Sustainable Innovation: worldwide trends in the scientific production through a bibliometric study

Rosanna Cataldo, Corrado Crocetta, Maria Gabriella Grassia, Paolo Mazzocchi, Antonella Rocca, Claudio Quintano

1. The Sustainable Innovation

The scientific production on the Innovation, especially on Sustainable Innovation, has grown in recent years. Research on sustainable innovation has expanded rapidly in order to understand how new technologies can make societies more sustainable.
Various expressions and definitions for sustainability and innovation have been reported in the literature. Sometimes the two concepts are combined and described with one term, *Sustainable Innovation*. Research on sustainable innovation has grown in popularity due to the need to incorporate sustainability within business practices (Boons and Lüdeke-Freund, 2013). Innovation that is seen not only as a tool to guarantee a competitive advantage for companies but also as a tool that provides environmental benefits and produces social well-being (Cillo et al., 2019).
Tello and Yoon (2008) define the Sustainable innovation as "the development of new products, processes, services and technologies that contribute to the development and well-being of human needs and institutions while respecting natural resources and regeneration capacities". Several studies have focused on sustainable innovation and they stated that sustainable innovation can be studied on the basis of three main perspectives: internal managerial, external relational and performance evaluation (Cillo et al., 2019).

The paper contributes to the literature on sustainable innovation by providing the worldwide trend in the scientific production over time through a research conducted on the metadata of Web of Science, the main database commonly used by researchers. A bibliometric analysis has been developed to analyse a total of 1,511 documents published between 2000 and 2021 in order to discover the research trends in this field and the main dimensions and words related to the term "Sustainable Innovation".

2. Methodology

A bibliometric analysis has been used to explore the evolution of research in the innovation field. Bibliometric analysis is a quantitative approach for the analysis of academic literature using bibliographies to provide the description, evaluation and monitoring of the published research (Garfield et al., 1964); (White and McCain, 1989).
The methodological aim is to analyze publications, citations and sources of information (Rodriguez - Soler et al., 2020). The scientific community has always used bibliometric methods as a tool for analysis. For this study, the Bibliometrix package (Aria and Cuccurullo, 2017), in the R programming language (https://www.r-project.org/) was used. This recent R-package

Rosanna Cataldo, University of Naples Federico II, Italy, rosanna.cataldo2@unina.it, 0000-0002-6324-8252
Corrado Crocetta, University of Foggia, Italy, corrado.crocetta@unifg.it, 0000-0001-9059-5092
Maria Gabriella Grassia, University of Naples Federico II, Italy, mariagabriella.grassia@unina.it, 0000-0002-7128-7323
Paolo Mazzocchi, University of Naples Parthenope, Italy, paolo.mazzocchi@uniparthenope.it, 0000-0002-6632-314X
Antonella Rocca, University of Naples Parthenope, Italy, antonella.rocca@uniparthenope.it, 0000-0001-8171-3149
Claudio Quintano, University of Naples Suor Orsola Benincasa, Italy, claudio.quintano@unisob.na.it, 0000-0001-8315-8476

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Rosanna Cataldo, Corrado Crocetta, Maria Gabriella Grassia, Paolo Mazzocchi, Antonella Rocca, Claudio Quintano, *Sustainable Innovation: worldwide trends in the scientific production through a bibliometric study*, pp. 49-54, © 2021 Author(s), CC BY 4.0 International, DOI 10.36253/978-88-5518-461-8.10, in Bruno Bertaccini, Luigi Fabbris, Alessandra Petrucci (edited by), *ASA 2021 Statistics and Information Systems for Policy Evaluation. Book of short papers of the on-site conference*, © 2021 Author(s), content CC BY 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISSN 2704-5846 (online), ISBN 978-88-5518-461-8 (PDF), DOI 10.36253/978-88-5518-461-8

provides a set of tools for quantitative research in bibliometrics and scientometrics, supporting scholars in all key phases of analysis from the data importing to the visualization of results.

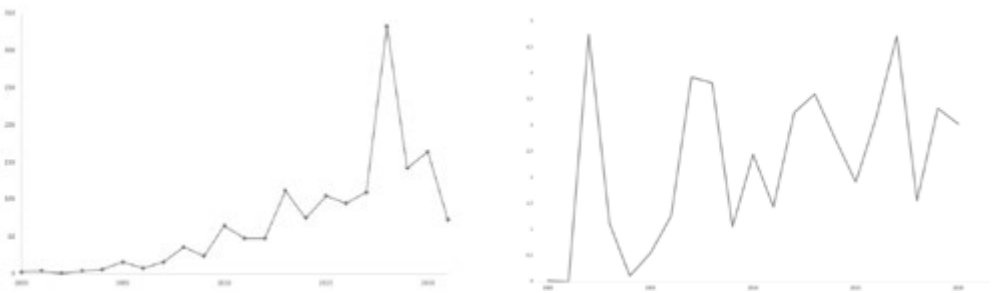
3. Analysis

The data for this research project were collected in the Web of Science's database of the Institute for Scientific Information (ISI). Web of Science (WoS) is the world's most trusted independent global citation database. It is recognised as covering a broad range of relevant journals and peer-reviewed articles of high quality (Cataldo et al., 2019).
To collect the documents published on this topic field in the past 20 years, we queried the WoS database on July 7th, 2021. A total of 1,511 documents published between 2000 and 2021 (incl.) containing the topic "Sustainable Innovation" were retrieved. The majority (907; 60%) were research articles. The second most common type of documents was proceeding papers which constituted 32.43%. Details about documents were shown in Table 1. Those documents show an average citation per documents of 13.08 in the considered period and were written by 3,897 authors from 663 different sources, such as journals, books, etc. The author's keyords are 3,694, while the keywords plus are 2,341.
According to Garfield (1990), the keyword plus "provides search terms extracted from the titles of papers cited in each new article in the ISI database, is an independent supplement for title-words and author keywords". The collaboration index, that represents the mean number of authors per joint paperand is calculated as total authors of multi-authored articles/total multi-authored articles (Elango and Rajendran, 2012), is equal to 2.96. It implies the research team falls between 2 and 3 in the field of sustainable innovation.

Table 1: General Information

About Data	Timespan	2000-2021
	Sources (Journals, Books, etc)	663
	Documents	1511
	Annual Growth Rate	16.42 %
	Average citations per documents	13.08
Document Types	Articles	907
	Books	5
	Books reviews	11
	Editorial materials	37
	Proceedings papers	490
	Reviews	61
Document Contents	Author's Keywords	3694
	Keywords Plus	2341
Authors	Authors	3897
	Authors of single-authored documents	197
	Authors of multi-authored documents	3700
Authors Collaboration	Documents per Author	0.388
	Authors per Documents	2.58
	Collaboration Index	2.96

Figure 1 (a) presents the annual-trends of publications, indicating that sustainable innovation literature has been growing since 2007, peaking in 2018 with 333 documents published. Generally, almost 17% of annual growth rate has been observed in the production of research articles during the study period (see Table 1). Figure 1 (b) shows the annual number of citations. The works published in the first years of analysis have accumulated a lot of recognition. It is possible to note that the average of citations in 2002 was equal to 4.74, and a similar average is reached in 2017.



(a) Annual scientific production (b) Average Citations per Year

Figure 1: Scientific production (2000-2021), n=1511

Figure 2 shows the main ten sources of pubblication. The first source is a book with the title "A Creative Path to Sustainable Innovation" related to the Siam Physics Congress 2018 (SPC2018) with 190 documents published. From Figure 2 it is possible to note that the most relevant sources, based on the number of articles, are *Sustainability*, *Journal of Cleaner Production*, *Green Technologies for Sustainable & Innovation in Materials*, journals whose aims are to provide up-to-date information on new developments and trends in relation to this topics.

Figure 2: Main sources of pubblication

Figure 3 shows the number of articles produced by the authors of different countries and the rate of cooperation of each country's authors with other countries' authors (SCP: Single Country Publications; MCP: Multiple Country Publications).

Thailand produced a large number of papers in the analysis period, showing a rather low collaboration rate (MCP) with authors from other countries. This means that the Thai authors who write on this topic do not collaborate with foreign researchers. The USA, despite having the same number of documents as Thailand, has a higher MCP than Thailand. England is the nation with the highest rate of collaboration with foreign authors, followed by China and Netherlands. These links are highlighted in the Figure 4.

In the network the size of the circle of the country is related to the number of works published on the analyzed topic, the different colors of the countries and of the links represent the clusters that have been formed, as determined by the Louvain algorithm, while the strength of the collaboration is indicated by the thickness of the links (Crocetta et al., 2021). The networking analysis emphasizes the strong collaboration of the USA with China. USA collaborates with almost all the countries shown in the network, except for some such as Malaysia and Portugal.

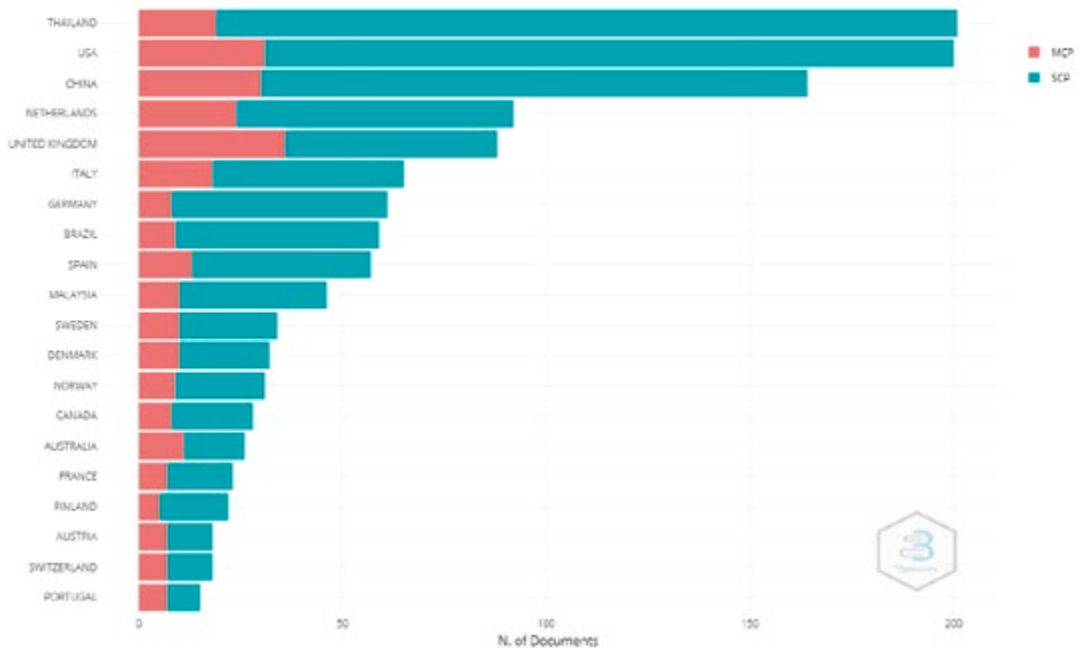


Figure 3: Corresponding Author Country

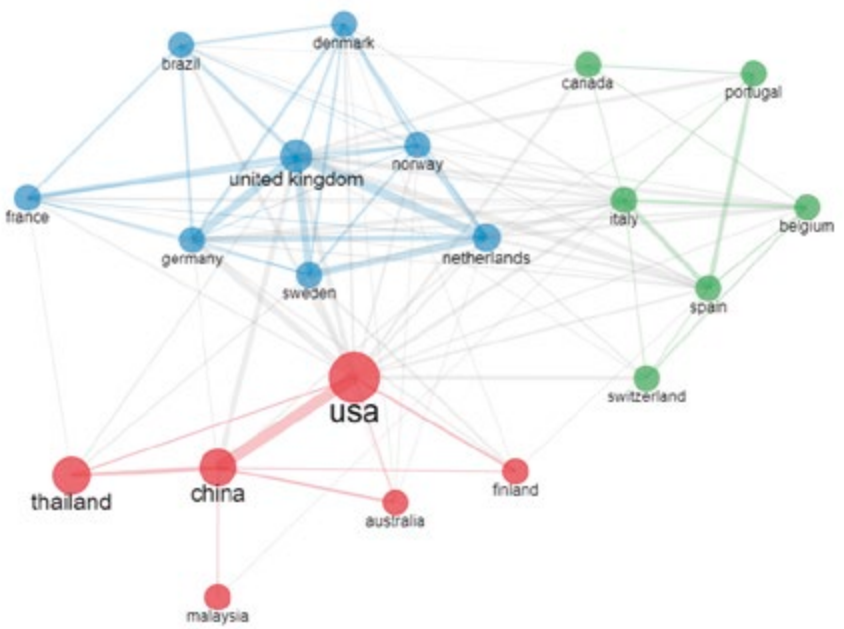


Figure 4: Collaboration Network

In the network we can see that there are only five connections from Thailand (to USA, China, Sweden, United Kingdom and France) and this reinforces what has been said about the low rate of collaboration.

The last Figure, Figure 5, is the thematic maps, an intuitive plot in which author's keywords

are viewed as themes, classified by different levels of density (which represents the development degree) and centrality (which represents the relevance degree) in the network of scientific keywords (Cataldo et al., 2019).

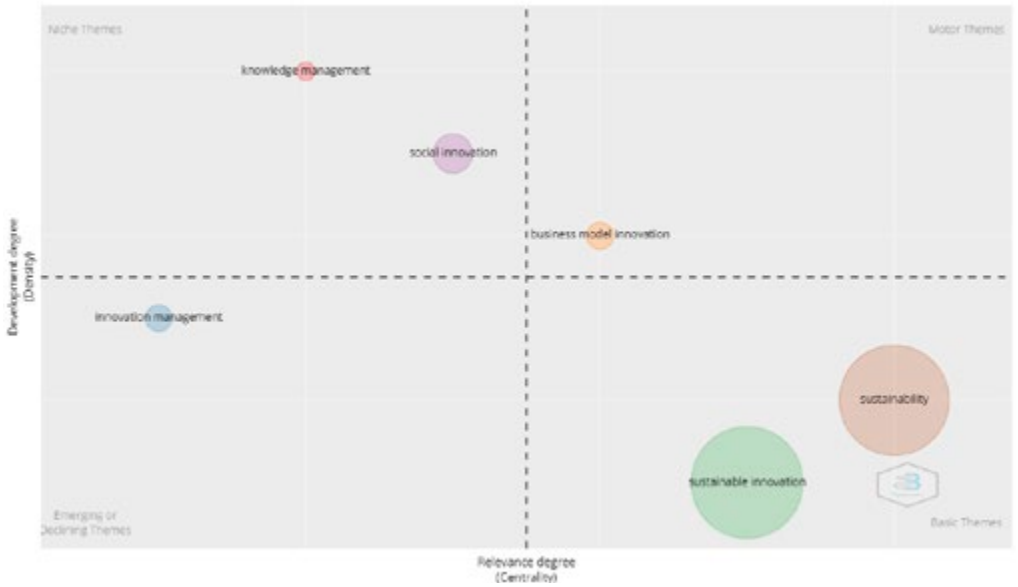


Figure 5: Thematic Map

The cluster named “business model innovation” represents the motor theme, topic that is developed and relevant to the research field. In this cluster there are keywords such as “innovation system”, “barriers”, “innovation ecosystems”, “drivers”, “green buildings”. The themes such as “sustainability” and “sustainable innovation” represent the basic themes, topics that appear ubiquitously in different scientific works and can be considered a common synthesis of the content expressed in the literature. The cluster named “innovation management” is positioned as emerging or declining themes, because this cluster is formed by keywords that are weakly developed and marginal. This cluster includes keywords such as “big data”, “environment”, “research and development”. Finally, the cluster “knowledge management” represents the isolated theme. It is formed by keywords such as “product innovation”, “literature review”, “organizational learning”, “process innovation”, all topics that are of limited importance for the research topic.

4. Final remarks

The main purpose of this paper was to review the literature related to the sustainable innovation. This study has tried to provide a comprehensive view of scientific papers between 2000 and the first six months of 2021 in this research field. In doing so, we identify 1,511 documents found relevant in the Web of Science database by using the keyword “sustainable innovation”. The scientific production has grown very gradually over the years reaching a peak of 333 products in 2018, in the previous year there were only 110. This shows that until a few years ago the concept of sustainable innovation was not yet widespread in the scientific community.

This research has shown the Thailand, USA and China have been the most productive countries in this area. In particular, the main authors who write on this topic are from Thailand and

collaborate with each other, showing a very low collaboration rate with foreign researchers. British researchers, on the other hand, are those who collaborate with authors from different countries. The thematic map analysis has identified that cluster of "business model innovation" is the motor theme in this research field, while the cluster of "innovation management" has been emerging or declining theme. It must be said that the theme analyzed in this work is a fairly new and constantly evolving theme in literature. Therefore the results of this bibliometric analysis could be different in a few years. Furthermore, the analysis was carried out only with documents downloaded from the web of science, so it could be more global using other scientific databases. However, we hope the present study may assist researchers in investigation this theme in their researches.

References

Aria, M., and Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics*, Elsevier, **11**(4), pp 959–975

Boons, F., and Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner production*, Elsevier, **45**, pp 9–19.

Cataldo, R., Grassia, M.G., Lauro, C.L., Marino, M., and Voytsekhovska, V. (2019) A Bibliometric Study of the Global Research Activity in Sustainability and Its Dimensions. *International Conference on Data Science and Social Research*, Springer, pp 91-102

Cillo, V., Petruzzelli, A., Ardito, L., and Del Giudice, M. (2019). Understanding sustainable innovation: A systematic literature review. *Corporate Social Responsibility and Environmental Management*, Wiley Online Library, **26**(5), pp 1012–1025.

Crocetta, C., Antonucci, L., Grassia, M. G., Marino, M., and Cataldo, R. (2021). A bibliometric study of global research activity in relation to the use of partial least squares for policy evaluation. In *ASA 2021 Statistics and Information Systems for Policy Evaluation*, Firenze, **127**, pp. 49–54).

Elango, B., and Rajendran, P. (2012) Authorship trends and collaboration pattern in the marine sciences literature: a scientometric study. *International Journal of Information Dissemination and Technology*, Maharishi Markandeshwar University, **2**(3), pp 166–169.

Garfield, E. (1990). KeyWords Plus-ISI's breakthrough retrieval method. 1. Expanding your searching power on current-contents on diskette. *Current contents*, INST SCI INFORM INC 3501 MARKET ST, PHILADELPHIA, PA 19104 USA **32**, pp 5–9.

Garfield, E., Sher, I.H., and Torpie, R.J. (1964). The use of citation data in writing the history of science. *Institute for Scientific Information Inc Philadelphia PA*

Rodriguez-Soler, R., Uribe-Toril, J., and Valenciano, J. D. P. (2020). Worldwide trends in the scientific production on rural depopulation, a bibliometric analysis using bibliometrix R-tool. *Land Use Policy*, 97, 104787.

Tello, S.F., and Yoon, E. (2008). Examining drivers of sustainable innovation. *International Journal of Business Strategy* Citeseer, **8**(3), pp 164–169.

White, H.D., and McCain, K.W. (1989) Bibliometrics. *Annual review of information science and technology*, **24**, pp 119–186