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INNOVATION ECOSYSTEM AND LIVING LAB: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Highly developed innovation ecosystems have the infrastructure necessary to enable innovative entrepreneurship and the continuous development of innovations. Living Labs, in turn, are innovation environments that aim to foster the co-creation of innovative solutions. As an emerging research theme, the aim of this study is to demonstrate how both subjects are related. Therefore, a bibliometric review of the literature is carried out, which allows to demonstrate networks of co-occurrence of keywords, evolution of research fields, authors and co-authorship network, publication sources and countries of origin of publications. The data reveal that this theme is still emerging and needs a greater number of studies that can deeply address this connection.

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INTRODUCTION

For many years, innovation technology parks, business incubators and regional innovation centers were considered the most prevalent types of innovation to be carried out, being considered as intermediaries of innovation. The rapid development of digital technologies has resulted in the emergence of new types of innovation brokerage, helping companies to obtain bilateral technology solutions and markets for ideas. An example of these intermediary spaces is Living Labs (LL), which can facilitate the process of diffusion of innovation, new technologies, intellectual property and licensing within innovation ecosystems (GAMIDULLAEVA, 2018). Highly developed innovation ecosystems have the necessary infrastructure to enable innovative entrepreneurship (ROMANO *et al*., 2014) and the continuous development of innovations (GASTALDI; CORSO, 2016). In addition to physical infrastructure, these ecosystems have a network of entrepreneurs, mentors, service providers and investors that can be exploited to support the creation and development of high-growth and scalable startups (HAINES, 2016). Innovation intermediaries, such as LL, should be considered as the basic object within innovation ecosystems, providing complex support to all stakeholders, which is significantly important in all phases of the life of innovations (GAMIDULLAEVA, 2018). From the perspective of the quadruple helix, Living Lab can be considered a dynamic and valuable approach that makes possible active cooperation between users, companies, research organizations and public authorities, thus experiencing the dynamics of the innovation ecosystem where a large and differentiated set of actors are involved in process innovation (DEL VECCHIO *et al*., 2017). Thus, local intermediaries such as Living Labs are prominent actors in innovation ecosystems, as they unite different actors and serve as a test environment to solve different ecosystem challenges (SCHUURMAN *et al*., 2012). Another important aspect of Living Labs is the characteristic of co-creation (PIERSON; LIEVENS, 2005), a fundamental aspect of innovation ecosystems (GOMES *et al*., 2018). From the importance of Living Labs as innovation environments aimed at co-creating solutions in innovation ecosystems, the need to understand the relationship of both concepts is exposed. With the purpose of exploring this theme, this research aims to demonstrate how both subjects are related. To achieve the proposed objective, the article has, in addition to the introduction, a section on theoretical framework, method, results and conclusion.

Theoretical Reference

Innovation ecosystem: The concept of innovation ecosystem is recent in the field of innovation management, introduced in the early 2000s (D'AURIA *et al*., 2016), and is mainly based on the extensive literature in the field of innovation networks (JUCEVICIUS, *et al*., *et al*., al., 2016). In addition, the literature on strategy, innovation, business and entrepreneurship has grown increasingly (GOMES *et al*., 2018; GRANSTRAND; HOLGERSSON, 2020).The concept of innovation ecosystem evolved from the concept of business ecosystems, which was coined in the mid-1990s by author James Moore (GOMES *et al*., 2018). Gomes *et al*. (2018) reviewed the

literature on both concepts and found that the term innovation ecosystem began to be used more frequently from 2006, based on the work of Adner (2006) and, later, Adner and Kapoor (2010). Adner (2006) in his study considered the business ecosystem to be an ecosystem of innovation, described as "collaborative agreements through which companies combine their individual offerings into a coherent customer-oriented solution". Adner (2006) adds that ecosystems allow companies to create value that no company could create alone. Another tipping point article that contributed to the dissemination of the term innovation ecosystem was developed by Adner and Kapoor (2010, p. 309), who suggested the ecosystem construct as "a way to make interdependencies more explicit". While the business ecosystem captures value, the innovation ecosystem creates value, thus, value co-creation is one of the main characteristics of innovation ecosystems (GOMES *et al*., 2018). Value creation is the processes and activities that are developed to create value for a stakeholder. Innovation ecosystems are an integration mechanism between the creation of new knowledge and its exploitation for value co-creation (VALKOKARI, 2015). The innovation ecosystem also enables social interactions between a wide and diverse community of actors. These interactions take place between a group of local actors who, through dynamic processes, produce solutions to different challenges (ROMANO *et al*., 2014; VALKOKARI, 2015).

Living Lab: The concept of Living Lab (LL) began to emerge in the mid-1990s, created by Professor William Mitchell at MIT (ZHENG; FU; ZHU, 2015; ACUTO *et al*., 2019), initially used to refer to a real place, like a house, where routine activities and interactions of everyday life could be observed, recorded for further analysis and experimentally manipulated (SCHUURMAN *et al*., 2012). Only from 2006 did LLs gain strength and dissemination with the creation of the European Network of Living Labs (ENOLL) (ACUTO *et al*., 2019; ENOLL, 2021). From this moment onwards, LL became an experimental platform in which the user is studied in their everyday habitat, as an ecosystem in which users are subjected to a combination of research methodologies while testing new technologies that are still under development (SCHUURMAN *et al*., 2012).

Living Labs (LL) are a way to develop innovation for cities and improve urban competitiveness. For Zheng, Fu and Zhu (2015), LL is a paradigm of collaborative innovation design, where user-oriented research and innovation will jointly create new services, products or social structure. These spaces addressed the specific involvement of stakeholders in innovative scenarios. It is a concept that supports the development of information and communication technology systems in a user-oriented way. The objective is to produce additional value for society, through the commitment of users in the application development processes in realistic environments (VALE *et al*., 2018). Living Labs can be defined as:

> They are physical regions or virtual realities in which interested parties form public-private partnerships (4Ps) of companies, public agencies, universities, institutes and users, all collaborating for the creation, prototyping, validation and testing of new technologies, services, products and systems in real life contexts (WESTERLUND; LEMINEN, 2011, p.20).

The objective is to produce additional value for society, through the commitment of users in the application development processes in realistic environments (VALE *et al*., 2018). They are considered innovative and useful mechanisms that effectively support the cooperation model for innovation with an impact on a vast network of regional actors, such as companies, universities and public authorities, allowing their cooperation and supporting their innovation processes (DEL VECCHIO *et al*., 2017). As this concept is still diffuse and with different approaches (ACUTO *et al*., 2019), it is possible to find different aspects of LL. According to Følstad (2008), the discussion of divergent perspectives within the LL literature identifies two aspects that can be used to distinguish different LL:

- **Contextualized co-creation:** Living Labs supporting context research and co-creation with users;
- **Testbed Association:** Living Labs serving as an extension of testbeds, where testbed apps are accessed in contexts familiar to users.

Characteristics of LL that focus on contextualized co-creation include the co-creation of new services and technologies and the collection of information about the context of use with, sometimes, ethnographic approaches to enable data collection (PIERSON; LIEVENS, 2005). LT associated with testbeds are used to describe controlled network environments for testing and validation, mainly for ICT services (SCHUURMAN *et al*., 2012).

METHODS

To achieve the proposed objective, the method used for this research was the bibliometric review. The bibliometric review makes it possible to observe the scenario of scientific production on a given topic that is registered in a data repository. Using bibliometrics, it is possible to place a country in relation to the world, an institution in relation to a country, and individual scientists in relation to the scientific communities themselves. The bibliometric review is based on counting scientific articles, authorships and citations (RAIO, 1986). Therefore, bibliometrics can help identify trends in the growth of knowledge on a particular topic, most cited authors and institutions, most used journals, among other items (SOARES *et al*., 2016). For this research, we analyzed keyword co-occurrence networks, evolution of research fields, authors and co-authorship network, publication sources and countries of origin of publications. The database used to retrieve publications was Scopus. The search string used to retrieve the works was ("innovation ecosystem*" AND "Living Lab*"). The total number of works retrieved was 372. From then on, the terms were filtered to those that occurred in the title, abstract or keywords. From this filter, a total of 33 publications were obtained. The final string used was TITLE-ABS-KEY ("innovation ecosystem*" AND "Living Lab*"). The survey was carried out on 19/08/2021. The software used to analyze the data extracted from the articles was the VOSviewer, version 1.6.17. VOSviewer is a software tool for building and viewing bibliometric networks.

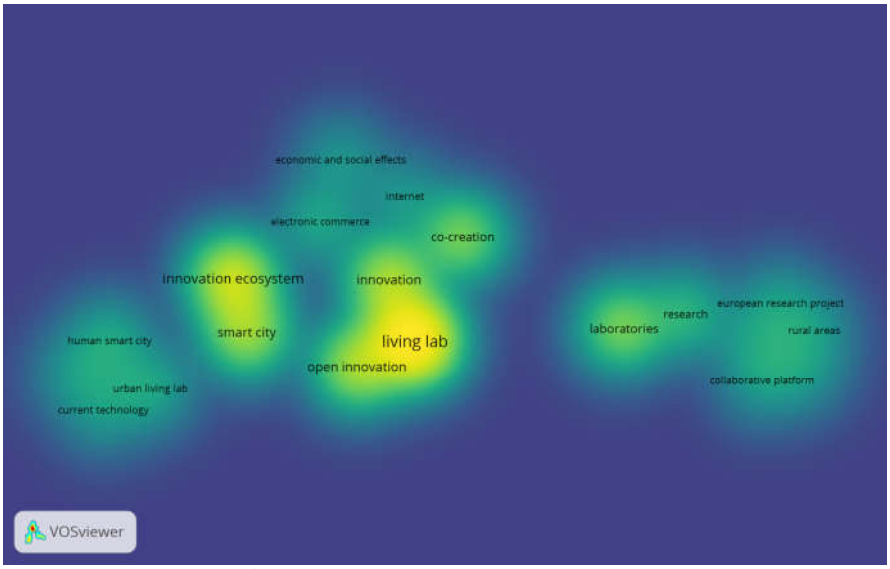
RESULTS

Keyword Analysis: By analyzing the study's keywords, trends and relationships between them can be indicated. From the 33 publications retrieved, 202 keywords were identified in total. Then, the 20 keywords that most occurred in the publications that are presented in Table 1 were selected. The most used keyword in the set of studies surveyed is Living Lab with 26 occurrences, revealing to be the most significant term. Then there are innovation ecosystem with 14 occurrences, innovation and open innovation with 11 occurrences each, smart city with 10 occurrences and co-creation with 8 occurrences. It is important to highlight the occurrence of the co-creation keyword, being the 6th that most occurs. Thus, co-creation is a feature of both innovation ecosystems and Living Labs, as stated in the literature review by Pierson and Lievens (2005), Valkokari (2015) and Gomes *et al*. (2018). Figure 1 illustrates the terms with the highest occurrence density. From Figure 2, it can be described that the most important terms are Living Labs, which is directly related to innovation and open innovation, and innovation ecosystem directly related to smart city.

Table 1. Number of occurrences of keywords

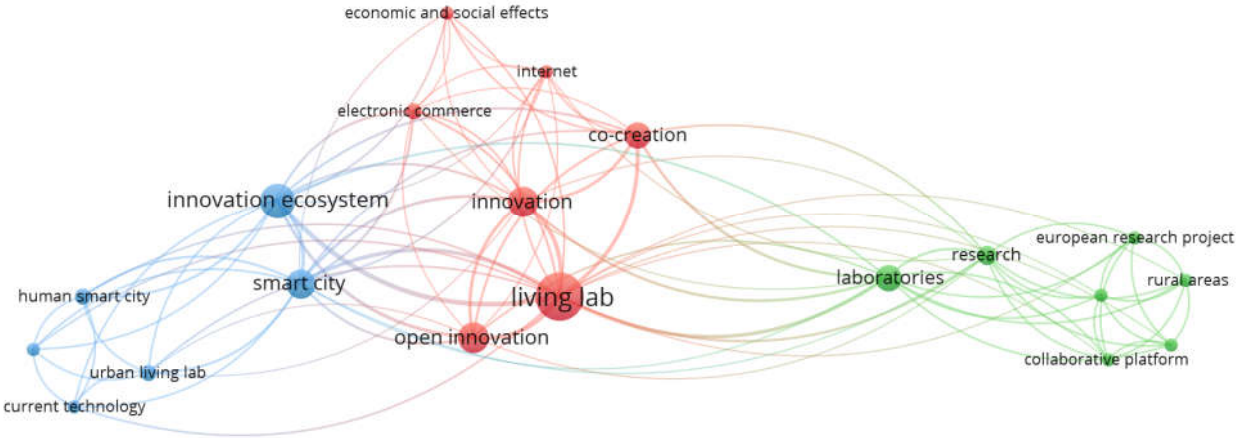
Keywords	Nº	Keywords	Nº
Living Lab	26	Human smart city	3
Innovation ecosystem	14	Collaborative platform	2
Innovation	11	European research Project	2
Open innovation	11	Internet	2
Smart City	10	Large-scale interconnection	2
Cocreation	8	Rural áreas	2
Laboratories	4	Ubiquitous computing	2
Research	3	Current technology	2
Eletronic commerce	3	Myneighborhood	2
Urban Living Lab	3	Economic and social effects	2

Source: elaborated by the author.



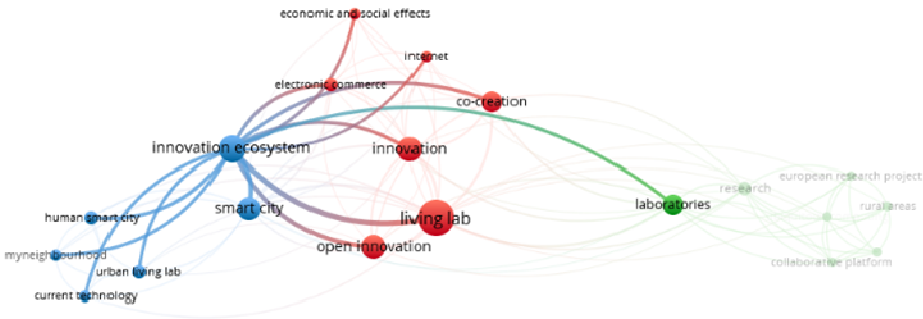
Source: elaborated by the author.

Figure 1. Keyword occurrence density



Source: elaborated by the author.

Figure 2. Visualization of the keyword co-occurrence network



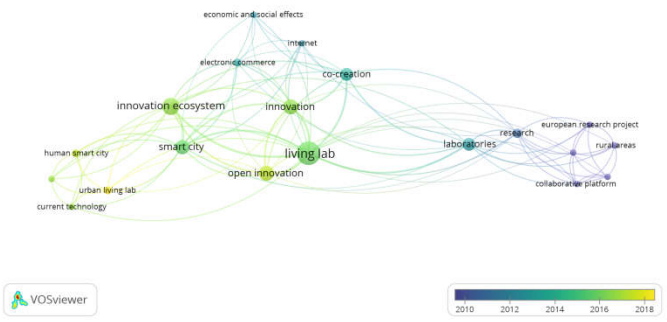
Source: elaborated by the author.

Figure 3. Innovation ecosystem keyword co-occurrence network

The co-occurrence network presents the keywords that occur together, demonstrating which keywords have the greatest relationship. In Figure 2, it is possible to visualize the keyword network. From Figure 2, it is possible to visualize the existence of three clusters of keywords. The cluster in red is formed by seven terms: Living Lab as the main term; open innovation; co-creation, economic and social effects; electronic commerce; innovation and internet. This cluster interacts with both the blue cluster and the green cluster. The blue cluster is formed by the words: innovation ecosystem as the main term; smart city; human smart city; myneighbourhood; urban Living Lab and current technology. This cluster has a greater relationship with the red cluster.

The cluster in green color is formed by: laboratories as the main term; research; European research Project; rural areas; collaborative platform; large-scale interconnection and ubiquitous computing. Figure 3 illustrates the co-occurrence network for the keyword innovation ecosystem. The distance between two clusters approximately indicates the relationship of the clusters in terms of citations. Clusters located close to each other tend to be closely related in terms of citations. In other words, the cluster where the term innovation ecosystem is present is closer to the Living Lab cluster, in relation to the laboratory cluster. These two clusters also have the highest number of publications, since the size of a cluster depends on the number of publications belonging to the same group.

Evolution of search terms: Regarding the year of publication of the items, it is noted that studies on the subject can be considered recent. The terms research, project research and collaborative platform are older, with their peak around 2010. The term laboratories can be considered a transition keyword that connects with more recent terms such as co-creation, internet, electronic commerce and economic and social effects and, also with the term Living Lab, around 2016. This connects with the concept of smart city, innovation ecosystem and innovation, close to 2017. Finally, the most current themes are open innovation, human smart city and urban Living Lab, as illustrated in Figure 4.



Source: elaborated by the authors. Subsection 4.3 analyzes research authors and publication sources.

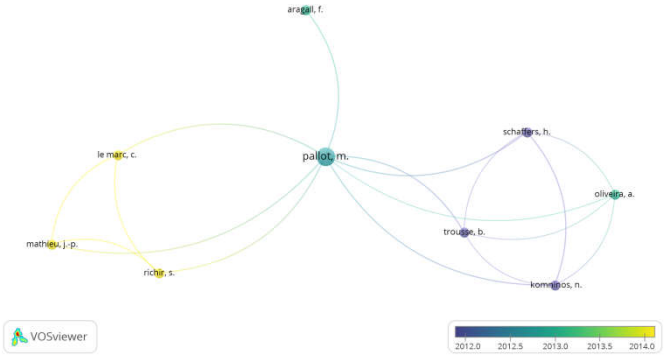
Figure 4. Year of publication of terms

Table 2. Authors, citations and published documents

Author	Citation	Documents	Author	Citation	Documents
Pallot M.	885	8	Ahl A.	28	1
Komninos N.	838	2	Chopra S.S.	28	1
Schaffers H.	838	2	Goto M.	28	1
Oliveira A.	711	3	Kumar N. M.	28	1
Trousse B.	675	2	Sagawa D.	28	1
Nilsson M.	657	1	Tanaka K.	28	1
Campolargo M.	52	1	Yarime M.	28	1

Source: elaborated by the author.

Analysis of authors and publication sources: In all, 92 authors who published on the subject were retrieved. Of these, 7 authors have more than 20 citations and are shown in Table 2. Pallot is the most cited author with 885 citations and is also the author with the highest number of publications, 8 in total. Nilsson has 657 citations in his single article. It should be noted that the topic is not addressed by a specific group of authors, with only two actors having more than two publications. The most cited document in the literature is called Smart cities and the future internet: Towards cooperation frameworks for open innovation, in 2011, by the authors Schaffers, Komnimos, Pallot, Trousse, Nilsson and Oliveira with 657 citations. In other words, this study is the most important in this sample. Due to this publication, all its authors became the most cited in the subject. The research is published in a book series titled Lecture Notes in Computer Science. The document explores "smart cities" as user-oriented and open innovation environments to experience and validate internet-enabled services of the future. As a result, from Living Labs, common resources related to research and innovation can be identified and can be shared in open innovation environments. Effective sharing of these common resources for the purpose of establishing urban and regional innovation ecosystems requires sustainable partnerships and cooperative strategies among key stakeholders. Figure 5 illustrates the co-authorship network that demonstrates the collaboration network of different authors in terms of publications. Nodes represent author names, links represent coauthor relationships between different authors, and node sizes represent each author's number of publications. The results of the co-authorship network analysis show that author Pallot is the most influential author in terms of co-authorship relationships, interacting with 8 other authors. Publication sources are concentrated in different places of publication. The international conference called International Conference on Engineering, Technology and Innovation: Engineering Responsible Innovation In Products And Services – 2014 and Sustainability has 3 published works. In Lecture Notes in Computer Science and Lecture Notes in Business Information Processing 2 documents were published. In all other sources, only 1 publication was made. In Table 3, it is possible to visualize the most cited sources of publication.



Source: elaborated by the author.

Figure 5. Co-authorship network

Table 3. Publication sources with the highest number of citations

Source	Citation
Lecture Notes in Computer Science	659
Journal of the Knowledge Economy	181
Proceedings of the Annual Hawaii International Conference on System Sciences	52
Renewable and Sustainable Energy Reviews	28
17th International Conference on Concurrent Enterprising, ICE 2011	18
International Journal of Economics and Business Administration	14
International Conference on Engineering, Tecnlogy and Innovation: Engineering Responsible Innovation in Products and Services, ICE 2014	12
Handbook of Research on Serious Games as Educational, Business and Research Tools	11
18th International Conference on Engineering, Tecnology and Innovation, ICE 2012	10
International Journal of Business Innovation and Research	10

Source: elaborated by the author Subsection 4.3 analyzes the countries of origin of publications.

Table 4. Publications by countries

Country	Document	Country	Document
France	11	Germany	1
Finland	7	Hong Kong	1
United Kingdom	7	Ireland	1
Spain	5	Japan	1
Italy	4	Mexico	1
Belgium	3	Netherlands	1
United States	3	Romania	1
Brazil	2	Russian Federation	1
Greece	2	Slovenia	1
Portugal	2	Kouthkorea	1
Canada	1	Sweden	1

Source: elaborated by the author.

Source: elaborated by the author.

Figure 7. Publication by countries

It should be noted that Lecture Notes in Computer Science is the book in which the most cited article in the sample is published, with 657 citations, and a total of 659 citations.

Analysis of the countries of origin of publications: When analyzing Table 4, it is clear that the country with the highest number of publications on the subject is France, with 11 studies. Then come Finland and the United Kingdom with 7 publications each. Brazil has 2 documents published. France has the highest number of citations (887), followed by Greece (838), Portugal (709), Italy (683), Sweden (657), Finland (208) and the United Kingdom (80). Figure 7 illustrates the most relevant countries. Thus, European countries stand out in terms of citation and quantity of publication. United States in North America, Brazil in South America and Hong Kong in Asia are representatives of the other continents.

CONCLUSION

From the analysis of the co-occurrence of keywords, it can be identified that the most relevant being Living Lab; innovation ecosystem, innovation, open innovation and smart city. Another finding of the research was the occurrence of the term co-creation, a characteristic present in both innovation ecosystems and the Living Lab. It was also possible to identify a cluster led by the term innovation ecosystem that has a greater link with the smart city and another cluster led by the Living Lab which has the greatest connection with open innovation. Regarding the timeline of publications, the term laboratories that occurs with greater density between 2012 and 2014 can be considered a transitional keyword for the concept of Living Lab. Since then, more recent terms appear as smart city and innovation ecosystem and, finally, urban Living Lab as the most current, which can be considered as a research trend. The most relevant author on the subject is Pallot, with 885 citations and eight published documents. The most important document is called Smart cities and the future internet: Towards cooperation frameworks for open innovation, published in 2011. This document relates Living Labs to the concept of smart cities as a resource provider for open innovation and the need for partnerships strategies of innovation ecosystems. There is a concentration of publications on the European continent, with emphasis on France as the country with the most publicity on the subject. Finally, it is concluded that this theme is still emerging and lacks a greater number of studies that can deeply address this connection due to the low number of publications and the concentration of relevance in a single document. Future studies can expand the databases used. In addition, they can explore the theme to produce theoretical and empirical studies on the role of Living Labs in innovation ecosystems and how one influences the performance of the other.

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