

Article

Renewable Energy Integration for Sustainable Economic Growth: Insights and Challenges via Bibliometric Analysis

Chien-Heng Chou ¹, Sa Ly Ngo ² and Phung Phi Tran ^{3,*} 

¹ Department of International Business Administration, Chinese Culture University, Taipei 11114, Taiwan; chouchdr@faculty.pccu.edu.tw

² Faculty of Business Administration, Dong A University, Da Nang City 50000, Vietnam; lynts@donga.edu.vn

³ Faculty of Business Administration, Ton Duc Thang University, Ho Chi Minh City 729000, Vietnam

* Correspondence: tranthiphung@tdtu.edu.vn

Abstract: This study investigates trends in research at the intersection of economic growth and renewable energy, recognizing the pressing need for sustainable long-term development. Through a comprehensive bibliometric analysis of 6794 research papers sourced from the Web of Science database spanning the period from 1990 to June 2023, this research provides valuable insights into the evolving research landscape. It sheds light on seminal works, noteworthy authors, and emerging themes within this interdisciplinary field. The findings of this study underscore the critical importance of harnessing renewable energy sources in the pursuit of enduring economic growth. Beyond the well-documented environmental benefits, renewable energy plays a pivotal role in catalyzing a green economic transformation. This transformation not only mitigates adverse ecological impacts, but also fosters job creation, local community development, and enhanced energy security. Moreover, our analysis uncovers a compelling positive correlation between the adoption of renewable energy and key economic indicators, including Gross Domestic Product (GDP) growth, industrial productivity, and technological innovation. This correlation is particularly pronounced in regions endowed with abundant renewable resources, reaffirming the potential for renewable energy to stimulate investment, propel economic expansion, and promote equitable development. This study serves as a roadmap toward a more sustainable and resilient future by advocating for the integration of renewable energy, the advancement of sustainable economic growth, and the formulation of effective strategies. The insights gleaned from this research are instrumental in guiding policymakers, researchers, and stakeholders toward the realization of a greener and more prosperous world.

Keywords: renewable energy; economic growth; sustainability; bibliometric analysis; energy transition; green economy



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1. Introduction

The pursuit of economic growth has long stood as the central objective for nations, propelling advancements in technology, infrastructure, and industry on a global scale [1]. Simultaneously, this unrelenting drive towards industrialization and economic prosperity has brought forth significant environmental costs. The extensive reliance on fossil fuels, a hallmark of this growth, has spawned adverse consequences such as climate change and environmental degradation, as underscored by reports from the Intergovernmental Panel on Climate Change (IPCC) in 2018 and the United Nations Environment Programme (UNEP) in 2019. Amid these mounting challenges, a growing recognition of the urgent need to transition to renewable energy sources has emerged as a linchpin for achieving sustainable economic growth [2,3].

This paradigm shift towards renewables, encompassing solar, wind, hydro, and geothermal power sources, holds significant promise as a replacement for fossil fuels. However, realizing the full potential of renewable energies entails understanding both

their benefits and limitations. Moreover, scholars have emphasized the critical importance of assessing the environmental, economic, and social implications of renewable energy technologies to gauge their effectiveness in mitigating greenhouse gas emissions, combating climate change, and fostering sustainable development [2–4]. Furthermore, it is imperative to identify the constraints and challenges that hinder the extensive implementation of renewable energies to formulate efficacious policies and strategies [5,6]. In conclusion, the aforementioned research serves to assist policymakers and stakeholders in making well-informed decisions on the practical challenges, technological limitations, and infrastructure prerequisites associated with the integration of renewable energy.

Furthermore, the attainment of sustainable development necessitates a comprehension of the variables that impact environmentally-friendly economic expansion. Energy is a crucial component of economic activities, and the shift towards cleaner and more sustainable energy sources is a significant catalyst for the growth of environmentally friendly economic development. A thorough examination of energy efficiency, technological innovation, policy frameworks, and market dynamics is necessary to assess the impact of different energy-related factors on economic growth, as suggested by various sources [3,5,7,8]. Therefore, it is imperative that a thorough examination of energy efficiency, technological innovation, policy frameworks, and market dynamics is necessary to assess the impact of different energy-related factors on economic growth. By conducting such an analysis, policymakers can formulate and execute proficient strategies aimed at encouraging the uptake of renewable energy sources, catalyzing investments in environmentally friendly technologies, and cultivating sustainable economic development.

Crucially, this endeavor demands a thorough exploration of the hurdles and obstacles hindering the widespread adoption of renewable energy. Policymakers and stakeholders require insights into the practical challenges, technological constraints, and infrastructural prerequisites associated with this transition [5,6]. By delving into the intricate interplay between renewable energy, economic growth, and environmental sustainability, this research strives to provide comprehensive guidance to policymakers and industry leaders in their quest to shape effective policies and strategies. However, previous research efforts have often fallen short in certain key areas [4]. A comprehensive investigation into distinct renewable energy technologies, including their unique advantages and drawbacks, remains a critical gap. Additionally, an absence of regional or national contextualization limits our understanding of the diverse challenges and opportunities in achieving sustainable economic development [5]. Furthermore, interdisciplinary research linking economic development and renewable energy integration is still underexplored, impeding a holistic comprehension of this multifaceted challenge [8,9]. Furthermore, this research not only deepens our understanding but also sheds light on possible trade-offs and synergies that may exist between economic growth and energy consumption. Ultimately, the insights gained from this research have a practical application as they can assist policymakers in developing sustainable energy planning and management strategies [3,9].

The process of shifting towards renewable energies is faced with various challenges and requires substantial investments in infrastructure, technological advancements, and human resources. This complex transition, marked by the incorporation of intermittent renewable energy sources into pre-existing energy systems, presents a multitude of technical and logistical obstacles. Contemporary research, exemplified by the bibliometric analysis carried out on the green economy and renewable energy policy, can provide valuable insights into the determinants that impact the uptake of renewable energy sources in addressing these intricate issues [8]. This was also highlighted by the comprehensive bibliometric analysis conducted [9], which explored the advancements in green and renewable energy technologies, providing insight into their potential impact on sustainable development.

It is crucial to examine the correlation between economic growth and renewable energies within the framework of sustainable development. This study extends significant insights to policymakers, industry leaders, and society at large by comprehensively examin-

ing the impacts and constraints of renewable energy integration, the determinants of green economic expansion, and the intricate interplay between economic growth and energy usage. Drawing on the findings of numerous academic papers, including those authored by [8,9] and several others, it becomes evident that these insights play a pivotal role in guiding the formulation of effective policies and strategies. These strategies aim to promote sustainable economic growth while simultaneously mitigating the environmental impacts associated with traditional energy sources. This study ultimately contributes to worldwide efforts toward a more environmentally friendly, resilient, and sustainable future.

Prior research may have exhibited a deficiency in concentrating on distinct renewable energy technologies, including solar, wind, hydro, and geothermal power, thereby requiring further comprehensive investigation [4]. Moreover, a lack of thorough examination of regional or national contexts results in an incomplete comprehension of the distinct obstacles and prospects for achieving sustainable economic development in various regions and countries, as stated by the European Commission in 2020. This underscores the necessity for a comprehensive examination of these domains [9]. Furthermore, the absence of interdisciplinary research impedes a thorough comprehension of the intricate interplay between various disciplines concerning economic development and the integration of renewable energy sources [8,9]. Further investigation is necessary to explore innovative financing mechanisms, business models, and public–private partnerships that can facilitate the adoption of renewable energies and promote sustainable economic growth, as noted by [8]. The identification and analysis of these gaps in the existing literature can offer policymakers, industry leaders, and society at large significant insights.

This paper employs bibliometric analysis to comprehend the research landscape concerning the correlation between economic growth and renewable energies. This methodology facilitates the identification of significant patterns and correlations within a given subject matter. Bibliometric analysis has the potential to uncover citation patterns and recognize significant works in the correlation between economic growth and renewable energies. This can aid policymakers in making well-informed decisions and advancing the field's knowledge [8,9]. The references cited are Qin and Ziabina both published in the year 2023 [6,7]. Citation analysis is a method used to identify noteworthy works and authors within a particular field by analyzing the citations present in academic papers. For example, it can assist in identifying pertinent research on the topics of economic growth and renewable energy. This study elucidates the basis of the field and recognizes noteworthy authors and publications [4,6]. Co-citation analysis is a valuable tool for researchers as it helps to identify relationships between academic works based on shared citations, providing a better understanding of the structure of the field. The present study investigates the interrelatedness of economic growth and renewable energy subtopics, with a focus on identifying themes and trends [7,9]. The analysis of co-authorship investigates the collaborative efforts among researchers. Co-authorship networks can be utilized by researchers to identify significant contributors to economic growth and renewable energy research, including authors, teams, and institutions. This analysis identifies collaborative networks, interdisciplinary research initiatives, and influential research groups that are currently engaged in research on the subject [7,8]. The analysis of co-occurrence is a method utilized to identify the frequency and patterns of terms or keywords within the literature. According to Tan, the utilization of co-occurrence network analysis can effectively identify central themes and emerging topics in the fields of economic growth and renewable energies [7]. This approach can also assist in identifying key research areas and trends. To address the correlation between renewable energy and economic growth, the specific impacts of renewable energy integration, and the insights gained from the bibliometric analysis, the research was conducted with the following research questions. First, to what extent does the utilization of renewable energy sources correlate with economic indicators such as GDP growth, industrial productivity, and technological innovation across different regions and countries from 1996 to June 2023? Second, how does the integration of renewable energy contribute to job creation, local development, and enhanced energy security within regions

rich in renewable resources, and what are the key factors that influence this relationship? Last, what are the emerging research themes, significant works, and influential authors in the field of economic growth and renewable energy, as revealed by a thorough bibliometric analysis of 6794 papers from the Web of Science database, and how can this information inform strategies for promoting sustainable economic growth through renewable energy integration? These research questions align with the objectives of our study and can serve as a solid foundation for the research.

2. Literature Review

2.1. *The Role of Renewable Energy in Economic Growth*

The conventional approach to achieving economic growth has been heavily dependent on fossil fuels, which has resulted in unfavorable ecological outcomes [10]. The IPCC has acknowledged the imperative of shifting towards renewable energy sources to attain sustainable economic progress [11]. The objective of this literature review is to investigate the correlation between renewable energy and economic growth through an examination of pertinent research across diverse fields of study. The document offers a thorough examination of the current body of literature, delineates significant discoveries, and underscores areas of deficiency and nascent patterns for subsequent scholarly inquiry.

The relationship between renewable energy and economic growth has been the subject of numerous research studies. Empirical data indicate a correlation between the utilization of renewable energy sources and economic metrics, such as the expansion of the Gross Domestic Product (GDP) [12,13]. A study conducted by Apergis and Payne utilized a panel design to examine countries within the Organization for Economic Cooperation and Development (OECD) [12]. The research indicated that augmenting the utilization of renewable energy sources has a favorable effect on the advancement of the economy. The statement suggests that there exists a positive correlation between the utilization of renewable energy sources by nations and their corresponding levels of economic advancement. The investigation conducted by Martinez-Duart and Garcia-Muros contributes to the existing body of literature by examining the correlation between renewable energy and economic metrics [13]. Although their outcomes may vary, they furnish supplementary substantiation for the beneficial influence of renewable energy on economic development. Prior studies have underscored the capacity of renewable energy to act as a catalyst for economic advancement. The adoption of renewable energy sources can serve as a dual-purpose strategy for nations to address environmental issues and promote economic development by reducing their dependence on non-renewable energy sources. The results underscore the significance of promoting the adoption of renewable energy and allocating resources toward the development of renewable energy infrastructure to attain sustainable economic growth over an extended period.

2.2. *Regional and Country-Specific Contexts*

The examination of regional and country-specific contexts is a crucial aspect of academic inquiry. It involves analyzing the unique social, cultural, political, and economic factors that shape a particular region's approach to renewable energy and its impact on economic growth. The interplay between renewable energy and economic growth is significantly influenced by regional and national contexts. It is imperative to take into account the distinct renewable energy capacities, regulatory frameworks, and organizational structures that are specific to individual nations or regions. The correlation between economic growth and renewable energy is subject to the influence of regional and country-specific factors. The deployment outcomes of renewable energy can be influenced by various factors such as policy frameworks, institutional arrangements, and renewable energy potentials, which vary across different countries [13,14].

Martinez-Duart and Garcia-Muros underscore the significance of contextual factors in their study [13]. The authors highlight the significance of regional variations in the potential for renewable energy, as well as the efficacy of policy frameworks, in shaping the results of

renewable energy implementation. The investigation of factors related to renewable energy and economic growth allows researchers to acquire a more comprehensive comprehension of the intricate and multifaceted nature of their relationship. The study examined the influence of regional and country-specific variables on the relationship between renewable energy and economic growth [14]. The study's results provide insight into the impact of institutional arrangements and policy support systems on the consequences of renewable energy investments and subsequent economic growth.

Charfeddine and Mrabet contributed to the existing literature by performing a panel data analysis across various nations [15]. The study conducted by the researchers revealed that the influence of renewable energy on the economic development of a nation is subject to variation based on the country in question, underscoring the significance of considering regional and country-specific factors. Policymakers can formulate specific approaches that can optimize the economic advantages of integrating renewable energy sources, by considering the distinct attributes and circumstances of individual nations. The existing body of literature suggests that the correlation between renewable energy and economic growth is subject to the influence of regional and country-specific factors. Comprehending the contextual variables is of utmost importance in formulating efficacious policies and tactics that employ renewable energy sources to propel sustainable economic expansion. By considering the unique regional and country-specific contexts, policymakers can develop customized strategies that effectively utilize the renewable energy potential of each area while simultaneously promoting economic growth objectives.

2.3. Challenges in Renewable Energy Integration

Notwithstanding the potential advantages, the integration of renewable energy sources is beset with impediments and complexities. The aforementioned factors encompass technological limitations, elevated upfront expenses, inadequate infrastructure, and regulatory hindrances [4]. Liu et al. conducted a comprehensive evaluation of renewable energy development in China and found that policy barriers pose a significant challenge to the widespread adoption of renewable energy technologies [16]. Comprehending and surmounting these hindrances is of utmost importance in advancing the utilization of renewable energy sources and achieving their economic viability. The full potential of renewable energy integration for economic growth is hindered by various obstacles and challenges that require resolution. The challenges that impede the implementation of this technology encompass technological limitations, substantial upfront expenses, inadequate infrastructure, and regulatory impediments [4,16] have identified technological constraints as a notable impediment to the integration of renewable energy sources. The discourse centers around the difficulties posed by sporadic energy sources such as solar and wind power, in addition to the necessity for sophisticated technologies and storage remedies to guarantee a consistent and dependable energy provision. The study underscores the significant cost associated with the initial investment in renewable energy projects [16]. The authors deliberate upon the economic obstacles encountered by developers of renewable energy and underscore the necessity of financial instruments that incentivize investment in renewable energy infrastructure, such as subsidies and incentives. A deficiency in infrastructure represents an additional obstacle to the integration of renewable energy sources. This encompasses concerns related to the capacity of the grid, as well as issues about the transmission and distribution systems.

Nonrenewable energy sources, particularly fossil fuels like coal, oil, and natural gas, have played a pivotal role in driving economic growth for centuries. These energy sources have fueled industrialization, allowing nations to develop and expand their economies rapidly. The availability of abundant and affordable nonrenewable energy has been a cornerstone for various economic sectors, including manufacturing, transportation, and construction. Industries heavily reliant on energy, such as steel production and chemical manufacturing, have thrived on the consistent and concentrated power provided by nonrenewable sources [17]. Additionally, nonrenewable energy has powered the transportation

sector, facilitating global trade and commerce, which is indispensable for robust economic growth [18].

The significance of nonrenewable energy in economic growth is further underscored by its role in technological advancement. Access to consistent and affordable energy has driven innovation and the development of energy-intensive technologies that have transformed societies. Furthermore, nonrenewable energy has been a catalyst for urbanization, as it enables the construction of infrastructure and the provision of services in densely populated areas [19]. This rapid urbanization, in turn, has stimulated economic growth by creating employment opportunities and fostering economic diversification. In essence, the historical link between nonrenewable energy and economic development is undeniable, with these energy sources acting as crucial drivers of growth. Renewable energy sources represent a critical component of future economic growth, offering a sustainable and environmentally responsible alternative to nonrenewable counterparts. Solar, wind, hydro, and geothermal power, among others, have the potential to accomplish the ambitious goals set forth by proponents of renewable energy. Firstly, renewable energy is characterized by its low environmental impact, making it a key player in mitigating the adverse effects of climate change. As international concern about climate change grows, the adoption of renewable energy becomes essential for securing long-term economic stability [11]. Renewable energy's ability to provide clean and sustainable power underpins its potential to drive comprehensive economic development. It offers a pathway to energy security, reducing dependence on finite fossil fuel resources and enhancing the resilience of energy systems [2]. Moreover, the renewable energy sector can generate employment opportunities and stimulate economic growth through investments in research, development, and infrastructure [3]. By harnessing the power of renewables, nations can create a virtuous cycle of economic progress, environmental sustainability, and energy security, demonstrating that renewable energy has the potential to accomplish the multifaceted goals set out for it.

3. Research Methods

3.1. Data Collection

The present study used the comprehensive Web of Science database, widely recognized for its extensive compilation of scholarly literature spanning various academic fields. This repository presents an extensive collection of academic journals, conference proceedings, and diverse scientific publications. A rigorous and methodical approach was employed to guarantee the dependability and pertinence of data compilation.

The search strategy employed in this study involved carefully selecting keywords, such as “renewable energy”, “economic growth”, and related subtopics. In order to maintain the highest level of currency and pertinence in the literature, our search was limited to scholarly articles published between 1990 and June 2023.

The selection criteria were carefully aligned with our research objectives, particularly emphasizing studies examining the relationship between economic growth and renewable energy. The research also prioritized studies that comprehensively understand the potential benefits and drawbacks of adopting renewable energy sources. Additionally, we focused on research that identifies the factors driving green economic growth and explores the obstacles and barriers associated with integrating renewable energy.

A systematic screening process was utilized after retrieving the initial articles from the Web of Science database. The methodology employed in this study involved thoroughly examining article titles, abstracts, and keywords to determine their alignment with our research goals. The dataset for further analysis comprised exclusively of articles that satisfied our rigorous selection criteria.

The utilization of the Web of Science database played a crucial role in granting us the opportunity to access a wide range of peer-reviewed articles sourced from reputable entities. Utilizing this methodology greatly enhanced the dependability and robustness of our research outcomes. In addition, including a significant body of scholarly articles totaling 6794 enhanced the comprehensiveness of our literature review. It allowed for thorough

examination of the research landscape concerning the relationship between renewable energy and economic growth. To obtain a visual depiction of our research methodology, please consult Figure 1.

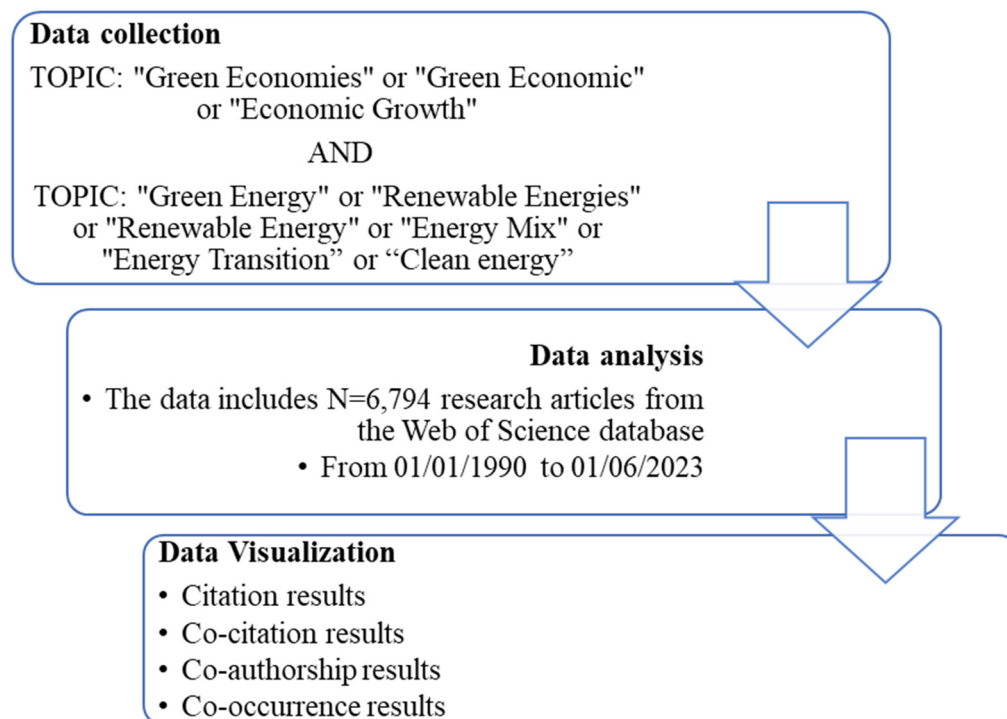


Figure 1. Research process.

3.2. Bibliometric Analysis

In this study, we employed bibliometric analysis as a research tool, which has been recognized as influential and potent [20]. Our investigation examined the complex relationship between renewable energy and economic growth. This approach involved a comprehensive analysis of citations using keywords and terms, co-citation patterns, co-authorship dynamics, and the recurrence of critical themes in scholarly writing. The comprehensive observations obtained from this approach allow us to see the extensive field of research, locate significant publications, recognize influential authors, and reveal emerging themes [21].

In the context of this comprehensive framework, citation analysis served to shed light on the scholarly terrain, directing our attention toward influential works and esteemed authors who have made significant contributions to our understanding of the interdependent connection between economic growth and renewable energy [12,13]. Upon further examination, the practice of co-citation analysis reveals thematic clusters, thereby exposing the complex interweaving of research ideas and highlighting significant areas of study [22]. This approach effectively demonstrates the interconnectedness of research concepts, elucidating the core of essential research domains.

In co-authorship analysis, we focused on examining collaborative networks and highly productive authors. This examination allowed us to gain insights into multidisciplinary research endeavors and influential research groups [23]. The analysis of co-authorship networks in this study revealed essential collaborations. It highlighted the crucial partnerships that contribute to our understanding of the relationship between renewable energy and economic growth.

Furthermore, by employing co-occurrence analysis, we methodically examined the frequency and patterns of keywords and concepts embedded throughout the scholarly literature. The aforementioned scholarly analysis comprehensively explores critical themes

and developing subjects [24]. This analysis provided significant insights into the extensively studied aspects of renewable energy and its impact on economic growth, indicating prospective areas that warrant additional investigation.

Significantly, this bibliometric approach functions as an academic endeavor and serves as a guiding principle for politicians and industry leaders. This methodology facilitates the identification of research gaps, emerging trends, and areas that require more examination, hence informing decision-making and strategy development [20]. The statement above highlights the significance of a compass in formulating efficacious policies and strategies to promote the uptake of renewable energy sources and foster sustainable economic development [25,26]. Therefore, it facilitates a comprehensive comprehension of the research environment, driving researchers and policymakers toward influential contributions and informed decisions [20].

4. Results and Discussions

4.1. Data Visualization

The analysis of publication trends offers significant insights into the research landscape and scholarly interest pertaining to the intersection of renewable energy and economic growth. According to the data presented in Figure 2, there is a steady upward trend in the quantity of publications from 1996 to 2023. From 1996 to 2006, Martinez-Duart and Garcia-Muros observed that the annual publication count ranged from four to ten, suggesting a reasonable degree of research engagement throughout that period [13]. From the mid-2000s forward, a noticeable surge in the number of published works became evident. Since 2010, there has been a notable surge in research productivity, which serves as evidence of an expanding scholarly fascination with the subject matter [13]. In the year 2010, the number of publications exceeded 50, and it exhibited a consistent upward trend in subsequent years.

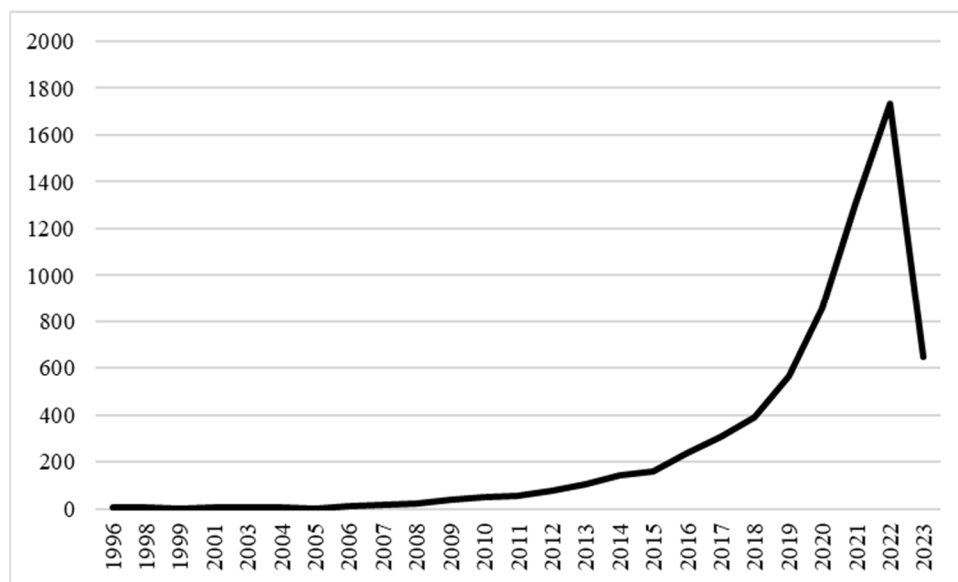


Figure 2. Publications per year.

Significantly, the time frame spanning from 2017 to 2023 exhibits a notable surge in publications, which serves as evidence of intensified study emphasis on the correlation between renewable energy and economic expansion, as indicated by the Web of Science database. Notably, the years 2021 and 2022 exhibit a noteworthy volume of publications, amounting to 1308 and 1731, respectively, as documented in the Web of Science database. The aforementioned figures illustrate a notable surge in research endeavors and underscore the escalating importance of the subject matter in recent times.

It is worth mentioning that there is a little decrease in the number of publications in 2023 compared to the previous two years, which might potentially be attributed to the conclusion of the data-gathering period in June. The increasing quantity of published works serves as evidence of the broadening scope of research and the escalating scholarly fascination with investigating the correlation between renewable energy and economic growth [13]. The aforementioned findings underscore the need to comprehend and tackle the obstacles and prospects linked to the integration of renewable energy in order to attain sustainable economic development.

The examination of research domains demonstrates the interdisciplinary character of the investigation into renewable energy and its correlation with economic advancement, as depicted in Figure 3. The results suggest that a significant proportion, specifically 47.492%, of the publications examined pertain to the field of Environmental Sciences Ecology. This observation underscores the importance placed on comprehending the environmental consequences associated with the adoption of renewable energy sources and its capacity to tackle ecological issues [27,28]. The significant increase in the value of Energy Fuels (31.411%) serves as evidence of the exploration and development of various energy sources and technologies. This underscores the importance of technological advancements in aiding the shift towards renewable energy [29,30]. Furthermore, it is worth noting that Science, Technology, and Other Topics account for 26.291%, indicating the extensive scope of scientific and technological research pertaining to renewable energy [31].

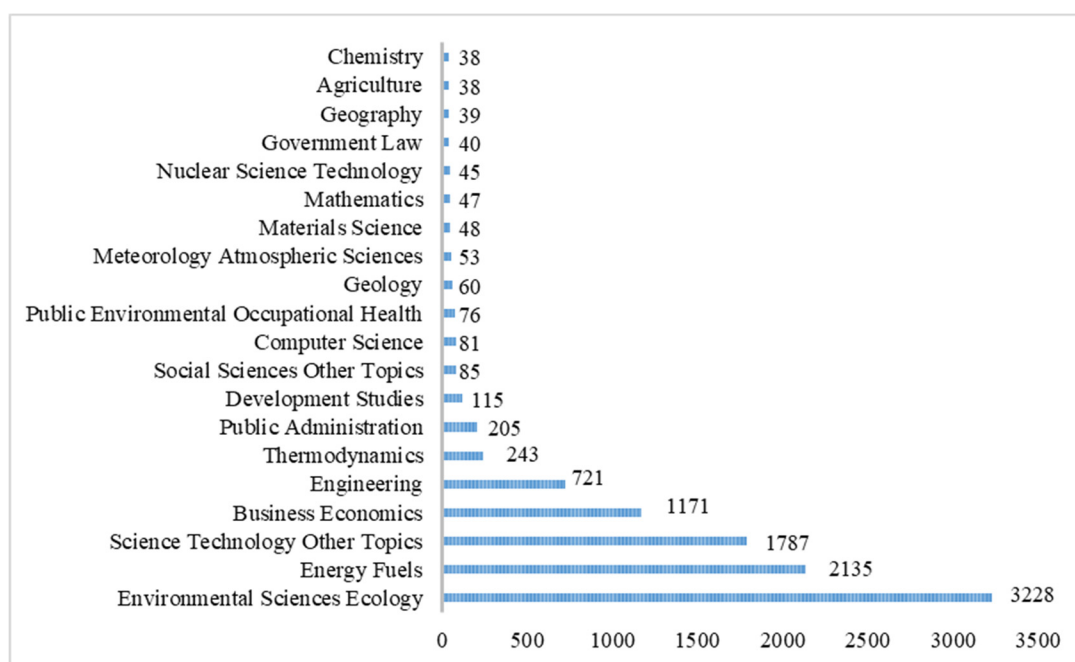


Figure 3. Research areas.

The inclusion of Business Economics (17.228%) and Engineering (10.608%) as notable fields of study indicates the acknowledgment of the economic and technical dimensions of renewable energy's contribution to fostering sustainable economic development [32,33]. The aforementioned fields of study have made significant contributions towards comprehending the economic ramifications, market dynamics, and mechanisms of innovation pertaining to the incorporation of renewable energy sources. Furthermore, the incorporation of fields such as Thermodynamics, Public Administration, Development Studies, and other areas within the Social Sciences showcases a thorough investigation into various aspects of renewable energy deployment. This includes the assessment of thermodynamic efficiency, policy frameworks, governance structures, socioeconomic dimensions, and social acceptance [34,35].

The incorporation of Computer Science, Public Environmental Occupational Health, and other fields, which have a limited number of records, serves to exemplify the interdisciplinary nature of research pertaining to renewable energy. The aforementioned highlight the significance of computational modeling, health impact assessment, and the interconnectedness of many factors within the renewable energy domain [36,37].

The present analysis highlights a diverse range of research domains, underscoring the necessity for interdisciplinary collaboration and knowledge synthesis in order to fully grasp the intricate interplay between renewable energy and economic development. The utilization of an interdisciplinary approach enables a thorough understanding of the various environmental, economic, technological, and social issues that are implicated. The acquisition of complete insights is crucial in order to facilitate the formulation of effective strategies, regulations, and frameworks that facilitate the sustainable incorporation of renewable energy sources and stimulate sustainable economic growth.

The analysis of the spatial distribution of scholarly articles pertaining to the relationship between renewable energy and economic growth offers significant scholarly contributions in terms of understanding the regional emphasis of research endeavors within this domain (refer to Figure 4). China has emerged as the primary contributor, representing 37.3% of all papers, which signifies the country's substantial research endeavors and increasing focus on renewable energy as a catalyst for sustainable economic development. Turkey and Pakistan are ranked second in terms of the percentage of publications, with a share of 13.1%. This underscores the importance of these regions in contributing to the knowledge and exploration of the potential of renewable energy in fostering economic growth [38]. The United States and India exhibit notable involvement and commitment to research on renewable energy and its potential impact on economic growth, as evidenced by their respective shares of 6.7% and 6.5% in publications related to this field. These countries have acknowledged the importance of shifting towards renewable energy sources and have achieved notable progress in terms of policy and technological breakthroughs in this domain [12,39]. The presence of Malaysia, England, Saudi Arabia, Nigeria, Australia, and Spain in the distribution is indicative of their dedication to investigating the impact of renewable energy on attaining sustainable economic development.

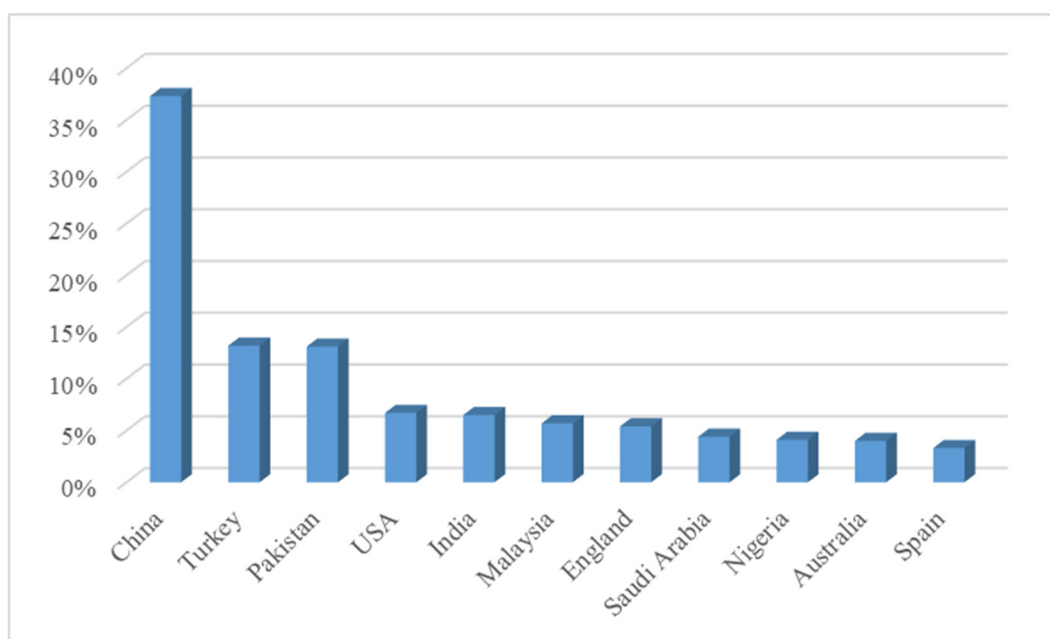


Figure 4. Country publications.

The inclusion of many nations and locations in the analysis highlights the worldwide importance of renewable energy as a catalyst for economic development [36,40]. Different countries have diverse circumstances, priorities, and obstacles as they strive for sustainable economic growth through the utilization of renewable energy. This is evident from the variable levels of engagement and research output seen [15]. The aforementioned findings underscore the importance of engaging in worldwide information exchange, collaboration, and the dissemination of best practices in order to facilitate collective learning and expedite the uptake of renewable energy technologies. It is worth noting that various factors, including research funding, government support, policy frameworks, and regional goals, might potentially influence the distribution of research production. However, it was observed that certain countries have higher levels of research output. The geographical allocation of publications among countries and regions serves as a fundamental basis for conducting comparative analysis, facilitating a more profound comprehension of the distinct challenges and opportunities encountered by different nations in their endeavor to achieve sustainable economic growth through the utilization of renewable energy sources [41].

The examination of authorship patterns provides insights into the intellectual contributions within the realm of renewable energy and its impact on economic growth. Figure 5 illustrates the esteemed scholars who have made noteworthy contributions to the specific area of investigation, as evidenced by the comprehensive list of authors and their corresponding publication records.

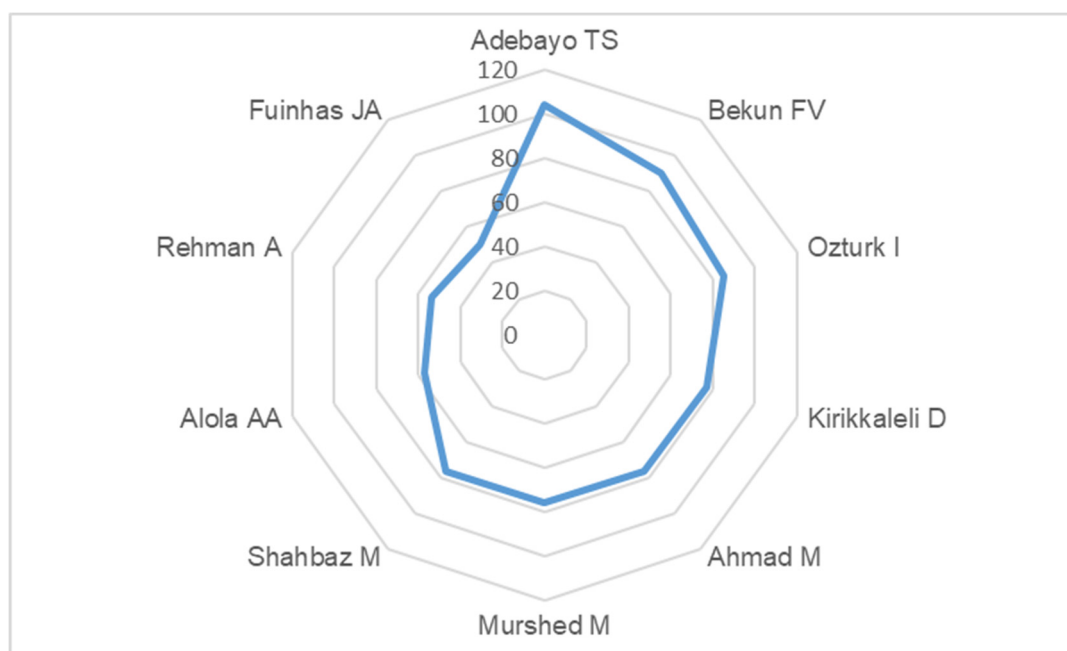


Figure 5. Author's number of publications.

Adebayo TS has demonstrated the highest level of productivity among the recognized authors, with a total of 104 contributions. This statement implies that a considerable amount of scholarly investigation has been dedicated to exploring the relationship between renewable energy and economic growth. Adebayo's research is anticipated to encompass an examination of the economic ramifications, policy considerations, and technological advancements associated with the integration of renewable energy. Bekun FV demonstrates a noteworthy research output, as evidenced by their record number of 90. Bekun's contributions mostly encompass areas such as investment in renewable energy, analysis of market dynamics, and examination of sustainability factors within the framework of economic growth. Ozturk I, Kirikkaleli D, Ahmad M, Murshed M, and Shahbaz M exhibit comparable research output, with record counts of 85, 77, 76, 76, and 76, respectively. This

suggests their active engagement in exploring the correlation between renewable energy and economic growth. The authors may have conducted research on several aspects, such as the environmental consequences, energy strategies, and the contribution of renewable energy towards attaining sustainable development. Alola AA, Rehman A, and Fuinhas JA have made noteworthy contributions, achieving records of 57, 54, and 50, respectively. The primary focus of their research is expected to center around the economic feasibility, market obstacles, and regulatory structures aimed at facilitating the integration of renewable energy sources, as well as the subsequent impact on economic development.

The fact that they are widely recognized in the literature indicates their high level of knowledge and their focus on researching renewable energy and its impact on economic development. The collaborative endeavors of these individuals collectively contribute to the progression of knowledge and facilitate a more profound understanding of the complex interplay between renewable energy and economic development.

It is imperative to acknowledge that further investigation is necessary to explore the contributions of these authors. This can be achieved through a comprehensive analysis of their publications, which should encompass an evaluation of the specific research topics they have addressed, the methodology they have employed, and the insights they have created. Through a comprehensive analysis of the literary contributions made by these authors, policymakers and researchers can acquire useful insights pertaining to the present state of research, identify areas where research is lacking, and ascertain the prospective avenues for furthering knowledge in this crucial domain.

4.2. Linking between Articles, Authors, Organizations, and Countries

4.2.1. Citation Analysis

The analysis of citations offers a compelling insight into the profound influence and impact of several key publications within the expansive field of renewable energy and its intricate relationship with economic growth (see Figure 6). At the forefront of this academic discourse stands the groundbreaking [42]. With an impressive citation count of 6415, their study has become emblematic of the field's foundational literature. Its widespread recognition within the academic community unequivocally underscores its pivotal role in shaping the discourse and providing fundamental insights into the intersection of renewable energy and economic progress.

Another pivotal contribution to the field is the work of Baptista, R.; published in 2014, which has garnered 3423 citations. This significant citation count signifies its substantial impact on the research discourse. Equally noteworthy are Su's article with 1058 citations [43], and the works of Apergis and Bhattacharya, boasting 787 and 740 citations, respectively [12,44]. These studies have made commendable strides in unraveling critical facets of renewable energy adoption, particularly in the context of economic implications and employment dynamics. Their contributions have enriched our comprehension of the socio-economic benefits inherent in this transition.

In the landscape of renewable energy and economic growth research, the studies of Suganthi (2012) [44], Balsalobre-Lorente (2018) [45], and Bekun (2019a) [46] shine as beacons of insight. These works have garnered significant attention, with citation counts of 704, 673, and 663, respectively. Their contributions have been instrumental in advancing our understanding of the intricate relationship between renewable energy adoption and economic expansion. Their enduring influence is a testament to their relevance and applicability in contemporary research.

Furthermore, the research conducted by Menyah (2010) [47] and Herbert (2007) [48], boasting substantial citation counts of 620 and 614, respectively, holds a place of significance. Their studies have left an indelible mark on the research domain, serving as guideposts for future investigations. Moreover, they inform the decisions of policymakers and other stakeholders, particularly by exploring critical dimensions of renewable energy adoption. These dimensions encompass economic implications, environmental sustainability, and

employment opportunities, illuminating the multifaceted advantages of transitioning to renewable energy sources.

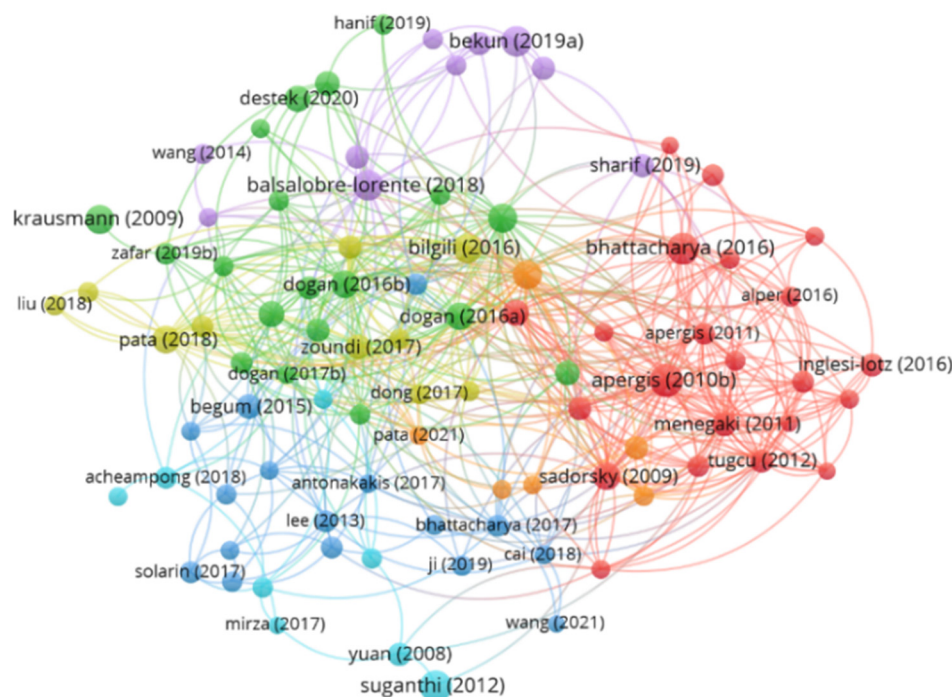


Figure 6. Map of document citation linking by author.

These influential works collectively shape academic discourse and provide valuable insights for policymakers, industry leaders, and society. Their contributions span a spectrum, from economic implications to employment opportunities, underscoring the multifaceted advantages of renewable energy adoption. Through offering a robust knowledge foundation, these seminal studies continue to inform and inspire further research, policy development, and real-world applications. Their enduring impact reaffirms their role as cornerstones in pursuing a sustainable and prosperous future (Table 1).

Table 1. Citation analysis results by documents.

Author	Article Title	Citations	Reference
Lewis, N. S.; Nocera, D. G.(2006)	"Powering the planet: Chemical challenges in solar energy utilization"	6415	[16]
Baptista, R (2014)	"The impact of human capital on the early success of necessity versus opportunity-based entrepreneurs. Small Business Economics"	3423	[49]
Su (2014)	"China's 19-year city-level carbon emissions of energy consumptions, driving forces and regionalized mitigation guidelines"	1058	[50]
Apergis (2010)	"Renewable energy consumption and economic growth: evidence from a panel of OECD countries"	787	[12]
Bhattacharya (2016)	"The effect of renewable energy consumption on economic growth: Evidence from top 38 countries"	740	[43]
Suganthi (2012)	"Energy models for demand forecasting—A review Energy models for demand forecasting—A review"	704	[44]
Balsalobre-Lorente (2018)	"How economic growth, renewable electricity and natural resources contribute to CO ₂ emissions"	673	[45]
Bekun (2019)	"Toward a sustainable environment: Nexus between CO ₂ emissions, resource rent, renewable and nonrenewable energy in 16-EU countries"	663	[46]

Table 1. *Cont.*

Author	Article Title	Citations	Reference
Menyah (2010)	“CO ₂ emissions, nuclear energy, renewable energy and economic growth in the US”	620	[47]
Herbert (2007)	“Renewable energy and economic regeneration in Devon, UK: The role of stakeholders in the transition to a low-carbon economy”	614	[48]

4.2.2. Co-Authorship Analysis

The examination of co-authorship offers useful insights into patterns of collaboration and the impact of writers in the realm of renewable energy and economic growth, as illustrated in Table 2 and Figure 7. The individual in question is Tomiwa Adebayo. According to Adebayo, Sunday is recognized as a highly productive author, having made substantial contributions to a total of 95 articles and garnering an impressive number of citations, amounting to 3845 [51]. These statistics not only highlight Sunday’s extensive research output but also underscore their substantial influence within the academic community. Bekun, Festus Victor has made significant contributions to the research domain, as evidenced by his extensive publication record of 80 articles and a total of 4564 citations [46]. According to Ozturk’s findings, Ilhan Ozturk is positioned in the third place in terms of research production, with a total of 74 documents [52]. Additionally, Ozturk has accumulated 7673 citations, indicating a significant level of scholarly significance.

Table 2. Co-authorship analysis results.

Author	Affiliation	Country	Docs	Citations	TLS
Adebayo, Tomiwa Sunday	Cyprus International University	Cyprus	95	3845	160
Bekun, Festus Victor	istanbul gelişim üniversitesi	Turkey	80	4566	138
Ozturk, Ilhan	University of Sharjah	UAE	74	7673	115
Murshed, Muntasir	North South University	Bangladesh	73	2846	117
Shahbaz, Muhammad	Beijing Institute of Technology	China	70	6670	80
Kirikkaleli, Dervis	European University of Lefke	Turkey	69	3206	103
Alola, Andrew Adewale	CREDS	Norway	51	3237	58
Lin, Boqiang	Minjiang University	China	47	2050	5
Fuinhas, Jose Alberto	Universidade de Coimbra	Portugal	44	932	46
Balsalobre-Lorente, Daniel	University of Castilla-La Mancha	Spain	43	2906	77

As active field contributors, Murshed, Muntasir, Shahbaz, Muhammad, and Kirikkaleli, Dervis have 73, 70 and 69 documents, with 2846 and 6670 citations, and 3206 citations, respectively [51–53]. These authors have significantly advanced the field by examining multiple perspectives on economic development and renewable energy.

Scholars such as Andrew Alola Adewale, Lin Boqiang, Jose Alberto Fuinhas, and Daniel Bal-Salobre-Lorente have made noteworthy academic contributions, as evidenced by the number of documents and citations associated with their work. Specifically, Andrew Alola Adewale has authored 51 documents with 3237 citations [46], Lin Boqiang has authored 47 documents with 2050 citations [54], Jose Alberto Fuinhas has authored 44 documents with 932 citations [55], and Daniel Bal-Salobre-Lorente has authored 43 documents with 2906 citations [45]. The individual’s active involvement in the field is substantiated by their research productivity and impact, thereby attesting to their valuable contributions.

The collaborative strength and effect of author networks can be measured by the total link strength, which is the cumulative value of link strengths between co-authors derived from joint publications and citations received. A more comprehensive examination of these co-authorship networks, encompassing an examination of particular collaborations, fields of research, and multidisciplinary associations, can enhance our comprehension of the generation and distribution of information within the discipline.



Figure 7. Author collaborations in growth and renewable energy.

4.2.3. Co-Citation Analysis

As depicted in Table 3 and Figure 8, the co-citation study offers valuable insights into the influential sources and their interconnections within renewable energy and its impact on economic growth. By examining citation frequency and cumulative link strength, it is possible to ascertain the impact and significance of these sources in shaping academic discussions.

Table 3. Co-citation analysis results by Source.

Source	Docs	TLS
Energy Policy	29,344	1,494,010
Renewable and Sustainable Energy Reviews	24,588	1,276,801
Environmental Science and Pollution Research	22,915	1,297,011
Energy Economics	19,087	1,061,435
Journal of Cleaner Production	16,071	900,721
Energy	12,528	718,279
RENEW Energy	10,737	615,019
Science of The Total Environment	7751	470,287
Applied Energy	6988	387,000
Ecological Economics	5910	345,509

The journal “Energy Policy” holds the highest number of citations, with a total of 29,344 and a substantial link strength of 1,494,010, making it the most frequently referenced source inside the co-citation network. The influence of renewable energy in impacting research and policy considerations around economic expansion is evident. “Renewable and Sustainable Energy Reviews” exhibits its significant influence in the field, as seen by its substantial citation count of 24,588 and a total link strength of 1,276,801.

The significance of “Environmental Science and Pollution Research” in understanding the environmental consequences of renewable energy is evident from its ranking as the third most cited publication, with 22,915 citations and a link strength of 1,297,011. The academic journals “Energy Economics” and “Journal of Cleaner Production” exhibit significant impact, as seen by their respective citation counts of 19,087 and 16,071, together with total link strengths of 1,061,435 and 900,740.

significant roles in scholarly publishing. India has contributed 418 documents and 14,023 citations, whereas the United States has contributed 419 documents and 23,664 citations. The figures above illustrate the scholarly productivity and impact of researchers from various countries. Malaysia, England, Saudi Arabia, Nigeria, and Australia are recognized for their substantial contributions to the academic literature. These nations have demonstrated their active involvement and significant impact on scholarly research by producing a substantial number of academic documents and receiving citations.

Table 4. Bibliography coupling results by countries.

Country	Documents	Citations	TLS
China	2350	74,583	12,754,992
Pakistan	828	27,586	7,350,697
Turkey	822	40,350	7,515,654
USA	419	23,664	1,595,309
India	418	14,023	3,175,672
Malaysia	362	16,114	2,607,428
England	337	11,721	1,846,573
Saudi Arabia	285	6969	2,372,633
Nigeria	257	7641	2,333,733
Australia	255	11,837	1,796,805

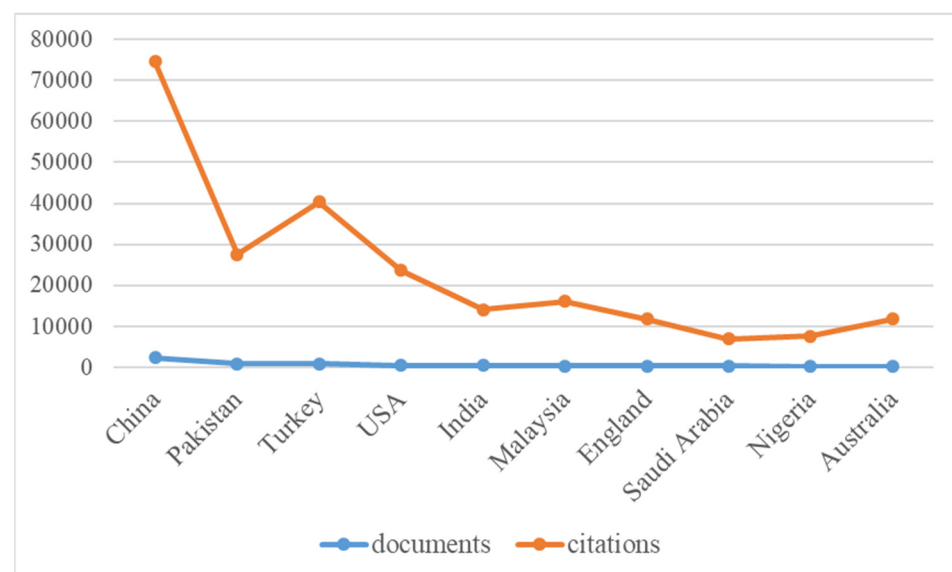


Figure 9. Top 10 country contributions.

The bibliography coupling analysis highlights the collaborative efforts and knowledge dissemination among countries in the academic community. It underscores the importance of international collaborations and knowledge sharing for advancing research and fostering a global research ecosystem.

4.2.5. Co-Occurrence Analysis

By visually representing the co-occurrence of keywords in different clusters and colors, the research provides a comprehensive overview of the interrelationships between various concepts and research areas, aiding researchers in identifying key themes and potential areas for further investigation and collaboration (see Figure 10). Each cluster is represented by a unique color, denoting distinct thematic areas or topics. In the following, there are five clusters.

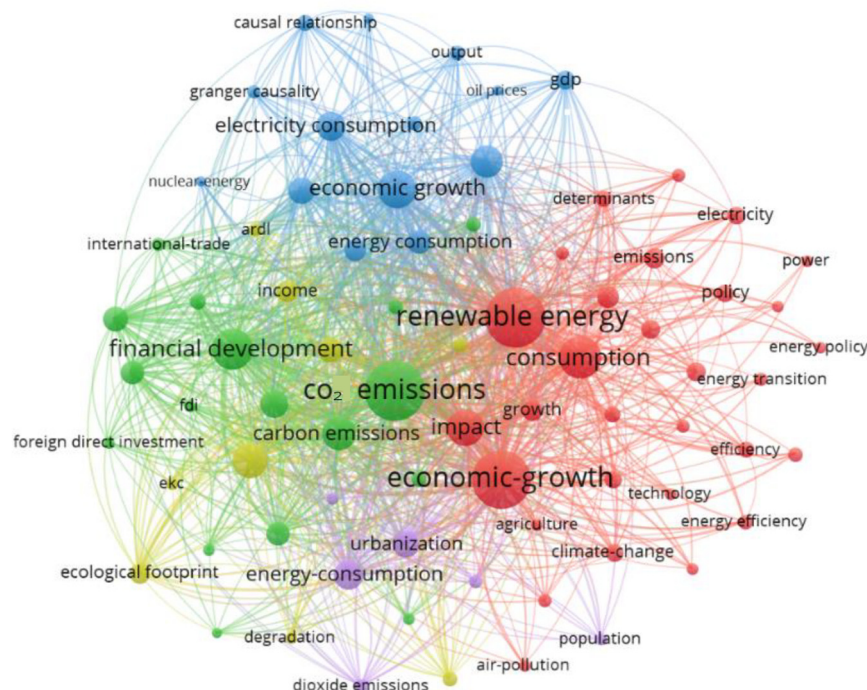


Figure 10. Keyword co-occurrence results.

Red Cluster: Renewable Energy to Achieve Sustainable Economic Growth

The provided link illustrates the importance of transitioning to renewable energy sources in order to attain sustainable economic development and mitigate environmental consequences, as indicated by the red cluster. Renewable energy, referred to as “energy”, “energy policy”, “energy transition”, and “generation”, exerts a significant influence on the course of economic development. The adoption and integration of renewable energy technologies, such as solar and wind, have the potential to enhance energy security, facilitate energy efficiency, and mitigate greenhouse gas emissions [56]. These technologies serve as the fundamental building blocks for the generation of sustainable energy, enabling the establishment of a more robust and environmentally friendly energy system. The utilization of terms such as “economic growth”, “consumption”, “demand”, and “efficiency” pertains to the endeavor of achieving economic expansion, necessitating meticulous examination of energy resources and their ecological consequences. The achievement of long-term sustainability requires the careful management of economic growth alongside the promotion of energy efficiency and responsible consumption [57]. According to Sorrell, the implementation of technological advancements and policy adjustments can effectively separate energy consumption from economic growth, resulting in resource conservation and reduced environmental impact [58]. Moreover, the transition towards renewable energy sources has the potential to foster economic growth and facilitate the generation of employment opportunities. The formation of new job and entrepreneurship prospects is driven by local and regional economic growth as a result of national investments in renewable energy infrastructure and technology [1]. The observed correlation between the utilization of renewable energy sources and economic growth serves as evidence for the potential existence of a green economy, whereby sustainable development and wealth can coexist harmoniously.

Nevertheless, it is imperative to acknowledge the intricate and multifaceted dynamics inherent in the correlation between economic growth and renewable energy. The rate and extent of renewable energy deployment and its integration into economic systems are influenced by various factors, such as legislative frameworks, investment incentives, technology breakthroughs, and societal attitudes [59]. In order to achieve a thorough

comprehension of this link, it is imperative to engage in interdisciplinary research, foster stakeholder collaboration, and employ evidence-based policies.

By harnessing the potential of renewable energy, governments and researchers have the ability to concurrently foster sustainable economic growth and tackle environmental concerns. The transition to a renewable energy economy has substantial promise in terms of attaining energy security, mitigating carbon emissions, and cultivating a society that is more inclusive and resilient.

Green Cluster: The Intersection of Environmental Sustainability, Renewable Energy, and Economic Development

The cluster provided insights into economic development's complex interplay and dynamics, environmental considerations, and the shift towards renewable energy sources. The analysis highlights a prominent subject of the pressing necessity to confront environmental challenges that arise from economic expansion and energy usage. The utilization of the phrases "carbon emissions", "carbon dioxide emission", "environmental", and "pollution" underscores the need to mitigate carbon emissions, address pollution, and safeguard environmental integrity. These findings emphasize the significance of promptly enacting efficient policies and measures to address environmental consequences, which align with previous scholarly investigations [60,61]. The analysis reveals that economic issues play a significant influence in influencing sustainable development. The buzzwords mentioned earlier, namely "evidence of economic growth", "FDI", "financial development", and "trade openness", underscore the intricate nexus between economic growth and environmental factors. The discovery mentioned above implies that the utilization of economic growth can be utilized as a means to promote sustainability goals by integrating environmental factors into policies related to foreign direct investment, financial development, and trade [62,63]. Furthermore, the analysis underscores the significance of technical advancement and the utilization of renewable energy sources in attaining environmental sustainability. The terms "clean energy", "renewable energy", and "technological advancement" are commonly used phrases that emphasize the shift towards sustainable energy sources. The discovery mentioned above underscores the significance of allocating financial resources towards advancing research and development initiatives to promote clean energy technologies and their seamless integration into current energy systems [64,65]. Using renewable energy sources enables civilizations to mitigate their dependence on fossil fuels and alleviate the adverse environmental impacts of their usage. Moreover, the analysis illustrates the influence of international trade on environmental sustainability. The concepts of "international trade" and "trade openness" underscore the importance of considering the environmental impacts of trade operations. This discovery implies the significance of formulating trade policies that facilitate adopting sustainable practices and mitigate detrimental environmental externalities. In order to effectively align trade activities with the goals of sustainable development, it is imperative to achieve a harmonious equilibrium between the pursuit of economic growth and the preservation of the environment [66].

Blue Cluster: The Complex Dynamics between Economic Growth and Energy Consumption

The cluster has contributed significant insights into the fundamental factors and interconnections that shape this relationship, offering a deep comprehension of the complex dynamics between economic growth and energy use. One of the key findings derived from the co-occurrence analysis is the establishment of a causal relationship between economic growth and energy use. Scholars have extensively investigated the relationship and causal linkages between these variables through the application of several econometric methodologies [10,67]. This research has enhanced our comprehension of the relationship between variations in energy usage and economic growth.

The notion of cointegration, which denotes a state of long-term equilibrium between economic growth and energy consumption, is a prominent concept that is often seen in scholarly literature [68,69]. Cointegration analysis enables researchers to ascertain a

dependable relationship that captures the long-term dynamics between the variables under investigation. By employing the concept of cointegration, scholars are able to enhance their understanding of the enduring correlation between continuous economic growth and energy use.

The analysis additionally underscores the importance of nonrenewable energy sources and their correlation with oil prices. The use of phrases like “non-renewable energy” and “oil prices” in conjunction highlights the correlation between energy prices and consumer behavior, as well as the direction of economic growth [70,71]. Numerous scholarly investigations have been conducted to explore the correlation between fluctuations in oil prices and key economic indicators, including the Gross Domestic Product and energy consumption. These studies have provided valuable insights into the potential effects of such price variations on overall economic performance.

The presence of terms pertaining to the utilization of renewable energy and electricity in close proximity serves as an additional indication of the growing interest in comprehending the ways in which renewable energy sources can facilitate sustainable economic development [12,72]. Scholars have conducted investigations into the effects of electricity and the use of renewable energy on economic indicators, emphasizing the potential of clean energy to foster economic growth.

Yellow Cluster: Modeling Application in the Relationship between Economic Development and Sustainability

The inclusion of the keywords “ARDL”, “CO₂ emissions”, “degradation”, “EKC”, “environmental”, “sustainability”, “income”, and “trade” in the discussion provides valuable insights into various significant aspects pertaining to the intersection of environmental sustainability and economic development. This paper encompasses various subjects, including the utilization of modeling approaches, the investigation of environmental degradation, the analysis of the Environmental Kuznets Curve concept, and the endeavor to achieve sustainability. Additional investigation into these subject matters has the potential to enhance our understanding of the complex interconnections among economic activity, environmental harm, and the endeavor for sustainability. The utilization of the Autoregressive Distributed Lag (ARDL) model for the purpose of investigating the causal association and enduring dynamics between economic variables and carbon dioxide (CO₂) emissions has gained significant attention based on the examination of relevant keywords [73,74]. By employing this modeling methodology, scholars are able to examine the complex dynamics and immediate interactions among factors such as income, commerce, and environmental indicators. The ARDL model has been widely utilized to investigate the correlations among trade, economic development, and environmental sustainability.

The use of terminology such as “degradation” and “CO₂ emissions” indicates that the issue of environmental degradation is underscored by the keywords mentioned in the sources [10,18]. The aforementioned emphasis underscores the principal objective of the study, which is to ascertain the adverse environmental impacts resulting from human activities. Scholars have conducted investigations of the magnitude of environmental degradation resulting from economic activities, as well as initiatives aimed at mitigating and reversing such degradation.

The identification of the Environmental Kuznets Curve (EKC) emerges as a noteworthy subject based on the analysis of keywords. The EKC hypothesis posits an inverse correlation between income and environmental degradation [75,76]. Researchers have employed this theoretical framework to assess the potential of sustainable development by investigating the correlation between economic development, income, and other environmental indicators, including CO₂ emissions.

The inclusion of terms such as “environmental”, “sustainability”, and “trade” serves to underscore the prominence of sustainability as a central issue. The aforementioned concepts underscore the significance of achieving equilibrium among social advancement, ecological conservation, and economic expansion [77,78]. Numerous scholarly investiga-

tions have examined the intricate dynamics and compromises involved in the interplay among economic growth, trade openness, and environmental sustainability, with the aim of identifying the most effective approaches to attaining sustainable development goals.

Purple Cluster: Interactions between Human Activities, Energy Consumption, Population Growth, and Carbon Emissions toward Environmental Sustainability

The understanding of the complex interconnections of human activities, energy consumption, population expansion, and their impacts on carbon emissions and environmental quality relies heavily on the analysis of this cluster. The terms “CO₂ emission”, “carbon emission”, “dioxide emissions”, “energy consumption”, and “population” collectively pertain to the concepts of urbanization, energy use, and environmental sustainability.

The examination of carbon dioxide and carbon emissions as metrics for assessing environmental effects arises as a noteworthy subject based on the findings of the keyword investigation. The investigation of energy consumption patterns, industrial processes, and transportation networks that contribute to the release of carbon dioxide and carbon emissions has been identified as a key area of research [79,80]. The objective is to formulate policies aimed at mitigating carbon emissions and promoting the adoption of renewable energy sources.

A plethora of scholarly investigations have been conducted to explore the correlation between energy consumption and carbon emissions, duly recognizing the role played by energy consumption and production in the generation of greenhouse gas emissions [81,82]. Researchers have conducted studies on the effects of energy efficiency initiatives, the utilization of renewable energy sources, and technical breakthroughs on the mitigation of carbon emissions and the establishment of sustainable energy systems.

The examination of population and urbanization offers valuable insights into the interplay between demographic patterns and carbon emissions. The phenomenon of urbanization and the concurrent increase in population size have significant implications for the demand for energy, the development of infrastructure, and the release of carbon emissions [42,61]. Scholars have conducted investigations on the influence of urbanization processes, urban form, and population dynamics on energy consumption patterns and carbon emissions in order to provide insights for urban planning and the development of sustainable strategies.

5. Conclusions

This study conducted a thorough bibliometric analysis of 6794 scholarly articles from the Web of Science database, covering the time frame from 1996 to June 2023. The objective was to comprehensively understand the complex correlation between renewable energy and economic growth within the sustainable development framework. The analysis provided valuable insights into the research environment, key papers, notable authors, and emerging themes in this critical study area.

The findings of this study emphasize the significant significance of utilizing renewable energy sources as a catalyst for long-term economic development. The implementation of renewable energy sources signifies a shift towards a more environmentally sustainable economy and effectively reduces the negative environmental consequences linked with traditional energy sources. In addition to its ecological advantages, renewable energy has promising commercial opportunities, promoting energy stability, supporting regional economic growth, and creating job prospects.

Examining citations within scholarly literature demonstrates the significant impact of pivotal publications and authors. The study conducted by Lewis, N.S. and Nocera, D.G. in 2006 has received significant attention, as evidenced by its remarkable 6415 citations. This substantial number of citations firmly establishes it as the most frequently referenced publication, highlighting its extensive reputation among scholars and researchers. The work of Baptista has received extensive scholarly attention, as evidenced by its substantial citation count of 3423 [50]. It serves as a testament to the enormous influence and contribution of

the work within the realm of research discourse. These literary works have significantly influenced and shaped subsequent studies on the topic.

Investigating co-authorship networks provides insights into prominent writers and collaborative tendencies within renewable energy and economic growth. Sunday Tomiwa, an author with an impressive record of 95 publications and 3845 citations, demonstrates a noteworthy level of productivity and significant impact within the realm of study. Festus Victor Bekun holds the second position in terms of scholarly output, having made a substantial contribution with 80 documents and garnering 4564 citations. Ilhan Ozturk has achieved commendable academic standing by securing the third position with 74 scientific documents and an excellent citation count of 7673. This noteworthy accomplishment highlights the significant impact of her scholarly contributions.

The application of co-citation analysis reveals prominent sources within the domains of renewable energy and economic growth, such as “Energy Policy”, “Reviews of Renewable and Sustainable Energy”, “Environmental Science and Pollution Research”, and “Energy Economics”. The utilization of these sources is of utmost significance in influencing scholarly discussions and providing direction for research endeavors in renewable energy and economic advancement.

The examination of bibliographic coupling reveals the presence of joint endeavors and the exchange of knowledge among nations, highlighting their impact on intellectual pursuits. China is the leading contender in document count and citations, with Pakistan, Turkey, the United States, and India following suit. These countries demonstrate exceptional levels of research productivity and significant academic influence. In addition, it is noteworthy that Malaysia, England, Saudi Arabia, Nigeria, and Australia make substantial contributions to the scholarly literature on this particular topic.

The co-occurrence analysis reveals the presence of five theme clusters, each of which signifies unique areas of emphasis. The red cluster highlights the significant importance of renewable energy technology in improving energy efficiency, mitigating greenhouse gas emissions, and strengthening energy security. The green cluster focuses on tackling environmental challenges arising from heightened energy consumption and economic growth. It emphasizes the interconnectedness of economic factors, renewable energy, technological advancement, and international trade in promoting environmental sustainability. The research conducted by the blue cluster focuses on examining the complex interplay of several factors, including the utilization of renewable energy, the promotion of sustainable economic development, and the integration of both renewable and nonrenewable energy sources.

This investigation also considers the influence of oil prices and the availability of nonrenewable energy supplies. The yellow cluster centers to utilize the Autoregressive Distributed Lag (ARDL) model to adverse impacts of human activities on the environment and the endeavor to achieve sustainable development. Finally, the purple cluster focuses on the influence of CO₂ emissions, carbon emissions, energy consumption, population increase, and urbanization on the environment and urban development.

This study provides significant valuable insights to policymakers, industry executives, and scholars. This statement highlights the significance of obtaining accurate information to create well-founded policies and implement successful strategies that can facilitate the adoption of renewable energy sources, foster sustainable economic growth, and contribute to a more sustainable and resilient future. The findings of this research emphasize the pressing necessity for stakeholders to prioritize the deployment of renewable energy and the transition toward an economy that is both low-carbon and sustainable. By adopting renewable energy sources, nations have the potential to effectively tackle environmental challenges while also fostering economic development, establishing the groundwork for a sustainable and thriving future.

Nevertheless, it is imperative to recognize some constraints within this study, namely, the degradation of the ecosystem, the concept of sustainability, and the methodologies employed in modeling. More reliance on data aggregated at the national or regional

level may result in the masking of local differences and the diverse nature of patterns of environmental deterioration. In order to obtain a more precise comprehension of the intricacies of environmental processes, it is essential to have sector-specific, detailed data. Moreover, it is crucial to acknowledge the methodological constraints inherent in cross-sectional studies. Longitudinal studies, which involve the continuous monitoring of specific regions or countries over an extended period, play a vital role in elucidating the enduring effects of sustainability programs and establishing causal relationships between human activities and environmental degradation.

Further investigation is warranted to examine the potential of technical developments and eco-friendly practices in disentangling environmental degradation from economic growth. Examining the efficacy of ecologically sustainable practices, renewable energy sources, and sustainable technology can yield significant information regarding the advancement of sustainable development. The inclusion of social dimensions in the analysis holds equal significance since comprehending the social and behavioral elements that impact sustainable practices can provide valuable insights for developing effective policies and interventions. Moreover, a comprehensive analysis of the interconnections and compromises among social well-being, environmental preservation, and economic development can foster more all-encompassing and equitable strategies toward achieving sustainability. Ultimately, effectively converting research discoveries into policy suggestions and practical applications is of utmost importance. It is crucial in facilitating evidence-based decision-making and achieving tangible outcomes in tackling environmental issues.

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