

Innovative development in a university environment based on the triple helix concepts: A systematic literature Review

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Abstract. Integrating university, industry, and government can represent innovation development in a university environment based on the concepts of the Triple Helix. Thus, there needs to be more research that considers university innovation ecosystems, indicating an opportunity to improve their understanding and functioning. This article proposes a Systematic Literature Review (SLR) to map the actions, actors, concepts and functioning of the innovation ecosystem that involves the university. The first step of the SLR was the search for articles from 2017 to 2022 containing the keywords: disruptive innovation, sustainability, and digital transformation, resulting in 27 selected articles. The research identified the roles and recommendations of each actor in the ecosystem and ways to develop it sustainably, focusing on actions to improve its current innovation strategy, contributing to the academic literature by providing initiatives in innovation ecosystems and synthesis of related concepts.

Keywords: Innovation Ecosystem, Triple Helix, University, Disruptive Innovation, Sustainability, Digital Transformation.

1 Introduction

The demands for innovation have increased enormously in recent years. Due to the emergence of technologies, the focus on sustainability and cost reduction, improvements in the user experience and impact on society have produced initiatives to offer incremental or disruptive innovations in their different forms. With the growth of innovation systems, relationships between universities and companies have become an integral part of an ecosystem necessary to support the growth of these new initiatives. In this sense, the Triple Helix concept [1] contemplated the contribution of actors in representing three helices: university, industry, and government, to develop innovation. Posteriorly, this concept was revisited and expanded to the Quintuple Helix model [2], which adds the importance of involving civil society and the environment in the Triple Helix.

After conducting the initial phase of research on the subject, it was found that there is a need for an adequate conceptual structure that can fully address innovation ecosystems, as it is a current theme in constant evolution. So, through the definition of concepts and method of literature review, this study seeks to compile data about innovative development in the university's environment based on the Triple Helix concepts.

2 Theoretical background

As previously mentioned, the Triple Helix concept considers the university, industry, and government as agents for innovation development [1]. In this sense, each agent has a respective role in this ecosystem to work and produce results. Moreover, "The interaction between university, industry and government is the key to innovation and growth in a knowledge-based economy" [3]. A literature review and analysis of the development of the triple helix ecosystem summarized five main aspects of the functioning of this ecosystem [4]: 1) The complex relationships between various agents in regional innovation are simplified according to the social geometry of triadic interactions; 2) The mechanism of Triple Helix interactions is "taking the role of the other"; 3) Its development is an evolutionary process that must be pre-structured and coordinated; 4) Triple helix interactions require integrating top-down coordination and bottom-up initiatives; 5) Certain tangible and intangible conditions make the triple helix model possible.

This article consists of understanding and analyzing the functioning of this ecosystem from different points of view and ways of analyzing the same ecosystem. However, all with the same theoretical basis based on the definition proposed by [1]. Although there are variations in how ecosystems operate due to geographic, cultural, and economic variations, there are common characteristics [4]. Studies suggest that trust in social relationships benefits innovation and interactive learning [5].

3 Method

An article that follows the Systematic Literature Review aims to identify the most relevant articles that direct the research on the theme [6], in this case, the innovation ecosystem. The articles' criteria for inclusion and filtering are described in the image below.

The last criteria for exclusion were a preliminary analysis of the articles and identifying aspects that were considered essential to be approached by the articles: University, Industry, Government, and Sustainability involving the social, environmental, and economic aspects. The articles that approach most or all these aspects were selected; with it, twenty-seven works were chosen for deeper analysis.

Fig. 1. Systematic Literature phases.



4 Results

Due to an analysis of the articles selected in the systematic literature review, it was possible to analyze them based on their contributions and applications.

4.1 Contribution

Most of the Contributions aim to describe and find a way to develop the interaction [7, 8, 39], relation [9] and cooperation [10] between the actors of the ecosystem, such as increasing the number of actions that aims to develop academic research [11], that may be applied in the industry. Also, promoting events to present research and projects to the market and with it stimulated its commercialization and application. Furthermore, most of the Contributions were analyses with several objectives, such as categorizing the interaction between universities and companies [8], com-prehending the micro and macro dynamics of the open innovation in a sustainable model [12], a mechanism of analyses of the collaboration between research institutes and companies [13], the strategies implemented by an entrepreneurial university [14, 39], a structure to analyze and identify points to develop aiming to improve the ecosystem [15]. The Contributions were also related to identifying the roles of each actor in the ecosystem [16, 17] and the concept of sustainable innovation towards entrepreneurship [18, 19] to be maintained in the long term.

4.2 Application

Among the applications of the articles studied in this work, the most common topic was sustainable innovation. Works describing ways to develop it, such as digital application, sharing knowledge [13], co-working [26], and the impact of micro and macro actions for sustainable innovation [12], which reinforces the importance of the relationship between sustainability and innovation [24]. Studies about the innovation ecosystem helix [22] were found which aimed to describe and better understand the relation

[8] and the importance of the actors in the triple and quadruple helix [7], and with it facilitates their actions and improve its operation [16, 17, 9].

Another topic was innovative entrepreneurship and its initiatives to develop and propitiate it [19, 31, 33], the importance of actions to encourage academics and in-tern politics to improve the way it is approached [11] and the student's point of view of the actions towards innovative entrepreneurship development [20]. The articles also studied the research and its relation as a step to development, as well as knowledge transfer, the teaching of innovation and social innovation [30], presenting ways to improve the development of emerging economies, such as the industry and university collaboration may be efficient [14] and to enlarge the range of engineering research and natural science creation [21]. The search for development in instability propitiates more sustainable creations [18].

5 Discussion and Conclusion

This research has discussed the content found in the twenty-seven articles selected, making it evident that the interaction and roles between the triple helix ecosystem actors are the central themes of the contributions and applications of the articles.

A better understanding of the innovation process for development allows us to develop responsible research and innovation methods. Research that will not only help a business make profits but also contribute to the common good of society and science. The development of innovative research requires transparency to implement and to build trust, which strengthens cooperation, and interdependencies between ecosystem stakeholders are stronger [7]. Since innovations emerge because of collaboration between all helices, there are desirable attitudes of all actors to responsible innovation and clear definitions of the types of responsibilities to be fulfilled by innovators [7]. Collaboration with big corporations is relevant, as they can become customers or partners, bridging the financing for innovation [16]. Each actor must manage resources, activities, value addition, and capture [15]. The university is a strategic actor recognised as a primary actor in the innovation ecosystem [8]. The universities with a relevant contribution to innovation ecosystems have as roles: support for start-up creation and growth, collaboration with police makers and firms, innovation sponsor, networking with other universities, stakeholder involvement and research, knowledge, and infrastructure share [33].

For universities which work in 4.0 domains, the authors suggested that universities also should increase or start actions to a) prioritise research and engineering projects; b) improve communication of related research results to the industry beyond the roles previously cited [33]. The authors suggest actions for university innovation which support sustainability in two categories of approaches: people-based approaches: a sustainability expert within a university innovation support unit; collaboration with a significant university sustainability coordinator/team; collaboration with a range of sustainability/cleantech experts in the university; collaboration with sustainability/cleantech-oriented organisations outside the university; sustainability objectives for the innovation support unit; environmental management system for the innovation support unit;

sustainability reporting to university level; sustainability questions/criteria in project proposals/decisions; use of lifecycle analyses in projects [21].

Another perspective in the articles is that the entrepreneurial universities' innovation strategy calls for effective ways of integrating research, innovation, and application. It also stresses the importance of international innovation cooperation [37]. However, in current higher education policies and practices, international research cooperation primarily aims for research excellence, while university ecosystems often have a local focus. Universities' engagement on a global scale should be emphasised in future policies since their engagement in innovation ecosystems crosses the boundaries of geographical locations [19]. There is a conceptualisation of two types of universities [19]: a) The entrepreneurial university: a knowledge producer for technology transfer from the academy to the industry as universities' reciprocal collaborations with industries and governments based on the triple helix model. Additionally, this university profile meets the societal needs of an entrepreneurial university concerning economic growth and innovation. b) The sustainable entrepreneurial university must be understood as an anchor organisation for knowledge exchange to help academics develop innovative research questions, conduct better research, and provide an improved understanding of research applications in industry and shape a better future society.

There are some components and conditions to entrepreneurship development: financing of entrepreneurship; state policy; state programs in entrepreneurship; entrepreneurial education; introduction of scientific and technical developments; commercial and legal infrastructure; market openness; physical infrastructure; cultural and social norms [25]. Moreover, some entrepreneurship and innovation indicators may evaluate the fostering factors: legislation; level of motivation for entrepreneurial activity; information accessibility; entrepreneurial culture and education; human capital; financial infrastructure, IT infrastructure and communication technologies, and market potential of the region [26].

To foster innovation in entrepreneurial universities and promote engagement actions is necessary to offer continued education programs on related topics such as frugal innovation, social inclusion, environmental challenges, and collaboration with external stakeholders. Additionally, it is suggested that curriculum design development and entrepreneurship education programs emphasise problem-based learning, STEM (Social, Technology, Engineering and Mathematics) and social disciplines [14]. As well as to prepare students to participate in the production process that generates income [34]. In this way, economic sustainability must be an essential pillar of entrepreneurship, which can be taught to help the student learn with practice, incorporate methods, network, and increase their interest in creating a new business [20].

In specific studies [20, 25], the training consists of students selecting a project from a technology portfolio and evaluating its marketing potential through the methodologies of the master's degree. Applying these methodologies has favored the emergence of sustainable initiatives within the students' projects, learning their business ideas, create a network with colleagues and teachers. This training allowed students to develop skills for innovation, technology transfer, the creation of new companies, the commercialization of innovative ideas, and entrepreneurial abilities since student becomes relevant in contributing to the solution of environmental issues and collaborates in economic development [20, 25]. Some challenges universities must face to succeed in

innovation ecosystems are the reduction of favoritism that leads to unfair academic participation, the funding of technology acquisitions, the reduction of the inflexibility of university administration and restrictive regulations, the teaching overload of academics and inadequate industry links [33].

A challenge for university management and knowledge transfer is balancing the generation of technologies and their acquisition from the environment, how to transfer and commercialise research results and how to encourage university high-tech entrepreneurship and practical aspects. Other implications concern the difficulty creating relationships among firms, policymakers, and universities. There is a challenge when approaching the management of the University-Enterprise linkage due to the complex conditions of the Latin American ecosystem. Building interactive networks to develop specific programs and collaborative projects is a path to boost this new linkage [8].

5.1 Industry Roles for Innovation Ecosystems

Industrial ecosystems are "localised socioeconomic formations achieving sustainable development through the circulation of resources in the objective, environmental, process, and project subsystems" [35]. Furtherly, the ecosystem operates based on information, knowledge, technologies, or critical resources with distinct levels of exchange between business, industry, the scientific community, and government. These arrangements respond to digital challenges and ecological and industrial trends in innovation projects, products, digital platforms, and technologies [25, 38].

In the context of the new industrial revolution, the authors highlight the following principles for industrial ecosystems establishment: transboundary ecosystem processes; (self) organisation, regulation, and development; collaborative development, use of information, and intellectual resources; a continuous flow of projects; agility and flexibility to external challenges; project and client-orientation. Additionally, other principles may support the development of an industrial ecosystem: diversity of actors and network organisation design; collaboration based on partnership, trust, cooperation, and mutual help; balance between goals and objectives of actors; knowledge circulation; resources conservation priority; maintaining and development of each actor's potential; circularity principles enabling to extend the life cycle of resources and to regenerate them for use in other projects [26].

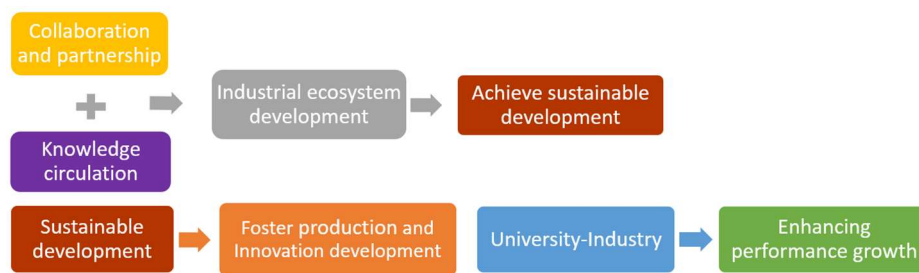
The university-industry connection enhances performance growth, and there are five main academic activities which contribute to the innovative process within firms take place: technological development carried out by academic research and linked to the industry; training and development of engineers and scientists able to deal with problems associated with the innovation process within companies; creation of new scientific instruments and techniques; creation of spin-offs by the academic community.

Recent studies demonstrate that different technologies have been applied to better understand and support ecosystem innovation development. The study shows that machine learning and artificial intelligence are used to understand and predict ecosystem innovations and collaborations to build constructive collaboration between international universities and industry cooperations. [10]. Additionally, digital platforms and applications are used to create innovation opportunities and strengthen sustainable

innovation ecosystem alerts in heterogenous ecosystems, which is particularly interesting to entrepreneurs in potential as well as policymakers [33]. So, we define sustainable development of an industrial ecosystem as technological, innovative, and economic transformations fostering production and innovation potential development of all its actors and system through balancing digital transformation and circularity with human capital and technological development [26, 38].

The image below encapsulates the essence of the preceding text by serving as a concise summary that portrays the key elements and themes and the result of its application.

Fig. 2. Key elements and the result of its application.



5.2 Knowledge and technology transfer

The studies presented ways to contribute to knowledge transfer and regional and social development: universities acquiring and increasing their role in R&D projects, innovation performance and results. Additionally, universities should concern about high-tech entrepreneurship. University technology transfer is attracting greater attention from the high-tech segment [11]. Knowledge transfer is a common factor researched in the articles, with technology transfer being the specific link between universities and firms. Knowledge and technology transfer permits the exchange of different areas of knowledge by companies, and it improves their innovative capacity and market performance [36]; it can facilitate long-term growth, competitiveness, and transition towards sustainable development [31]. Especially regarding approaches for communicating corporate innovation capabilities outside the ecosystem [28] through university alliances. The Universities are acquiring and increasing their role in research and development projects, innovation performance and results to contribute to knowledge transfer and regional and social development.

5.3 Government Roles for innovation ecosystems

Government roles are related to encouraging knowledge exchange between the university and industry by promoting innovation as the natural path to a sustainable future [9]. Also, the government's role is to promote technical knowledge accumulation, develop internal learning processes in innovative firms, and widen the scientific and technological base essential to sustainable growth [9].

Policymakers should reinforce innovative practices, entrepreneurship, and presence in new markets, so they become more active rather than a simple regulator [9]. The state must have an “entrepreneurial” role, acting on allocating public resources to strategic areas where the private initiative has not yet invested, fulfilling uncertainty markets [9]. Policymakers must become more flexible and work with others outside their specialization to ensure the system’s continued regional and national competitiveness [31]. The adaptability of policymakers towards continuous learning and interaction outside their direct field is necessary to aid knowledge-intensive entrepreneurial firms, which can be achieved by further policy experimentation, including dynamic monitoring practices, adaptation to recent problems, and working with adjacent policy fields to solve new challenges [31]. When approaching enterprises at distinct stages, they have different demand types (including product, applied, and basic generic technology) for collaborative research and development (R&D). In other words, there are differences in technologies to solve in R&D collaboration that were observed. The degree of such goal differences will harm knowledge transfer by affecting enterprises’ learning willingness and absorptive capacity [13]. The demands from enterprises and R&D must be strictly linked to work together and achieve their respective goals. To accomplish goals towards development, universities must comprehend societal responsibility and the necessity of direct and continuous interchanges with firms and policymakers to develop a competitive knowledge-based society [11].

The university must have more flexible structures, a new action-oriented research approach, and social participation in networks to socialize the bidirectional flow of socially pertinent knowledge [8]. Sustained incentives to create bottom-up progress are necessary for existing start-ups and new entrants to the ecosystem. Given that, to move towards the future, the induction of existing actors to change their businesses to accomplish sustainable development [31]. With government facilitation, collaboration among companies can result in knowledge, product, and economic sustainability [12, 38].

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