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From Knowledge Generation to Ecosystem Governance: The Evolving Role of Universities in Innovation Ecosystems

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Abstract: This study examines how universities contribute to innovation ecosystems by engaging with multiple actors and assuming roles of varying complexity across different stages of ecosystem development. A Systematic Literature Review (SLR) was conducted using the Scopus and Web of Science databases, yielding a final sample of 70 articles from an initial set of 301 studies. The authors analyzed studies using bibliometric techniques and qualitative content analysis to identify the main university roles and their distribution across the innovation ecosystem lifecycle. The findings disclose ten categories of university roles, including knowledge generation, university–industry collaboration, ecosystem structuring, regional development, entrepreneurship, open innovation, platform creation and management, technology transfer, territorial impact, and relational orchestration. The results demonstrate that these roles are not static but evolve according to ecosystem maturity and increasing coordination complexity. While knowledge generation remains central across all stages, universities progressively assume broader entrepreneurial, integrative, and governance-oriented functions as ecosystems evolve. The study contributes to the literature by proposing an integrative, dynamic framework that explains how university roles accumulate and reconfigure across the stages of ecosystem development. By positioning universities as adaptive institutional actors, the article advances the understanding of the co-evolutionary relationship between universities and innovation ecosystems.

Keywords: Universities; Innovation ecosystems; University roles; Ecosystem stages; Systematic literature review.

I. Introduction

The concept of innovation ecosystems has its roots in Moore's (1993) ecological perspective on organizational interactions, which emphasizes the coexistence of competition and cooperation among actors. Over the past two decades, this approach has consolidated as a powerful analytical framework for understanding collaborative innovation processes that transcend traditional organizational boundaries (Zen et al., 2024). Within this context, firms, governments, and research institutions interact in an interdependent manner to generate value and address the increasing challenges of competitiveness (Autio & Thomas, 2014; Adner, 2006). Among these actors, universities have assumed an increasingly central role, not only as knowledge producers but also as agents capable of shaping the structure, dynamics, and evolution of innovation ecosystems (Mercan & Goktas, 2011).

In this evolving landscape, universities have expanded beyond their traditional missions of teaching and research, taking on a more active role in economic and social development by engaging with innovation ecosystems. By interacting with other actors, they contribute to the Triple Helix — university, industry, and government — and the Quadruple Helix, which also incorporates civil society (Carayannis et al., 2018). Despite the growing body of literature on university roles, existing studies tend to focus on isolated cases or specific functions, resulting in a fragmented understanding of how universities operate within innovation ecosystems. Moreover, there is still limited knowledge regarding how these roles vary across different stages of ecosystem development.

Addressing these gaps, this study aims to systematically analyze universities' roles in innovation ecosystems and examine how these roles differ across stages of ecosystem development. To achieve this, a Systematic Literature Review is

conducted, integrating empirical evidence from multiple contexts to provide a comprehensive and comparative perspective.

By linking university roles to the lifecycle of innovation ecosystems, this study advances the literature by moving beyond static representations of university functions and proposing a dynamic, stage-based understanding of their contributions. In doing so, it offers both theoretical insights into the evolving role of universities and practical implications for policymakers and university managers seeking to strengthen innovation ecosystems.

II. Theoretical Background

The concept of innovation ecosystems (IE), originally inspired by biological sciences, has been widely adopted to describe collaborative arrangements in which firms combine their individual offerings into coherent solutions for the market (Adner, 2006). This perspective emphasizes the importance of interactions among multiple actors who, through interconnected relationships, generate new products, services, and business models. Despite significant advances, the field remains in a stage of conceptual consolidation, with evolving boundaries and ongoing efforts toward theoretical systematization (Foguesatto et al., 2021).

Among the different perspectives on innovation ecosystems, Adner (2006) highlights the value proposition as a central element, which was later extended to value co-creation in interdependent contexts (Adner, 2017). Within this view, ecosystems are characterized by the simultaneous presence of cooperation and competition among actors, reinforcing their inherently relational and dynamic nature (Carayannis et al., 2018). Complementing this perspective, Granstrand and Holgersson (2020) conceptualize innovation ecosystems as the interactions among actors, activities, and artifacts, thereby expanding the analytical scope of the phenomenon. Taken together, these approaches suggest that innovation ecosystems are structured around interdependence, coopetition, and shared value creation (Gomes et al., 2018; Steinbruch et al., 2022; Granstrand & Holgersson, 2020).

Building on these contributions, this study adopts the definition proposed by Foguesatto et al. (2021), which conceptualizes innovation ecosystems as systems composed of multiple actors—including citizens, industries, universities, and research centers—who interact to create value. This definition is particularly suitable for the present study, as it explicitly recognizes both the diversity of actors and the centrality of their interactions, which are fundamental to understanding universities' roles within innovation ecosystems.

Within this context, examining the role of universities is essential, particularly given their historical evolution and the consolidation of the entrepreneurial university model (Etzkowitz et al., 2008). Traditionally, universities were primarily understood as institutions dedicated to teaching, focusing on human capital development (Galán-Muros et al., 2017). With the advancement of industrialization, their role expanded to include the production of scientific knowledge, establishing research as a second mission. Subsequently, especially following the enactment of the Bayh-Dole Act of 1980 in the United States, universities increasingly engaged in knowledge transfer to industry, reinforcing their contribution to economic value creation (COGR, 1999; Rosa & Zen, 2022).

This evolution contributed to a broader expansion of university functions, incorporating economic and social development into their institutional mission. As a result, universities have progressively transitioned from primarily being knowledge producers to strategic actors within innovation ecosystems, actively engaging in the articulation of actors and the promotion of innovation processes.

The evolution of university missions—from education to research and, more recently, to economic development—has led to the consolidation of the concept of the entrepreneurial university (Clark, 2001). In this model, universities strengthen their organizational identity and reduce their dependence on state and market pressures. Clark (2004) further emphasizes the need for universities to establish systematic interactions to create value, promote gradual institutional change, and assume risks in transforming knowledge into action. In this sense, the entrepreneurial university represents a significant paradigm shift, moving from a traditionally passive role to a proactive position in economic and social development. This transformation implies deeper integration with the external environment and reinforces the central role of universities in innovation ecosystems.

A gradual transition can thus be observed from the traditional role of universities—centered on human capital formation—to a more active engagement in regional and societal development. By contributing to regional development, universities assume greater responsibility toward their surrounding environments, moving away from the "ivory tower" model and aligning more closely with societal demands (Etzkowitz et al., 2008; Etzkowitz & Leydesdorff, 2000). In this context, the entrepreneurial university is increasingly oriented toward the applicability of knowledge and the resolution of real-world problems. However, how this third mission is operationalized varies across institutional contexts.

These variations are particularly evident when comparing developed and emerging economies. In developed countries, such as the United States and England, universities tend to adopt a more entrepreneurial posture, driven by global competitiveness and strong industry linkages. In contrast, in emerging economies—particularly in Latin America and Africa—universities often assume broader roles, frequently collaborating with governments to address structural gaps and promote regional development (Oliveira & Rodrigues, 2022). This heterogeneity indicates that institutional, economic, and social contexts strongly condition university roles within innovation ecosystems.

The combination of the entrepreneurial university model and the Triple Helix framework has further contributed to the repositioning of universities as active agents in knowledge management and technological diffusion through their interactions with industry and government (Cai & Etzkowitz, 2020). In this context, universities go beyond their role as knowledge providers and assume broader functions within innovation ecosystems, including coordinating interactions and strengthening innovation dynamics. By establishing partnerships with industry and local governments, universities not only contribute to workforce development and technological upgrading but may also act as orchestrators of innovation ecosystems, coordinating interactions and enhancing collective outcomes (Thomas et al., 2021).

By mobilizing their intellectual capital, reputation, and capacity to attract resources, universities can integrate the efforts of different actors within the Triple Helix, thereby influencing the performance of innovation ecosystems (Heaton et al., 2019). However, the effectiveness of this role is not uniform and varies according to institutional conditions and levels of development. While universities in developed countries tend to assume a more entrepreneurial role through stronger industry connections (Trippl et al., 2015), in emerging contexts their contributions are often more closely associated with regional development and social initiatives in collaboration with government (Mello et al., 2022).

In addition to contextual factors, the effectiveness of university engagement also depends on internal capabilities that enable adaptation to complex and uncertain environments. The dynamic capabilities perspective highlights the importance of developing abilities to sense opportunities, mobilize resources, and reconfigure strategies over time (Teece, 2007; 2009). These capabilities are particularly relevant for understanding how universities adjust their roles across different contexts and stages of innovation ecosystem development.

Despite the advances in the literature, important gaps remain. Existing studies are often fragmented and tend to focus on specific roles or isolated cases, limiting a more comprehensive understanding of university engagement in innovation ecosystems. Moreover, there is still a limited understanding of how these roles evolve and vary across different stages of ecosystem development. This gap restricts the development of a more dynamic and context-sensitive perspective on the role of universities.

Addressing this gap is essential for advancing the field, as it enables a more systematic and integrated understanding of how universities operate within innovation ecosystems. In this regard, identifying the stages of ecosystem development provides a relevant analytical lens for examining how university roles emerge, evolve, and adapt over time.

Based on the contributions of Etzkowitz and Klofsten (2005) and Piqué, Miralles, and Berbegal-Mirabent (2019), innovation ecosystems can be understood as evolving through distinct stages, such as birth, growth, consolidation, and maturity (Table 1), each characterized by specific dynamics, challenges, and resource configurations. Considering these stages allows for a more nuanced analysis of how university roles are shaped and reconfigured throughout the lifecycle of innovation ecosystems.

Table 1. Definitions of the stages of development of Innovation Ecosystems (IE)

Phases of IE	Definitions
Birth	Actors engage and align a value proposition, such as a shared vision on the ecosystem's initial infrastructure.
Growth	A routine for the ecosystem's functioning is established. There is an increase in collaboration among actors to generate and capture value from complementarities.
Consolidation	Collaborations and resource flows are maintained, but they occur at a slower pace. Entrepreneurs and investors help create structures that foster a culture of collaboration.
Maturity	The actors' efforts are optimized for the ecology of innovation, with continuous renewal, thereby preventing the decline of IE. Connection with other international innovation hubs is promoted. The innovation area should assess whether it is appropriate to expand the experience or transfer it to other regions.

Source: Adapted from Etzkowitz and Klofsten (2005) and Piqué, Miralles, and Berbegal-Mirabent (2019).

By identifying the stage at which an innovation ecosystem is situated, it becomes possible to better understand the challenges and opportunities associated with university engagement. This perspective provides the foundation for the methodological approach adopted in this study, which is presented in the following section.

III. Methodology

This study adopts a Systematic Literature Review (SLR) to investigate universities' roles in innovation ecosystems and identify patterns, trends, and research gaps in the existing literature (Page et al., 2021). The SLR approach enables a structured, transparent, and replicable process for synthesizing knowledge across multiple studies.

The review was conducted using two major academic databases—Scopus and Web of Science—widely recognized for their comprehensive coverage across management, business, and the social sciences. The search included publications up to December 2025, with no restriction on the initial publication date. The search strategy considered titles, abstracts, and keywords, using the following descriptors: "universit*" AND "innovation ecosystem*".

To ensure the relevance and quality of the selected studies, the following inclusion criteria were applied: (i) full-length research or review articles; (ii) publications written in English; (iii) studies classified within the fields of management, business, or social sciences; and (iv) articles that explicitly addressed the role or involvement of universities in innovation ecosystems.

The initial search identified 301 articles. Duplicate records were identified using the Rayyan software (Ouzzani et al., 2016) and subsequently removed by the authors through manual verification to ensure accuracy. After duplicates were removed, all abstracts were screened for relevance. Articles that did not address both innovation ecosystems and universities were excluded at this stage.

Following this screening process, 169 articles were selected for full-text reading. After a detailed evaluation, 70 articles were retained, as they directly addressed the roles of universities in innovation ecosystems (Figure 1).

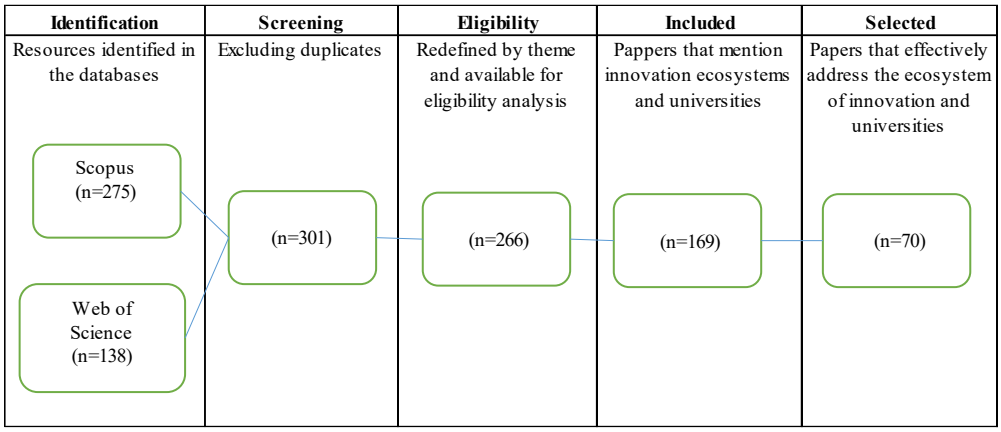


Figure 1. Flowchart of the main stages of article identification, screening, and selection in the systematic literature review.

Source: the authors.

The final sample of 70 articles was analyzed using qualitative content analysis, following Bardin's (2016) approach. The analysis adopted an inductive and semantic perspective, enabling the identification and categorization of the roles universities play within innovation ecosystems based on recurrent meanings and patterns across the studies. Initially, the articles were systematically read to identify explicit descriptions related to university engagement in innovation ecosystems. Subsequently, semantic similarities among the identified activities, functions, and institutional practices were grouped into broader thematic categories representing distinct university roles. The categories emerged inductively from the analyzed material rather than from predefined theoretical classifications.

Throughout the analytical process, the categories were iteratively refined through comparisons across studies to ensure conceptual consistency and analytical coherence. To enhance reliability, the categorization procedures and stage classifications were reviewed and discussed among the authors until consensus was achieved. The analysis identified 10 university roles: knowledge generation, university–industry collaboration, ecosystem structuring, regional development,

entrepreneurship, open innovation, platform creation and management, technology transfer, territorial impact, and relational orchestration.

IV. Results and Discussion

A significant increase in publications addressing the role of universities in innovation ecosystems (IEs) is evident from 2017 onwards, with notable peaks in 2019, 2021, 2024, and 2025. This trend indicates the recent consolidation of the topic within the academic literature. Most of the studies are empirical (67 out of 70), with a strong geographical concentration in Europe, the United States, China, and Brazil. Publications are distributed across multidisciplinary journals, with no clear dominance by any author, reinforcing the field's still fragmented nature.

The analysis identified 10 roles universities play in innovation ecosystems (Table 2), noting that a single study may encompass multiple roles simultaneously. Since 2018, there has been a marked increase in the diversity of these roles. Among them, knowledge generation, technology transfer, territorial impact, and entrepreneurship emerge as the most prominent, while themes such as open innovation and relational orchestration remain comparatively underexplored.

Table 2. Definitions of role groupings according to the role of universities in innovation ecosystems

Groupings	Definitions
Knowledge Generation	Studies addressing the role of universities in research activities aimed at generating new knowledge.
Innovation Ecosystem Structuring	Studies describing the formation of innovation ecosystems, from their emergence to maturity, detailing how universities are embedded in this process.
Regional Development	Studies examining how innovation ecosystems can be implemented and how universities contribute to reducing inequalities in wealth creation.
Entrepreneurship	Studies highlight how universities foster an environment conducive to talent development and the creation of new products, services, and businesses.
Open Innovation	Studies addressing the intentional acquisition and exchange of knowledge to enhance both internal and external sources of innovation.
Platform Creation and Management	Studies describing universities' role in building and managing shared platforms that integrate knowledge, technologies, processes, products, and outcomes.
University–Industry Collaboration	Studies focusing on collaboration between universities and firms to address specific demands, such as problem-solving within innovation ecosystems.
Technology Transfer	Studies examining the processes and mechanisms through which universities and firms interact to transfer knowledge, leading to technological application, licensing, and commercialization.
Relational Orchestration	Studies in which universities coordinate collaborative practices among multiple actors without hierarchical authority.
Territorial Impact	Studies in which universities promote transformations within the ecosystem's territory by creating firms, startups, spin-offs, or partnerships.

Source: elaborated by the authors based on research findings

4.1 Knowledge Generation

Knowledge generation remains a central function of universities, reflecting their historical mission and academic legitimacy (Galán-Muros et al., 2017). Within innovation ecosystems, however, this role extends beyond scientific production to include collaboration with industry and engagement in strategic areas such as renewable energy and the hydrogen economy (Csedö et al, 2021).

The literature highlights the growing importance of interdisciplinarity, particularly in complex fields such as synthetic life sciences (Baum et al., 2025), where integrating diverse areas of knowledge is essential for innovation. In this context, universities serve as knowledge integrators, contributing to the resolution of complex problems and scientific advancement. Hence, knowledge generation remains a structural foundation of innovation ecosystems, while simultaneously evolving to meet contemporary demands for integration, applicability, and innovation.

4.2 University-Industry Collaboration

University–industry collaboration is analyzed as a central mechanism for enhancing the innovative capacity of innovation ecosystems, being influenced by factors such as alignment of interests, trust, and perceived benefits (Hossen et al., 2025; Puerta-Sierra et al., 2021). When these elements are present, collaboration tends to intensify; conversely, their absence creates barriers that limit its effectiveness.

The literature reveals significant variation across contexts. In more structured environments, collaboration typically takes the form of strategic partnerships, joint training initiatives, and curriculum integration (Marra et al., 2022). In contrast, in less developed contexts, institutional and economic constraints tend to reduce the potential for effective cooperation (Kravchenko et al., 2019).

In addition, universities may adopt a proactive role by identifying ecosystem failures and proposing solutions, as illustrated in the case of Boston (Calza et al., 2021). Overall, university–industry collaboration is strongly context-dependent and relies on alignment among actors, a critical factor in the performance of innovation ecosystems.

4.3 Technology Transfer

Technology transfer refers to the intentional process of interaction through which knowledge and technologies are transferred between organizations, aiming to enhance capabilities and generate value (Battistella et al., 2016). Within innovation ecosystems, this role positions the university as an intermediary between scientific production and its market application.

The literature highlights that universities and firms perform complementary functions in this process, encompassing activities that range from knowledge generation to commercialization through licensing and applied innovation (Wu et al., 2018). However, the effectiveness of technology transfer depends on actors' ability to adapt practices to the specificities of each ecosystem, as successful models are not necessarily replicable in less developed contexts (Meng et al., 2019).

Recent studies point to the expansion of this role, including the mobility of researchers toward industry, the strengthening of science and technology parks, and the creation of intermediary structures that facilitate interactions among academia, government, and industry (Li et al., 2023; Davies et al., 2021). In addition, relational practices, such as competence mapping, networking, and trust-building, are essential to reducing barriers among actors and enabling research and innovation agreements (Delorme, 2023).

Another important development concerns the use of digital technologies, such as artificial intelligence, to support partner identification and enhance knowledge transfer processes, thereby expanding their impact in areas such as clean energy and sustainability (Sarpong et al., 2025; Uyar et al., 2024).

The role of universities in technology transfer extends beyond mere knowledge dissemination, encompassing the articulation of actors, the strengthening of absorptive capacities, and the promotion of applied innovation. This role becomes particularly relevant in contexts where university–industry interaction still faces structural limitations. It highlights the importance of examining how technology transfer practices vary across different stages of ecosystem development.

4.4 Open Innovation

Open innovation, defined as the intentional inflows and outflows of knowledge to enhance internal and external sources of innovation (Chesbrough et al., 2017), broadens universities' roles within innovation ecosystems by extending their activities beyond bilateral interactions toward a more systemic engagement. In this context, universities play a key role in facilitating the circulation of knowledge among diverse actors, thereby fostering integration and increasing the ecosystem's dynamism.

The literature indicates that this role is operationalized through mechanisms such as collaborative networks, incubators, science and technology parks, and open educational ecosystems, where universities, firms, and governments jointly share resources, knowledge, and capabilities (Barile et al., 2024; Mejia et al., 2019; Yan et al., 2020). Within these arrangements,

universities serve as trusted intermediaries, mitigating intellectual property risks and facilitating cooperation among ecosystem participants (Rayna & Striukova, 2014).

Moreover, the adoption of open innovation practices is influenced by public policies and institutional strategies, particularly those aimed at supporting small and medium-sized enterprises in digital transformation processes and reducing resistance to knowledge sharing (Costa & Matias, 2020).

Therefore, universities contribute to open innovation by enabling continuous knowledge flows, lowering barriers to collaboration, and strengthening the innovative capacity of ecosystems. However, despite its recognized potential, the literature on this role remains underdeveloped, underscoring the need for further research into the barriers to the effective implementation of open innovation practices in academic contexts.

4.5 Platform Creation and Management

The role of platform creation and management refers to the university's involvement in developing infrastructure—often digital—that connects actors, organizes information flows, and enables collaboration within innovation ecosystems (Santos & Zen, 2022). These platforms function as shared spaces for interaction, where knowledge, technologies, and processes are integrated and made accessible to multiple stakeholders.

The literature indicates that universities perform this role by structuring digital repositories, interorganizational networks, and collaborative environments that connect firms, research institutions, and other ecosystem actors (Wang & Yu, 2019; Grobbelaar, 2018). Such initiatives contribute to project governance, facilitate knowledge dissemination, and support the formation and coordination of innovation communities.

Furthermore, these platforms may evolve into more complex systems that integrate academic, business, and societal services, thereby expanding their capacity to create value. In some cases, they also contribute to user empowerment and to the development of applied knowledge in strategic domains such as healthcare and energy (Csedő et al., 2021; Ngongoni et al., 2022).

In summary, the university's role in platform creation and management extends beyond providing technological infrastructure to include coordinating interactions, managing knowledge flows, and strengthening collaborative dynamics within innovation ecosystems.

4.6 Relational orchestration

Orchestration refers to the deliberate coordination of innovation networks through collaborative practices, in the absence of hierarchical authority, to create and capture value within the ecosystem (Dhanaraj & Parkhe, 2006; Hurmelinna-Laukkanen & Nätti, 2018). Within innovation ecosystems, this role emphasizes the university's ability to articulate actors, align interests, and foster strategic interactions.

Empirical evidence indicates that universities may act as orchestrators by assuming roles such as initiators, facilitators, coordinators, and enablers of ecosystem dynamics (Amitrano & Bifulco, 2024). This role becomes particularly relevant in complex environments, where coordination among multiple actors is essential to enable innovation.

The literature further suggests that orchestration is associated with the increasing complexity of innovation ecosystems and emerges as a governance strategy grounded in collaboration and intermediation among actors. In this sense, universities extend their traditional functions by incorporating capabilities related to coordination and systemic articulation.

However, this field remains relatively underdeveloped, with limited theoretical systematization and a scarcity of studies examining how the orchestration role varies across different stages of ecosystem development (Bittencourt et al., 2020; 2021). In addition, contextual and institutional factors may influence the extent to which universities can effectively perform this role.

According to our findings, relational orchestration positions the university as a governance actor within innovation ecosystems, responsible for coordinating interactions, reducing asymmetries, and fostering collective value creation. Nevertheless, further research is needed to better understand how this role evolves over time and across different contexts.

4.7 Regional Development

The role of universities in regional development is closely associated with their capacity to reduce inequalities, promote innovation, and strengthen the articulation among ecosystem actors. In this context, university engagement can contribute to both the dynamization of already consolidated regions and the advancement of less developed territories.

The literature provides evidence that universities may act as catalysts for regional development by integrating knowledge, innovation, and public policies, thereby contributing to regional prosperity, as observed in consolidated ecosystems (Brito, 2018; Etzkowitz, 2019). Furthermore, their involvement may vary from more traditional academic support functions to more direct participation in governance and regional planning processes (Rosli & Cacciolatti, 2022).

However, in emerging or transition economies, structural constraints may limit this role, resulting in reduced protagonism or more indirect contributions to regional development (Chekanov, 2022). In such contexts, challenges such as weak integration among actors, institutional misalignment, and limited absorptive capacity hinder ecosystem performance (Aparecido-Tomaz et al., 2022; Khoirunisa et al., 2023).

Nevertheless, universities may adopt hybrid strategies that combine social innovation and entrepreneurial orientation to foster regional development, particularly in peripheral contexts (Fischer et al., 2021). In addition, emerging approaches—such as artificial intelligence—are being explored to support the assessment and strengthening of ecosystem maturity (Popelo et al., 2025).

In essence, the role of universities in regional development is strongly conditioned by institutional and economic contexts, which vary across the functions of support, coordination, and leadership. This heterogeneity underscores the need for comparative and context-sensitive analyses of university engagement in innovation ecosystems.

4.8 Innovation Ecosystem Structuring

The role of universities in structuring innovation ecosystems refers to their involvement in the formation, development, and consolidation of these arrangements over time. This process entails articulating actors, mobilizing resources, and establishing institutional conditions conducive to innovation.

The literature indicates that universities contribute to the emergence and strengthening of innovation ecosystems by integrating diverse actors—such as firms, government agencies, and investors—and by fostering value creation in interdependent contexts (Ma et al., 2019; Umemura, 2025). This role may assume different configurations, including bottom-up approaches driven by local initiatives and top-down strategies shaped by public policies (Sun et al., 2019).

In addition, universities may act as agents of organizational and institutional transformation, influencing processes of legitimation, adaptation, and change within ecosystems (Villani & Lechner, 2021). Interactions between universities and industry, often characterized by mutualistic relationships, play a key role in shaping innovation culture and regional dynamics (Schaeffer et al., 2021).

In specific contexts, this role may expand to encompass the coordination of complex processes, such as digital transformation and value chain integration, highlighting the university's ability to operate simultaneously as a local actor and a global articulator (Tolstykh et al., 2021; Taxt et al., 2022).

Taken together, these findings indicate that the university's participation in structuring innovation ecosystems entails the progressive development of relationships, capabilities, and coordination mechanisms that vary across contexts and at different stages of ecosystem development. While the analyzed experiences provide valuable insights, their replicability remains limited, underscoring the need for further research exploring diverse trajectories and lifecycle dynamics of innovation ecosystems.

4.9 Territorial Impact

Territorial impact refers to universities' capacity to drive transformations within the geographic space of innovation ecosystems by attracting and creating firms, startups, spin-offs, and strategic partnerships. In this sense, university engagement contributes to the reconfiguration of economic and productive dynamics at both local and regional levels.

The literature indicates that this role materializes in the formation of innovation hubs and in the revitalization of territories, driven by the articulation among universities, industry, and government (Condom-Vilà, 2020; Ma et al., 2019). Across different contexts, universities act as facilitators of territorial reorganization, promoting sectoral integration and the diversification of economic activities (Abremski & Roben, 2021).

In short, the territorial impact of universities in innovation ecosystems stems from their ability to attract actors, structure activities, and stimulate the creation of new productive arrangements, thereby contributing to regional development and competitiveness.

4.10 Entrepreneurship

Entrepreneurship, understood as the process of identifying and exploiting opportunities to create new products, services, and ventures (Venkataraman, 2004), plays a key role for universities within innovation ecosystems. In this context, the entrepreneurial university contributes to the development of competencies, the stimulation of new venture creation, and the consolidation of environments conducive to innovation.

The literature indicates that universities promote entrepreneurship through educational programs, the development of entrepreneurial skills, and support for students' career trajectories, thereby influencing career choices and enhancing employability (Castro et al., 2019; Guerrero et al., 2020). Moreover, these effects tend to extend over time, being reflected in firm creation, participation in organizations, and the continuation of entrepreneurial initiatives (Roberts et al., 2019).

Beyond individual-level development, universities also contribute to entrepreneurship by establishing strategic partnerships with firms and fostering collaborative environments that support the creation of new ventures (Schiuma & Carlucci, 2018). In more consolidated ecosystems, this role may directly influence regional dynamics, stimulate startup formation, and attract investment (Klein et al., 2021).

However, the literature also highlights several challenges, including the need for more practice-oriented approaches, limitations in mentor development, and difficulties in adapting entrepreneurship programs to diverse cultural and institutional contexts (Vedana & Andreassi, 2024; Hayter et al., 2025).

In summary, universities' role in entrepreneurship encompasses developing human capital, stimulating venture creation, strengthening networks, and generating long-term impact within innovation ecosystems. This role, however, varies with context and institutional capabilities, underscoring the need for further research into its effectiveness across different environments.

4.11 Distribution of University Roles Across Ecosystem Development Stages

Weighted percentage distribution of university roles across innovation ecosystem development stages based on a cross-analysis of 70 selected articles (Table 3). Percentages are calculated on a column-by-column basis, where each column sums to 100% to represent the relative prominence of roles within each exclusive ecosystem stage.

Table 3. Diversity roles across stages of innovation ecosystem development

University roles in IEs	Birth	Growth	Consolidation	Maturity
University–industry collaboration	0.0%	6.6%	7.2%	2.0%
Regional development	9.1%	9.8%	8.4%	11.8%
Entrepreneurship	9.1%	16.4%	13.8%	15.7%
Ecosystem structuring	9.1%	8.2%	10.2%	15.7%
Knowledge generation	18.2%	21.3%	20.4%	17.6%
Territorial impact	13.6%	14.8%	15.6%	13.7%
Open innovation	4.5%	3.3%	4.2%	2.0%
Platform creation and management	13.6%	3.3%	4.2%	2.0%
Technology transfer	13.6%	16.4%	15.0%	15.7%
Relational orchestration	9.1%	0.0%	1.2%	3.9%

Note: Percentages are column-based and correspond to ecosystem development stages.

Source: elaborated by the authors based on research findings

A cross-tabulation analysis was conducted to synthesize the relationship between university roles and innovation ecosystem stages across 70 articles. Each paper was classified into a single ecosystem development stage (birth, growth, consolidation, or maturity) to ensure mutually exclusive categories for the structural stages. Conversely, the classification of university roles was non-exclusive, as a single article could document multiple roles. To normalize the data and identify distribution patterns, a weighted calculation was performed to determine the relative representativeness of each role within each stage. The resulting synthesis is expressed as percentages by column, with the sum of classifications within each ecosystem stage equal to 100%.

The results reveal that university roles vary substantially across the stages of ecosystem development. While knowledge generation remains predominant throughout the lifecycle, other functions become prominent as the ecosystem matures. In early stages, universities are more strongly associated with platform creation, territorial articulation, and relational orchestration. During growth and consolidation, entrepreneurship, technology transfer, and university–industry collaboration become more relevant, whereas ecosystem structuring and regional development become more prominent in mature ecosystems. These findings suggest that university engagement evolves alongside ecosystem complexity and institutional development.

Based on the patterns identified across ecosystem stages, the findings also allow the proposal of an integrative framework (Table 4) that connects ecosystem maturity, university capabilities, predominant roles, and ecosystem outcomes.

Table 4. Dynamic Evolution of University Roles Across Innovation Ecosystem Stages

Innovation Ecosystem Stage	Evolutionary Layer	Predominant University Roles	Dominant Institutional Capabilities	Main Ecosystem Outcomes
Persistent Across All Stages	Academic Core	Knowledge generation	Scientific production, knowledge creation, research excellence, human capital development	Knowledge base formation, scientific legitimacy, and long-term innovation support
Birth	Relational Foundation Layer	Platform Creation and management; Relational orchestration; Territorial articulation	Legitimacy building; actor mobilization; coordination; initial network formation	Ecosystem alignment; initial connectivity; emergence of collaborative structures
Growth	Entrepreneurial Expansion Layer	Technology transfer; Entrepreneurship; University–industry collaboration	Opportunity exploitation; commercialization; external engagement; partnership development	Innovation expansion; startup generation; scaling of collaborative activities
Consolidation	Systemic Integration Layer	Ecosystem structuring; Territorial impact; Sustained technology transfer	Institutional integration; ecosystem coordination; resource stabilization; collaboration management	Ecosystem stability; collaborative density; institutional consolidation
Maturity	Governance and Renewal Layer	Regional development; Ecosystem governance; Global articulation; Strategic coordination	Governance capability; strategic renewal; international articulation; adaptive reconfiguration	Ecosystem sustainability; resilience; international integration; long-term renewal

Source: elaborated by the authors based on research findings

The findings suggest that, as innovation ecosystems evolve, increasing institutional density, actor interdependence, and coordination complexity generate new demands for universities, requiring the progressive development of broader relational, entrepreneurial, and governance capabilities. In this sense, university engagement in innovation ecosystems does not occur through static or isolated institutional functions but rather through an adaptive, cumulative process shaped by ecosystem maturity and relational dynamics. While knowledge generation remains central across all stages - reflecting the enduring academic mission highlighted by Galán-Muros et al. (2017) - other university roles evolve and accumulate over time according to the changing needs of the ecosystem. Interestingly, the results indicate that traditional academic functions are not replaced as ecosystems mature but instead are layered with new institutional responsibilities for coordination, entrepreneurship, technology transfer, and ecosystem governance.

In early-stage ecosystems, universities tend to perform enabling and legitimizing functions through orchestration, platform creation, and actor articulation, supporting the emergence of collaborative structures and shared value propositions, as suggested by Adner (2006) and Carayannis et al. (2018). As ecosystems evolve toward growth and consolidation, universities increasingly engage in entrepreneurship, technology transfer, and university–industry collaboration, reinforcing the entrepreneurial university perspective and the Triple Helix dynamics proposed by Etzkowitz and Leydesdorff (2000). In mature ecosystems, universities appear to assume broader governance and regional development functions, acting not only as knowledge providers but also as strategic coordinators of ecosystem evolution.

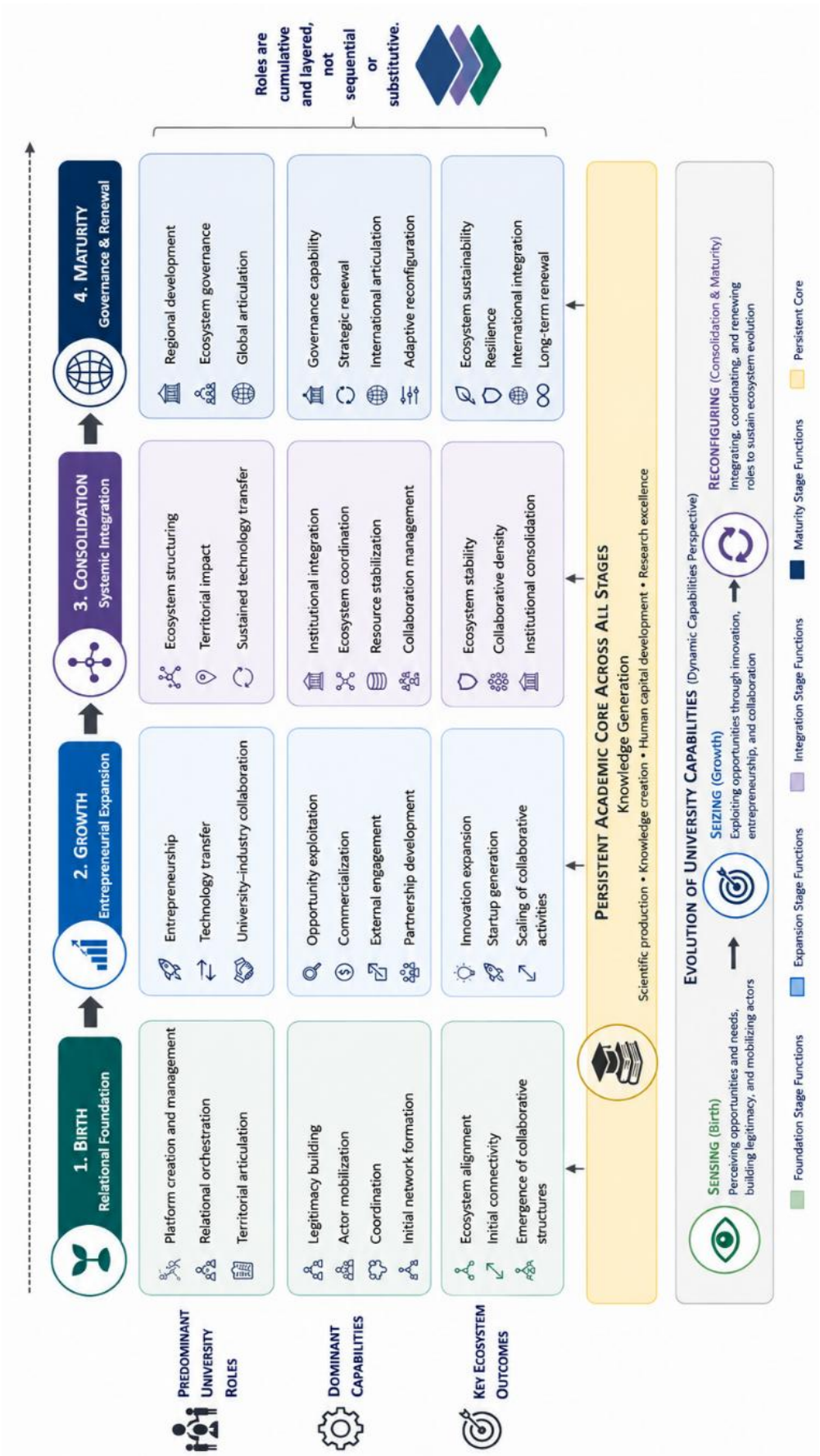


Figure 2. Dynamic Layered Evolution Framework of University Roles
Source: the authors

These results extend the dynamic capabilities perspective (Teece, 2007; Heaton et al., 2019) by suggesting that universities continuously reconfigure their institutional capabilities and relational positions in response to ecosystem evolution. More specifically, the proposed framework indicates that university roles evolve through layered accumulation of capabilities, in which foundational relational and legitimizing functions support the emergence of more complex entrepreneurial, integrative, and governance-oriented activities over time. Therefore, rather than representing fragmented institutional activities, university roles appear to constitute an evolving portfolio of capabilities that expands in response to ecosystem maturation. This perspective advances innovation ecosystem theory by positioning universities as adaptive institutional actors whose functions co-evolve with the ecosystem's development trajectories (Figure 2).

The next session brings the conclusion of the study.

V. Conclusion

This study advances the literature on innovation ecosystems by examining how university roles evolve across different stages of ecosystem development. Through a Systematic Literature Review, the findings demonstrate that university engagement extends far beyond traditional knowledge generation and technology transfer, encompassing broader functions in ecosystem structuring, entrepreneurship, relational orchestration, regional development, and governance. More importantly, the study shows that these roles are not static institutional functions, but adaptive, evolving forms of engagement shaped by ecosystem maturity and relational complexity.

By integrating the innovation ecosystem perspective with the dynamic capabilities approach, the study contributes theoretically by proposing that universities progressively reconfigure their institutional capabilities, relational positions, and strategic functions throughout the ecosystem lifecycle. In this sense, the proposed framework, Dynamic Evolution of University Roles Across Innovation Ecosystem Stages, provides a dynamic understanding of how universities co-evolve with innovation ecosystems over time. The findings suggest that universities move from foundational and legitimizing roles in early ecosystem stages toward more complex governance, coordination, and regional leadership functions in mature ecosystems.

This perspective contributes to the literature in three main ways. First, it advances prior studies that predominantly conceptualize universities as entrepreneurial or knowledge-producing actors by demonstrating that universities' roles vary across trajectories of ecosystem development. Second, the study introduces a lifecycle-based perspective that highlights the temporal and contextual dimensions of university engagement. Third, the findings propose that advanced university functions emerge through the cumulative development of organizational, relational, and institutional capabilities, reinforcing the importance of adaptive capacity in ecosystem evolution.

From a practical standpoint, the study offers implications for university managers and policymakers, suggesting that university strategies should be aligned with ecosystem maturity and regional innovation needs. The proposed framework may therefore support strategic decision-making regarding capability development, partnership formation, governance structures, and innovation policies.

Despite its contributions, the study presents some limitations. The predominance of single-case studies and reliance on secondary data may limit the generalizability of the findings. In addition, the literature still presents uneven coverage of certain university roles, particularly open innovation and relational orchestration, which remain comparatively underexplored.

Future studies should adopt longitudinal and comparative approaches to examine how universities develop and reconfigure their capabilities over time within different institutional and regional contexts. Further research is also needed to investigate how universities manage the increasing complexity of ecosystems, governance tensions, and collaborative dynamics in mature innovation ecosystems. Such efforts may contribute to a more process-oriented and evolutionary understanding of university engagement in innovation ecosystems.

Declaration of Generative AI Use

The authors used generative artificial intelligence (AI) tools, including the ChatGPT model GPT-5.5, during the development of this manuscript to support language refinement, text organization, and conceptual visualization. AI-assisted resources were employed to improve clarity, coherence, and the quality of academic writing, and to support the graphical representation of the proposed conceptual framework. However, all literature selection, data analysis, categorization procedures, interpretation of findings, theoretical arguments, and final decisions regarding the manuscript content were conducted exclusively by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the work presented in this study.

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