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Driving research on eco-innovation systems: Crossing the boundaries of innovation systems

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ABSTRACT

Sustainability is now a part of all areas of today's society and has become a cornerstone of economic, social, and environmental prosperity. Its pivotal role means that sustainability has also influenced the innovation process. Over the last few decades, new innovation-related concepts linked to sustainable development have emerged in the form of environmental, green, sustainable, and eco-innovations; nevertheless, technological and innovation developments still occur within the boundaries of an innovation system. Innovation systems possess unique characteristics that shape activities, actions, and decisions. The separate bodies of literature on eco-innovation and innovation systems are extensive; however, the status of the literature on the intersection of these two topics is less clear. This study provides an overview of the scientific literature in the area where eco-innovation and innovation systems meet, and a bibliometric analysis shows that the joint study of eco-innovation and innovation systems is an unexplored knowledge field. Thus, the main authors and documents that provide the foundation of the literature on eco-innovation and innovation systems were identified, and theoretical knowledge was grouped into four clusters according to thematic areas: Cluster 1 related to eco-innovation; Cluster 2 related to innovation systems; and Clusters 3 and 4, which include the elements that constitute and interact within eco-innovation systems. We hope that this study will encourage scholars to conduct research on eco-innovation systems, which could have positive implications for the design and implementation of new policies and instruments to achieve sustainable development.

1. Introduction

Since the 1990s, nations have implemented innovation policies as part of their political strategies (López-Rubio et al., 2021b). The reason for this political interest is that innovation has become a crucial element in boosting business and regional competitiveness (Odei and Appiah, 2022). A region's competitiveness, as well as the business that takes place within it, is shaped by the region's characteristics, which include economic activity, institutional quality, infrastructure, and clustering (Aiginger and Firgo, 2017). Therefore, the custom of comparing regions and imitating practices by policymakers has led to failures in regional development, helping maintain regional differences and inequalities (Asheim et al., 2011). The need to

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resolve these failures has led to the development of innovative systems that may refer to the innovation characteristics of either a country (i.e., a national innovation system [NIS]) or region (i.e., a regional innovation system [RIS]). Innovation systems, which develop continuously over time, are created through collaboration and cooperation among entities within a region or country (Doloreux and Parto, 2005).

The innovation process requires the participation and collaboration of agents in the system. Through participation and collaboration, knowledge, information, and know-how are transmitted easily and rapidly, encouraging the adoption of innovations that improve economic, social, and environmental well-being. The importance of sustainable development and innovation has increased over the last few decades, and political and social awareness is now greater (Díaz-García et al., 2015; Hojnik and Ruzzier, 2016; Păcesilă and Ciocoiu, 2017). To reflect this greater awareness, new concepts of innovation have emerged in relation to sustainability and its three dimensions (economic, social, and environmental). The authors refer to such innovations as green (Azzone and Noci, 1998; Driessen and Hillebrand, 2002), environmental (Carraro and Siniscalco, 1992; Green et al., 1994; Porter and van der Linde, 1995), sustainable (Brundtland, 1987; Schiederig et al., 2012), and eco-innovation (Fussler and James, 1996; Rennings, 2000). Eco-innovation can drive a country's economic prosperity and well-being. Economic prosperity and well-being are closely associated with the environment (European Environment Agency, EEA, 2015), and this link suggests that eco-innovation develops within the boundaries of innovation systems, influenced by a country or region's individual characteristics.

The literature on eco-innovation and innovation systems is extensive when these topics are considered separately. However, what is the literature that studies both topics jointly and what are its characteristics? This study explores the research trends that arise when eco-innovation and innovation systems are considered together to identify the theoretical references (authors and documents) underpinning the literature on both topics. Thus, it provides academics with a comprehensive overview of the literature, and bibliometric methods are used for this purpose. Specifically, this study presents co-occurrence and co-citation analyses. Co-occurrence analysis reveals links between author keywords for eco-innovation and innovation systems, while co-citation analysis reveals common literature that provides a foundation for research on both eco-innovation and innovation systems. The data on this topic were obtained from the Web of Science Core Collection (WoS CC). These findings reflect that the joint field of eco-innovation and innovation systems remains unexplored, contrary to the extensive existing research on both topics when considered separately, even though sustainability in all areas of society has become a crucial part of achieving sustainable development. In addition, we identify the main authors and documents that provide the theoretical frameworks used in the literature on this topic. The specific areas studied by these authors are then grouped into four thematic clusters: Cluster 1 is related to eco-innovation; Cluster 2 is related to innovation systems; and Clusters 3 and 4 include the elements that constitute and interact with eco-innovation systems.

The originality of this study lies in its application of bibliometric analyses to study two topics that are broadly discussed in the literature when considered independently (eco-innovation and innovation systems). Thus, research gaps and trends that could encourage scholars to further research eco-innovation systems were identified. Further research could contribute to achieving sustainable development by providing policymakers with crucial insights integrated within the national innovation system. Therefore, innovation-sustainability-related policies and instruments can be adapted to each national context to guarantee the success of sustainable development.

The remainder of this paper is structured as follows. Section 2 describes national and regional innovation systems and eco-innovation. Section 3 introduces the bibliometric analysis method and contextualizes the research on eco-innovation and innovation systems. Section 4 presents the results of the bibliometric analysis. Finally, Section 5 presents the main conclusions, limitations, and possibilities for future research.

2. Theoretical framework

2.1. National and regional innovation systems

National and regional innovation systems have emerged in light of growing international competition, the limitations of current policies and development models, and the creation of clusters of successful industries and companies (Doloreux and Parto, 2005; Enright, 2003). An innovation system is defined as a set of economic and institutional agents that, together with the implementation of policies, can influence innovation performance and behavior (Freeman, 1987; Lundvall, 1992; Nelson, 1993).

Innovation systems facilitate the flow of information and technology among institutions, firms, and individuals (Alaie, 2020). The participation of these actors is essential for the success of the innovation process because technological development and innovation arise from complex relationships among the actors in the innovation system (OECD, 1997). According to Asheim and Isaksen (2002), clusters and other agglomerations can stimulate and incentivize collective learning and innovation through communication, collaboration, and cooperation among companies, sociocultural structures, and institutional environments. In this sense, collective learning and innovation are embedded in the regions and societies in which they occur.

Innovation systems focus on the factors that can influence a region's technological capabilities (Cooke et al., 1997; Nelson and Rosenberg, 1993). The diversity found in national innovation systems results from differences in economic, institutional, and research and development (R&D) frameworks, and the institutional and cognitive structures of a given region shape what occurs within it. These structures increase regional differences, resulting in different innovation potentials (Asheim et al.,

2011). Many studies have investigated the influence of innovation activities and processes on modern societies and economies (Cancino et al., 2017; López-Rubio et al., 2021d). To improve regional competitiveness and growth, it is essential to identify patterns of innovation in each region and adapt these patterns to different regional characteristics (Lorenz and Lundvall, 2006); doing so could reduce the inequalities between regions resulting from innovation. Asheim and Isaksen (2002) show that business clusters that ultimately drive regional development employ different innovation resources. Hence, clusters use different innovation strategies, which may be successful based on their characteristics, situations, and processes. Tödtling and Trippl (2005) argue that an ideal innovation policy model does not exist, but each policy must be adapted to the economic, political, social, cultural, institutional, and environmental contexts of the region in which it is implemented. The concept of innovation policy and its subsequent implementation highlights its importance in driving and supporting innovation processes (López-Rubio et al., 2021d).

2.2. Eco-innovation

An innovation is "the implementation of a new or significantly improved product (good or service), process, marketing method, or organizational method in business practices, workplace organisation, or external relations" (OECD, 2005, p. 46). Technological innovations affect the society and environment in which they are implemented (Omri, 2020; Weitzman, 1997). Traditional innovation is based on maximizing profits and financial results without considering the indirect effects (Silvestre and Ţîrcă, 2019). However, growing social and environmental concerns have led to other types of innovation that attempt to cover the economic, social, and environmental dimensions of sustainability (Chen et al., 2018).

Numerous terms have been used in the literature to refer to innovations related to one or more sustainability dimensions. Social innovation is a new social practice arising from intentional, collective, and goal-oriented actions, and it aims to achieve a sustainable quality of life by reconfiguring the goal-achievement system (Periac et al., 2018). This type of innovation prioritizes the social dimension of sustainability by aiming to improve social capital and contribute to society's well-being (Dawson and Daniel, 2010; Silvestre and Ţîrcă, 2019). Many scholars have not reached a consensus on the terms used to describe other sustainability-related innovations (Zubeltzu-Jaka et al., 2018). These terms include "green" (Azzone and Noci, 1998; Driessen and Hillebrand, 2002), "environmental" (Carraro and Siniscalco, 1992; Green et al., 1994; Porter and van der Linde, 1995), "sustainable" (Brundtland, 1987; Schiederig et al., 2012), and "eco-innovative" (Fussler and James, 1996; Rennings, 2000). Although some authors use these terms interchangeably (e.g., Dias Angelo et al., 2012; Hsu et al., 2021), others make a distinction (Díaz-García et al., 2015; Schiederig et al., 2012).

Green innovation is aimed at reducing a company's environmental impact, integrating environmental objectives and innovation processes, products, and services (Triguero et al., 2013). This type of innovation combines innovation-driven development with green development by relying on the basic concepts of environmental optimization, energy conservation, and innovation (Su and An, 2018). According to Watson et al. (2018), environmental innovation encompasses the environmental dimensions of sustainability. For example, Tariq et al. (2022) argue that the development of green technology and energy can contribute to sustainable development, guaranteeing ecological security because implementing eco-innovations can mitigate climate change. Schiederig et al. (2012) argue that sustainable innovation is the only type of innovation that includes the economic, social, and environmental dimensions of sustainability, while the other three terms (green, environmental, and eco-friendly) cover only the economic and environmental dimensions. Nevertheless, eco-innovation promotes a green economy and technology creation and acquisition, improves social well-being, and ensures environmental protection and natural resource conservation (Demirel and Kesidou, 2019; Zubeltzu-Jaka et al., 2018). Accordingly, it can be argued that eco-innovation includes all three dimensions of sustainability.

Fussler and James (1996) introduced in the literature the term "eco-innovation." The Eco-Innovation Observatory defines eco-innovation as "the introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle" (Eco-Innovation Observatory, 2010, p. 7). Hojnik and Ruzzier (2016) approve of this definition, arguing that this type of innovation enables more efficient use of resources and reduces the negative impact of resource use on the environment; thus, eco-innovation can improve the environmental performance of nations, regions, and businesses (Kanda et al., 2019). Despite the lack of consensus on the definition of eco-innovation, most definitions emphasize the role of the environmental dimension of sustainability. Reducing the negative environmental impacts and improving the use of natural resources should enhance the environment. This improvement in environmental quality should have positive effects on society by increasing social well-being and quality of life. Innovation is a crucial driver of economic growth because it increases product variety and stimulates employment (Guinet and Pilat, 1999). Hence, the concept of eco-innovation covers not only environmental aspects but also sustainable development (Rennings, 2000).

Given the wide variety of concepts and definitions related to sustainability-related innovation, this study uses the terms "green," "environmental," "sustainable," and "eco-innovation" interchangeably. The term "eco-innovation" is used the most, but it is assumed to encompass the other three types of innovation (i.e., green, environmental, and sustainable). By simultaneously analyzing the research avenues of the literature on eco-innovation and innovation systems, it is expected to identify the theoretical references (authors and documents) that support this literature.

3. Method and data

The literature on eco-innovation and national and regional innovation systems is extensive when these topics are considered separately. As of December 2021, the published documents on eco-innovation were 5469 and those on innovation systems 2789. According to WoS CC, the first paper on eco-innovation was published in 1978, and it was titled "The Adoption Process and Environmental Innovations: A Case Study of a Government Project" (Taylor and Miller, 1978).

Despite the extensive literature on these two topics and their importance within the current framework of sustainable development, research combining them is scarce. According to the WoS CC, the literature on both topics consists of only 42 documents, which is considerably smaller than that on either topic in isolation. Given the limited literature on the intersection of eco-innovation and national and regional innovation systems, this study aims to identify and analyze research avenues in this area while offering relevant insights (illustrated in Fig. 1).

Bibliometric methods capture the nuances and evolutionary trends of existing scientific knowledge in different fields and configure and shed light on large data volumes. The development of bibliometric software (e.g., Gephi and VOSviewer) and scientific databases (WoS and Scopus) has facilitated the collection and analysis of these large data volumes. Using bibliometric methods, scholars can gain a broad literature overview while identifying knowledge and research gaps that may suggest new research possibilities (Donthu et al., 2021). Although the increasing use of bibliometrics is recent, discussions on this topic started in 1950 (Wallin, 2005). The categories of bibliometric analysis are two: first, performance analysis focuses on the scholars' research contributions, and it includes publication-, citation-, and publication-related metrics; second, science mapping allows to study the relationships between publications and academics. Techniques for this category of bibliometric analysis include citation, co-citation, bibliographic, co-word, and co-authorship analyses (Donthu et al., 2021).

Bibliometric methods are used to provide a comprehensive overview of the literature on eco-innovation and innovation systems by applying statistical measures (do Adro and Leitão, 2020). First, co-occurrence analysis was conducted to capture the co-occurrence of author keywords (van Eck and Waltman, 2010). This analysis was conducted twice—once for research on eco-innovation and once for research on national and regional innovation systems. The aim was to identify the keywords for each of the major blocks. This analysis helps explain the current state of research in this area because it shows the links between topics graphically and in such a way that they can be easily identified (Callon et al., 1983; López-Rubio et al., 2021a). Second, co-citation analysis was conducted. The purpose of co-citation analysis is to identify the common literature that provides a theoretical framework for each publication. When one or more documents cite two papers or authors, the two papers or authors are co-cited (López-Rubio et al., 2021c; Small, 1973). Both analyses were conducted using the VOSviewer software.

Fig. 2 shows a bibliometric map of the connections among the keywords for eco-innovation. The search covered 5469 documents, including articles, proceedings, papers, book chapters and reviews, review articles, editorial materials, books, new items, letters, and meeting abstracts. This concept (together with green, environmental, and sustainable innovation) is strongly related to sustainable development, the environment, business, and regional management. These terms cover aspects related to the production and consumption models adopted by region (such as circular or green economies), corporate social responsibility (CSR), and competitiveness. This figure reflects the relevance of the environment when dealing with eco-innovation because it includes concepts such as renewable energy, climate change, and eco-design. Moreover, the literature also focuses on entrepreneurship, small and medium-sized enterprises (SMEs), and R&D, suggesting that their contribution to eco-innovation is important.

Fig. 3 presents an overview of research on national and regional innovation systems, and it presents 2789 documents comprising articles, proceedings, papers, book chapters and reviews, review articles, editorial materials, books, new items, letters, and meeting abstracts. The figure shows that these concepts are directly related to innovation and highlights the importance of innovation system agents. Examples of such agents include institutions, universities, clusters, and governance structures. The figure also includes factors that may affect innovation systems, such as technology, science, policy, collaboration, entrepreneurship, R&D, and knowledge. These interconnected elements constitute the national or regional innovation system. Some studies have also dealt with the effects of innovation systems on the competitiveness, efficiency, development, and growth of a country or region. The implication is that when both the actions and relationships of these interconnected elements are grounded in sustainability principles, countries can achieve sustainable development and thus enhance their economic, social, and environmental growth.

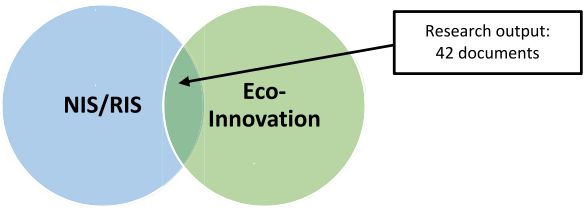

Fig. 1. Intersection between innovation systems and eco-innovation.

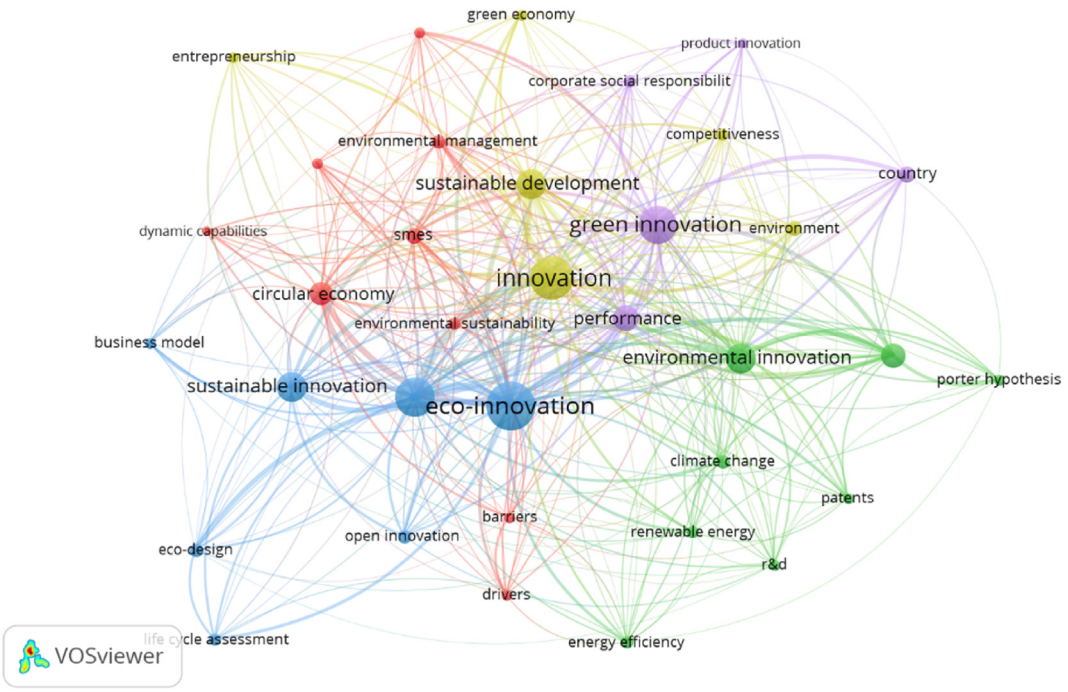

Fig. 2. Overview of eco-innovation keywords.

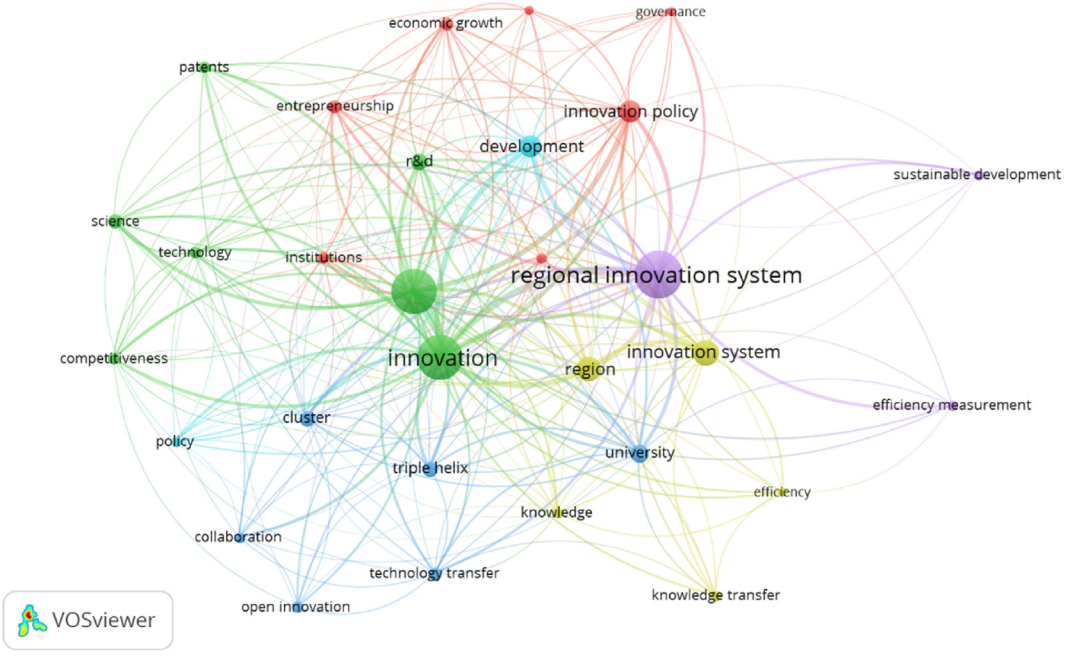

Fig. 3. Overview of innovation systems keywords.

This study examined the literature on the intersection of eco-innovation and national and regional innovation systems. The literature search included 42 documents from the time of the study, which was conducted in January 2022 based on the WoS CC database. The data refer to all documents published up to December 31, 2021. The search query used to gather data was as follows:

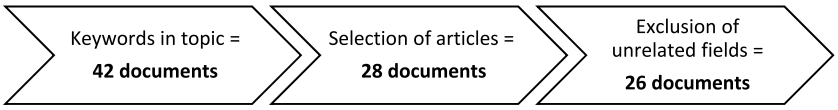

Fig. 4. Article selection process.

Table 1
Distribution of publications, citations, and citations per publication over the study period.

Period	TP	P/Y	TC	C/P
1990–1999	1	0.1	36	36
2000–2009	1	0.1	114	114
2010–2014	6	1.2	363	60,5
2015–2019	11	2.2	225	20,45
2020–2021	7	3.5	26	3,71

Note: TP = Total publications; P/Y = Publications per year; TC = Total citations; C/P = Citations per publication.

Topic = ("national innov* system*" OR "national system* of innov*" OR "regional innov* system*" OR "regional system* of innov*") AND ("eco-innov*" OR "eco innov*" OR "ecoinnov*" OR "green-innov*" OR "green innov*" OR "greeninnov*" OR "sust* innov*" OR "sust*-innov*" OR "environ* innov*" OR "environ*-innov*").

This query returned 42 records: 28 articles, 14 proceedings papers, two book chapters, and two early access documents. The 28 articles were used for analysis, representing 67% of the documents. Two of these 28 articles, which focused on architecture and physics, were excluded because they were unrelated to knowledge. Therefore, the analysis was based on the remaining 26 articles. Fig. 4 illustrates the article selection process used in this study.

4. Results: identifying patterns in the literature

To illustrate the focus of the research on eco-innovation and innovation systems between 1990 and 2021, 26 articles were categorized based on several variables. Table 1 presents the publications, number of citations, publications per year (P/Y), and citations per publication (C/P) for the 1990–1999, 2000–2009, 2010–2014, 2015–2019, and 2020–2021 sub-periods. In the 1990s and the 2000s, only one study was published per decade. The influence of publications from the 2000s appears to have been greater, as they received 114 citations. In the later sub-periods, the number of publications increased. Although the 2015–2019 sub-period had the highest number of publications (11), the 2010–2014 sub-period had the highest number of citations (363). The sub-period from 2020 to 2021 had a higher ratio of publications per year than any other sub-period. Therefore, scientific research on eco-innovation and innovation systems is expected to increase in the coming years.

Table 1 also offers insights into the evolution of literature on eco-innovation and innovation systems. Despite some variations in scientific production, the trend has generally been increasing. Only two studies were published between 1998 and 2008, but scientific production has increased significantly over the last decade. In 2019 and 2020, the number of publications per year was four, making these the years with the highest scientific production (30.8% of the total scientific production on the topic). Three papers published in 2004, 2010, and 2013 received 114, 131, and 158 citations, respectively, highlighting their importance and influence. These findings are corroborated by Table 2, which presents the 10 most influential papers published from 1990 to 2021.

The paper with the highest number of citations is "Determinants and Specificities of Eco-Innovations Compared to Other Innovations-An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey" by J. Horbach, V. Oltra, and J. Belin, which was published in 2013 and has received 158 citations. In this study, the authors analyze the factors of eco-innovation across countries to determine whether they show national characteristics that depend on national innovation systems. "The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach"' by Buesa, Heijs, and Baumert was published in 2010 and has received 121 citations. It explains that national and regional environments, innovative companies, universities, and public R&D are key drivers of innovation systems. Finally, "Regional Innovation Systems in Canada: A comparative study" by D. Doloreux was published in 2004 and is the third most-cited article. The authors investigated the innovation activities undertaken by SMEs to evaluate their collaborative interactions with other innovative organizations.

Table 3 presents the number of publications per country between 1990 and 2021. China had the most publications (four); Spain was responsible for three studies on eco-innovation and innovation systems, and Germany and the United States had two publications each. Several other countries (e.g., Australia, Finland, Lithuania, and Russia) were responsible for publishing only one paper. These findings indicate that the country with the most interest in studying the relationship between eco-innovation and innovation systems is China, followed by Spain. The conclusions and implications of publications by authors from China may help achieve sustainable national development; hence, China may have an advantage over other countries, not only in terms of economic and technological growth (as shown in recent years) but also in terms of sustainability. These four publications link the three social agents of the Triple Helix (universities, companies, and governments) to

Table 2
The most influential publications on the topic of eco-innovation and innovation systems based on total citations.

Authors	Title	Year	TC	C/Y
Horbach, J.; Oltra, V.; Belin, J.	Determinants and Specificities of Eco-Innovations Compared to Other Innovations- An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey	2013	158	17.56
Buesa, M.; Heijs, J.; Baumert, T.	The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach	2010	121	10.08
Doloreux, D.	Regional Innovation Systems in Canada: A comparative study	2004	114	6.33
del Rio, P.; Penasco, C.; Romero-Jordan, D.	Distinctive Features of Environmental Innovators: An Econometric Analysis	2015	65	9.29
Fabrizi, A.; Guarini, G.; Meliciani, V.	Green patents, regulatory policies and research network policies	2018	64	16
Leyden, D. P.	Public-sector entrepreneurship and the creation of a sustainable innovative economy	2016	38	6.33
Chapple, K.; Kroll, C.; Lester, T. W.; Montero, S.	Innovation in the Green Economy: An Extension of the Regional Innovation System Model?	2011	37	3.36
Roberts, R.	Managing innovation: The pursuit of competitive advantage and the design of innovation intense environments	1998	36	1.50
Chen, K. H.; Guan, J. C.	Mapping the innovation production process from accumulative advantage to economic outcomes: A path modeling approach	2011	29	2.64
Arranz, N.; Arroyabe, C. F.; Fernández de Arroyabe, J. C.	The effect of regional factors in the development of eco-innovations in the firm	2019	15	5

Note: TC = Total citations; C/Y = Citations per year.

Table 3
Countries with the most citations for eco-innovation and innovation systems research.

Country	TP	TC	C/P
Spain	3	201	67
Germany	2	158	79
Canada	1	114	114
USA	2	75	37.5
Italy	1	64	64
China	4	52	13

Note: TP = Total publications; TC = Total citations; C/P = Citations per publication.

collaboration, innovation production processes, environmental impact, sustainability policies, and SMEs. Three publications by Spanish authors studied the main determinants of environmental innovators and business eco-innovations within regional innovation systems.

Table 4 lists the five journals that published the highest number of articles on eco-innovation and innovation systems. The journals *Business Strategy and the Environment* and *Research Policy* published three studies on this topic. However, the three papers published in *Research Policy* received a higher number of citations (221 vs. 80 for papers published in *Business Strategy and the Environment*). The most-cited *Research Policy* paper is by M. Buesa, J. Heijs, and T. Baumert, and it is the second most influential in terms of the number of citations (Table 2). *European Planning Studies*, *Journal of Cleaner Production*, and *Small Business Economics* each have two publications, while *Applied Economics* has only one publication. These top five journals have a strong commitment to the environment, sustainability, and national, regional, and business development, in addition to focusing on development through innovative solutions.

Co-citation analysis was conducted to identify the relationships between the authors and references cited in 24 of the 26 articles. Two of the 26 articles (Koblianska et al., 2020; Song et al., 2020) were excluded from analysis; therefore, they were not included in the co-citation analysis. The minimum number of citations required for an author to be included in the analysis was five, leading to the selection of 68 authors with the greatest total link strength. Fig. 5 and Table 5 present the results of the co-citation analysis based on cited authors. Fig. 5 shows the core authors cited in the 24 articles grouped into

Table 4
Journals with the most publications on eco-innovation and innovation systems.

Journal	TP	TC	C/P
Business Strategy and the Environment	3	80	26,67
Research Policy	3	221	73,67
European Planning Studies	2	20	10
Journal of Cleaner Production	2	7	3,5
Small Business Economics	2	47	23,5
Applied Economics	1	4	4

Note: TP = Total publications; TC = Total citations; C/P = Citations per publication.

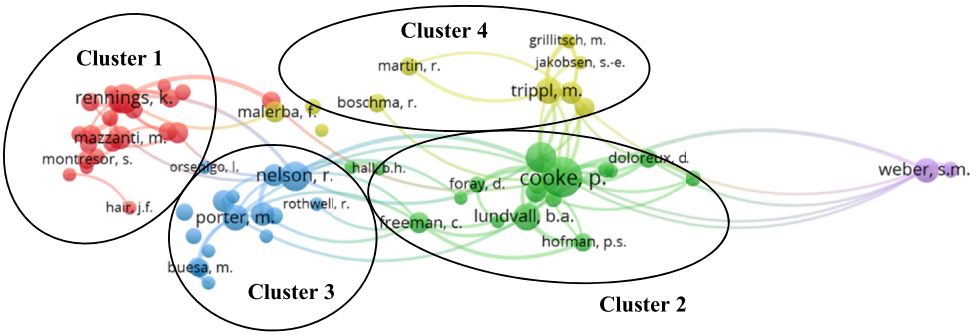

Fig. 5. Co-citation of authors in the eco-innovation and innovation systems literature.

four clusters: Cluster 1 (red) consists of 22 authors focused on innovations that benefit the economy, society, and the environment (green, environmental, sustainable, and eco-innovation). Cluster 2 (green) comprises 17 authors specializing in national and regional innovation systems. Cluster 3 (blue) includes 16 authors whose research is associated with innovation, entrepreneurship, and development, as well as authors studying innovation systems. This combination of research areas can be justified by the fact that innovation, entrepreneurship, and development are studied within the context of innovation systems because of their interactions with each other within the system. Finally, Cluster 4 (yellow) consists of 11 authors who focus on other elements that interact within an innovation system, namely clusters, knowledge, policy, and industry, which may affect eco-innovation activities and decisions. Table 5 complements this information by displaying the authors belonging to each cluster and their main research topics.

Table 6 shows the 10 most-cited authors in papers that simultaneously address eco-innovation and national and regional innovation systems. Cooke, Asheim, and Nelson are the three most cited authors, and their research is mainly related to innovation systems. Six of the 10 most-cited authors belong to Clusters 2 and 3 (three to Cluster 2 and three to Cluster 3). This distribution makes sense because research on innovation, entrepreneurship, development, and innovation systems has a decade-long history. However, the literature on eco-innovation and its drivers is more recent as sustainability concerns were first associated with innovation after 1987. In 1987, the World Commission on Environment and Development (WCED) introduced the concept of sustainable development, which is crucial in explaining eco-innovation.

Finally, Table 7 presents the findings of the co-citation analysis based on the cited references in the 26 journals. The minimum number of citations for a cited reference to be included in the analysis was two, and only 16 of the 1580 references met this threshold. These 16 references were selected as the studies on which the literature on eco-innovation and innovation systems is based. The number of co-citations received by each cited reference is reflected in the total link strength (López-Rubio et al., 2021a). The study with the highest total link strength among eco-innovation and innovation systems articles is titled “On the drivers of eco-innovations: Empirical evidence from the UK” and was authored by E. Kesidou and P. Demirel. This study attempts to identify the drivers of eco-innovation using a sample of 1566 UK firms. The authors highlight the role of environmental regulations in encouraging firms to become involved in eco-innovation. Although 13 of the remaining articles had a total link strength of 200, two had a value of 100. Regarding the total number of citations in WoS, only five articles had at least 1000 citations: they were authored by Teece, Pisano, and Shuen (13,593 citations), Z. Griliches (2960 citations), K. Pavitt (2737 citations), K. Rennings (1142 citations), and F. Tödtling and M. Trippl (1098 citations). Of these five articles, only one

Table 5
Four clusters of authors according to their research areas.

Cluster number and color	Authors	Topic
1 (red)	Cainelli, G.; Chesbrough, H.; de Marchi, V.; del Rio, P.; Demirel, P.; Hair, J.F.; Hascic, I.; Horbach, J.; Jaffe, A.B.; Johnstone, N.; Kemp, R.; Kesidou, E.; Marzucchi, A.; Mazzanti, M.; Montresor, S.; Oltra, V.; Popp, D.; Rammer, C.; Rennings, K.; Wagner, M.; Ziegler, A.; Zoboli, R.	Eco-innovation
2 (green)	Asheim, B.; Cooke, P.; de Laurentis, C.; Defourny, J.; Doloreux, D.; Edquist, C.; Etxebarria, G.; Etzkowitz, H.; Foray, D.; Freeman, C.; Hall, B.H.; Harmaakorpi, V.; Heidenreich, M.; Hofman, P.S.; Lundvall, B.A.; Rosenberg, N.; Tödtling, F.	National and regional innovation systems
3 (blue)	Acs, Z.; Archibugi, D.; Audretsch, D.B.; Brouwer, E.; Buesa, M.; Fritsch, M.; Furman, J.L.; Griliches, Z.; Heijs, J.; Martinez Pellitero, M.; Nelson, R.; Orsenigo, L.; Pavitt, K.; Porter, M.; Rothwell, R.; Stern, S.	Innovation, entrepreneurship, and development
4 (yellow)	Boschma, R.; Coenen, L.; Frenken, K.; Grillitsch, M.; Isaksen, A.; Jakobsen, S.-E.; Malerba, F.; Martin, R.; Njøs, R.; Storper, M.; Trippl, M.	Clusters, knowledge, policy, and industry

Note: Some authors have studied topics in other clusters; however, they were added to the cluster closest to the main area of specialization.

Table 6
Authors of eco-innovation and innovation systems studies.

	Author	Cluster	TC	TLS
1	Cooke, P.	2	40	3218
2	Asheim, B.	2	23	2121
3	Nelson, R.	3	22	2017
4	Rennings, K.	1	21	1907
5	Lundvall, B.A.	2	18	1725
6	Porter, M.	3	17	1631
7	Trippl, M.	4	16	1401
8	Weber, S.M.*		15	692
9	Acs, Z.	3	13	1134
10	Mazzanti, M.	1	13	1232

Note: TC = Total citations; TLS = Total link strength. * Weber's scientific research is mainly based on organizational pedagogy; therefore, this author did not fit into any of the clusters.

Table 7
The 16 most-cited eco-innovation and innovation systems papers.

PY	Authors	Title	TLS	TC-WoS
1984	Pavitt, K.	Sectoral patterns of technical change: Towards a taxonomy and a theory	200	2737
1990	Griliches, Z.	Patent statistics as economic indicators: a survey	100	2960
1992	Cooke, P.	Regional innovation systems: competitive regulation in the new Europe	200	527
1997	Teece, D. J., Pisano, G., & Shuen, A.	Dynamic capabilities and strategic management	200	13,593
2000	Rennings, K.	Redefining innovation—eco-innovation research and the contribution from ecological economics	200	1142
2004	Smits, R., & Kuhlmann, S.	The rise of systemic instruments in innovation policy	200	359*
2005	Tödtling, F., & Trippl, M.	One size fits all?: Towards a differentiated regional innovation policy approach	200	1098
2007	Wagner, M.	On the relationship between environmental management, environmental innovation and patenting: Evidence from German manufacturing firms	200	253
2008	Horbach, J.	Determinants of environmental innovation—New evidence from German panel data sources	200	785
2008	Wagner, M.	Empirical influence of environmental management on innovation: Evidence from Europe	200	198
2009	Oltra, V., & Saint Jean, M.	Sectoral systems of environmental innovation: an application to the French automotive industry	100	221
2011	Demirel, P., & Kesidou, E.	Stimulating different types of eco-innovation in the UK: Government policies and firm motivations	200	248
2012	Kesidou, E., & Demirel, P.	On the drivers of eco-innovations: Empirical evidence from the UK	300	372
2012	Horbach, J., Rammer, C., & Rennings, K.	Determinants of eco-innovations by type of environmental impact—The role of regulatory push/pull, technology push and market pull	200	657
2012	De Marchi, V.	Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms	200	572
2012	Cainelli, G., Mazzanti, M., & Montresor, S.	Environmental innovations, local networks and internationalization	200	142

Note: PY = Publication year; TLS = Total link strength; TC-WoS = Total citations according to WoS. * This document is not available in WoS; therefore, citation values were obtained from Scopus.

directly dealt with eco-innovation. The remainder papers of the table cover the general concept of innovation. Therefore, given that eco-innovation is a relatively recent concept and given the high number of citations of the article by Rennings (2000), this article may be regarded as a seminal study in the field of eco-innovation.

Despite the small number of studies that simultaneously address eco-innovation and innovation systems, the co-citation analysis reveals the existence of a collection of key authors and studies commonly used to build a theoretical framework for research in this area. These authors and studies seem to coincide with those that formed the basis for studies on eco-innovation or national and regional innovation systems.

5. Conclusions

This study provides an overview of the literature on eco-innovation and innovation systems. The aim was to identify research avenues in specialist literature by examining the authors and articles that form the basis for the theoretical framework within this field, given that the literature on the intersection of eco-innovation and innovation systems is less clear than the literature that covers both topics separately. Scientific publications on eco-innovation (5,469) or innovation systems (2,789) are numerous; however, research on both topics is scarce. According to the WoS, only 42 documents exist. A bibliometric analysis was performed on 26 of the 42 articles.

The literature on eco-innovation and innovation systems is growing. China (four articles) and Spain (three articles) have the highest scientific production in this field. Such research could provide insights for designing and implementing eco-innovation policies based on each national innovation system, as well as promoting sustainable behavior at all levels of society.

Co-citation analysis based on the most-cited authors resulted in four clusters of authors corresponding to different research focuses. Cluster 1 (red cluster) focuses on eco-innovation, while Cluster 2 (green cluster) focuses on innovation systems. These clusters include the most authors (22 and 17 authors, respectively), suggesting that they have become the basis of the eco-innovation and innovation systems literature. Clusters 3 (blue) and 4 (yellow) focus on elements that constitute and interact with the innovation system. These elements can also affect a nation, region, or company's eco-innovation ability. Co-citation analysis based on the most-cited documents identified 16 references cited at least twice by 24 articles. As mentioned previously, two of the 26 articles (Koblianska et al., 2020; Song et al., 2020) were not located and were, therefore, not included in the co-citation analysis. As these studies are most commonly found within the theoretical frameworks of eco-innovation and innovation systems, in addition to the aforementioned studies, these articles could be crucial in explaining eco-innovation systems.

The 26 articles used for the bibliometric analysis in this study were selected from the 42 documents returned by searching for research on these two topics. This low scientific production reflects a scarcity of research on eco-innovation and innovation systems. This indicates that this field of research remains unexplored. However, the growing importance of sustainability and its relevance in all areas of society, including innovation systems, reflects the need for detailed studies on the functioning and characteristics of eco-innovation systems. Eco-innovation systems can provide international organizations, nations, and policymakers with appropriate instruments and skills to achieve sustainable development by boosting eco-innovation. Eco-innovation will be successful with a collective effort to consider the individual characteristics of the individual countries that together constitute the eco-innovation system.

Altenburg and Pegels (2012) introduce the concept of sustainability-oriented innovation systems as a call to action for governments as actors capable of encouraging the use of alternative technologies to promote sustainable development. The difference between innovation systems and sustainability-oriented innovation systems lies in the importance of the government's role in driving environmentally sustainable innovation. This aligns with Sun et al. (2019), which argue that adopting eco-innovation largely depends on government support and funding; therefore, the exploitation of eco-innovation varies within eco-innovation systems. However, these systems are characterized by an open flow of knowledge between agents from other systems as well as the relevance of geographic proximity in fostering this knowledge flow (Cooke, 2011), and the concept of eco-innovation is inherent in these systems (Horbach, 2005). Innovation systems emerge from the gradual process of interaction between agents (Suurs and Hekkert, 2012). It is thus reasonable to assume that eco-innovation systems are a key topic given the links between sustainability and innovation, which have been well documented since the end of the 1990s.

For example, Yin et al. (2019) used the institutional and innovation systems theory to explain how to achieve balanced sustainable development of the rural innovation system. Similarly, Miremadi et al. (2019) provide a holistic framework for studying eco-innovation systems based on innovation processes and government involvement through support and governance policies. Ouyang and You (2021) conclude that firms should be more aware of green R&D to shift toward eco-innovation systems, and such awareness accelerates the adoption of green and sustainable business practices that drive sustainable national development. Other studies have focused on China's eco-innovation system (Li et al., 2020; Wu et al., 2021), emphasizing the prominent role of the government, institutions, R&D, knowledge, geographic proximity, and geographic characteristics in the study of eco-innovation systems. These elements were also identified in the four clusters previously described, demonstrating the relationship between eco-innovation and innovation systems. Given the need to shift toward sustainable development, the literature could contribute to countries' progress by addressing the characteristics of eco-innovation systems. Such research could provide countries with crucial insights and tools to depart from traditional growth and development models and adopt new ones based on the three dimensions of sustainability. Recent studies have offered evidence of the novelty and growing importance of eco-innovation systems.

This study has some limitations. Scientific research on eco-innovation and innovation systems not available in the WoS CC was not included in the bibliometric analysis; thus, publications that may have made crucial contributions to this field but that do not appear in the WoS CC were not considered. In addition, co-cited references and authors might not have been cited for the same purpose or might not have expressed the same idea in all 24 articles. Some citations were included for unrelated reasons; however, in this study, it was assumed that co-citations reflected a similar focus. Despite these limitations, this study successfully identifies the state-of-the-art eco-innovation and innovation systems literature by providing research opportunities and trends on this topic.

Declaration of competing interest

The author(s) declare no conflict of interest.

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References

Aiginger, K., & Firgo, M. (2017). Regional competitiveness: connecting an old concept with new goals. In R. Huggins, & P. Thompson (Eds.), *Handbook of Regions and Competitiveness: Contemporary Theories and Perspectives on Economic Development* (pp. 155–191). Edward Elgar Publishing. https://doi.org/10.4337/9781783475018.00013.

Alaie, S. A. (2020). Knowledge and learning in the horticultural innovation system: a case of Kashmir valley of India. *Int. J. Innov. Stud., 4*(4), 116–133. https://doi.org/10.1016/j.ijis.2020.06.002

Altenburg, T., & Pegels, A. (2012). Innovation and Development Sustainability-oriented innovation systems-managing the green transformation. *Innov. Dev., 2*(1), 2–22. https://doi.org/10.1080/2157930X.2012.664037

Asheim, B. T., & Isaksen, A. (2002). Regional innovation systems: the integration of local 'sticky' and global 'ubiquitous' knowledge. *J. Technol. Tran., 27*(1), 77–86. https://doi.org/10.1023/A:1013100704794

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing regional advantage: platform policies based on related variety and differentiated knowledge bases. *Reg. Stud., 45*(7), 893–904. https://doi.org/10.1080/00343404.2010.543126

Azzone, G., & Noci, G. (1998). Seeing ecology and "green" innovations as a source of change. *J. Organ. Change Manag., 11*(2), 94–111.

Brundtland, G. H. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. World Commission on Environment and Development.

Callon, M., Courtial, J. P., Turner, W. A., & Bauin, S. (1983). From translations to problematic networks: an introduction to co-word analysis. *Soc. Sci. Inf., 22*(2), 191–235. https://doi.org/10.1177/053901883022002003

Cancino, C. A., Merigó, J. M., & Coronado, F. C. (2017). Big names in innovation research: a bibliometric overview. *Curr. Sci., 113*(8), 1507–1518.

Carraro, C., & Siniscalco, D. (1992). Environmental innovation policy and international competition. *Environ. Resour. Econ., 2*(2), 183–200.

Chen, J., Yin, X., & Mei, L. (2018). Holistic innovation: an emerging innovation paradigm. *Int. J. Innov. Stud., 2*(1), 1–13. https://doi.org/10.1016/j.ijis.2018.02.001

Cooke, P. (2011). Transition regions: regional–national eco-innovation systems and strategies. *Prog. Plann., 76*(3), 105–146. https://doi.org/10.1016/J.PROGRESS.2011.08.002

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: institutional and organisational dimensions. *Res. Pol., 26*(4–5), 475–491. https://doi.org/10.1016/S0048-7333(97)00025-5

Dawson, P., & Daniel, L. (2010). Understanding social innovation: a provisional framework. *Int. J. Technol. Manag., 51*(1), 9–21.

Demirel, P., & Kesidou, E. (2019). Sustainability-oriented capabilities for eco-innovation: meeting the regulatory, technology, and market demands. *Bus. Strat. Environ., 28*(5), 847–857. https://doi.org/10.1002/BSE.2286

Dias Angelo, F., Chiappetta Jabbour, C. J., & Vasconcellos Galina, S. (2012). Environmental innovation: in search of a meaning. *World J. Entrepren. Manag. Sustain. Dev., 8*(2/3), 113–121. https://doi.org/10.1108/20425961211247734

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: insights from a literature review. *Innovation, 17*(1), 6–23. https://doi.org/10.1080/14479338.2015.1011060

do Adro, F. J. N., & Leitão, J. C. C. (2020). Leadership and organizational innovation in the third sector: a systematic literature review. *Int. J. Innov. Stud., 4*(2), 51–67. https://doi.org/10.1016/J.IJIS.2020.04.001

Doloreux, D., & Parto, S. (2005). Regional innovation systems: current discourse and unresolved issues. *Technol. Soc., 27*(2), 133–153. https://doi.org/10.1016/J.TECHSOC.2005.01.002

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: an overview and guidelines. *J. Bus. Res., 133*, 285–296. https://doi.org/10.1016/J.JBUSRES.2021.04.070

Driessen, P. H., & Hillebrand, B. (2002). Adoption and diffusion of green innovations. In W. Nelissen, & G. Bartels (Eds.), *Marketing for Sustainability: towards Transactional Policy-Making* (pp. 343–355). IOS Press.

Eco-Innovation Observatory. (2010). *Eco-Innovation Observatory Methodological Report*. www.eco-innovation.eu.

Enright, M. J. (2003). Regional clusters: what we know and what we should know. In J. Bröcker, D. Dohse, & R. Soltwedel (Eds.), *Innovation Clusters and Interregional Competition* (pp. 99–129). Springer. https://doi.org/10.1007/978-3-540-24760-9_6.

European Environment Agency (EEA). (2015). *The European Environment — State and Outlook 2015: Synthesis Report*. https://www.eea.europa.eu/soer/2015/synthesis/report/0c-executivesummary.

Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*. Pinter Publishers.

Fussler, C., & James, P. (1996). *Eco-innovation: a Breakthrough Discipline for Innovation and Sustainability*. Pitman.

Green, K., McMeekin, A., & Irwin, A. (1994). Technological trajectories and R&D for environmental innovation in UK firms. *Futures, 26*(10), 1047–1059. https://doi.org/10.1016/0016-3287(94)90072-8

Guinet, J., & Pilat, D. (1999). Promoting innovation - does it matter? *OECD Obs., 217*, 63.

Hojnik, J., & Ruzzier, M. (2016). What drives eco-innovation? A review of an emerging literature. *Environ. Innov. Soc. Transit., 19*, 31–41. https://doi.org/10.1016/J.EIST.2015.09.006

Horbach, J. (2005). Methodological aspects of an indicator system for sustainable innovation. In *Indicator Systems for Sustainable Innovation* (pp. 1–19). Physica-Verlag HD.

Hsu, C. C., Zhang, Y. Q., Ch, P., Aqdas, R., Chupradit, S., & Nawaz, A. (2021). A step towards sustainable environment in China: the role of eco-innovation renewable energy and environmental taxes. *J. Environ. Manag., 299*, Article 113609. https://doi.org/10.1016/J.JENVMAN.2021.113609

Kanda, W., Río, P. del, Hjelm, O., & Bienkowska, D. (2019). A technological innovation systems approach to analyse the roles of intermediaries in eco-innovation. *J. Clean. Prod., 227*, 1136–1148. https://doi.org/10.1016/J.JCLEPRO.2019.04.230

Koblianska, I., Kalachevska, L., Mishenin, Y., & Mykhailova, L. (2020). System of indicators to measure eco-innovation potential of Ukrainian regions. *Int. J. Ecol. Dev., 35*(1), 75–88.

Li, H. F., Ci, F. Y., & Shi, J. L. (2020). Research on the model of regional green innovation system in China: a case study of Shandong provinc. *Ecol. Econ., 2*.

López-Rubio, P., Mas-Tur, A., Merigó, J. M., & Roig-Tierno, N. (2021a). Leading trends in technology transfer. In *Technology Transfer and Entrepreneurial Innovations* (pp. 21–41). Cham: Springer. https://doi.org/10.1007/978-3-030-70022-5_2.

López-Rubio, P., Roig-Tierno, N., & Mas-Tur, A. (2021b). Which regions produce the most innovation policy research? *Pol. Stud.*. https://doi.org/10.1080/01442872.2021.1937595

López-Rubio, P., Roig-Tierno, N., & Mas-Tur, A. (2021c). Mapping trending topics and leading producers in innovation policy research. *Inf. Res., 26*(3). https://doi.org/10.47989/IRPAPER905

López-Rubio, P., Roig-Tierno, N., & Mas-Tur, A. (2021d). A research journey from national systems of innovation to national systems of entrepreneurship: introducing the sextuple Helix. *Int. J. Innovat. Technol. Manag., 18*(8), 1–23. https://doi.org/10.1142/S0219877021300081

Lorenz, E., & Lundvall, B.Å. (2006). *How Europe's Economies Learn: Coordinating Competing Models*. Oxford University Press.

Lundvall, B. A. (1992). *National Systems of Innovation: towards a Theory of Innovation and Interactive Learning*. Pinter.

Miremadi, S. I., Saboohi, Y., & Khajepuor, H. (2019). Development of a comprehensive framework to analyse systems of energy and environmental innovation. *J. Improv. Manag., 12*(4), 70–95.

Nelson, R. R. (1993). *National Innovation Systems. A Comparative Analysis*. Oxford University Press.

Nelson, R., & Rosenberg, N. (1993). *Technical Innovation and National Systems*. Oxford University Press.

Odei, S. A., & Appiah, M. K. (2022). Unravelling the drivers of technological innovations in the Czech Republic: do international technological linkages matter? *Int. J. Innov. Stud., 7*(1), 32–46. https://doi.org/10.1016/j.ijis.2022.09.002

OECD. (1997). *National Innovation Systems*.

OECD. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*.
Omri, A. (2020). Technological innovation and sustainable development : does the stage of development matter? *Environ. Impact Assess. Rev., 83*, Article 106398. https://doi.org/10.1016/J.EIAR.2020.106398
Ouyang, L., & You, D. (2021). The green innovation effect on heavy-polluting enterprises under the environmental protection law. *Front. Energy Res., 9*, 176. https://doi.org/10.3389/FENRG.2021.681334/BIBTEX
Păcesilă, M., & Ciocoiu, C. N. (2017). Systematic literature review on eco-innovation determinants. *Manag. Res. Pract., 9*(3), 30–44.
Periac, F., David, A., & Roberson, Q. (2018). Clarifying the interplay between social innovation and sustainable development: a conceptual framework rooted in paradox management. *Eur. Manag. Rev., 15*(1), 19–35. https://doi.org/10.1111/EMRE.12121
Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *J. Econ. Perspect., 9*(4), 97–118.
Rennings, K. (2000). Redefining innovation — eco-innovation research and the contribution from ecological economics. *Ecol. Econ., 32*(2), 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3
Schiederig, T., Tietze, F., & Herstatt, C. (2012). Green innovation in technology and innovation management – an exploratory literature review. *R D Manag., 42*(2), 180–192. https://doi.org/10.1111/J.1467-9310.2011.00672.X
Silvestre, B. S., & Ţîrcă, D. M. (2019). Innovations for sustainable development: moving toward a sustainable future. *J. Clean. Prod., 208*, 325–332. https://doi.org/10.1016/J.JCLEPRO.2018.09.244
Small, H. (1973). Co-citation in the scientific literature: a new measure of the relationship between two documents. *J. Am. Soc. Inf. Sci., 24*(4), 265–269. https://doi.org/10.1002/ASI.4630240406
Song, Y., Zhang, J., Song, Y., Fan, X., Zhu, Y., & Zhang, C. (2020). Can industry-university-research collaborative innovation efficiency reduce carbon emissions? *Technol. Forecast. Soc. Change, 157*, Article 120094. https://doi.org/10.1016/J.TECHFORE.2020.120094
Su, Y., & An, X. (2018). Application of threshold regression analysis to study the impact of regional technological innovation level on sustainable development. *Renew. Sustain. Energy Rev., 89*, 27–32. https://doi.org/10.1016/J.RSER.2018.03.005
Sun, H., Edziah, B. K., Sun, C., & Kporsu, A. K. (2019). Institutional quality, green innovation and energy efficiency. *Energy Pol., 135*, Article 111002. https://doi.org/10.1016/J.ENPOL.2019.111002
Suurs, R., & Hekkert, M. (2012). Motors of sustainable innovation: understanding transitions from a technological innovation system's perspective. In *Governing the Energy Transition* (pp. 163–190). Routledge.
Tariq, G., Sun, H., Ali, I., Pasha, A. A., Khan, M. S., Rahman, M. M., Mohamed, A., & Shah, Q. (2022). Influence of green technology, green energy consumption, energy efficiency, trade, economic development and FDI on climate change in South Asia. *Sci. Rep., 12*(1), 1–13. https://doi.org/10.1038/s41598-022-20432-z
Taylor, D. L., & Miller, W. L. (1978). The adoption process and environmental innovations: a case study of a government Project. *Rural Sociol., 43*(4), 634.
Tödtling, F., & Trippl, M. (2005). One size fits all?: towards a differentiated regional innovation policy approach. *Res. Pol., 34*(8), 1203–1219. https://doi.org/10.1016/J.RESPOL.2005.01.018
Triguero, A., Moreno-Mondéjar, L., & Davia, M. A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecol. Econ., 92*, 25–33. https://doi.org/10.1016/J.ECOLECON.2013.04.009
van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3
Wallin, J. A. (2005). Bibliometric methods: pitfalls and possibilities. *Basic Clin. Pharmacol. Toxicol., 97*(5), 261–275. https://doi.org/10.1111/J.1742-7843.2005.PTO_139.X
Watson, R., Wilson, H. N., Smart, P., & Macdonald, E. K. (2018). Harnessing difference: a capability-based framework for stakeholder engagement in environmental innovation. *J. Prod. Innovat. Manag., 35*(2), 254–279. https://doi.org/10.1111/jpim.12394
Weitzman, M. L. (1997). Sustainability and technical progress. *Scand. J. Econ., 99*(1), 1–13. https://doi.org/10.1111/1467-9442.00043
Wu, W., Sheng, L., Tang, F., Zhang, A., & Liu, J. (2021). A system dynamics model of green innovation and policy simulation with an application in Chinese manufacturing industry. *Sustain. Prod. Consum., 28*, 987–1005. https://doi.org/10.1016/J.SPC.2021.07.007
Yin, X., Chen, J., & Li, J. (2019). Rural innovation system: revitalize the countryside for a sustainable development. *J. Rural Stud.*. https://doi.org/10.1016/j.jrurstud.2019.10.014
Zubeltzu-Jaka, E., Erauskin-Tolosa, A., & Heras-Saizarbitoria, I. (2018). Shedding light on the determinants of eco-innovation: a meta-analytic study. *Bus. Strat. Environ., 27*(7), 1093–1103. https://doi.org/10.1002/bse.2054