



Entrepreneurial and innovation ecosystems: a scoping review on the complexity of nested configurations

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ABSTRACT

Entrepreneurial ecosystems (EEs) and innovation ecosystems (IEs) are conceptualised as distinct constructs, yet their interplay remains theoretically fragmented. This study addresses this gap through a scoping review of 48 peer-reviewed publications, investigating how the literature conceptualises their intersection. Guided by complex systems theory, our analysis reveals four nested configurations that emerge from the selected papers: startup ecosystems, entrepreneurial university ecosystems, entrepreneurial innovation ecosystems, and regional innovation ecosystems. These configurations are classified along two dimensions: (i) the dominant orientation of the ecosystem, which leans towards either an entrepreneurial or innovation logic; and (ii) the prevailing form of complexity, shaped by bottom-up or top-down dynamics. Our findings reveal that each configuration varies to the extent to which entrepreneurial processes are embedded within broader innovation structures or how innovation dynamics are driven by entrepreneurial foundations. We also identify systems where complex dynamics originate either at the micro-level or at the macro-level, subsequently influencing the other dimension. Thus, by showing that EEs and IEs can coexist within nested configurations than as separate domains, this study contributes to ecosystem literature and to the theoretical development of complex systems theory. The analysis advances conceptual understanding by explaining how these configurations are shaped by different forms of complexity: bottom-up dynamics are grounded in effectuation logics, and top-down patterns reflect causation and coordinated strategies. The study offers practical guidance for policymakers and ecosystem orchestrators, as it shows how governance strategies can be aligned with the specific systemic dynamics of each configuration.

Introduction

Entrepreneurial ecosystems (EEs) and innovation ecosystems (IEs) have attracted the attention of policymakers, federal agencies, venture capitalists, business enterprises, and members of academia (Ozkan et al., 2023; Tsujimoto et al., 2018). Broadly, EEs are defined as multifaceted structures (Spigel, 2017; Van de Ven, 1993), with entrepreneurial outputs generated from the combination of financial, knowledge, institutional, social, and technological components (Audretsch et al., 2019; Nicotra et al., 2018). By contrast, IEs are deemed the evolving set of actors, activities, and artifacts, and institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors

(Granstrand & Holgersson, 2020). While these two concepts have often been treated separately, several contributions have focused on delineating their boundaries and divergences (Cobben et al., 2022; De Bernardi et al., 2020; Valkokari, 2015).

Strongly rooted in the regional development literature (Acs et al., 2017), EE dynamics are shaped by regional trajectories and present sharp sensitivity to initial conditions (Cloutier & Messegem, 2022; Molla & Biru, 2023). By contrast, IEs are frequently associated with orchestrated, innovation-driven value networks, typically coordinated by a focal firm that aligns the activities of diverse actors towards shared innovation goals (Adner, 2017; Cobben & Roijakkers, 2019). However, despite these differences, the distinction between the two ecosystems is not precise. As noted by Scaringella & Radziwon (2018), details

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regarding how different ecosystems mutually influence and intersect with each other are limited. Indeed, while EEs and IEs may follow different logics, they are not mutually exclusive, even though the nature of their interconnection is rarely addressed in the literature (Thomas et al., 2018; Xu & Maas, 2019). The interdependence of such ecosystems is evident when certain configurations of EEs emerge as subtypes of IEs, or vice versa. For example, De Vasconcelos Gomes et al. (2018) suggest that some types of EEs are effectively subtypes of IEs, while other contributions frame specific types of IEs as being situated within broader EE domains (Guerrero & Martínez-Chávez, 2020).

Given their grounding in ecological and biological domains, both EEs and IEs can be viewed as complex adaptive systems of heterogeneous agents that learn, adapt, and co-evolve over time through feedback loops and dynamic interactions (Roundy et al., 2018; Russell & Smorodinskaya, 2018). However, several scholars deem that it is imperative to study the dynamics of ecosystems through the analytical lens of complex systems theory to capture their evolution, emergent properties, and behaviours (Neto et al., 2024; Ritala & Gustafsson, 2018; Wurth et al., 2022). Cobben et al. (2022) show that new research employing complex systems theory could advance understanding of the relational perspective of organisations within ecosystems. Further research is required for a holistic view of an ecosystem's diverse and interacting elements, recognizing that relationships and interactions among autonomous actors are more critical than hierarchies, which indicates that focus should shift to the underlying components of these interrelations (Philips & Ritala, 2019).

This perspective offers a fertile ground to explore their interrelations and nestedness. The concept of nestedness captures the complexity that arises from interrelations, overlaps, and mutual dependencies among different systems. In ecology, nestedness is a situation where the species composition of a poorer site is a strict subset of a richer site (i.e. the richer site includes unique species not found in the poorer site), but no species is replaced by others (Baselga, 2012). This logic has been extended beyond ecological systems to other domains, such as technological changes. For instance, Christensen & Rosenbloom (1995) describe how the hierarchical structure of value networks can be decomposed into interdependent subsystems that operate simultaneously as part of a broader system of use. According to the authors, nestedness emerges when complex systems are not interpreted as rigid structures. That is, their characteristics are nested within one another and interrelated, forming dynamic configurations that constitute the broader system.

This line of reasoning can be extended to ecosystem research, particularly in innovation and entrepreneurship. This study maps how academic literature conceptualises the relationship between IEs and EEs and identify the nested configurations that emerge at their intersection. It also seeks to interpret these configurations through the lens of complex systems theory, assessing the extent to which key properties of complex systems are present and discussed in the literature. To guide this scoping review, we propose the following research questions: 'How can the relationship between innovation and entrepreneurial ecosystems be conceptualised within nested configurations?' and 'What type of systemic complexity characterises the nested configurations of innovation and entrepreneurial ecosystems?'

This study contributes to the ecosystem literature and complex systems theory by clarifying that EEs and IEs can coexist within nested configurations, rather than as distinct or competing entities. First, we advance theoretical understanding by introducing the perspective of nested configurations as a bridge between EEs and IEs, showing how these systems interact and evolve as interdependent rather than separate domains. Using complex systems theory, we show how systemic properties vary across configurations, based on whether bottom-up or top-down complex dynamics emerge. This study shows that bottom-up complexity arises from micro-level interactions driven by effectuation logics – more adaptive in identifying and capturing emerging opportunities – whereas top-down complexity is shaped by macro-level

structures and interventions, reflecting causation, goal-driven logics centred on coordinated strategies. Second, we reconceptualise nestedness as a dynamic, functional relationship between ecosystems, offering a more integrated framework for understanding their evolution and interaction. Specifically, within entrepreneurial-nested configurations, innovation activities are driven by growth-oriented strategies and orchestrated by entrepreneurial actors. By contrast, in innovation-nested configurations, entrepreneurship is embedded within broader innovation structures and integrated into formal infrastructures and regulatory frameworks. Practically, our findings support policymakers in formulating governance strategies to the specific logic of each configuration, promoting adaptive, context-sensitive approaches to ecosystem development. Finally, we outline future research directions to explore the interplay between EEs and IEs.

The remainder of the paper is structured as follows. Section 2 outlines the theoretical background, introducing complex systems theory and highlighting its application to both EEs and IEs. Section 3 details the methodology, which follows the PRISMA Extension for Scoping Reviews (PRISMA-ScR). Section 4 presents the findings, including a descriptive analysis of the selected studies and the identification of four nested configurations, offering a conceptual synthesis of each configuration and their implications for complexity and nestedness. Section 5 outlines directions for future research, while Section 6 presents the main theoretical insights, practical implications, and concluding remarks.

Theoretical background

EEs and IEs are the central constructs to understand how economic and technological value emerges through interdependent networks of actors (Ozkan et al., 2023). Typically, EEs are defined as multifaceted and territorially embedded structures that enable the creation and growth of new ventures through the interaction of financial, institutional, social, and knowledge components (Audretsch et al., 2019). The configuration and performance of EEs are shaped by regional trajectories and localised path-dependencies, which influence the collective conditions for entrepreneurship (Acs et al., 2017; Cloutier & Messelghem, 2022). Conversely, IEs are conceptualised as the evolving set of actors, activities, and artifacts, and institutions and relations, including complementary and substitute relations that are important for the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2020). This theoretical perspective transcends linear models of innovation, instead emphasizing the complex, interdependent relationships that shape ecosystem dynamics (Jackson, 2011; Kirkels & Duysters, 2010). Typically, these ecosystems are coordinated around focal organisations that orchestrate complementary resources and align diverse actors towards shared innovation goals (Adner, 2017; Cobben & Roijakkers, 2019). Despite extensive conceptualisation efforts, the relationship between EEs and IEs continues to generate debate regarding their theoretical boundaries and degree of interdependence.

Although it is widely acknowledged that not all entrepreneurial activities inevitably result in innovation (Autio et al., 2014), the concepts of entrepreneurship and innovation are often treated as interdependent when applied to ecosystem research. In several studies, entrepreneurship is regarded as a key mechanism for transforming innovation into economic and social value (Neto et al., 2024; Ritala & Gustafsson, 2018), whereas innovation is considered as the process that sustains and amplifies entrepreneurial activity (Farinha et al., 2018). This interdependence has contributed to a partial conceptual overlap, where the boundaries between EEs and IEs are sometimes blurred. Scholars have examined what characterises each ecosystem type, seeking to identify their distinctive properties and underlying mechanisms (De Bernardi et al., 2020; Valkokari, 2015). In IEs literature, ecosystem-level goals are often a derivative of the orchestrator's goals, while EEs scholars tend to emphasise the importance of regional development outputs (Cobben et al., 2022). Specifically, IEs are characterised by structured and

orchestrated processes of knowledge creation, while EEs rely on informal, network-based interactions that foster new knowledge through social proximity and trust (Scaringella & Radziwon, 2018). A growing body of research highlights that these conceptual distinctions are increasingly blurred, as the two constructs are deeply interconnected and should not be treated as separate or mutually exclusive domains (Thomas et al., 2018; Xu & Maas, 2019), with recent scholarship highlighting the key role of innovation-oriented intermediate actors in fostering regional EEs development (Ancona & Ceci, 2025). Despite the fragmented and still limited theoretical integration, several studies suggest that EEs and IEs partly overlap, as one may encompass the other depending on scope and function. Previous research has shown that EEs and IEs can be interrelated in multiple ways: EEs may operate as sub-components of IEs, driving the commercialisation of innovations, while IEs may exist within broader entrepreneurial domains that foster new venture creation (De Vasconcelos Gomes et al., 2018; Guerrero & Martínez-Chávez, 2020).

Building on these interconnections, the notion of nestedness provides a valuable lens to interpret how EEs and IEs coexist as interconnected layers within a broader system. Originally rooted in ecology, nestedness describes a situation wherein the composition of a species-poor site is a strict subset of a species-rich site, that is, the rich site includes unique species not found in the poor one, yet no species is replaced by others (Baselga, 2012). This lens has been adopted beyond ecological systems to explain these interdependencies in other domains, such as technological changes. Thus, Christensen & Rosenbloom (1995) illustrate how the hierarchical structure of value networks can be decomposed into interdependent subsystems that simultaneously operate as parts of a wider system of use. Applied to ecosystem research, this perspective implies that EEs and IEs may be nested within one another, with their components and characteristics interrelated and mutually shaping.

Entrepreneurial and innovation ecosystems as complex adaptive systems

Complex systems theory, originally rooted in the natural and physical sciences, has gained momentum in applications such as innovation (Frenken, 2006), management (Mason, 2007), and entrepreneurship (McKelvey, 2004). It focuses on the dynamic analysis of complex systems, emphasizing the bidirectional and non-separable relationship between the identity of parts and that of the whole (Morin, 2022). These systems are shaped by reciprocal interactions among their constituent elements, which collectively give rise to emergent behaviours (Estrada, 2023; Thurner et al., 2018). Complex systems can be examined through their structural properties to map systemic dynamics and behavioural patterns and are often modelled as networks of interacting entities (Barabási, 2016; Newman, 2018). The interactions within such systems are typically non-uniform, non-linear, and heterogeneous, yet specific to the nature of the elements involved (Thurner et al., 2018).

The lens of complex systems theory has been used to examine EEs (e.g. Isenberg, 2016; Leendertse et al., 2021; Roundy et al., 2018) during the last decade. Essentially, this approach builds on Isenberg's (2016) pioneering contribution, which first integrates the concept of self-organisation into the conceptualization of EEs. Applying complex systems theory to the study of EEs can contribute towards delineating ecosystem boundaries and their interactions with the external environment, identifying emergent and adaptive behaviours, and analysing the evolving interlinkages among ecosystem components over time (Fredin & Lidén, 2020). Likewise, Roundy et al. (2018) provided the first definition of EEs, grounded in complex systems theory, as self-organised and adaptive communities of complex agents that operate at multiple levels and interact in a non-linear way over time. Thus, self-organisation, adaptation, and non-linearity, along with sensitivity to initial conditions (Han et al., 2021), emerge as the defining complex system properties of EEs.

Indeed, the evolutionary behaviour of EEs follows inherently chaotic and non-linear trajectories (Brown et al., 2023; Haarhaus et al., 2020),

unfolding through sequential phases of 'creative destruction' and crises, followed by restructuring periods shaped by self-organizing mechanisms (Auerswald & Dani, 2017; Cloutier & Messegem, 2022; Horváth & Rabetino, 2019). This dynamic aligns with the concept of 'punctuated equilibrium' introduced by Eldredge & Gould (1972), according to which the trajectory of complex systems is generally homeostatic, disrupted occasionally by rapid and episodic events of speciation. From a public policy perspective, both incremental and large-scale policy changes emerge from the interaction among multilevel political institutions and behavioural decision-makers, a pattern that induces multiple punctuated equilibria (True et al., 2019). Extending this reasoning to EEs, we observe that multilevel policy mechanisms often overlap with path-dependent and self-reinforcing dynamics (Cloutier & Messegem, 2022), making EEs highly sensitive to initial conditions. Contextual factors are central to understanding and mapping the emergence of EEs, with regional pre-conditions, pre-entry capabilities, and historical trajectories influencing their development (Molla & Biru, 2023). The emergence of successful entrepreneurial actors indeed, co-evolves within multidimensional geographical boundaries (Han et al., 2021). In addition to being self-organised and path-dependent, EE dynamics are adaptive, exhibiting certain inherent resilience during crises events such as shocks and disturbances. This allows EEs to absorb tensions, reconfigure internal structures, and pursue new entrepreneurial opportunities (Cantner et al., 2021; Roundy et al., 2017). Such mechanisms are enabled by the interplay between stability and diversity (Ives & Carpenter, 2007), with the presence of heterogeneous actors affecting equilibrium conditions (Ancona et al., 2023).

A final foundational property of complex systems, increasingly recognised in EE research, is their causal complexity and associated feedback mechanisms. As noted by Wurth et al. (2023), the complexity of EEs is attributable to the interdependence between various ecosystem components, involving both upward and downward causation among elements and entrepreneurial outputs and outcomes. These dynamics generate feedback loops, manifest structurally through reciprocal interactions between ecosystem actors and components (Ancona et al., 2023). However, this level of causal complexity tends to decrease overtime, as EEs mature owing to a typical reduction in the number of input factors affecting outputs and a gradual decline in causal asymmetry (Vedula & Fitza, 2019).

Similarly, IEs have been framed as complex adaptive systems, a perspective that explains their dynamic, non-linear, and evolving nature (Boyer, 2020; Phillips & Ritala, 2019; Russell & Smorodinskaya, 2018). This theoretical lens shifts the focus away from linear models of innovation, instead emphasizing the complex and interconnected nature of the relationships that underpin ecosystem dynamics (Autio & Thomas, 2014; Jackson, 2011; Kirkels & Duysters, 2010). Non-linearity is a core defining property of IEs. Innovation processes within IEs do not unfold in predictable, step-by-step sequences, rather they follow iterative and nonlinear patterns shaped by continuous feedback (Autio & Thomas, 2014). Indeed, feedback loops emerge from the reciprocal interactions between ecosystem actors and components, reinforcing patterns of collaboration, learning, and resource exchange that sustain and evolve the innovation process over time (Arthur et al., 2023; Jackson, 2011). Moreover, self-organisation, heterogeneity of actors, and co-evolution have been increasingly used to describe IEs (Jucevičius & Grumadaitė, 2014). Specifically, IEs are orchestrated by a lead organisation, sometimes referred to as an 'ecosystem leader' (Adner, 2017). From an organisational perspective, firms orchestrate IEs through open innovation initiatives over time (Remneland Wikhamn & Styhre, 2023). Through interactions, agents react to each other's behaviour, which adjusts the performance of the entire ecosystem, ensuring high adaptability to change and dynamic sustainability through continuous internal recombination of shared assets (Russell & Smorodinskaya, 2018). Path-dependency refers to how past decisions, interactions, and structures constrain future strategic options in IEs (Taibi-Voigts et al., 2025). Actors within IEs are highly sensitive to coordination dynamics and

must be strategically aligned with the value proposition defined by the orchestrator, who typically holds a position of power (Lingens & Hiber, 2023; Taibi-Voigts et al., 2025). Heterogeneity assumes critical characteristics. Moreover, IEs are composed of a diverse set of actors - firms, universities, public institutions, intermediaries, users - each with their own goals, capabilities, and perspectives (Granstrand & Holgersson, 2020; Reiter et al., 2024). Finally, IEs are characterised by co-evolution. Ecosystem actors and components evolve together over time, responding to and influencing each other's trajectories (Breslin et al., 2021; Ritala & Almpapoulou, 2017).

Thus, both EEs and IEs have recently been investigated through the lens of complex systems theory. However, what emerges from the existing literature is that the complexity inherent in such systems tends to revolve around a predominant dynamic within the bidirectional and inseparable relationships between the parts (micro-level) and the whole (macro-level) (Estrada, 2023; Funtowicz & Ravetz, 1994; Thurner et al., 2018). To address this, we introduce the concepts of bottom-up and top-down complexity. Bottom-up complexity characterises systems in which dynamic interactions at the micro-level give rise to emergent properties at the macro-level. By contrast, top-down complexity refers to systems where complex dynamics originate at the macro-level and influence micro-level behaviour. In this context, EEs are typically associated with bottom-up complexity, driven by self-organizing processes and path-dependent mechanisms, strongly induced by regional pre-conditions. Conversely, IEs tend to reflect top-down complexity, where non-linear and co-evolutionary dynamics – mostly in terms of collaborative ties and resource exchanges – are often shaped by the coordination of a complex agent, such as an orchestrator.

To interpret these dynamics, it is useful to recall the distinction between causation and effectuation introduced by Sarasvathy (2001). Causation refers to a goal-driven logic in which actors begin with a specific objective and select the most efficient means to achieve it. It relies on prediction, planning, and deliberate design, features that characterise more managed and coordinated innovation processes. By contrast, effectuation is a means-driven logic in which actors start from their existing resources ('who I am, what I know, and whom I know') and progressively co-create goals through interaction and experimentation. Effectuation thus emphasises non-predictive control, adaptability, and the capacity to leverage contingencies and emergent opportunities. These two logics reflect the different modes of systemic complexity introduced above. Effectuation represents a bottom-up and emergent approach in which ecosystems evolve through adaptive interactions, experimentation, and self-organisation. This logic is particularly associated with entrepreneurship, where the creation of new ventures and opportunities often emerges from local initiatives, contextual conditions, and evolving stakeholder commitments (Sarasvathy, 2008). By contrast, causation aligns with a top-down perspective, where ecosystem evolution is often guided by coordinated strategies, planning, and deliberate design. This logic is more consistent with innovation processes that tend to be managed through institutional frameworks, orchestrating actors, and structured policy interventions (Berends et al., 2014).

Table 1 summarises the complex system properties manifest within EE and IE research.

While both EEs and IEs have been examined using complex systems theory, this scoping review seeks to clarify the complex system nature of nested configurations that emerge at their intersection. Specifically, we aim to understand if nested environments characterised by both entrepreneurial and innovation drivers predominantly exhibit bottom-up or top-down forms of complexity. Fig. 1 provides an overview of the logic guiding our research design.

Methodology

This study adopted a scoping review approach following the PRISMA-ScR protocol (Tricco et al., 2018). The aim is to map how

Table 1
Complex systems properties in EE and IE research.

Property	Entrepreneurial Ecosystems	Innovation Ecosystems
Self-organisation	Self-organised communities of complex agents emerging from the bottom-up dynamics (Isenberg, 2016; Roundy et al., 2018).	Self-organisation often unfolds through top-down orchestration by a lead organisation that coordinates actors and resources over time (Adner, 2017; Remneland Wikhamn & Styhre, 2023).
Non-linearity and co-evolutionary behaviours	Evolutionary trajectories are chaotic and discontinuous (Brown et al., 2023), with entrepreneurial activities and actors co-evolving with regional patterns (Han et al., 2021).	Innovation processes unfold through iterative, nonlinear patterns shaped by continuous feedback, and mutual co-evolution of actors and components (Autio & Thomas, 2014; Breslin et al., 2021; Ritala & Almpapoulou, 2017)
Adaptability and resilience	Ability to absorb shocks, reconfigure internally, and pursue new opportunities (Cantner et al., 2021; Roundy et al., 2017).	Dynamic sustainability is achieved through internal recombination of shared assets (Russell & Smorodinskaya, 2018).
Feedback loops and complex causation	Structural feedback among actors and components, also affecting entrepreneurial outcomes and reinforcing system dynamics (Ancona et al., 2023; Wurth et al., 2023).	Feedback reinforces collaboration, learning, and resource exchange among actors (Arthur et al., 2023; Jackson, 2011).
Sensitivity to initial conditions and path-dependence	Sensitivity to regional conditions and historical trajectories influencing ecosystem emergence (Han et al., 2021) through self-reinforcing mechanisms (Cloutier & Messeghem, 2022).	Path-dependency describes how early decisions, interactions, and structures constrain future strategic options, with actors particularly sensitive to the orchestrator's value proposition (Lingens & Hiber, 2023; Taibi-Voigts et al., 2025).
Heterogeneity	The system maintains a certain degree of stability and equilibrium due to the presence of diverse and heterogeneous actors (Ancona et al., 2023; Ives & Carpenter, 2007).	Presence of diverse actors (firms, universities, users, institutions) with different roles and objectives (Granstrand & Holgersson, 2020; Reiter et al., 2024).

academic research frames the relationship between EEs and IEs, focusing specifically on studies that discuss, compare, or integrate both constructs.

This approach is well suited to clarify key concepts and definitions by identifying their core characteristics and related knowledge gaps (Munn et al., 2018). We employed this method as scoping reviews are used to present a broad overview of the evidence pertaining to a topic (Tricco et al., 2018), thus enabling us to capture the diversity of theoretical and conceptual approaches in the literature.

Protocol and registration

The review protocol was developed prior to data collection and aligned with PRISMA-ScR guidelines. Although the review was not formally registered, the search strategy, inclusion criteria, and analytical framework were documented in advance. The protocol was jointly discussed and refined by three researchers with expertise in innovation and entrepreneurship studies and complex systems theory to ensure methodological consistency and theoretical coherence. An initial screening conducted in February 2025 confirmed the absence of previous scoping reviews addressing this specific conceptual inquiry.

Before launching the full search, a pilot test of the Boolean query was

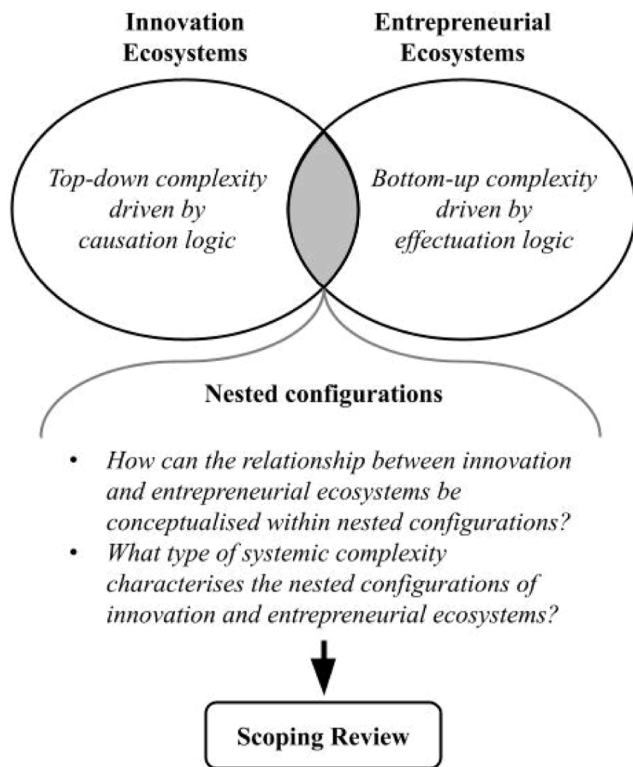


Fig. 1. Overview of the logic guiding our research design.
Source: Authors' own work

conducted to verify the adequacy of database coverage and the relevance of retrieved records. Minor adjustments were made to refine the search syntax and reduce noise in the results. The entire review process, including search, screening, and synthesis, was recorded in a shared research log to guarantee transparency and traceability. The overall methodological design followed four main stages: (1) database search and bibliometric preprocessing, (2) screening and selection, (3) data extraction and charting, and (4) thematic analysis and conceptual synthesis.

Eligibility criteria

We included peer-reviewed articles published in English between 2005 and early 2025 that explicitly mention 'entrepreneurial ecosystem (s)' or 'innovation ecosystem(s)' in the title, abstract, or keywords. We started from 2005 because the ecosystem metaphor began to consolidate in management and innovation studies during this period (Adner, 2006).

The eligibility criteria comprised conceptual engagement with the literature on IEs and EEs. Additional inclusion criteria required that articles are peer-reviewed, written in English, and have full-text availability for data coding. We excluded unpublished or non-peer-reviewed works, articles not written in English, studies published before 2005, those without accessible full texts, and papers lacking theoretical engagement with either EE or IE. Table 2 presents the inclusion and exclusion criteria.

Information sources

Scopus was selected as the primary database for its broad coverage of innovation and entrepreneurship literature. Moreover, Scopus provides a broader coverage than Web of Science, particularly in social sciences, management, and interdisciplinary research (Falagas et al., 2008). Although Google Scholar may offer access to additional grey literature, its inclusion of preprints and non-peer-reviewed material raises

Table 2
Inclusion and exclusion criteria.

SN	Inclusion Criteria	Exclusion Criteria	Motivation
1	Articles engaging with literature on IEs and EEs	Articles lacking theoretical engagement with IE or EEs	To avoid general definitions of ecosystems
2	Articles that have been published in the English language	Articles that are not in English	To ensure accessibility and consistency in the analysis
3	Articles that have been published in a peer-reviewed journal	Unpublished and non-peer-reviewed articles	To ensure the reliability and academic rigor of the sources
4	Articles that were published between the years 2005 to early 2025	Articles that have been published before the year 2005	To align with the foundational conceptualisation of IEs (Adner, 2006)
5	Full texts of publications chosen for data coding are available	Full texts of publications chosen for data coding are not available	To guarantee completeness and allow for in-depth analysis

concerns about source quality and reliability (Falagas et al., 2008). The dataset was exported from Scopus into a Microsoft Excel file, including complete citation information, author affiliations, publication years, keywords, and source titles. The data were used to manage the corpus, remove duplicates, and verify the disciplinary and temporal distribution of the retrieved articles. Although basic descriptive information such as publication trends and source distribution was reviewed to contextualise the dataset, bibliometric indicators were not included during the analytical stage. This decision reflects the main study purpose, which was not to perform a bibliometric mapping of the field but to develop a conceptual synthesis linking EEs and IEs through the lens of nested configurations and complex systems theory. The cleaned dataset thus served as the foundation for the subsequent screening and thematic analysis. To ensure completeness, we also conducted backward and forward citation tracking on the identified articles. The last search was completed in May 2025.

Search strategy

To focus exclusively on studies addressing both EEs and IEs, we used the following query in TITLE-ABS-KEY ('innovation ecosystem*' OR 'entrepreneurial ecosystem*' OR 'entrepreneurship ecosystem*'). The search was limited to publications in English between 2005 and early 2025. A pilot test of the Boolean string was conducted to verify the adequacy of database coverage and the precision of retrieved results. Minor adjustments were made to refine the syntax and remove semantically unrelated records (e.g. studies referring to natural or biological ecosystems). No disciplinary filters were applied, as the objective was to capture the broadest conceptual articulation of how the two constructs are framed across different domains. This strategy ensured the retrieval of articles that engage with both constructs, allowing derivations, overlaps, and conceptual interlinkages to emerge organically from the literature.

Selection of sources of evidence

Following duplicate removal, three reviewers independently screened titles and abstracts based on the inclusion criteria. The screening process was organised in two stages: an initial relevance assessment (title and abstract) followed by a full-text review of the remaining studies. Each reviewer applied the eligibility criteria outlined in Section 3.2 to ensure consistency and reduce potential bias. All screening decisions were recorded in a shared Excel file, where the inclusion/exclusion rationale were documented to ensure transparency and traceability during the process. Full texts were then reviewed for

relevance and conceptual depth. We resolved disagreements on study selection and data extraction through consensus and discussion with other reviewers, whenever required. A PRISMA flow diagram illustrates the selection process (Fig. 2).

Data charting process

From each selected paper, data were recorded in a structured Excel sheet to ensure transparency and comparability across studies. Three researchers charted the data independently and reconciled differences via regular meetings to maintain consistency. The process was iterative, enabling refinement of the Excel template when new configurations emerged, and all charting decisions were documented to create an audit trail linking raw data to the thematic analysis.

Data items

For each article, we captured bibliographic details (author, year, journal), keywords, whether the article aligned the construct with EE, IE, both, or left the relationship undefined, nature of the conceptual relationship, any theoretical rationale supporting their interpretation, and all the properties derived from complex systems theory that ecosystems exhibited. Additional columns were created in the Excel sheet to record the way each study described the relationship between EEs and IEs and to capture references to ecosystem properties derived from complex systems theory. These data items provided the foundation for the thematic analysis and the identification of the nested configurations presented in Section 4.

Critical appraisal of individual sources of evidence

Evidence obtained from the studies was verified for adequacy of the study design in relation to the research objectives, elimination of potential biases, and a thorough documentation of the research process. Given the conceptual focus of this review, this evaluation was extended beyond methodological aspects to include theoretical soundness, conceptual rigor, and internal coherence. The aim was not to exclude studies, but to ensure that the selected sources provided sufficient conceptual clarity and theoretical depth to meaningfully inform the synthesis of how EEs and IEs are framed and interrelated. Each contribution was, therefore, examined with respect to the (i) presence of a clear and explicit definition of the ecosystem construct, (ii) theoretical rationale to explain or frame the relationship between EEs and IEs, (iii) internal coherence between theoretical assumptions, conceptual arguments, and analytical reasoning, and (iv) transparency and completeness with which the research process and rationale were documented.

We conducted this assessment reflexively through the charting and thematic analysis phases than through a formal scoring procedure. We focused on how studies engaged with complex systems theory, assessing if properties (e.g. adaptability, feedback loops) were employed in a theoretically consistent and meaningful way. Critical assessment acted as a qualitative lens for conceptual robustness, guiding the interpretation of results and supporting the development of a coherent and theoretically anchored understanding of how EEs and IEs are conceptualised in the literature.

Synthesis of results

We analysed the results through an inductive thematic process that involved coding article terminology, classifying EE–IE relationships, and identifying nested configurations emerging from the literature. When we identified systematic reviews, we counted the number of studies included in the review that potentially fulfilled our inclusion criteria and noted the number of studies that our search had missed. To structure the synthesis, we employed a thematic approach that enable to identify recurrent conceptual patterns across the corpus (Mak & Thomas, 2022;

Braun & Clarke, 2006). The analysis proceeded iteratively, with researchers developing inductive codes from the textual data and progressively grouping papers into broader thematic areas conceptualised by the literature as connecting EEs and IEs.

Findings were aggregated into the identified thematic groups, and a conceptual matrix visually represented how these constructs relate to EE and IE frameworks. Finally, we summarised the key patterns and developed a typology of how the literature positions and interrelates EEs and IEs, as proposed by Mwangakala et al. (2024). Our analysis is visually enriched by a network mapping of keyword co-occurrence among the identified articles. Specifically, we first retrieved the keywords reported for each contribution from Scopus, consistent with the previous steps of the methodology. We standardised keywords that reflected the same concept (e.g. ‘entrepreneurship ecosystem’ and ‘entrepreneurial ecosystem’). Subsequently, we used the software RStudio (R Core Team, 2014) and the ‘igraph’ package (Csardi & Nepusz, 2006) to build networks in which each node represents a paper from our final selection, and the links between nodes indicate the co-occurrence of one or more shared keywords. Accordingly, edge weight represents the number of keywords shared between any two papers. This process enables visual inspection of the interconnectedness among articles based on their thematic similarity – proxied by keyword co-occurrence – and to explore the interrelatedness of the identified nested configurations.

A summary of the key steps employed in the methodology, accompanied by a graphic representation of the PRISMA research design (Fig. 2) is as follows: (i) coding data from included articles, (ii) categorizing the coding into major themes, (iii) building themes, (iv) displaying data, (v) identifying key patterns in the data and identifying sub-categories, and (vi) summarising the findings.

Results

Descriptive analysis

The final pool of 48 studies¹ comprised 47 journal articles and a single (one) book chapter, reflecting a predominantly peer-reviewed academic production.

These publications covered the period from 2014 to 2025, despite the initial search query, including articles as early as 2005. This time lag is justified by the fact that the EE construct gained conceptual maturity only during the mid-2010s, following the publication of several foundational studies. Among these, Stam’s (2015) work is considered a milestone, offering one of the first systematic efforts to conceptualise EEs and define their core components.

The number of publications, therefore, grew from 2014 onward, with a clear acceleration after 2019 and a peak in 2023 (eight publications) and 2024 (seven publications), reflecting the substantial academic interest in ecosystem-related research. The studies are distributed across 19 distinct academic journals, highlighting the conceptual fluidity and fragmentation that characterise the field. This fragmentation likely reflects the multidimensional scope of ecosystem research, which includes innovation studies, entrepreneurship, regional development, and technology management.

While no single outlet dominates the field, some journals appear more frequently than others. The Journal of Innovation & Knowledge hosts four articles, followed by R&D Management and the Journal of Open Innovation: Technology, Market, and Complexity, each with three articles. Other journals with at least two publications include the Technology Innovation Management Review, the Journal of Business Research, and Growth and Change. Finally, the presence of only one book chapter in the dataset reinforces the dominance of peer-reviewed journal articles in shaping the scholarly conversation on EEs and IEs.

¹ The full list of selected articles is included in the Appendix.

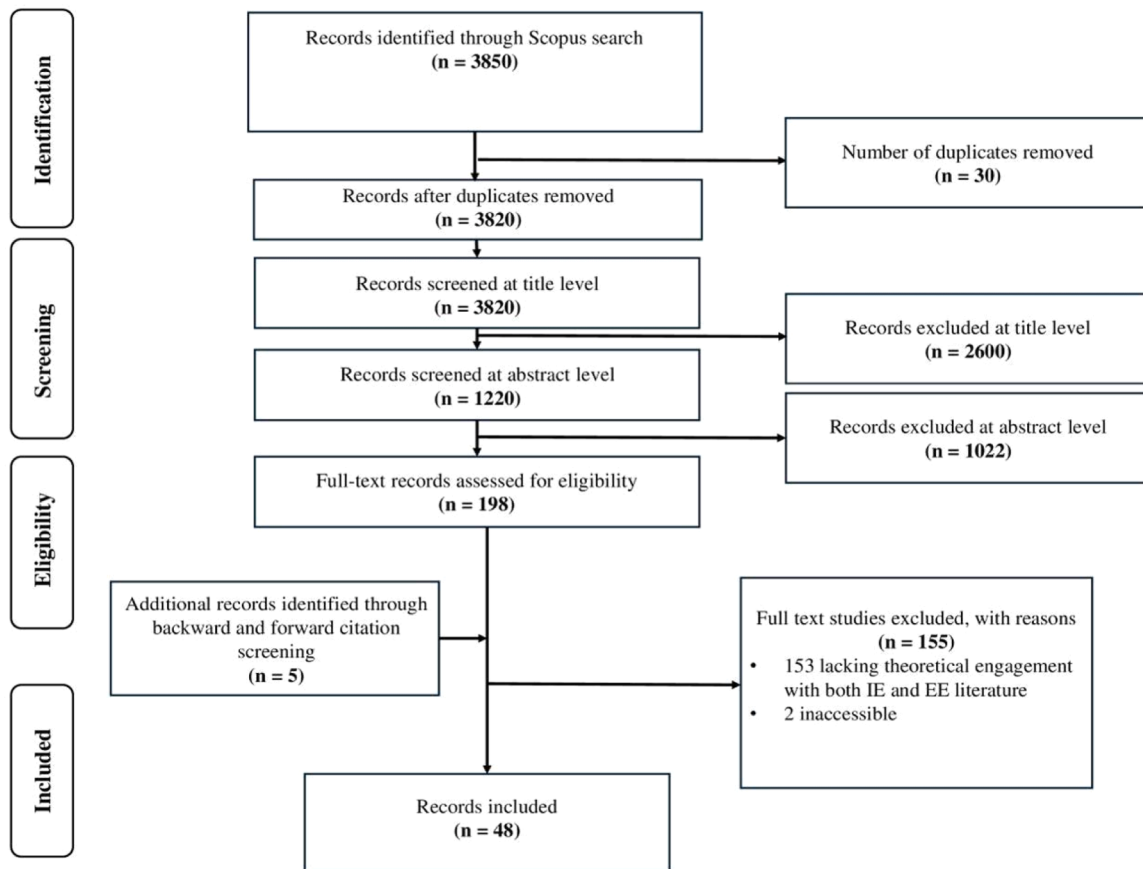


Fig. 2. PRISMA flow diagram.
Source: Authors' own work

Thematic classification of selected papers across nested ecosystem configurations

We classified the 48 eligible studies thematically to interpret the existing literature's articulation of the relationship between EEs and IEs. Thematic analysis is a suitable method for identifying, analysing, and reporting patterns (themes) within data, especially in combination with scoping reviews (Mak and Thomas, 2022). Following Braun and Clarke (2006), the process began with familiarisation and engagement with the data through reading and re-reading, while noting initial ideas. Subsequently, initial codes were generated by systematically labelling relevant features of the data across the entire dataset. These codes were then examined and collated into potential themes that reflect ecosystem configurations discussed in the literature and situated at the intersection between EEs and IEs. Once the codes were developed, we reviewed their content and interrelations to identify the recurring patterns. This process enabled the association of each selected contribution with a specific nested ecosystem configuration identified in the literature that integrated elements from both EEs and IEs: (i) startup ecosystems, (ii) entrepreneurial university ecosystems, (iii) entrepreneurial innovation ecosystems, and (iv) regional innovation ecosystems.

Tables 3–6 detail the contributions identified for each configuration, with each table dedicated to one nested configuration, as explained in the subsequent subsections.

The classification was conducted inductively, organizing studies based on their central themes and focus. For each cluster, we identified if the literature primarily engaged with EE concepts, IE concepts, or treated both domains equally. This helped assess the degree of conceptual balance or dominance in each configuration.

To interpret how nested configurations between EEs and IEs are

articulated in the literature, we introduced a classification grounded in two analytical dimensions. We defined the first concerns as the 'logic of nestedness', that is, whether the ecosystem is primarily engaging with EE or IE dynamics. Specifically, in entrepreneurial-nested configurations, innovation activities, such as product development, process reengineering, and patenting, are driven by growth-oriented strategies and orchestrated by entrepreneurial actors, typically startups, incubators, and accelerators (e.g. Cozzolino & Geiger, 2024). By contrast, in innovation-nested configurations, entrepreneurship is embedded within broader innovation structures - such as Nation Systems of Innovation - and integrated into formal infrastructures and regulatory frameworks (e.g. Acs et al., 2014). The second dimension captures the type of systemic complexity. Specifically, we aimed to determine whether complex dynamics observed across different configurations predominantly emerge from micro-level interactions and effectuation logics (bottom-up complexity) or are driven by macro-level structures and interventions strictly related to causation mechanisms (top-down complexity). Therefore, we analysed all the studies through the lens of complex systems theory, assessing how the properties outlined in Table 1, namely, adaptability and resilience (ADRES), feedback loops and complex causation (FLCC), heterogeneity (HET), non-linearity and co-evolution (NLCE), sensitivity to initial conditions and path-dependence (SIPD), and self-organisation (SORG) are addressed within each configuration.

Prior to discussing the four nested configurations, we present our analysis of selected papers based on keyword co-occurrence. Fig. 3 displays a network where each node represents a paper from our final

Table 3
Characterisation of the startup ecosystem configuration.

Authors	Year	Title	EE	IE	Complex Systems Properties
Ancona et al.	2023	Network-based principles of entrepreneurial ecosystems: A case study of a start-up network	x		ADRES, FLCC, HET, NLCE, SORG
Baloutsos et al.	2022	Identifying contradictions in an incumbent-startup ecosystem – an activity theory approach	x	x	ADRES, FLCC, HET, NLCE, SORG
Berger & Kuckertz	2016	Female entrepreneurship in startup ecosystems worldwide	x		ADRES, FLCC, NLCE, SIPD, SORG
Corvello et al.	2023a	Building start-up acceleration capability: A dynamic capability framework for collaboration with start-ups	x		ADRES, FLCC, NLCE, SORG
Corvello et al.	2023b	Start-up collaboration units as knowledge brokers in Corporate Innovation Ecosystems: A study in the automotive industry	x	x	ADRES, FLCC, NLCE, SORG
Eslamloo et al.	2025	Successful commercialisation in startup accelerator programmes: How different startup ecosystems matter	x	x	ADRES, FLCC, HET, NLCE, SORG
Haines	2016	Developing a Startup and Innovation Ecosystem in Regional Australia	x	x	ADRES, FLCC, HET, NLCE, SIPD, SORG
Krishnan & Krishna	2024	Introduction: Start-ups and innovation ecosystems	x	x	ADRES, FLCC, HET, NLCE, SORG
Marcon & Duarte Ribeiro	2021	How do startups manage external resources in innovation ecosystems? A resource perspective of startups' lifecycle	x	x	ADRES, FLCC, HET, NLCE, SORG
Marcon et al.	2024	How the interplay between innovation ecosystems and market contingency factors impacts startup innovation	x	x	ADRES, FLCC, HET, NLCE, SORG
Motoyama & Knowlton	2017	Examining the connections within the startup ecosystem: A case study of St. Louis	x		ADRES, FLCC, NLCE, SORG
Ojaghi et al.	2019	A synthesized framework for the formation of startups' innovation ecosystem: A systematic literature review	x	x	ADRES, FLCC, HET, NLCE, SORG
Primario et al.	2024	Peer innovation as an open innovation strategy for balancing competition and collaboration among technology start-ups in an innovation ecosystem	x	x	ADRES, FLCC, HET, SORG
Saccol Filho et al.	2024	A measurement tool for the competitiveness of startups' innovation ecosystem	x	x	ADRES, FLCC, HET, NLCE, SORG
Singh et al.	2020	Analyzing the startup ecosystem of India: A Twitter analytics perspective	x		ADRES, FLCC, NLCE, SORG
Ziakis et al.	2022	Start-Up Ecosystem (StUpEco): A conceptual framework and empirical research	x		ADRES, FLCC, NLCE, SORG

Table 4
Characterisation of the entrepreneurial university ecosystem configuration.

Authors	Year	Title	EE	IE	Complex System Properties
Abreu & Grinevich	2024	The entrepreneurial university: strategies, processes, and competing goals	x		ADRES, FLCC, NLCE
Alam et al.	2023	Success Components of University Entrepreneurial Ecosystem: A Multimethod Exploration	x		ADRES, FLCC, NLCE
Guerrero et al.	2020	Entrepreneurial university ecosystems and graduates' career patterns: do entrepreneurship education programmes and university business incubators matter?	x		ADRES, FLCC, NLCE
Johnson et al.	2019	Entrepreneurial dynamism and the built environment in the evolution of university entrepreneurial ecosystems	x		ADRES, FLCC, NLCE
Kwong et al.	2022	How entrepreneurial are social entrepreneurship education providers? The role of universities' entrepreneurial ecosystems in the provision of elective social entrepreneurship courses to business students	x		ADRES, FLCC, NLCE, SIPD
Lahikainen et al.	2019	Challenges to the development of an entrepreneurial university ecosystem: The case of a Finnish university campus	x		ADRES, FLCC, NLCE
Prokop	2021	University entrepreneurial ecosystems and spinoff companies: Configurations, developments and outcomes	x		ADRES, FLCC, HET, NLCE
Rücker Schaeffer et al.	2021	Mutualism in ecosystems of innovation and entrepreneurship: A bidirectional perspective on universities' linkages	x	x	ADRES, FLCC, HET, NLCE
Tejero et al.	2019	Analysis of the Dynamism in University-Driven Innovation Ecosystems Through the Assessment of Entrepreneurship Role	x	x	ADRES, FLCC, HET, NLCE
Thomas et al.	2018	Linking entrepreneurial and innovation ecosystems: The case of AppCampus	x	x	ADRES, FLCC, HET, NLCE

selection,² and the links between these nodes indicate the co-occurrence of one or more keywords shared between the corresponding papers. Accordingly, node size reflects the degree of each node, that is, the number of connections within the network, and indicates the extent of potential thematic overlap with other contributions. Similarly, edge width is proportional to the number of keywords shared between any two papers.

To enhance interpretability, nodes are coloured based on the various configurations to which the corresponding papers belong,³ while edges are coloured to reflect intra-cluster (green, blue, sky-blue/light grey, or

² Four papers were excluded from the network representation – three owing to the absence of keywords and one did not share any keywords with the other papers. As a result, the final network comprised 44 nodes.

³ Green nodes represent papers within the startup ecosystem thematic group; blue nodes correspond to the entrepreneurial university ecosystem group; sky blue/light grey nodes indicate the entrepreneurial innovation ecosystem group; and red nodes represent papers within the regional innovation ecosystem thematic group.

Table 5
Characterisation of the entrepreneurial innovation ecosystem configuration.

Authors	Year	Title	EE	IE	Complex System Properties
Audretsch et al.	2023	Sustainable orientation management and institutional quality: Looking into European entrepreneurial innovation ecosystems	x	x	ADRES, FLCC, HET, NLCE, SORG
Autio et al.	2014	Entrepreneurial innovation: The importance of context	x	x	ADRES, FLCC, NLCE, SORG
Ferreira et al.	2023	The role of entrepreneurial ecosystems in technological and social challenges	x	x	ADRES, FLCC, HET, NLCE, SORG
Guerrero & Martínez-Chávez	2020	Aligning regional and business strategies: Looking inside the Basque Country entrepreneurial innovation ecosystem	x	x	ADRES, FLCC, HET, NLCE, SORG
Leceta & Könnölä	2021	Fostering entrepreneurial innovation ecosystems: Lessons learned from the European Institute of Innovation and Technology	x	x	ADRES, FLCC, HET, NLCE, SIPD, SORG
Ozkan et al.	2023	The Next Generation of Innovation	x	x	ADRES, FLCC, HET, NLCE, SORG
Rivera Vargas & de León Arias	2022	The entrepreneurial ecosystem of Guadalajara, Jalisco, Mexico: Its technology-based and fast-growing startups and entrepreneurial-employees	x	x	ADRES, FLCC, HET, NLCE, SORG
Shashlo et al.	2018	Determinants of integration interaction among the subjects of the entrepreneurial innovation ecosystem of macro region	x	x	ADRES, FLCC, HET, NLCE, SIPD, SORG
Vettik-Leemet & Mets	2024	Entrepreneurship and Innovation—Process Overlap or the Same? Systematic Overview and Converging Process-Dynamic Model	x	x	ADRES, FLCC, HET, NLCE, SORG

red) or inter-cluster (black) connections. Thus, we visualised the thematic overlaps both within and across the configurations. As Fig. 3 clearly illustrates, most links are black (63.4%), indicating a substantial level of thematic nestedness between the different conceptual clusters and a notable degree of fuzziness at their intersections. This observation reinforces the rationale for conducting this scoping review.

In particular, clusters related to startup ecosystems and entrepreneurial university ecosystems exhibit high levels of internal connectivity, with subnetwork densities⁴ of 64.8% and 73.3%, respectively, which are clearly visible through the green and blue intra-cluster links. By contrast, the clusters corresponding to entrepreneurial innovation ecosystems and regional innovation ecosystems are weakly connected internally, with subnetwork densities of 41.7% and 26.7%, respectively. This suggests that the concepts of startup ecosystems and entrepreneurial university ecosystems are comparatively mature and better defined in the literature, whereas the notions of entrepreneurial innovation ecosystems and regional innovation ecosystems are still emerging and conceptually less consolidated. The following sections provide a further discussion of these patterns and possible implications.

⁴ Network density is computed as the ratio between the actual number of links and the maximum possible number of ties among nodes in the network.

Table 6
Characterisation of the regional innovation ecosystem configuration.

Authors	Year	Title	EE	IE	Complex System Properties
Bramwell et al.	2019	Growing entrepreneurial ecosystems: Public intermediaries, policy learning, and regional innovation	x	x	ADRES, FLCC, HET, NLCE, SIPD
Carayannis et al.	2018	The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/ Quintuple Helix Innovation Models	x	x	ADRES, FLCC, HET, NLCE, SIPD
Cooke	2016	The virtues of variety in regional innovation systems and entrepreneurial ecosystems	x	x	ADRES, FLCC, HET, NLCE, SIPD
Farinha et al.	2018	Regional innovation systems and entrepreneurial embeddedness	x	x	ADRES, FLCC, HET, NLCE, SIPD
Freire-Gibb & Gregson	2019	Innovation systems and entrepreneurial ecosystems: Implications for policy and practice in Latin America	x	x	ADRES, FLCC, HET, NLCE, SIPD
Fu & Qian	2023	Building innovative capacity in regional entrepreneurship and innovation (eco)systems: Startups versus incumbent firms	x	x	ADRES, FLCC, HET, NLCE, SIPD
Kraus et al.	2021	The role of innovation and knowledge for entrepreneurship and regional development	x	x	ADRES, FLCC, HET, NLCE, SIPD
López-Rubio et al.	2020	Regional innovation system research trends: toward knowledge management and entrepreneurial ecosystems	x	x	ADRES, FLCC, HET, NLCE, SIPD
Markkula & Kune	2015	Making Smart Regions Smarter: Smart Specialization and the Role of Universities in Regional Innovation Ecosystems	x		ADRES, FLCC, HET, NLCE, SIPD
Nieth et al.	2018	Embedding entrepreneurial regional innovation ecosystems: reflecting on the role of effectual entrepreneurial discovery processes	x	x	ADRES, FLCC, HET, NLCE, SIPD
Pidorycheva et al.	2020	A Conceptual Framework for Developing of Regional Innovation Ecosystems		x	ADRES, FLCC, HET, NLCE, SIPD
Radziwon et al.	2017	Creating and capturing value in a regional innovation ecosystem: A study of how manufacturing SMEs develop collaborative solutions		x	ADRES, FLCC, HET, NLCE, SIPD
Thomas et al.	2021	Universities as orchestrators of the development of regional innovation ecosystems in emerging economies		x	ADRES, FLCC, HET, NLCE, SIPD, SORG

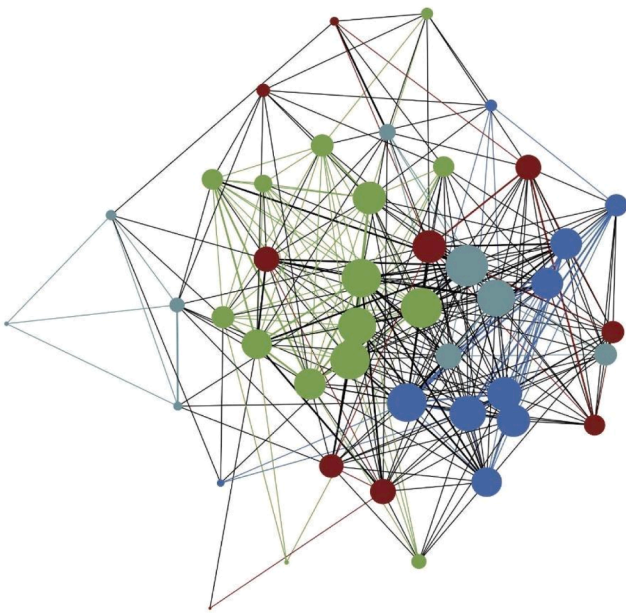


Fig. 3. Network of selected papers based on keyword co-occurrence. Node colors represent different ecosystem configurations: blue nodes correspond to the Entrepreneurial University Ecosystem group; red nodes to the Regional Innovation Ecosystem group; green nodes to the Startup Ecosystem group; and sky blue/light grey nodes to the Entrepreneurial Innovation Ecosystem group. Source: Authors' own work

Startup ecosystems: entrepreneurial-nestedness and bottom-up complexity

The selected literature on startup ecosystems portrays them as emergent, dynamic, and interaction-driven configurations, where innovation unfolds through adaptive behaviour and mutual learning. These ecosystems comprise networks of startups, investors, and intermediaries that foster new venture creation and scaling, often concentrated in specific urban areas (e.g. the Silicon Valley). A key insight across studies is that these ecosystems function without centralised control, relying instead on informal mechanisms and feedback loops.

Adaptability and resilience are two of the most common and complex properties within this configuration. They stem from the fluid adjustment of network ties to external changes, as startups continuously adapt their connections and strategies in response to shifting contextual conditions (Motoyama & Knowlton, 2017). The adaptability of startup ecosystems is associated with the concept of effectuation: startup entrepreneurs are primarily opportunity-driven, reflecting a proactive approach in which new ventures arise from initiative and contextual sensing rather than necessity (Ziakos et al., 2022). Accordingly, adaptability and resilience evolve alongside local constraints and in response to contextual shifts (Eslamloo et al., 2025).

The capacity to adapt to external shocks is enabled by feedback loops and complex causation mechanisms that arise as startups and support organisations to mutually influence their strategic behaviours (Ancona et al., 2023). Tensions between startups and incumbents are frequent, generating contradictions that stimulate transformation rather than breakdown, thus fuelling ecosystem evolution through continuous feedback loops and learning mechanisms (Baloutsos et al., 2022). Acceleration capabilities foster startup growth by enhancing iterative learning and strategic flexibility (Corvello et al., 2023a), generating an indirect impact on ecosystem performance (Saccol Filho et al., 2024).

Startup ecosystems are typically described as highly dynamic and heterogeneous network configurations wherein diverse actors interact through iterative learning and collaboration (Ancona et al., 2023). Such heterogeneity across actors and mechanisms fosters ecosystem flexibility (Saccol Filho et al., 2024), although relational density and local

proximity are occasionally observed as enablers of coordination and knowledge diffusion, particularly within smaller actor groups (Motoyama & Knowlton, 2017).

Non-linearity and co-evolution emerge from the unpredictable ways local interactions generate new opportunities and configurations within the ecosystem. In peer-based open innovation environments, startups adjust to one another without predefined roles, co-evolving through dynamics of collaboration and competition (Primario et al., 2024). Startups also reconfigure their use of external resources as they evolve (Marcon & Duarte Ribeiro, 2021), with non-linearity emerging as they strategically reorient ecosystem behaviour in response to market contingencies (Marcon et al., 2024). Non-linearity is particularly evident in the way small digital or relational events can produce disproportionate outcomes, especially on social media platforms, where digital interactions continuously reshape patterns of collaboration and reciprocal influence among entrepreneurial actors (Singh et al., 2020).

The social and geographic embeddedness of startup activity influences entrepreneurial pathways, depending on the informal support systems emerging in diverse cultural contexts (Berger & Kuckertz, 2016). The effectiveness of these support systems (e.g. startup accelerators) varies across institutional environments with different degrees of ecosystem maturity (Eslamloo et al., 2025), revealing a certain sensitivity to initial conditions.

Relationships are formed among entrepreneurs, investors, and institutions within startup ecosystems and reorganise spontaneously over time, attributable to interactions and shared objectives rather than predefined structures, thereby highlighting self-organizing behaviours (Ojaghi et al., 2019). Informal bridging mechanisms often replace formal governance, facilitating cooperation through trust, shared goals, and experimentation (Corvello et al., 2023b). Thus, startup ecosystems develop even in peripheral regions, where limited institutional infrastructure promotes spontaneous creation, self-reliance, and locally grounded innovation pathways. Bottom-up entrepreneurial logics exist in such contexts, as startups rely on community networks and individual initiatives to create opportunities (Haines, 2016).

Finally, these ecosystems can be classified as entrepreneurial-nested, with startups as the primary catalysts of innovation activities centred on growth-oriented strategies and developing innovation processes that arise from complex interactive dynamics that are typical of entrepreneurial behaviours (Krishnan & Krishna, 2024).

Thus, a set of core complex system properties emerged across all studies, as summarised in Table 3. This leads to the characterisation of startup ecosystems as entrepreneurial-nested systems presenting bottom-up complexity, where innovation is not a top-down imposition of design but a process continuously shaped by interaction, context, and emergence.

Entrepreneurial University Ecosystems: entrepreneurial-nestedness and top-down complexity

Entrepreneurial university ecosystems are structured environments, with entrepreneurial activity institutionalised through deliberate policy choices, strategic infrastructures, and actor engagement. Entrepreneurship is built into everyday university activities through incubators, innovation hubs, and technology transfer offices that link researchers, students, and companies (e.g. Massachusetts Institute of Technology). Entrepreneurial programs are institutionalised as part of the university's mission, often reinforced by dedicated policy initiatives. Yet, these ecosystems remain dynamic, adaptive, and actor driven.

Entrepreneurial university ecosystems evolve through continuous adaptation and interaction among institutional and organisational actors, with entrepreneurial strategies shaped by competing institutional priorities (Abreu & Grinevich, 2024), guided by a causation- and goal-driven logic. Adaptability and resilience thus emerge as universities adjust their structures and practices in response to shifting objectives. For instance, university-industry relationships unfold through mutual learning, high flexibility, and co-adaptation, enabled by sustained

collaboration (Rücker Schaeffer et al., 2021).

The reciprocal influence between institutional strategies and entrepreneurial behaviour is also the main driver of feedback loops and complex causation. These dynamics manifest through the interplay between physical and organisational infrastructure, entrepreneurial dynamism, material resources, and individual behaviour (Johnson et al., 2019). Thomas et al. (2018) expand this perspective by examining the convergence between EEs and IEs, where shared goals and iterative experimentation generate dynamic yet institutionally grounded forms of collaboration. Within this process, informal initiatives affect institutional strategies, which in turn shape local entrepreneurial behaviours, causing recursive feedback.

Non-linearity and co-evolutionary behaviours appear as academic and entrepreneurial domains and evolve together through mutual learning. Specifically, entrepreneurship education and business incubators enhance long-term graduate outcomes, with their effects mediated by contextual responsiveness and evolving student trajectories (Guerrero et al., 2020). Over time, support mechanisms also co-evolve, incorporating new practices and feedback derived from entrepreneurial activities (Prokop, 2021).

Heterogeneity is evident in the diverse ways universities implement social entrepreneurship courses, demonstrating how institutional environments shape program outcomes (Kwong et al., 2022). Similarly, entrepreneurial roles are interpreted and enacted differently across departments and disciplines, with informal routines, such as mentoring and peer collaboration, playing a central role in shaping formal mechanisms (Tejero et al., 2019).

Entrepreneurial university ecosystems are extremely sensitive to local conditions, as they affect key success factors such as leadership, culture, and collaboration programs (Alam et al., 2023). Examining the diversity in social entrepreneurship courses, Kwong et al. (2022) identify a certain degree of institutional path-dependence, a property that, though less common in these representations, characterises various entrepreneurial university ecosystems. In fact, even though initiatives share similar goals, they often digress owing to variations in university culture, support systems, and external pressures. Consequently, well-intentioned policy interventions may be hampered by organisational rigidity and friction with formalised systems (Lahikainen et al., 2019).

Finally, this configuration can be described as entrepreneurial-nested, as innovation-driven research becomes the seed for entrepreneurial action. University entrepreneurial ecosystems integrate educational programs, dedicated infrastructures (incubators, business creation, and employment offices), university regulations (business creation norms and property rights), and an enabling academic culture (role models and attitudes towards entrepreneurship), collectively transforming scientific advancements into entrepreneurial ventures and growth opportunities (Guerrero et al., 2020).

This dual nature confirms the positioning of entrepreneurial university ecosystems as entrepreneurial-nested systems driven by top-down complex dynamics. Table 4 summarises such characterisations.

Entrepreneurial innovation ecosystems: innovation-nestedness and bottom-up complexity

The literature on entrepreneurial innovation ecosystems reveals dynamic and context-sensitive structures where innovation is deeply embedded within entrepreneurial processes and coordination unfolds with limited formal regulation. Entrepreneurial innovation ecosystems attract entrepreneurs, firms, and research actors in flexible and experimental settings where new technologies and business models emerge through collaboration and continuous adaptation (e.g. high-technology clusters). These systems are shaped by local contingencies, emergent dynamics, and multi-actor interactions that reinforce adaptability and learning.

Entrepreneurial innovation ecosystems address technological and social challenges by leveraging the complementarities of diverse actors

through the continuous recombination of different entrepreneurial ideas. Vettik-Leemet & Mets (2024) highlight the ecosystem's responsiveness to complexity through flexible, adaptive, and dynamic coordination mechanisms. In practice, the ecosystem responds informally and flexibly to contextual inputs, continuously reorganizing itself in reaction to external stimuli and engaging with various actors (Ferreira et al., 2023).

Feedback loops are a defining feature of these systems, as ongoing exchanges among knowledge, stakeholders, and resource mobility continuously reinforce learning and innovation (Ozkan et al., 2023). Indeed, feedback between institutional and entrepreneurial actors fosters the co-evolution of business and policy strategies, enabling the ecosystem to realign itself in response to contextual changes (Guerrero & Martínez-Chávez, 2020). Feedback becomes apparent from entrepreneurial failures and lessons learned, resulting in new ventures and collaborative initiatives (Rivera Vargas & de León Arias, 2022).

Audretsch et al. (2023) define entrepreneurial innovation ecosystems as heterogeneous environments, with distinct entrepreneurship behaviours and policies. Similarly, participants' heterogeneity, including academics, industries, and organisations, enhances the system's flexibility (Vettik-Leemet & Mets, 2024).

The characterisation of non-linearity is reflected in the ability of such systems to generate novel and unpredictable outcomes, not merely through institutional guidance or formal coordination but via informal mechanisms of interaction, experimentation, and openness that collectively sustain innovation over time. This process is often exercised in open innovation settings where internal and external actors dynamically interact with each other and define new business models (Guerrero & Martínez-Chávez, 2020). Vettik-Leemet & Mets (2024) extend this view by conceptualizing the ecosystem as an iterative and emergent process, where entrepreneurial and innovation dynamics co-evolve through continuous interactions among actors and the recombination of opportunities.

Entrepreneurial innovation ecosystems demonstrate sensitivity to initial conditions and path-dependence in exceptional cases. However, as noted by Leceta & Könnölä (2021) and Shashlo et al. (2018), such properties reflect the accumulation of knowledge within entrepreneurial contexts that promote innovation outcomes rather than institutional constraints that limit the scope of the ecosystem. Knowledge development in such ecosystems, therefore, follows a path-dependent trajectory and remains sensitive to initial conditions, while progressively evolving into autonomous and self-organizing processes (Shashlo et al., 2018).

Self-organisation is also a crucial characteristic, as entrepreneurs are motivated to learn from failures and accumulated experience, leading to the continuous generation of new ventures and collaborative initiatives (Rivera Vargas & de León Arias, 2022). This process reflects an effectuation logic, wherein actors apply lessons learned to design and pursue new entrepreneurial opportunities within the evolving ecosystem, especially through experimentation rather than top-down design (Vettik-Leemet & Mets, 2024). Similarly, Leceta & Könnölä (2021) illustrate that self-organisation and heterogeneity are not only tolerated but are integral to entrepreneurial innovation ecosystem vitality as previous entrepreneurial knowledge is integrated within flexible innovation programs.

Finally, in relation to the predominant logics of nestedness, Autio et al. (2014) established the conceptual foundations by arguing that, in these systems, entrepreneurial outcomes arise from context-dependent innovation frameworks. The configuration can be described as innovation-nested, as it harnesses the effectuation logic that is typical of entrepreneurial behaviour (Rivera Vargas & de León Arias, 2022) and redirects it towards the generation of collective innovation and systemic renewal.

Across these studies, entrepreneurial innovation ecosystems emerge as configurations where innovation is deeply embedded within entrepreneurial dynamics, although it is not steered by rigid institutional frameworks. This duality leads to the classification of entrepreneurial

innovation ecosystems as innovation-nested configurations characterised by bottom-up complexity (Table 5).

Regional innovation ecosystems: innovation-nestedness and top-down complexity

Regional innovation ecosystems emerge in the literature as highly structured yet dynamic configurations wherein innovation is embedded in institutional and territorial frameworks. They are built around local institutions, universities, and policy frameworks that coordinate firms, researchers, and public actors to stimulate innovation within a specific territory, combining formal governance with regional collaboration and knowledge exchange (e.g. European Union NUTS-2 regions). A common theme is the role of formalised infrastructures, such as public agencies, universities, and policy instruments, in enabling innovation while accommodating evolving actor interactions and localised adaptations.

This configuration displays adaptability and resilience as firms and institutions dynamically adjust their strategies to local contexts and shifting patterns of collaboration. Fu & Qian (2023) show that startups embedded within such ecosystems benefit from structured policy frameworks, which enable them to transform knowledge assets into enhanced innovative capacity. Adaptability and resilience emerge through the ecosystems' capacity to reconfigure institutional arrangements and coordination mechanisms in response to contextual political and economic changes (Bramwell et al., 2019; Freire-Gibb & Gregson, 2019).

Feedback loops and complex causation are fundamental properties of regional innovation ecosystems, enabling continuous learning and adaptation through reciprocal interactions among actors. Specifically, innovation emerges through shared practices, mutual learning, and iterative adjustments rather than top-down directives, capturing value co-creation approaches (Radziwon et al., 2017). Similarly, the alignment between local capabilities and place-based assets with evolving innovation trajectories enhance smart specialisation strategies within such ecosystems (Markkula & Kune, 2015).

Heterogeneity, another defining feature, manifests in the fluid coexistence of academia, industry, government, and civil society within the Quadruple/Quintuple Helix model (Carayannis et al., 2018), and in the ecosystem adaptive capacity strengthened by institutional variety (Cooke, 2016).

Non-linearity and co-evolution characterise how knowledge exchanges trigger cumulative and often unpredictable transformations. López-Rubio et al. (2020) show how ecosystems co-evolve as non-linear entities, especially when knowledge management practices are affected by regional policies. The continuous accumulation and exchange of knowledge enable regional innovation ecosystems to evolve dynamically, fostering new forms of innovation and growth (Kraus et al., 2021).

Sensitivity to initial conditions and path-dependence appear in how historical governance structures and institutional legacies influence regional innovation ecosystems, guiding their evolution along context-specific trajectories. Bramwell et al. (2019) show how well-established public bodies provide essential support services while coordinating and connecting multiple innovation ecosystems across regions. The central role of institutions is thus further reinforced by the region's historical path-dependencies and its specific geographical context (Freire-Gibb & Gregson, 2019). Nieth et al. (2018) complement this perspective by examining effectual discovery processes, where entrepreneurs act under uncertainty, relying on available resources within regional innovation contexts. However, while entrepreneurs usually follow effectuation logics – building from existing resources towards emergent outcomes – the encompassing ecosystem exhibits top-down complexity, as institutional frameworks and policy structures guide and constrain local experimentation through incentives and regional policies. This aligns with a causation-oriented logic of the policy design that guides local entrepreneurs towards innovation activities rather than general venture creation (Pidorycheva et al., 2020).

Eventually, the dual role of universities as orchestrators in regional

innovation ecosystems complements their conceptualisation. Specifically, universities channel resources and partnerships through formal governance structures, while also engaging in self-organizing collaborations with local actors (Thomas et al., 2021). Although rare, some regional innovation ecosystems may combine the logic of causation and effectuation, integrating their capacity to incorporate top-down coordination with bottom-up experimentation.

Finally, Farinha et al. (2018) introduce the concept of entrepreneurial embeddedness, illustrating that ecosystems and entrepreneurial activities co-evolve, each shaping and being shaped by the other. Thus, the configuration can be seen as innovation-nested because entrepreneurial activity emerges as both a product and a driver of innovation. Entrepreneurship is embedded within broader innovation dynamics, where the continuous interplay between new ideas, institutional frameworks, and market opportunities fuels mutual adaptation and systemic evolution.

This leads to the characterisation of regional innovation ecosystems (summarised in Table 6) as innovation-nested systems shaped by top-down complexity, where innovation, although influenced by emerging regional dynamics, is primarily driven by institutional arrangements.

Classification of nested configurations

Based on the above discussion, we characterise the four configurations identified at the intersection of EEs and IEs based on how complex system properties are addressed within each of them, as summarised in Table 7.

Following such characterisation, we introduce a classification of these nested configurations along two key dimensions: the logic of nestedness and the level of complexity. We classify startup ecosystems, entrepreneurial university ecosystems, entrepreneurial innovation ecosystems, and regional innovation ecosystems based on whether they are predominantly entrepreneurial or innovation-nested and exhibit bottom-up or top-down systemic complexity. Fig. 4 illustrates the outcome of this classification.

Apparently, startup ecosystems and entrepreneurial university ecosystems are characterised as entrepreneurial-nested configurations, wherein entrepreneurial logics drive innovation activity. In both cases, innovation strategies are typically growth-oriented and orchestrated by entrepreneurial actors. In the former, startups catalyse innovation activities around entrepreneurial principles; in the latter, universities play a central role by aligning research and educational programs with an entrepreneurial culture. Conversely, entrepreneurial innovation ecosystems and regional innovation ecosystems emerge as innovation-nested configurations, where entrepreneurship is embedded within broader and more formal innovation infrastructure, typically shaped by policies and regulatory frameworks. In the former configuration, entrepreneurial outcomes are closely related to context-dependent innovation systems; in the latter, entrepreneurial activity is continuously affected by the interplay between institutional arrangements and market opportunities.

The complexity dimension enriches understanding of these configurations, clarifying if their systemic dynamics emerge primarily from micro-level interactions (bottom-up complexity), driven by effectuation logics, which are more adaptive in identifying and capturing emergent opportunities, or shaped by macro-level structures and interventions (top-down complexity), reflecting a causation, goal-driven logics centred on coordinated strategies. In startup ecosystems and entrepreneurial innovation ecosystems, dynamic interactions and non-linear relationships among heterogeneous actors engender self-organizing mechanisms at the ecosystem level. These mechanisms reflect a predominant effectuation logic that is opportunity-driven and guided by iterative learning. By contrast, the complexity of entrepreneurial university ecosystems and regional innovation ecosystems emerges from institutional arrangements and policy frameworks. The dynamics of these ecosystems are often shaped by path-dependent mechanisms

Table 7
Characterisation of complex systems properties across nested configurations.

Property	Startup Ecosystems	Entrepreneurial University Ecosystems	Entrepreneurial Innovation Ecosystems	Regional Innovation Ecosystems
Self-organisation	Relationships among entrepreneurs, investors, and institutions typically form and organise spontaneously, with informal mechanisms replacing formal governance (Corvello et al., 2023b; Ojaghi et al., 2019).		Entrepreneurs primarily learn from failures and accumulated experience, leading to the continuous generation of new ventures and collaborative initiatives (Rivera Vargas & de León Arias, 2022).	Universities act as orchestrators combining formal governance structures and self-organizing collaborations with local actors (Thomas et al., 2021).
Non-linearity and co-evolutionary behaviours	Startups co-evolve through dynamics of collaboration and competition (Primario et al., 2024), reshaping ecosystem behaviours non-linearly in response to market configurations (Marcon et al., 2024).	Entrepreneurship education and business incubation co-evolve through mutual learning and mediated by contextual responsiveness (Guerrero et al., 2020).	Entrepreneurial and innovation dynamics co-evolve through continuous interactions among internal and external actors to redefine business models and identify opportunities (Guerrero & Martínez-Chávez, 2020; Vettik-Leemet & Mets, 2024).	Knowledge management practices are shaped non-linearly by regional policies, with the accumulation and exchange of knowledge co-evolving with new forms of innovation and growth (Kraus et al., 2021).
Adaptability and resilience	Startups adapt their network ties and strategies in response to shifting contextual conditions (Ancona et al., 2023; Motoyama & Knowlton, 2017).	Entrepreneurial strategies adapt to competing institutional priorities (Abreu & Grivenich, 2024), with university-industry relationships enabled by sustained collaboration (Rücker Schaeffer et al., 2021).	The continuous recombination of entrepreneurial ideas enables the ecosystem to respond informally and adaptively to contextual inputs and external stimuli (Ferreira et al., 2023).	Institutional arrangements and coordination mechanisms reconfigure in response to contextual political and economic changes (Bramwell et al., 2019; Freire-Gibb & Gregson, 2019).
Feedback loops and complex causation	Tensions between startups and incumbents stimulate transformation through continuous feedback loops and learning mechanisms (Baloutsos et al., 2022).	Informal initiatives inform institutional strategies, which in turn shape local entrepreneurial behaviours, giving rise to recursive feedback and complex dynamics (Thomas et al., 2018).	Feedback emerges primarily from entrepreneurial failures and lessons learned, as well as resource mobility, through which new ventures and collaborative initiatives arise (Rivera Vargas & de León Arias, 2022; Ozkan et al., 2023).	Innovation emerges through shared practices, mutual learning, and iterative adjustments rather than top-down directives, reflecting value co-creation approaches (Radziwon et al., 2017).
Sensitivity to initial conditions and path-dependence	The social, institutional, and geographical embeddedness of startup activity influences entrepreneurial pathways and the effectiveness of support organisations (Berger & Kuckertz, 2016; Eslamloo et al., 2025).	Local conditions affect leadership, culture, and collaboration programs (Alam et al., 2023), with a certain degree of institutional path-dependence (Kwong et al., 2022).	Knowledge development and accumulation follows a path-dependent trajectory, remaining sensitive to initial conditions while progressively evolving into more autonomous processes (Shashlo et al., 2018).	The central role of institutions is further reinforced by the region's historical path-dependencies and its specific geographical context (Freire-Gibb & Gregson, 2019).
Heterogeneity	Startups arise in highly dynamic and heterogeneous network configurations (Ancona et al., 2023), with such heterogeneity across actors and mechanisms fostering ecosystem flexibility (Saccol Filho et al., 2024).	Heterogeneity emerges in the diverse ways universities implement social entrepreneurship courses (Kwong et al., 2022) and in the entrepreneurial roles unfolding differently across departments and disciplines (Tejero et al., 2019).	Distinct entrepreneurial behaviours and policies - reflecting the heterogeneity of participants - enhance the system's flexibility (Audretsch et al., 2023; Vettik-Leemet & Mets, 2024).	Institutional variety - along with the coexistence of academic, industrial, governmental, and civil society actors - strengthens the ecosystem adaptive capacity (Carayannis et al., 2018; Cooke, 2016).

rooted in historical trajectories and align with a causation- and goal-oriented logic.

Thus, startup ecosystems and regional innovation ecosystems show internal coherence across both dimensions, aligning respectively with EE and IE paradigms. Nuanced insights emerge from the classification of entrepreneurial university ecosystems and entrepreneurial innovation ecosystems. Despite their formal structures, which are anchored in universities and supported by policy instruments, entrepreneurial university ecosystems demonstrate locally enacted, non-linear entrepreneurial dynamics. Conversely, although entrepreneurial innovation ecosystems prioritise innovation objectives, their complex dynamics arise primarily from local interactions, feedback loops, and adaptive learning processes rather than centralised coordination. The dual nature of these two configurations makes them the most highly nested systems among the four emerging from the literature at the intersection of EE and IE research.

To explore this further, we revisit the network of selected papers based on keyword co-occurrence, as done previously in Section 4.2 (Fig. 3), but this time applying the two-dimensional classification introduced above and colouring the nodes accordingly. In Fig. 5, the left panel differentiates papers based on complexity type (bottom-up vs. top-down), while the right panel reflects the logic of nestedness (entrepreneurial- vs. innovation-nested). Our findings show that inter-cluster connections (edges in black) are more prevalent when considering complexity level (42.9%) than when analysing nestedness logic (40.3%),

suggesting that boundaries are less clearly defined when it comes to the systemic complexity of nested configurations. Regarding subnetwork densities, we observe similar levels for papers addressing bottom-up and top-down complexity (41.7% and 44.7%, respectively). However, a more pronounced difference emerges between the entrepreneurial-nested and innovation-nested groups. The latter appears less internally connected (33.9%) compared to the former (50.9%), suggesting a greater cross-contamination of concepts within the configurations classified as entrepreneurial-nested - namely, startup ecosystems and entrepreneurial university ecosystems - than within the innovation-nested configurations (i.e. entrepreneurial innovation ecosystems and regional innovation ecosystems), which instead tend to be more thematically centred on innovation-related topics.

Towards a future research agenda on nested ecosystem configurations

Building on the typology of nested configurations and the type of systemic complexity identified, several promising avenues emerge for future research on the interplay between EEs and IEs. These avenues aim to move beyond static taxonomies and towards a deeper understanding of ecosystem dynamics, interrelations, and implications for governance and performance measurement.

First, our analysis of the keyword co-occurrence networks suggests that the concepts of startup ecosystems and entrepreneurial university

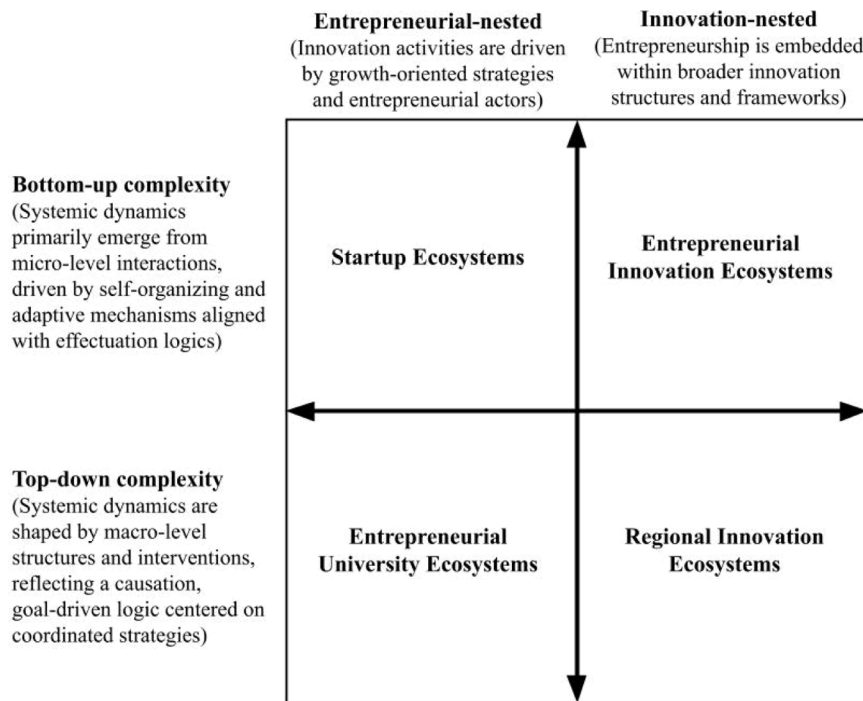


Fig. 4. Classification of nested configurations.
Source: Authors' own work

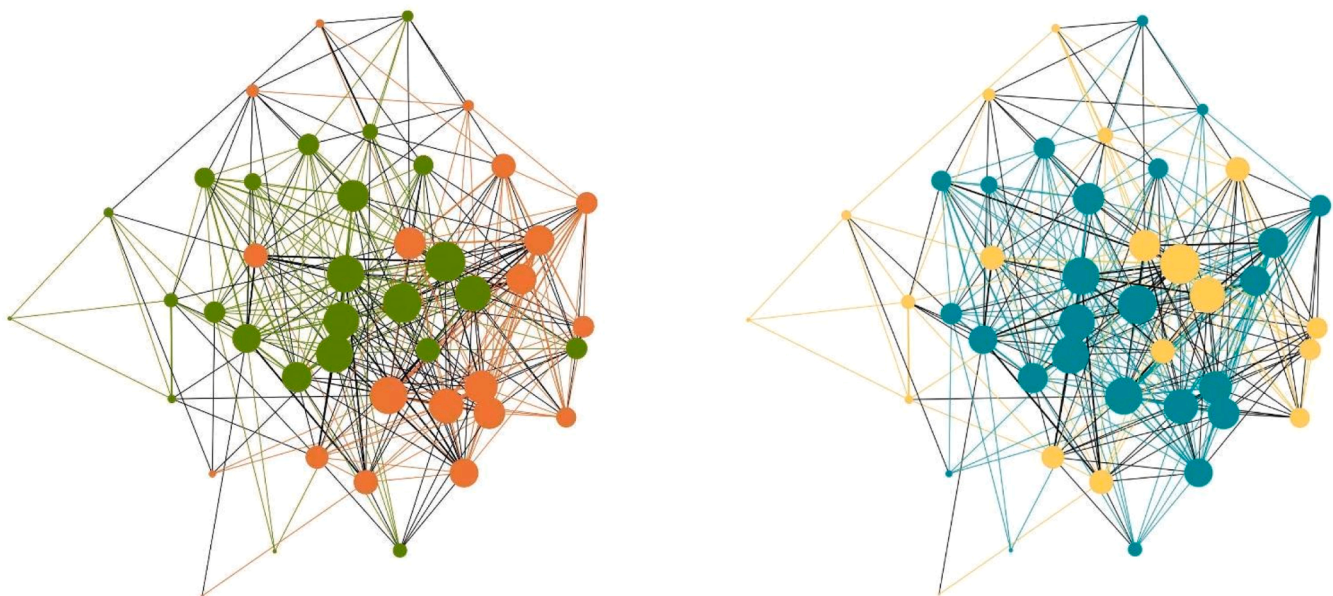


Fig. 5. Network of selected papers based on keyword co-occurrence. Node colors represent the level of complexity on the left (green nodes correspond to bottom-up complexity; orange nodes to top-down complexity) and the logic of nestedness on the right (aqua green nodes correspond to the entrepreneurial-nested group; yellow nodes to the innovation-nested group).
Source: Authors' own work

ecosystems are comparatively more mature and conceptually well-defined in the literature. By contrast, the concepts of entrepreneurial innovation ecosystems and regional innovation ecosystems appear to be still emerging and, therefore, theoretically less consolidated. This highlights the need for future research to examine and enhance these latter configurations, particularly their systemic complexity, and transcend the current focus on ecosystem boundaries. Scholars should aim to develop a more integrated discourse that addresses the interconnectedness, overlaps, and nested relationships across different ecosystem

types. A first research direction in this regard is the evolutionary processes of nested ecosystems, specifically to what extent do nested configurations follow distinct life cycles or transition from one archetype to another? What are the conditions under which entrepreneurial-nested ecosystems evolve into innovation-nested ones, or vice versa? How do tipping points, crises, or technological shifts influence these transformations? Future studies could adopt a longitudinal and comparative lens, using life-cycle models or the perspective of complex adaptive systems to pursue the emergence, consolidation, and potential decline of

ecosystem configurations. Focus should shift to understanding how these evolutionary paths are shaped by initial conditions, feedback loops, or the actions of orchestrators and intermediaries. A second area for exploration relates to the robustness, adaptability, and resilience of nested ecosystems. While all configurations exhibit some form of adaptive behaviour, there is limited empirical insight into how these ecosystems respond to external disturbances such as economic crises, technological disruptions, or geopolitical shocks. How do ecosystems reconfigure in response to such events? What internal mechanisms - such as heterogeneity, feedback loops, or self-organisation - enable recovery and renewal? Comparative case studies across regions or sectors could clarify the type of nested ecosystems that are resilient and those vulnerable to external shocks.

Another stream of inquiry could focus on the governance of nested ecosystems and the evolution of their coordination structures. How do governance mechanisms adapt over time in ecosystems that span both entrepreneurial and innovation logics? How is orchestration exercised in nested or overlapping systems, and the role of universities and public authorities in facilitating or constraining ecosystem dynamics? Additionally, how does organisational culture evolve in such systems, especially when entrepreneurial informality interacts with institutional formalisation? These questions call for deeper engagement with the micro-foundations of ecosystem governance, including actor motivations, institutional embeddedness, and informal coordination routines. Further compelling directions involve the interactions and transitions between different ecosystem types. What are the mechanisms through which startup ecosystems contribute to regional innovation ecosystems? How do entrepreneurial university ecosystems interact with the broader IEs? Are there hybrid or layered ecosystems that span multiple logics simultaneously? How do actors navigate such cross-ecosystem dynamics? Mapping these interactions could clarify how resources, capabilities, and practices circulate across different configurations, leading to convergence, conflict, or co-evolution.

A further research direction concerns the type of empirical designs required needed to unpack these complex interrelations. Qualitative studies could provide rich insights into how nested configurations between EEs and IEs manifest within specific institutional or industrial settings. For instance, case-based research could examine how university entrepreneurial ecosystems evolve towards innovation-oriented configurations through strategic industry collaboration, or how IEs develop entrepreneurial components through the emergence of spin-offs and technology transfer activities. How these nested configurations emerge and stabilise over time, and under what conditions do they interconnect? Comparative analyses across sectors such as biotechnology, energy, and creative industries could further clarify how nested configurations vary by knowledge intensity, regulatory environments, and market dynamics, underscoring how ecosystems transition from one archetype to another. Meanwhile, Social Network Analysis represents a powerful methodological approach for quantitatively examining mutual interactions and shifting ecosystem boundaries. Finally, what mechanisms drive these transitions, and how do institutional structures or technological paradigms influence their evolution? Complementarily, configurational approaches such as fuzzy set Qualitative Comparative Analysis could identify the combinations of institutional, technological, and relational conditions that enable the formation or persistence of nested configurations. Which constellations of factors are necessary or sufficient for such configurations to occur, and how do they differ across regions or industries?

A critical, underexplored aspect is measuring the impact and performance of nested ecosystems. Existing indicators often fail to capture the emergent, non-linear, and systemic nature of ecosystem value creation. What alternative metrics could better reflect the dynamic interplay of entrepreneurship and innovation? How can we incorporate real-time analytics, digital trace data, or complexity-sensitive indicators into performance measurement? Can we move beyond static outputs to assess adaptability, learning capacity, and systemic alignment over

time? These questions are particularly relevant for policymakers seeking to design evidence-based interventions tailored to specific ecosystem configurations.

Lastly, a largely overlooked but relevant dimension is understanding how organisational roles, leadership, coordination processes, and human resource management strategies evolve in nested ecosystems. The key questions include: How do roles, such as orchestrators, adapt across different ecosystem configurations? What leadership styles and human resource management practices best support learning, adaptability, and cross-organisational collaboration? How do coordination routines align with bottom-up or top-down complexity? How do institutional logics shape the cultural coherence of nested systems over time?

Discussion and conclusions

This study explores the complex relationship between EEs and IEs, aiming to clarify how the literature conceptualises their interaction and determine if complex dynamics observed across different configurations predominantly emerge from micro-level interactions (bottom-up complexity) or are driven by macro-level structures and interventions (top-down complexity). To this end, two main research questions guided our analysis: (i) 'How can the relationship between innovation and entrepreneurial ecosystems be conceptualized within nested configurations?' and (ii) 'What type of systemic complexity characterises the nested configurations of innovation and entrepreneurial ecosystems?' To answer these questions, we conducted a scoping review following the PRISMA-ScR protocol. After screening 3,850 records, we selected 48 eligible studies published between 2005 and 2025 that conceptually engaged with both EE and IE frameworks. We extracted and thematically analysed these studies to identify typologies of nested configurations and to assess how different complex system properties, that is, adaptability and resilience, feedback loops and complex causation, heterogeneity, non-linearity and co-evolution, sensitivity to initial conditions and path-dependence, and self-organisation are addressed within each configuration.

Specifically, we investigated four distinct nested ecosystem configurations identified in the literature that integrate elements from both EEs and IEs, each reflecting a dominant underlying logic: startup ecosystems, entrepreneurial university ecosystems, entrepreneurial innovation ecosystems, and regional innovation ecosystems. The first two are classified as entrepreneurial-nested configurations, where innovation activity is embedded within entrepreneurial dynamics and culture. By contrast, the latter two represent innovation-nested configurations, wherein entrepreneurial activity is shaped and coordinated within broader innovation frameworks. This classification offers a structured lens to interpret how nested ecosystems integrate entrepreneurial and innovation functions in different ways. Moreover, the systemic complexity of startup ecosystems and entrepreneurial innovation ecosystems is predominantly driven by bottom-up, non-linear dynamics emerging from micro-level interactions and path-dependent processes - features typical of EEs. Conversely, entrepreneurial university ecosystems and regional innovation ecosystems exhibit top-down complexity, where systemic properties largely derive from institutional arrangements and policy frameworks, consistent with the dynamics observed in IEs. Thus, our analysis reveals that the logic of nestedness and the level of systemic complexity provide valuable lenses for distinguishing between different ecosystem configurations. While startup ecosystems and regional innovation ecosystems align coherently with the entrepreneurial and innovation paradigms, respectively, more nested, and complex dynamics characterise entrepreneurial university ecosystems and entrepreneurial innovation ecosystems. Notably, entrepreneurial university ecosystems exhibit strong entrepreneurial orientations, but they are guided by a causation logic and rely on coordinated strategies. Conversely, despite their predominant focus on innovation, entrepreneurial innovation ecosystems display bottom-up complexity, driven by local interactions, feedback mechanisms, and effectuation-oriented

logics. The keyword co-occurrence network further supports these distinctions: papers on entrepreneurial-nested systems are internally more cohesive than those on innovation-nested systems, suggesting a stronger conceptual convergence. Additionally, thematic overlaps are prominent when comparing systems by their complexity type than by their nestedness logic, indicating fuzzier boundaries in how complexity is framed and operationalised in the literature. These findings highlight the need for greater conceptual clarity in mapping complex system dynamics within nested ecosystem configurations.

Theoretically, this study offers several contributions. First, this logic of nestedness clarifies how EEs and IEs may coexist and interact within a shared configuration, rather than being mutually exclusive. Thus, we address a gap highlighted in prior research that although the two ecosystem types are analytically distinct, the nature of their interconnection remains largely unexplored (Scaringella & Radziwon, 2018; Thomas et al., 2018; Xu & Maas, 2019). Second, we respond to the call for greater use of complex systems theory to investigate the dynamic nature of ecosystems (Cobben, 2022; Phillips & Ritala, 2019). While both IEs and EEs are increasingly framed as complex adaptive systems, existing studies rarely explore how complex system properties manifest in nested or intersecting configurations. In this work, we provide an integrative, systems-based framework for studying ecosystem evolution and interaction. This approach advances our understanding of complex systems dynamics by linking the concept of nestedness to the investigation of systemic levels of complexity. In our framework, nestedness is crucial for reconstructing the bidirectional non-separability between the identity of the parts and the identity of the whole (Estrada, 2023; Fun-towicz & Ravetz, 1994; Thurner et al., 2018), and for integrating the effectuation and causation logics (Saravathy, 2001). These logics respectively pose non-predictive control and adaptability against formal coordination and goal-driven behaviour, aligning with what we define as bottom-up and top-down forms of complexity. By understanding the nestedness of ecosystem configurations, we reconcile the apparent rigidity of these dynamics into an integrated view of interdependent systems and interrelated behaviours (Christensen & Rosenbloom, 1995). Third, we advance theoretical understanding of nestedness by reframing it as a dynamic and functional relationship rather than a static structural feature. While previous works have framed ecosystem nestedness in terms of organised groups within particular domains, such as industry-specific communities (e.g. Spigel, 2022), our approach builds conceptually on Christensen & Rosenbloom's (1995) notion of value networks as hierarchically structured systems, where each subsystem is composed of interdependent elements and simultaneously functions as part of a broader system. Accordingly, we argue that nested configurations should not be interpreted as sectoral subgroups, but rather as ecosystems that assume the properties of complex systems at a sub-systemic level. These include distinctive forms of self-organisation, feedback mechanisms, non-linearity, and adaptability, which characterise each configuration not just in terms of structural embeddedness but also in terms of their dynamic system behaviour. Finally, we refine the concept of self-organisation by showing how it varies according to the type of systemic complexity. In ecosystems characterised by top-down complexity, such as regional innovation ecosystems or entrepreneurial university ecosystems, self-organisation tends to emerge through formal coordination mechanisms, either orchestrated by a focal firm or a university, or embedded in structured policy frameworks. By contrast, ecosystems characterised by bottom-up complexity, such as startup ecosystems and entrepreneurial innovation ecosystems, exhibit self-organizing dynamics driven by informal interactions, emergent practices, and adaptive learning. This distinction deepens understanding of how self-organisation operates not as a universal property but as a context-contingent mechanism.

In addition to theoretical contributions, this work offers a set of insights that can support policymakers and ecosystem orchestrators in designing context-sensitive approaches to ecosystem development and governance. The typology of nested configurations developed in this

work provides a useful interpretive lens to distinguish between ecosystems that are primarily driven by entrepreneurial dynamics and those where innovation structures dominate. This distinction can inform the design of policy interventions that are aligned with the internal logic of each configuration. Entrepreneurial-nested ecosystems, such as startup or university-based ecosystems, may benefit from policies that support bottom-up experimentation, informality, and agile coordination mechanisms. By contrast, innovation-nested ecosystems, such as regional innovation ecosystems, are better served by top-down strategies that emphasise institutional alignment, long-term investment, and coordinated governance. Furthermore, by framing ecosystems as complex adaptive systems, the study highlights the importance of advancing environments that are proficient in adapting, learning, and evolving through feedback loops and interactions among heterogeneous actors. For governments and regional authorities, this implies the transcend static policy instruments and develop dynamic, responsive frameworks that can adjust to shifting conditions and emergent opportunities. The conceptual distinction between bottom-up and top-down complexity also offers practical guidance on ecosystem governance models. Bottom-up configurations entail enabling mechanisms that support distributed agency, peer learning, and fluid network formation. Top-down ecosystems, instead, require strong orchestrating roles, clearly defined institutional responsibilities, and mechanisms to ensure vertical coordination among actors at different levels. Similarly, the typology can be translated into configuration-specific toolkits that enable actors to drive 'complexity talk' into concrete decisions. For example, startup and entrepreneurial innovation ecosystems can adopt short self-assessment routines to evaluate readiness for collaboration and scaling, focusing on partner dependence, the stability of complementary assets, and the speed at which learning from failures is reinvested into new experiments. In entrepreneurial university and regional innovation ecosystems, the framework supports institutional audits that check if formal infrastructures and incentives reduce friction across the pipeline from research to commercialisation, and whether coordination is enabling rather than crowding out the local initiative. Across all configurations, the complex-systems framing encourages governance that treats policies as adaptive interventions, using periodic review cycles and feedback signals to recalibrate instruments when unintended consequences emerge.

This study is not without limitations. First, despite our efforts to ensure a comprehensive search, some relevant papers may have been excluded owing to issues of accessibility or database coverage. We attempted to mitigate this limitation by combining database searches with backward and forward citation tracking, yet we cannot completely rule out the omission of pertinent studies, particularly those published outside indexed journals or in grey literature. Second, while the scoping review follows the PRISMA-ScR protocol and includes a robust analytical framework, it remains inherently interpretive. The thematic classification of selected contributions across nested configurations and the mapping of complex system properties are based on inductive reasoning and may reflect subjectivity in judgment, despite triangulation among multiple reviewers. Third, our review focused exclusively on peer-reviewed articles published in English, which may have excluded valuable contributions written in other languages.

CRediT authorship contribution statement

Giuseppe Ceci: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Andrea Ancona:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Investigation, Formal analysis, Conceptualization. **Antonio Iovanella:** Writing – review & editing, Visualization, Validation, Software, Investigation, Formal analysis. **Eleonora Veglianti:** Writing – review & editing, Supervision, Resources.

Declaration of competing interest

None.

Appendix

Table 8

Full list of selected articles.

Authors	Year	Title	Source
Abreu & Grinevich	2024	The entrepreneurial university: strategies, processes, and competing goals	The Journal of Technology Transfer
Alam et al.	2023	Success Components of University Entrepreneurial Ecosystem: A Multimethod Exploration	IEEE Transactions on Engineering Management
Ancona et al.	2023	Network-based principles of entrepreneurial ecosystems: A case study of a start-up network	Small Business Economics
Audretsch et al.	2023	Sustainable orientation management and institutional quality: Looking into European entrepreneurial innovation ecosystems	Technovation
Autio et al.	2014	Entrepreneurial innovation: The importance of context	Research Policy
Baloutsos et al.	2022	Identifying contradictions in an incumbent–startup ecosystem – an activity theory approach	European Journal of Innovation Management
Berger & Kuckertz	2016	Female entrepreneurship in startup ecosystems worldwide	Journal of Business research
Bramwell et al.	2019	Growing entrepreneurial ecosystems: Public intermediaries, policy learning, and regional innovation	Journal of Entrepreneurship and Public Policy
Carayannis et al.	2018	The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models	R&D Management
Cooke	2016	The virtues of variety in regional innovation systems and entrepreneurial ecosystems	Journal of Open Innovation: Technology, Market, and Complexity
Corvello et al.	2023a	Building start-up acceleration capability: A dynamic capability framework for collaboration with start-ups	Journal of Open Innovation: Technology, Market, and Complexity
Corvello et al.	2023b	Start-up collaboration units as knowledge brokers in Corporate Innovation Ecosystems: A study in the automotive industry	Journal of Innovation & Knowledge
Eslamloo et al.	2025	Successful commercialisation in startup accelerator programmes: How different startup ecosystems matter	Journal of Innovation & Knowledge
Farinha et al.	2018	Regional innovation systems and entrepreneurial embeddedness	European Planning Studies
Ferreira et al.	2023	The role of entrepreneurial ecosystems in technological and social challenges	R&D Management
Freire-Gibb & Gregson	2019	Innovation systems and entrepreneurial ecosystems: Implications for policy and practice in Latin America	Local Economy
Fu & Qian	2023	Building innovative capacity in regional entrepreneurship and innovation (eco)systems: Startups versus incumbent firms	Growth and Change
Guerrero & Martínez-Chávez	2020	Aligning regional and business strategies: Looking inside the Basque Country entrepreneurial innovation ecosystem	Thunderbird International Business Review
Guerrero et al.	2020	Entrepreneurial university ecosystems and graduates' career patterns: do entrepreneurship education programmes and university business incubators matter?	Journal of Management Development
Haines	2016	Developing a Startup and Innovation Ecosystem in Regional Australia	Technology Innovation Management Review
Johnson et al.	2019	Entrepreneurial dynamism and the built environment in the evolution of university entrepreneurial ecosystems	Industrial and Corporate Change
Kraus et al.	2021	The role of innovation and knowledge for entrepreneurship and regional development	Entrepreneurship and Regional Development
Krishnan & Krishna	2024	Introduction: Start-ups and innovation ecosystems	Science, Technology and Society
Kwong et al.	2022	How entrepreneurial are social entrepreneurship education providers? The role of universities' entrepreneurial ecosystems in the provision of elective social entrepreneurship courses to business students	Studies in Higher Education
Lahikainen et al.	2019	Challenges to the development of an entrepreneurial university ecosystem: The case of a Finnish university campus	Industry and Higher education
Leceta & Könnölä	2021	Fostering entrepreneurial innovation ecosystems: Lessons learned from the European Institute of Innovation and Technology	Innovation: The European Journal of Social Science Research
López-Rubio et al.	2020	Regional innovation system research trends: toward knowledge management and entrepreneurial ecosystems	International Journal of Quality Innovation
Marcon & Duarte Ribeiro	2021	How do startups manage external resources in innovation ecosystems? A resource perspective of startups' lifecycle	Technological Forecasting and Social Change
Marcon et al.	2024	How the interplay between innovation ecosystems and market contingency factors impacts startup innovation	Technology in society
Markkula & Kune	2015	Making Smart Regions Smarter: Smart Specialization and the Role of Universities in Regional Innovation Ecosystems	Technology Innovation Management Review
Motoyama & Knowlton	2017	Examining the connections within the startup ecosystem: A case study of St. Louis	Entrepreneurship Research Journal
Nieth et al.	2018	Embedding entrepreneurial regional innovation ecosystems: reflecting on the role of effectual entrepreneurial discovery processes	European Planning Studies
Ojaghi et al.	2019	A synthesized framework for the formation of startups' innovation ecosystem: A systematic literature review	Journal of Science and Technology Policy Management,
Ozkan et al.	2023	The Next Generation of Innovation	Technology & Innovation
Pidorycheva et al.	2020	A Conceptual Framework for Developing of Regional Innovation Ecosystems	European Journal of Sustainable Development

(continued on next page)

Table 8 (continued)

Authors	Year	Title	Source
Primario et al.	2024	Peer innovation as an open innovation strategy for balancing competition and collaboration among technology start-ups in an innovation ecosystem	Journal of Innovation & Knowledge
Prokop	2021	University entrepreneurial ecosystems and spinoff companies: Configurations, developments and outcomes	Technovation
Radziwon et al.	2017	Creating and capturing value in a regional innovation ecosystem: A study of how manufacturing SMEs develop collaborative solutions	International Journal of Technology Management
Rivera Vargas & de León Arias	2022	The entrepreneurial ecosystem of Guadalajara, Jalisco, Mexico: Its technology-based and fast-growing startups and entrepreneurial-employees	Journal of technology management & innovation
Rücker Schaeffer et al.	2021	Mutualism in ecosystems of innovation and entrepreneurship: A bidirectional perspective on universities' linkages	Journal of Business Research
Saccol Filho et al.	2024	A measurement tool for the competitiveness of startups' innovation ecosystem	Journal of the knowledge economy
Shashlo et al.	2018	Determinants of integration interaction among the subjects of the entrepreneurial innovation ecosystem of macro region	Amazonia Investiga
Singh et al.	2020	Analyzing the startup ecosystem of India: A Twitter analytics perspective	Journal of Advances in Management Research
Tejero et al.	2019	Analysis of the Dynamism in University-Driven Innovation Ecosystems Through the Assessment of Entrepreneurship Role	IEEE access
Thomas et al.	2021	Universities as orchestrators of the development of regional innovation ecosystems in emerging economies	Growth and Change
Thomas et al.	2018	Linking entrepreneurial and innovation ecosystems: The case of AppCampus	Entrepreneurial ecosystems and the diffusion of startups
Vettik-Leemet & Mets	2024	Entrepreneurship and Innovation—Process Overlap or the Same? Systematic Overview and Converging Process-Dynamic Model	Administrative Sciences
Ziakis et al.	2022	Start-Up Ecosystem (StUpEco): A conceptual framework and empirical research	Journal of Open Innovation: Technology, Market, and Complexity

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