

A BIBLIOMETRIC ANALYSIS ON THE LINK BETWEEN GREEN INNOVATIONS AND CIRCULAR ECONOMY

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Abstract: *This study conducts a comprehensive bibliometric analysis to examine the complex interconnections among green innovations and circular economy - key concepts in advancing sustainable development. Given today's pressing environmental challenges, the circular economy has become one of the European Union's most significant policy priorities. In this context, growing attention is being directed toward identifying key pathways for facilitating the transition to this new economic model, with green innovations, or eco-innovations, playing a particularly prominent role. This paper explores the key aspects of the relationship between these concepts by presenting an analysis of the relevant research in this field. The analysis brings to the forefront an increasing interest in studying the link between the concepts and highlights research areas like Environmental Sciences Ecology, Business Economics, Science Technology Other Topics, Engineering, and Public Administration. Furthermore, the growing importance of cross-border collaborations in promoting green technologies and policies is highlighted, along with revealing the leading countries in terms of publication numbers regarding the link between green innovations and circular economy, i.e., Italy, Spain, England, and China, among which the most cited are those from England. As for the journals, the following stand out: the Journal of Cleaner Production, Sustainability, Ecological Economics, and the Business Strategy and the Environment journal. The concepts underlying the research that connects green innovations with the circular economy are often found alongside themes such as sustainability, innovation, sustainable development, small and medium-sized enterprises, barriers, recycling, climate change, business models, industrial ecology, eco-design, and corporate social responsibility.*

Keywords: *green innovations; eco-innovations; environmental innovations; sustainable innovations; circular economy; bibliometric analysis.*

JEL Classification: O31; Q01; Q55

1. Introduction

In recent decades, humanity has faced many environmental problems, especially climate change, including growing pollution, biodiversity loss, and depletion of limited

resources (Karlilar, Balcilar and Emir, 2023). In the United Nations Climate Change Conference in 2015, the participating nations signed the Paris Agreement (2016) in an attempt to limit the global temperature's increase to below 2°C above the pre-industrial level. In this context, Agrawal et al. (2024) highlight the growing interest regarding climate change, global warming, pollution, and other environmental problems from governments and regulators. Concepts such as green innovations and circular economy represent hot topics for research. This paper aims to conduct an in-depth analysis of the relationship between green innovations and the circular economy, as well as their necessity in the current economic context regarding the transition to a green economy, to facilitate the achievement of the European Green Deal objectives. In academic literature, the terms green innovations, ecological innovations, environmental innovations, and sustainable innovations are frequently used interchangeably by many authors, given that the differences between them are minimal. Consequently, we will refer to them as synonyms. Resource efficiency-oriented eco-innovation (green innovation) adoption is considered a key pillar for the European Union strategy regarding the transition to a circular economy (Cainelli, D'Amato and Mazzanti, 2020), all this in an attempt to achieve sustainable, balanced, and inclusive economic growth (Karlilar, Balcilar and Emir, 2023).

2. Theoretical background

In their research, Cobbinah, Osei and Amoah (2025) highlight the urgent need to focus on setting sustainable development goals and implementing them through processes and technologies grounded in green innovation. This necessity arises from the ongoing ecological, climatic, and environmental challenges we are currently facing, and the escalating research output in these domains underscores a growing recognition of their pivotal role in fostering sustainable development and mitigating environmental degradation (Bhardwaj et al., 2020). Eco-innovation can be conceptualized as a threefold approach, encompassing technological, social, and institutional dimensions (Hellstrom, 2007), necessitating a comprehensive reconstruction to align with principles of nature (Hofstra and Huisingh, 2013), which challenges firms to engage in continuous adaptation to a dynamic environment (Salim, Rahman and Wahab, 2018).

Martínez, Inés and Poveda (2021) consider sustainable development goals and the shift toward a green growth as means through which countries can achieve better economic performance with a lower negative impact on the environment, in which an essential role is played by science, technology, and innovation.

Green innovation is viewed and defined as the result of implementing ideas and knowledge from the economic field aimed at generating profit in a way that is as environmentally friendly as possible (Takalo, Tooranloo and Shahabaldini parizi, 2021), and it is increasingly being adopted by producers in pursuit of sustainable development, generating a lower cost of energy due to these green-manufacturing technologies (Kong et al., 2016). In a study conducted on OECD nations, Karlilar Balcilar and Emir (2023) highlight the crucial role of green innovation in reducing resource waste, as well as promoting greener and more energy-efficient technologies to be used in production, and so, to contribute to environmental sustainability. At the same time, Xie, Huo and Zou (2019) are talking about two types of green innovations, namely green process

innovations and green product innovations, the former with a positive impact on the latter and both with a significant impact on the financial performance of companies. Ecological innovation has a positive and significant impact on energy efficiency, thereby confirming its essential contribution to the green transition in Europe (Chatzistamoulou and Koundouri, 2024). In the authors' opinion, this aligns with European policy directives and recent scholarly literature, which emphasize the role of eco-innovation in promoting sustainability.

In an era defined by rapidly evolving green technologies and compressed product lifecycles (Tseng et al., 2012), this multifaceted concept extends beyond mere technological advancements; it encompasses organizational, marketing, and systemic changes that contribute to a more sustainable trajectory (Boons et al., 2012). Zartha et al. (2024) highlights the importance of eco-innovations or green innovations for the environment and for introducing economic models based on the circular economy. Agrawal et al. (2024) also make the connection between the circular economy and green innovations as well as green financing, arguing that green innovations fit into a circular society. The circular economy is regarded as an essential approach to achieve a more sustainable economic paradigm (De Jesus and Mendonça, 2018). Based on a literature review and a study conducted on several small and medium-sized companies, Bag et al. (2022) conclude that there is a clear link between eco-innovations, green supply chain management, and the circular economy, in the sense that the first two contribute to the implementation of the third. Cainelli, D'Amato and Mazzanti (2020) show the dependence of circular economy adoption with the help of various environmental innovations on the policy platform, more specifically, the European Union policy regarding waste management that has emerged over time, the latest regarding the launch of the circular economy strategy in 2015, with subsequent updates. On the other hand, Le, Ferraris and Dhar (2023) claim that circular economy practices encourage eco-innovation in order to increase resource efficiency and environmental performance. We can conclude that between eco-innovations and circular economy is a two-way reciprocal influence relationship. We agree with De Jesus and Mendonça (2018), who think that eco-innovation is considered an essential element for overcoming the barriers that stand in the way of achieving the circular economy. The dividing line between different concepts, such as circular economy, green economy, and bioeconomy, is quite blurred; these concepts are often based on common principles, but there are also substantial differences.

We can also find criticisms of these concepts, as Karlilar, Balcilar and Emir (2023) argue that green innovation can limit dependence on fossil fuels and at the same time promote alternative renewable energies. However, when it comes to the use of green energy, a negative effect can be observed on energy efficiency, suggesting the presence of a rebound effect that may undermine the benefits gained (Chatzistamoulou and Koundouri, 2024). Despite criticism, the transition to a circular economy, with an essential contribution from eco-innovations, can be a viable solution for a sustainable future.

3. Research methodology

A quantitative technique-based analysis (Donthu et al., 2021), the bibliometric approach used within research allows delving into the literature and uncovering trends, patterns, and implications within a specific domain (Passas, 2024). From a bibliometric perspective, our study aims to analyze the extent to which the link between green innovations and the circular economy has been researched in the specialized literature. To meet this objective, the study seeks to answer the following questions:

RQ1. What is the interest in investigating the link between green innovations and the circular economy?

RQ2. What countries have published the most and received the most citations for publications analyzing green innovations in the context of the circular economy?

RQ3. Which are the journals with the most published papers and the most citations of articles analyzing the link between green innovations and the circular economy?

RQ4. What are the most highly cited publications on the topic under investigation?

RQ5. Which countries are collaborating internationally on research focused on the link between green innovations and the circular economy?

RQ6. Which concepts and themes are most prominent in research on the link between green innovations and circular economy?

Accordingly, the Web of Science database was explored to support the fulfillment of our study's objectives. The search process was performed on April 22, 2025. The initial step in generating the dataset involved conducting a database search based on topic criteria, which in the case of Web of Science includes searching for terms in the title, abstract, author keywords, and keyword plus. In the literature, green innovations, ecological innovations, environmental innovations, and sustainable innovations are terms used interchangeably by many authors since the differences are only subtle. Therefore, our search included all these terms to obtain the most relevant results. The search was performed using the following algorithm:

("green innovati*" OR "eco-innovati*" OR "ecoinnovati*" OR "ecological innovati*" OR "environmental innovati*" OR "sustainable innovati*") AND ("circular econom*" OR "circularity" OR "circular strateg*" OR "circular* principles" OR "circular business*")

To retrieve results for different variations of words, we utilized the "*" symbol. In this way, searching for "green innovati*" will generate results like "green innovation", but also "green innovations", or "green innovative".

Our analysis targeted scientific research published until 2024, the most recent full year of available publications. In the second phase of dataset generation, we applied several refinements based on specific criteria. We focused on the "Article" and "Proceeding Paper" document types, excluding other categories such as reviews, books, and book chapters. Additionally, we limited our search to articles published in English. We chose to include all the research categories in our analysis. This decision aligns with the multidisciplinary nature of the topic. Following the application of the refinement criteria, the dataset contained 538 documents. In our analysis, we used VOSviewer, version

1.6.20, which is a software that allows for pursuing a bibliometric investigation of the chosen topic.

4. Results and discussions

In order to meet the objectives and address the proposed research questions, we carried out a series of investigations on the selected articles, with the results presented below. In the initial phase of our analysis, we sought to assess the level of interest in exploring the relationship between green innovations and the circular economy (RQ1). Accordingly, Figure 1 illustrates the evolution of the number of publications in our dataset addressing this topic, spanning from 2008, the year of the first recorded entry in the database, to 2024. It can be seen that the interest in researching this topic exists and that the role of green innovations in supporting the circular economy is increasingly being explored. Starting in 2016, the number of studies on this subject has risen steadily each year, reaching a total of 122 publications by 2024. The growing interest in this topic is likely driven primarily by the European Union's adoption of the transition to a circular economy as a core policy, following China's earlier implementation of a similar approach.

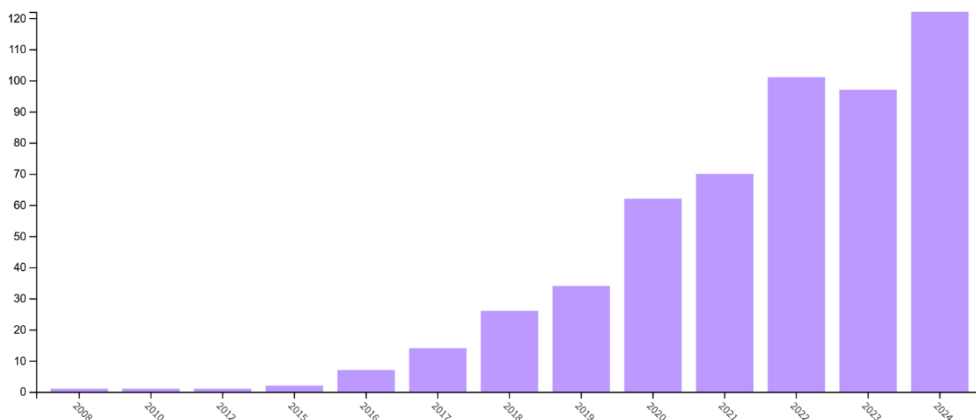


Figure 1: The annual progression of publication output regarding the role of green innovations in supporting the circular economy

Source: retrieved from Web of Science

Looking at the research area distribution, it can be observed that the majority of papers fall within the field of Environmental Sciences Ecology (284 records representing 52.788% of the total records), Business Economics (196 records representing 36.431% of the total records), Science Technology Other Topics (195 records representing 36.245% of the total records), Engineering (124 records representing 23.048% of the total records), and Public Administration (28 records representing 5.204% of the total records).

Figure 2 presents a more detailed breakdown of the number of papers by research area, highlighting the top 10 categories.



Figure 2: The distribution of articles across various research areas
Source: retrieved from Web of Science

Research Question 2 seeks to identify the countries that are most productive and influential in the scientific research related to the role of green innovations in supporting the circular economy. Countries with the highest publication output are Italy (83 documents representing 15.428% of the total records), Spain (82 documents representing 15.242% of the total records), England (73 documents representing 13.569% of the total records), China (67 documents representing 12.454% of the total records), and India (39 documents representing 7.249% of the total records).

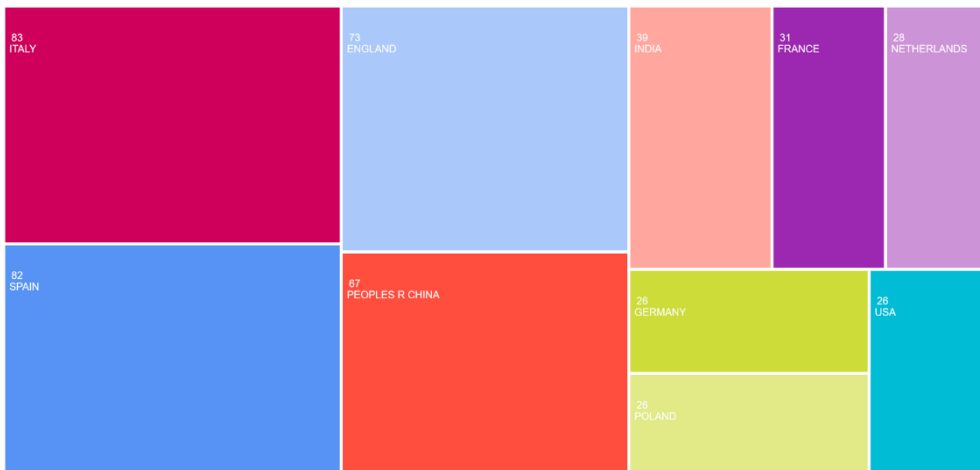


Figure 3: Countries with the highest publication output
Source: retrieved from Web of Science

Based on the number of citations received by publications from each country, our study reveals that the countries with the most impactful papers are England (4,256 citations),

followed by the Netherlands (3,591 citations), Spain (2,949 citations), Italy (1,936 citations), and Germany (1,742 citations).

Table 1: Citations count by country

Country	Number of citations	Documents
England	4256	73
Netherlands	3591	28
Spain	2949	82
Italy	1936	83
Germany	1742	26
China	1725	67
India	1211	39
Sweden	1148	23
France	907	31
Portugal	854	16

Source: Authors 'processing

As for the journals, we aimed to identify the most influential ones (RQ3). In this sense, we focused our analysis on considering both the scientific productivity of journals and their impact in the view of the topic under investigation. The figure below shows that the highest number of papers were published in the Sustainability journal (66 documents), the Journal of Cleaner Production (63 documents), and the Business Strategy and the Environment journal (35 documents).

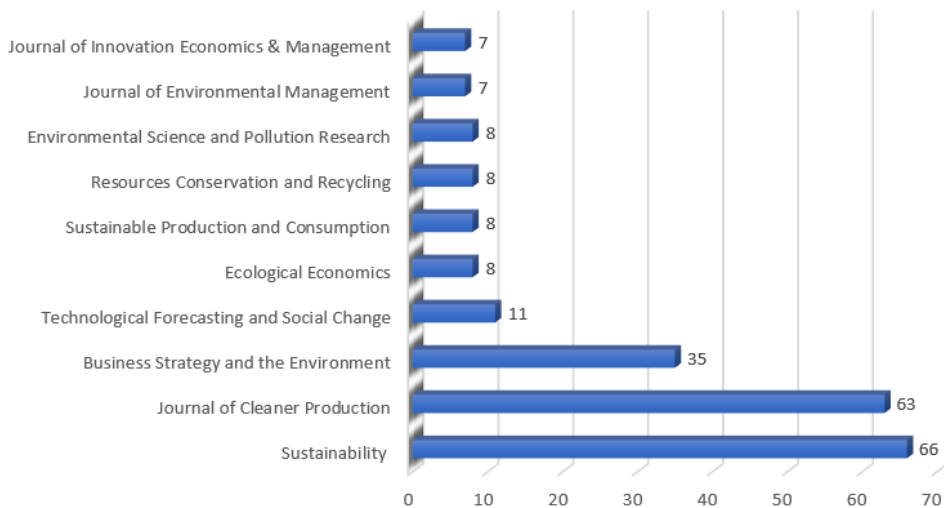


Figure 4: The leading ten journals by publication volume

Source: Authors 'processing

A journal's influence and relevance on a certain topic are commonly assessed through the total citations received by its publications. In Figure 5, we have included the first ten

journals whose publications on the analyzed topic received the highest number of citations.



Figure 5: The leading ten journals ranked by the citation count of their publications
Source: Authors 'processing

A relevant aspect we sought to explore, in line with Research Question 4, was the top 5 most cited articles within our dataset. Table 2 below presents the hierarchy of these high-impact papers, based on their total citation counts.

Table 2: The five articles with the highest citation count

Title	Author(s), publication year	Journal	Citations
Barriers to the Circular Economy: Evidence from the European Union (EU)	Kirchherr, J.; Piscicelli, L.; Bour, R.; Kostense-Smit, E.; Muller, J.; Huibrechtse-Truijens, A.; Hekkert, M. (2018)	Ecological Economics	913
Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy	de Jesus, A.; Mendonça, S. (2018)	Ecological Economics	630
Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers	Rizos, V.; Behrens, A.; van der Gaast, W.; Hofman, E.; Ioannou, A.; Kafyeke, T.; Flamos, A.; Rinaldi,	Sustainability	629

Title	Author(s), publication year	Journal	Citations
	R.; Papadelis, S.; Hirschnitz-Garbers, M.; Topi, C. (2016)		
Towards a consensus on the circular economy	Prieto-Sandoval, V.; Jaca, C.; Ormazabal, M. (2018)	Journal of Cleaner Production	619
Circular Economy in the building sector: Three cases and a collaboration tool	Leising, E.; Quist, J.; Bocken, N. (2018)	Journal of Cleaner Production	301

Source: Authors 'processing

The most frequently cited articles, along with their first authors and publication years, are illustrated in Figure 6.

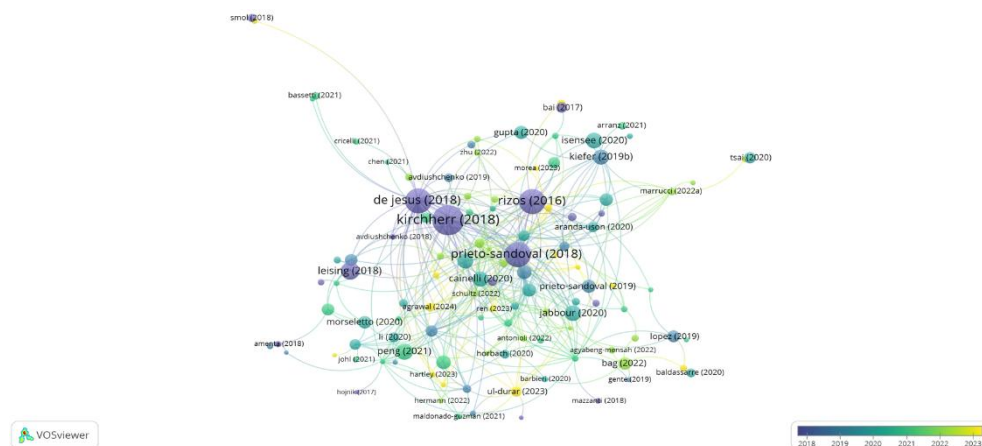


Figure 6: Highly cited articles, as determined by first author and publication year
Source: Authors 'processing

Further in this study, in line with Research Question 5, we proposed to reveal the co-authorship network map between countries involved in publishing research on the link between green innovations and circular economy, as collaborative activities play a vital role in advancing research. A minimum threshold of five documents was established, and out of 85 countries, 40 met this criterion. The countries are organized into eight clusters, representing closely connected collaborative communities. Among them, England, Spain, Italy, and China stand out as the most actively involved in international research collaborations.

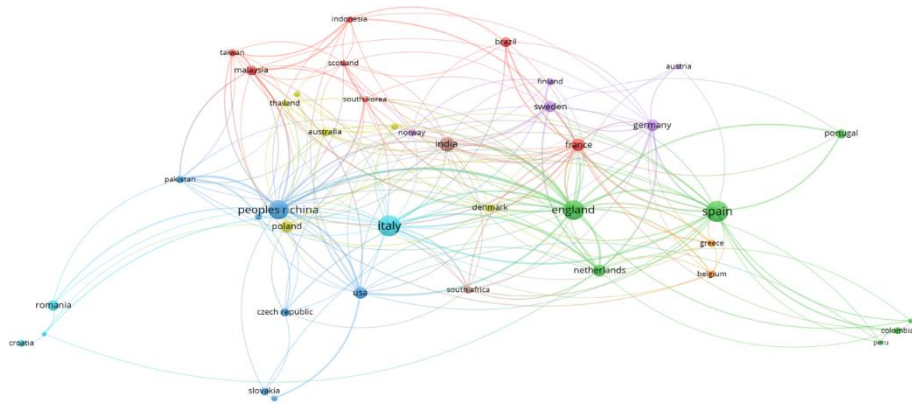


Figure 7: Cross-country research collaboration network
Source: Authors 'processing

To address Research Question 6, we performed a keyword co-occurrence analysis that revealed the main thematic clusters. In this network, each keyword is represented as a node, with its size reflecting how frequently it appears and, by extension, its importance within the dataset. This analysis was conducted using the keywords provided by the authors, with a threshold of at least five occurrences per keyword. The links between nodes represent keyword co-occurrences, indicating that the connected terms frequently appear together. Thicker links denote a higher frequency of co-occurrence, while shorter links suggest a stronger association between the keywords.

We have eliminated generic keywords related to green innovations and their synonyms, and circular economy concepts, as these were present across all papers and did not contribute to distinguishing thematic clusters. Additionally, to enhance the clarity and accuracy of the co-word network analysis, we developed and applied a thesaurus file to standardize terminology. This process involved consolidating terms that referred to the same concept but appeared in different forms, thereby reducing redundancy and enabling a more coherent visualization of the keyword network. The co-occurrence analysis was conducted on a selection of 45 keywords, drawn from a total of 1,613.

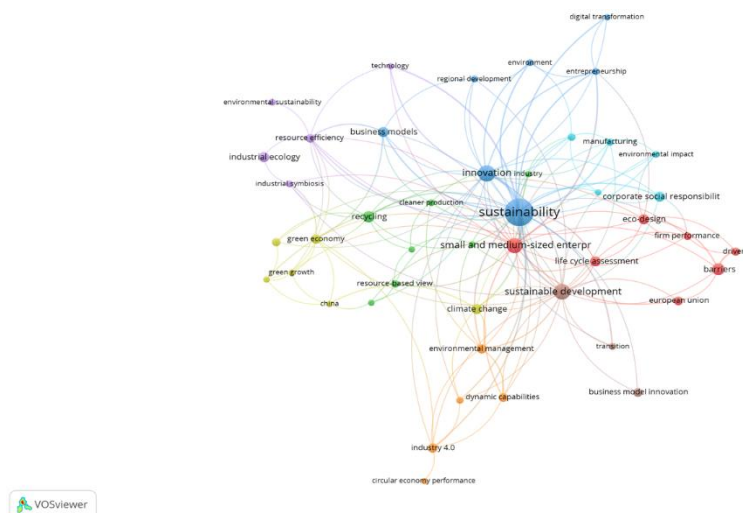


Figure 8: Author keywords co-occurrence network
Source: Authors 'processing

As a result, the map showed 8 clusters of keywords, encompassing 154 links and an overall link strength of 221. Cluster 1, with red color, is centered around the concepts of small and medium-sized enterprises, barriers, life cycle assessment, and eco-design. This cluster brings together concepts that point out both the influencing factors and the barriers that businesses face while attempting to align their products to meet the requirements of environmentally friendly economies, such as the circular economy and the green economy.

Cluster 2, with green color, contains the core concepts: recycling, resource-based view, and cleaner production. This points out the circularity as a new paradigm in carrying out economic activities by reintroducing materials into the economic circuit.

In cluster 3, with blue color, the relevant concepts are sustainability, innovation, and business models. This supports the idea that innovation is the driving force to develop entrepreneurship and create economic models in line with sustainable development.

Cluster 4, marked with yellow color, is dominated by concepts like climate change, green economy, and waste management. These topics indicate the concern about climate issues and the solutions needed to address them, also highlighting the role of waste management as a central instrument in both the green economy and the circular economy.

In cluster 5, represented with purple color, the core concepts included are industrial ecology, resource efficiency, environmental sustainability, and industrial symbiosis. This cluster brings together the main concepts related to an environmentally friendly economy, based on new technologies, for minimizing the use of resources, optimizing resource flows, waste reduction, and symbiotic industrial practices.

Cluster 6, marked with a light blue color, is centered around core concepts like corporate social responsibility, sustainability performance, manufacturing, and environmental impact. This cluster addresses the environmental dimension, as well as the social

dimension of sustainability, as regards the social responsibility of companies in trying to achieve cleaner manufacturing activities.

In cluster 7, represented with orange color, the central concepts are Industry 4.0, environmental management, and dynamic capabilities. These topics address the idea of a cleaner environment achieved through the latest technologies to support the transition to an efficient economy based on the principles of circularity.

Finally, cluster 8, represented with the brown color, includes concepts like sustainable development, business model innovation, and transition. This indicates the need to change the way business is done in order to achieve sustainable development with the contribution of innovation.

5. Conclusions

Green innovations and the circular economy are intrinsically linked concepts that collectively drive sustainable development by fostering resource efficiency, waste reduction, and environmental protection while simultaneously promoting economic growth (Xie, Huo and Zou, 2019). As Cainelli, D'Amato and Mazzanti (2020) stated, eco-innovation adoption is a key element in the transition to a circular economy, and by extension, in an attempt to achieve sustainable development, because a circular economy is considered to be essential for achieving a more sustainable economy (De Jesus and Mendonça, 2018).

In this paper, we carried out a bibliometric analysis focused on the publications with the highest relevancy from the Web of Science database that explore the relationship between green innovations and the circular economy. Our analysis of the scientific research related to the chosen topic had the objective of emphasizing the interest towards this topic, as well as identifying the most frequently explored concepts and themes.

Given the growing scholarly interest in the circular economy, this study seeks to assess the extent to which green innovations are examined within this framework. This bibliometric analysis reveals several key insights into the interconnected fields of green innovations and the circular economy, highlighting, at a global level, both the progress made in research and academic publishing on these topics and the international collaborations that contribute to the development of this multidisciplinary field.

We can observe that research addressing the subject of green innovations in the context of the circular economy exists, is increasingly numerous, and is carried out in different areas, many of them being included in research areas like Environmental Sciences Ecology, Business Economics, Science Technology Other Topics, Engineering, and Public Administration. Countries such as Italy, Spain, England, and China lead in terms of the number of published papers that analyze together the green innovations and circular economy topic. Researchers from these countries also stand out as being the most actively involved in international research collaborations. Our analysis revealed that the most influential journals are the Journal of Cleaner Production, Sustainability, Ecological Economics, and the Business Strategy and the Environment journal. A key objective of our analysis was to uncover the main concepts underlying the research that connects green innovations with the circular economy. In this regard, the analysis performed revealed that there is a focus on themes such as sustainability, innovation, sustainable development, small and medium-sized

enterprises, barriers, recycling, climate change, business models, industrial ecology, eco-design, and corporate social responsibility.

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