Open Innovation at University: A Systematic Literature Review

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Abstract. The aim of this paper is to describe the role of open innovation at universities around the world through a systematic literature review (SLR). The research was a methodology for SLR applied to engineer and education. The SLR selected 61 documents in the Scopus database. The obtained results allow us to identify why universities use open collaborative networks to link industry and academics through projects, link the triple helix model in their practices (spin-off), and through policies and strategies, organizations develop open innovation, while universities develop curricular strategies. Finally, university-enterprise financing is considered important for the development of products and services, preserving intellectual property.

Keywords: Knowledge networks · Transfer of knowledge · R&D

1 Introduction

Open innovation (OI) is a much studied topic in the management of organizations and industry, as well as, in small and medium enterprises, but, from the point of view of universities, it is a little explored area. For this reason, it has been decided to analyze the studies within this context, characterizing through fields such as interaction, cooperation, models, internal organization and collaboration.

In the context of Industry 4.0, it is currently demanded that the university be supported by models and platforms that allow it to respond adequately to the vertiginous requirements of the knowledge society in terms of the training of human talent. For this

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reason, a new substantive function is evident in Higher Education Institutions, which must be configured as an innovation hub that crystallizes the real contributions that universities must make towards society.

In Ecuador, there is a regulatory framework that defines elements that universities must consider in order to innovate and/or reinvent themselves in these times, for example, in the "Código Orgánico de la Economía Social de los Conocimientos", OI is defined as "*…the collaborative contribution of one or several people to find a solution to a problem presented by a third party with whom an employment relationship is not necessarily maintained*" [63], on the other hand, the same code promulgates that "*the Secretariat of Higher Education, Science, Technology and Innovation will facilitate social access to knowledge, in a public and open manner, so as to facilitate and promote open innovation processes*" [63]. Furthermore, in the context of technological innovation, in Ecuador's public institutions, it is necessary to execute and plan the migration of their digital technologies to free digital technologies.

In this systematic literature review (SLR), the methodology adapted by Torres-Carrion [56] was used, which is composed of three phases: planning, execution and reporting of results. 61 studies related to open innovation in universities were found. From this information, four research questions were defined that include the interaction of universities in collaborative networks, open innovation practices of universities, characteristics of environments where universities develop open innovation and the generation and transfer of knowledge from universities.

2 Systematic Literature Review

We use the methodology for SLR applied to engineering and education proposed in [56], which is based on three phases: planning, conducting and reporting.

2.1 Planning

Current State of Open Innovation

Research in the context of OI will be an added value in the development of universities, when transferring knowledge and technology to society, promoting a collaborative and innovative environment in the development of products and services. OI has been implemented in different universities around the world, with the aim of exchanging ideas between university researchers and businessmen from small and large companies, forming true knowledge networks.

Research Questions

Four research questions are defined, which will make it possible to identify the current state of OI at universities:

- RQ1: How do universities interact in collaborative networks?
- RQ2: What OI practices do universities implement?
- RQ3: What are the characteristics of the environment in which universities develop OI?
- RQ4: How is knowledge generated and transferred from universities?

Conceptual Mindset
The function of the conceptual mindset is to guide the SLR in OI at university. On the right are the concepts that do not belong to research and can be discarded, such papers of our research. On the left observe the characteristics that are linked to the central concept and that will be the keywords to execute the search in the different databases.

Semantic Search Structure
A script (search in Scopus databases) was generated with six layers for the search process. The first one involves OI within the university, the second one refers to the networks that exist for collaboration, the third one involves OI in the universities, the fourth and fifth ones refer to the environment and factors that affect innovation and, finally, the sixth one, the research questions that guide the semantic search.

Related Systematic Literature Reviews
There are SLR in the field of OI (see Table 2), which will support the present review. The databases Scopus, the Web of Science platform and the Google Scholar were searched, using the semantic search (see Table 1) and thus addressing the research questions.

Table 1. Layers for the support the semantic search.

L1	University	((“open innovation” and (universit* OR “higher education”))
L2	Networks	(collaboration OR cooperation OR “collaborative skills” OR determinants OR network OR integration)
L3	Practices	(model * OR spin-off OR framework * OR “ideas management” OR entrepreneurship OR enterprise)
L4	Environment	(challenge OR environment OR policy)
L5	Knowledge	(technology OR knowledge OR management)
L6		Q1: (Collaborative networks); Q2: (Open innovation practices); Q3: (Characteristics of the environment); Q4: (Generation and transfer of knowledge)

Selection of Journals and Databases
The selection of the journal was organized according to Scopus databases and 61 papers reviewed, and the list of journals in which the papers are indexed is also presented in the Table 3.

2.2 Conducting the Review

Definition of Inclusion and Exclusion Criteria
In this SLR, general and specific criteria have been defined for the selection to papers of journals, which will allow research questions to be answered, as well as exclusion criteria:

Table 2. Three SLR have been identified.

Study	Analysis	Papers reviewed
[46]	Factors affecting the participation of researchers in knowledge transfer in the context of OI, applies to the professional profile of 382 researchers	63
[24]	The most influential papers, authors and journals in OI are presented. Geographical locations are identified, and frequently used keywords are listed	293
[23]	The role of the main practices is identified in the management of human resources in organizations, where the relationship between these practices and OI has not been studied, and possible research based on human resources management and its role in OI is identified	79

Table 3. Relevant journals where they have been published according to the SJR scientometrics indicator.

Journals	#Papers	SJR		h5 Google
		IF	Cuartil	
Canadian Review of American Studies	1	0,1	Q4	5
Environmental Quality Management	1	0,15	Q4	7
Beijing HangkongHangtianDaxueXuebao/Journal of Beijing University of Aeronautics and Astronautics	1	0,23	Q3	–
Communications in Computer and Information Science	1	0,17	Q3	–
Innovations in Education and Teaching International	1	0,66	Q2	29
Journal of Visual Languages and Computing	1	0,23	Q2	–
Journal of the Canadian Academy of Child and Adolescent Psychiatry	1	0,52	Q2	18
Wireless Networks	1	0,4	Q2	34
Interaction Design and Architecture(s)	1	0,19	Q2	10
International Journal of e-Collaboration	1	0,51	Q2	–
IEEE Pervasive Computing	1	0,47	Q2	31
Multimedia Tools and Applications	1	0,34	Q1	52
International Journal of Human Computer Studies	1	0,69	Q1	39
IEEE Transactions on Image Processing	1	1,81	Q1	102
Production and Operations Management	1	3,28	Q1	48
American Journal of Occupational Therapy	1	0,67	Q1	31
IEEE Transactions on Visualization and Computer Graphics	1	0,96	Q1	65

- General: studies involving OI at universities and published in the last 7 years, between 2012 and 2019.
- Specific: studies that mention the characteristics of the environment in which universities develop OI, the generation of knowledge, the transfer of knowledge and collaborative networks in OI at universities.
- Exclusion: industry, organizations, enterprises, government.

Definition of Analysis Categories

The categories that have been defined are based on the research questions and their different variables:

- RQ1: cooperation, collaboration, collaborative skills, integration and partnerships.
- RQ2: entrepreneurship, spin-off, organizations, models, framework, idea management, integration and practices.
- RQ3: strategies, determining factors, factors, challenges, policy and curriculum.
- RQ4: knowledge transfer, technology transfer and R&D.

Preparing a Data Extraction Form

The Mendeley has been used for the extraction of information according Fig. 1.

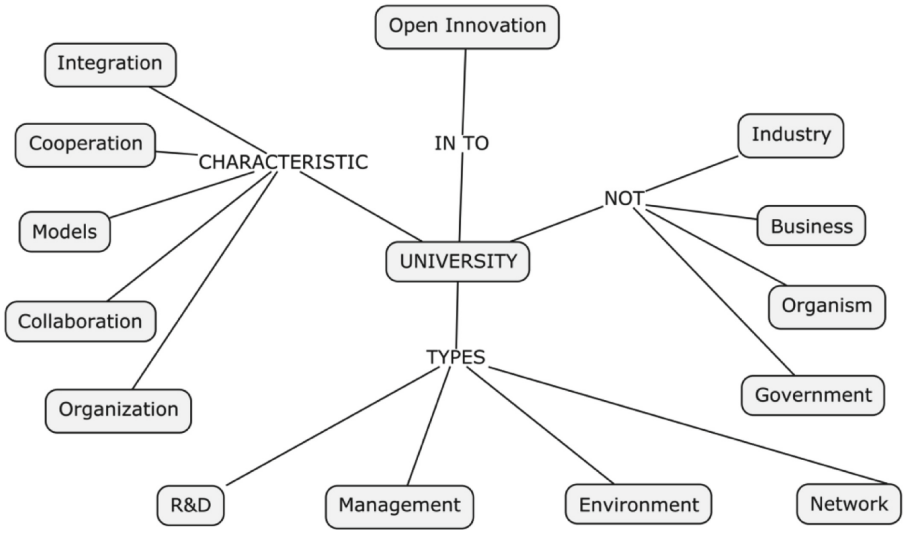

Fig. 1. Conceptual mindset to guide the literature search according to [56].

2.3 Reporting the Review

Table 4 shows the papers according to the RQ1: How do universities interact in collaborative networks?

Table 4. Number of papers to RQ1.

Characteristics	Papers	*f*
Networking	[6, 17, 26, 40, 62]	5
Cooperation	[39, 52, 61]	3
Collaboration	[2, 11, 18, 25, 28, 29, 34, 43, 48, 49, 53, 60]	12
Collaborative skills	–	0
Integration	[12]	1
Partnerships	–	0

Knowledge is the key to innovation in collaborative networks through projects between enterprises and universities, in some cases, a balanced scorecard is used to track, measure and improve the impact on the implementation of activities in projects. In other cases, the collaboration of the university differs greatly from the nature, location and performance of the company, so it is important to define the role to be played by the university, whose main actors are academics and students, so there should be a strong drive towards funding resources at university.

University-enterprise collaboration allows the development of new products and the commercialization of technology, through the management of partnerships in projects for the generation of new knowledge, being a great opportunity for the enterprise to be endorsed by a university, and thus obtain a better reputation in the environment, developing links with radical innovations, for which there should be government innovation policies and institutional mechanisms to promote innovation in small enterprises. The communities of practice as well as the innovation laboratories are a space for collaboration between the university and the industry, being the channel of knowledge exchange with motivational activities for researchers and entrepreneurs, arising with this, the need for the creation of intellectual property policies on the resulting inventions.

Table 5 shows the papers according to the RQ2: What OI practices do universities implement?

Table 5. Number of papers to RQ2.

Characteristics	Papers	*f*
Entrepreneurship	[1, 22, 59]	3
Spin-off	[54, 57]	2
Organizations	[8, 31, 38]	3
Models	[15, 21, 33, 35]	4
Framework	[3, 9, 21, 37]	4
Idea management	[7]	1
Integration	[20]	1
Practices	[10, 23, 44]	3

Models have been implemented based on research and innovation projects between the university and the enterprises in the area of technology evaluation, led by students and researchers, some models indicate technology transfer processes based on trust to identify drivers towards OI directed as a source of knowledge and technology for the enterprise through continuous dialogue; on the other hand, evaluation models have been implemented for university-industry collaboration to work with a group of researchers for decision making in collaborative projects between the university and the industry. There are other models based on university-industry-government called triple helix, for the division of direction in innovation for technology transfer, thus obtaining new perspectives on the same information with external and internal ideas of the university improving synergy and innovation, in addition, benefiting from educational activities, consequence of collaboration, emphasizing the capacities for the implementation of processes.

Table 6 shows the papers according to the RQ3: What are the characteristics of the environment in which universities develop OI?

Table 6. Number of papers to RQ3.

Characteristics	Papers	*f*
Strategies	–	0
Determining factors	–	0
Factors	[5, 16, 29, 46]	4
Challenges	[50]	1
Policy	[19, 27, 55, 58]	4
Curriculum	[30, 32, 37, 45]	4

The factors of OI at universities directly affect the participation of their researchers in different processes, one of those means were social networks, which have contributed to communication, participation and collaboration, in addition, it should be taken into account, the personal and professional profile that exists at university and in enterprises, which are open to collaborate in all decisions, without the presence of conflict of interest and intellectual property problems. It is demonstrated that the policy environment allows for a better scope in the improvement of programs for the funding of universities related to OI in small and medium-sized enterprises, focusing on science and engineering, designing incentives for interaction between researchers and entrepreneurs, opinions being valid to boost innovation.

OI proposes the curricular development between the university and the enterprise, and that satisfy the demands of services and products, it is for that reason, the university has implemented new methodologies for the improvement of the creative education and trains the students for the real world, developing the critical thought, behaviors and abilities, exchanging knowledge, fomenting the cooperation, basing on the confidence and the team work for the accomplishment of projects. The implementation of creative education programs is the basis of the development of ideas for students to generate results

and profits to enterprises, and thereby accumulate experience with the implementation of new ideas.

Table 7 shows the papers according to the RQ4: How is knowledge generated and transferred from universities?

Table 7. Number of papers to RQ4.

Characteristics	Papers	*f*
Knowledge transfer	[10, 41, 47]	3
Technology transfer	[13, 42, 59]	3
R&D	[4, 11, 14, 36, 51, 59]	6

Funding is an essential point in R&D, one way of achieving it is through connections from the university with enterprises (small and micro), focusing more on research projects for the development of small enterprises that at the time arose just as social networks, renewable energy, etc. These projects have arisen from the work between universities in cooperation with enterprises, generating new knowledge for the development of technologies and products; on the other hand, technology transfer is important, the university contributes to private enterprise innovation to commercialize and disseminate potential inventions, having as a challenge the investment in the administration of intellectual capital, which is often suppressed by technology.

OI research allows the transfer of knowledge from universities, emphasizing intellectual property, by contract, to enterprises, to ensure development and cooperation; on the other hand, to have the balance between enterprise and university, collaborative innovation is necessary for the fair distribution of income, allowing the transfer of knowledge between university and industry, being the main factor for decision-making processes in organizations.

3 Conclusions and Future Work

We identified 61 research studies of acceptable rigor, credibility and relevance. The papers studied the answers to four research questions about OI at university: (RQ1) two mechanisms have been identified that universities use in collaborative networks in OI: the first, R&D projects that involve industry and academics, taking different roles according to the form of participation; the second, conformation of communities of practice that allow the participation nexus to be less formal, but effective, supported by the use of social networks; (RQ2) OI practices in universities are implemented and consolidated mainly through models and frameworks. The most generalized model is the triple helix model, which involves the university-industry-government. One of the not so generalized practices, but of great projection, constitutes the generation of spin-offs as mechanisms of generation of enterprise, based on research within the universities; (RQ3) the factors for developing OI in universities consist of policies and strategies at the organizational level, while, at the university level, the creation of curricular content related to creativity

and the generation of ideas in open environments has acquired great importance; and finally (RQ4) the R&D process, universities are committed to research in association with medium and small companies, and with it finance developments in collaborative environments, the results of which are reflected in ideas and creations in advantage of the university-enterprise. For future work, the new SLR in the context of intellectual protection at university and management of human talent would be useful. Other works would be to design a model based in this paper and to study of the methodologies in base of the triple helix in OI.

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