control: Emerging Trends and a Way Forward. Journal of Money Laundering Control, 26(1), 1-22.
Sethi, L., Behera, B., Sethi, N. (2024), Do green finance, green technology innovation, and institutional quality help achieve environmental sustainability? Evidence from the developing economies. Sustainable Development, 32(3), 2709-2723.
Shahbaz, M., Raghutla, C., Song, M., Zameer, H., Jiao, Z. (2020), Public-private partnerships investment in energy as new determinant of CO_2 emissions: The role of technological innovations in China. Energy Economics, 86, 104664.
Shahbaz, M., Shahzad, S.J.H., Ahmad, N., Alam, S. (2016), Financial development and environmental quality: The way forward. Energy Policy, 98, 353-364.
Sharifi, A., Khavarian-Garmsir, A.R., Allam, Z., Asadzadeh, A. (2023), Progress and prospects in planning: A bibliometric review of literature in Urban studies and regional and Urban Planning, 1956-2022. Progress in Planning, 173, 100740.
Singh, N., Gupta, A., Kapur, B. (2023), A bibliometric analysis of IJQRM journal (2002-2022). International Journal of Quality and Reliability Management, 40(7), 1647-1666.
Sorrell, S. (2018), Explaining sociotechnical transitions: A critical realist perspective. Research Policy, 47(7), 1267-1282.
Tian, X.L., Bélaïd, F., Ahmad, N. (2021), Exploring the nexus between tourism development and environmental quality: Role of renewable energy consumption and income. Structural Change and Economic Dynamics, 56, 53-63.
Thakur, P., & Bhalerao, A. (2023), High Homocysteine Levels During Pregnancy and Its Association With Placenta-Mediated Complications: A Scoping Review. Cureus, 15(2).
Touijrat, B., Benaid, B., Bouzahir, H. (2021), The differences in mean and volatility shock transmission among Bitcoin, currencies from developed countries, and currencies from emerging countries. International Journal of Applied Economics, Finance, and Accounting, 10(2), 40-48.
Tranfield, D., Denyer, D., & Smart, P. (2003), Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British journal of management, 14(3), 207-222.
Ulucak, R. (2020), How do environmental technologies affect green growth? Evidence from BRICS economies. Science of the Total Environment, 712, 136504.
Van Eck, N., Waltman, L. (2010), Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523-538.
Van Eck, N.J., Waltman, L. (2011), Text mining and visualization using VOSviewer. [arXiv Preprint].
Van Eck, N.J., Waltman, L. (2013), VOSviewer Manual. Vol. 1. Leiden: Univeristeit Leiden. p1-53.
Van Eck, N.J., Waltman, L. (2014), Visualizing bibliometric networks. In: Measuring Scholarly Impact: Methods and Practice. Cham: Springer

International Publishing. p285-320.
Van Eck, N.J., Waltman, L. (2017), Citation-based clustering of publications using Cit Net Explorer and VOSviewer. Scientometrics, 111, 1053-1070.
Waltman, L., Van Eck, N.J. (2013), A systematic empirical comparison of different approaches for normalizing citation impact indicators. Journal of Informetrics, 7(4), 833-849.
Waltman, L., Van Eck, N.J., Noyons, E.C. (2010), A unified approach to mapping and clustering of bibliometric networks. Journal of informetrics, 4(4), 629-635.
Wang, D., Li, S., Sueyoshi, T. (2014), DEA environmental assessment on US Industrial sectors: Investment for improvement in operational and environmental performance to attain corporate sustainability. Energy Economics, 45, 254-267.
Wong, D. (2018), VOSviewer. Technical Services Quarterly, 35(2), 219-220.
Yang, L.C., Liu, F.H., Liu, C.M., Yu, C.H., Chang, Y.C. (2023), Bibliometric analysis of top-cited articles. Journal of Dental Sciences, 18(1), 338-344.
Zafar, M.W., Saud, S., Hou, F. (2019), The impact of globalization and financial development on environmental quality: Evidence from selected countries in the Organization for Economic Co-operation and Development (OECD). Environmental Science and Pollution Research, 26, 13246-13262.