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THEMATIC ANALYSIS OF INNOVATION ECOSYSTEMS: CONCEPTUAL EXPLORATION OF GOVERNANCE, SUSTAINABILITY, AND DIGITAL TRANSFORMATION ACROSS HELIX FRAMEWORKS

ANÁLISE TEMÁTICA DE ECOSSISTEMAS DE INOVAÇÃO: EXPLORAÇÃO CONCEITUAL DE GOVERNANÇA, SUSTENTABILIDADE E TRANSFORMAÇÃO DIGITAL EM MODELOS HELICOIDAIS

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ABSTRACT

The value generation in innovation ecosystems of organizations, institutions, and communities in changing environments is increasingly studied. So far, a large body of literature has been developed to conceptualize and apply the concepts of innovation ecosystems. However, there are still gaps to be closed, for instance, in the combination of helix models, in digitalization, and in ecosystem resilience. This paper presents a thematic analysis of the current literature on innovation ecosystems. A validated set of references was compiled through systematic database searches. The papers were analyzed using systematic coding with a coding scheme developed for this purpose. By using thematic analysis in combination with mapping software, six clusters were identified. The interrelations between the themes create opportunities and challenges for "ecosystem orchestration". The results of this study can be used to develop a more robust conceptualization of innovation ecosystems. Managers and policymakers can use the results for handling innovation ecosystems. Finally, the study shows the potential of thematic analysis for consolidating complex bodies of literature.

Keywords: thematic analysis; innovation ecosystems; corporate governance; sustainability; digital transformation.

RESUMO

A geração de valor em ecossistemas de inovação de organizações, instituições e comunidades em ambientes em transformação tem sido cada vez mais estudada. Até o momento, um vasto corpo de literatura foi desenvolvido para conceituar e aplicar os conceitos de ecossistemas de inovação. No entanto, ainda existem lacunas a serem preenchidas, por exemplo, na combinação de modelos em hélice, na digitalização e na resiliência do ecossistema. Este artigo

apresenta uma análise temática da literatura atual sobre ecossistemas de inovação. Um conjunto validado de referências foi compilado por meio de buscas sistemáticas em bases de dados. Os artigos foram analisados utilizando codificação sistemática com um esquema de codificação desenvolvido para este propósito. Utilizando a análise temática em combinação com um software de mapeamento, seis clusters foram identificados. As inter-relações entre os temas criam oportunidades e desafios para a “orquestração do ecossistema”. Os resultados deste estudo podem ser utilizados para desenvolver uma conceituação mais robusta de ecossistemas de inovação. Gestores e formuladores de políticas podem utilizar os resultados para lidar com ecossistemas de inovação. Finalmente, o estudo demonstra o potencial da análise temática para consolidar corpos complexos de literatura.
Palavras-chave: análise temática; ecossistemas de inovação; governança corporativa; sustentabilidade; transformação digital.

1. INTRODUCTION

An innovation ecosystem consists of a variety of actors (firms, institutions, government, and civil society) that interact and collaborate to increase innovation (Adner, 2006; Autio & Thomas, 2014; Leydesdorff & Etzkowitz, 1998; Oh et al., 2016). While an innovation ecosystem is not a fixed entity, its members change as they collaborate, compete, and develop in new ways. A systemic view of innovation is increasingly relevant, as firms and countries worldwide are struggling to increase competitiveness and become more sustainable amid rapid change. The recent emergence and subsequent growth of new technologies, the increasing sustainability requirements placed on organizations, and the greater globalization of the economy have all contributed to a greater

emphasis on the concept of innovation ecosystems. The development of digital platforms, the use of artificial intelligence and the advent of Industry 4.0 have, in recent years, enabled a number of changes to the more traditional forms of innovation that are possible, increasing in particular the number of possible collaborations between organizations and the ways in which value can be co-created across both space and industry (Benitez et al., 2020; Barile et al. 2026; Liu and Li, 2025). Sustainability challenges such as climate change and the increasing scarcity of resources on the planet are generating a need for 'green' and socially responsible forms of innovation which can be supported by innovation ecosystems (Carayannis and Campbell, 2018; Vargo et al., 2020; Yaghmaie and Vanhaverbeke, 2020). Thus, there is a need to study these systems in greater depth, using more appropriate conceptual frameworks and more rigorous methods.

The aim of this study is to close the previously mentioned research gaps through a thematic analysis of a large body of research on innovation ecosystems. As the study uses a validated corpus of references and a systematic coding procedure, it is the first study to integrate thematic analysis with large-scale bibliometric techniques, such as VOSviewer, to provide a very structured survey of the current state of research on innovation ecosystems. In addition, the study reveals the relationships between the single themes and the existing patterns within the state of research, and it analyses the aspects of governance of innovation ecosystems, sustainability transitions, digitalization of innovation, and collaboration within the frameworks of innovation ecosystems. Finally, this study provides information and insights from this research and, accordingly, can be used to develop new theories, best practices, and policies aimed at fostering innovation in 21st-century companies.

2. LITERATURE REVIEW

Over the last two decades, research into innovation ecosystems has grown exponentially. However, many questions related to research on innovation ecosystems have not yet been answered by scholars in the field. Among the open issues to be solved by scholars within the field of the study of innovation ecosystems, the lack of a shared definition of the term 'ecosystem for innovation' and of the elements within an 'ecosystem for innovation' to be studied, represent a first critical challenge (Adner, 2006; Autio & Thomas, 2014; Carayannis & Campbell, 2009, 2018, 2022, 2026; Carayannis & Sütö, 2010; Chrisman & Carter, 2017; Leydesdorff & Etzkowitz, 1998; Oh et al., 2016). In fact, while the triple helix model of innovation represents the root of the more recent developed quadruple and quintuple helix models of innovation (Carayannis & Campbell, 2009, 2012, 2018, 2022, 2026; Carayannis & Sütö, 2010, 2014, 2016, 2018), a shared definition of the term 'ecosystem for innovation' and of the elements within an 'ecosystem for innovation' to be studied is currently missing.

One major problem which also affects the practice of innovation ecosystems is the lack of a common definition and of clearly defined components of an innovation ecosystem which should be studied by a researcher (Adner, 2006; Autio & Thomas, 2014; Carayannis & Campbell, 2009, 2012, 2018, 2022, 2026; Carayannis & Sütö, 2010, 2014, 2016, 2018). The triple helix model of innovation by Leydesdorff and Etzkowitz (1998) has served as the basis for the more recently developed quadruple and quintuple helix models of innovation (Carayannis & Campbell, 2009, 2012, 2018, 2022, 2026; Carayannis & Sütö, 2010, 2014, 2016, 2018). Therefore, while some researchers study firms and markets in the context of innovation ecosystems, others examine the roles of universities, government, and civil society in

innovation (Carayannis et al., 2012; Carayannis & Sütö, 2014). A very large number of studies have been conducted focusing on specific industries (for example, de Vasconcelos Gomes et al., 2018; Faissal Bassis & Armellini, 2018; Ferasso et al., 2018), or have been conducted within specific geographic locations (for example, Barile et al., 2026; Liu, 2017; Xu & Li, 2025). These studies have obvious applications but are not very useful for identifying the general principles that would allow the establishment and efficient functioning of innovative, scalable, and resilient ecosystems. In many regional studies focused on innovation ecosystems across the world, an attempt has been made to highlight the roles of local institutions and government at the regional and local levels through policies that support innovation. However, none of these regional studies that have focused on different parts of the world have been able to provide a sufficient amount of detail with regard to the way in which innovation ecosystems are able to withstand the many different types of external shocks (including but not limited to, the spread of a new type of a pandemic, a financial crisis, a technological revolution), and to be able to adapt to changes in the external environment. It is therefore necessary to carry out comparative studies and analyze the different sectors of the economy in order to identify the general principles that determine an innovation ecosystem's resistance and scalability (Chrisman & Carter, 2017).

The third open issue is the wide variety of methodological approaches that, in recent years, have been increasingly employed by scholars in their studies of innovation ecosystems. Although recently some themes, such as digital innovation, sustainability transitions, and the governance of innovation ecosystems, have begun to be analyzed by an increasing number of scholars within the framework of innovation ecosystems, their analysis is not yet

very systematic. As a result, some studies are based on qualitative case studies, while others employ a more quantitative approach, such as network analysis or simulation models, to study topics related to innovation ecosystems. The lack of methodological consistency across studies on the ecosystems of innovation prevents comparison of results and hampers the construction of a more consistent, cumulative body of knowledge. The research on innovation ecosystems is vast and encompasses many themes studied by researchers worldwide. First, there are studies that focus on digital innovation ecosystems within the Industry 4.0 framework (Benitez et al., 2020; Liu & Li, 2025; Marchese et al., 2026). Then there are the studies that focus on the new forms of collaboration enabled by digital technologies and new business models, such as platform businesses (Liu & Li, 2025). Then there are studies on sustainability transitions and related circular innovation ecosystems (Battistella & Attanasio, 2026; Bojovic et al., 2025; Su et al., 2025). These studies focus on green technology adoption and on environmental governance (Battistella & Attanasio, 2026; Bojovic et al., 2025; Su et al., 2025). Finally, there are studies that focus on the governance structures of innovation ecosystems and the role of ecosystem orchestrators. These studies also focus on policy frameworks and institutional arrangements that support or hinder innovation processes (Attarpour et al., 2025; Cobben et al., 2026; Koch et al., 2026).

The study addresses the wide range of topics already discussed within the framework of innovation ecosystems. By means of a thematic analysis of the current state of research and coding of the discussed themes within the individual studies, this study aims to systematically analyze and make a new contribution to the discussion of topics already addressed in studies on innovation

ecosystems. The results of this analysis are discussed with respect to future research on innovation ecosystems to improve the theoretical basis and practical application of the term.

3. METHODOLOGY

This study follows a thematic analysis approach. The field of innovation ecosystems is characterized by high conceptual ambiguity and encompasses a wide variety of theoretical approaches and a large number of empirical studies. Against this background, thematic analysis is particularly suitable for a study of this kind, because by means of a systematic coding and categorizing of the literature, it is possible not only to merge the results of single studies within the body of literature, but also to identify patterns and to analyze the interrelations of the individual concepts in a structured way. The results of the analysis can then be presented in the form of a coherent narrative, which, in turn, can be used for both theoretical and practical interpretation of the findings (Saunders et al., 2009). The analysis follows a multi-stage coding procedure (Saunders et al., 2009, p. 310) inspired by Strauss/Corbin (1998). Initially, open coding is applied to the study's references to generate initial categories (first coding level). The categories obtained through open coding are then analyzed in more detail through axial coding to establish relationships among them (second coding level). In this study, various aspects of innovation ecosystems (e.g., governance, sustainability, digital and regional transformation) are linked to the broader ecosystem structure. In the third coding level, selective coding is applied to the key categories that represent the themes already identified in the analysis (third coding level). In the context of this study, the single categories analyzed in more detail through a close reading of the texts' arguments (i.e., the explicit content of the

texts and the latent structures the researcher himself creates) are merged to form so-called themes. To support the qualitative analysis of the literature reviewed, a range of bibliometric mapping tools and methods were used. First, the co-authorship networks, keyword co-occurrence, and citation clusters were mapped and analyzed using VOSviewer (Van Eck & Waltman, 2010). In doing so, the method enabled the researcher to identify clusters of influential authors, establish a range of new research areas emerging from the main themes, and cross-reference the findings from the bibliometric mapping with the themes identified through the qualitative coding of the literature reviewed.

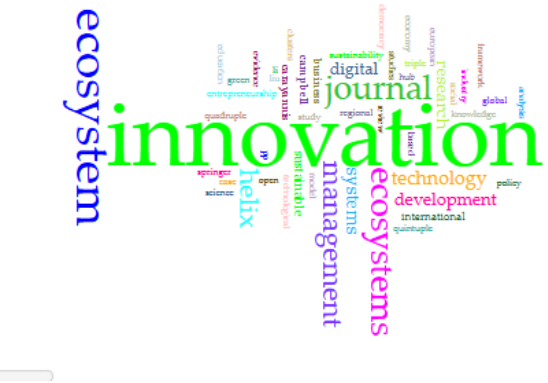
In addition to thematic coding, a text analysis of the entire reference set was conducted using Voyant Tools. This text analysis allows evaluation of word frequencies, collocations, and other relevant features. The results of this analysis show that most of the references on innovation ecosystems studied in this research deal with the digital transition, sustainability, and governance. This is achieved by employing qualitative thematic analysis as the primary method and by using corresponding text analysis with VOSviewer (Van Eck & Waltman, 2010) and Voyant Tools (Sinclair & Rockwell, 2026). The study introduces a novel, systematic research methodology that has the potential to complement the researcher's interpretative approach. Necessarily, any form of qualitative coding, including thematic analysis, has a number of limitations; not least the risk of the researcher introducing personal bias when coding, and achieving an acceptable level of intercoder agreement when applying the emerging themes to further data (Saunders et al., 2009). This study uses qualitative thematic analysis and bibliometric and text analysis to provide a thorough, systematic review of the literature on innovation ecosystems. The major problems in the

literature on innovation ecosystems are ambiguous definitions of key terms and concepts, and empirical research that is mostly fragmented. Furthermore, the majority of studies on innovation ecosystems use different methods for studying the same research object. The results of this study on innovation ecosystems contribute to both theory and practice in this field.

4. FINDINGS AND ANALYSIS

Six consistent themes emerged from the literature corpus studied for this chapter. Each theme that emerged from the studies analyzed in this chapter is discussed in more detail below. For each theme, a focus, relevant references, and the main findings from the analysis are set out. The six themes are: Definitional Ambiguity and Conceptual Frameworks; Empirical Fragmentation and Sectoral Focus; Methodological Diversity and Lack of Convergence; Emerging trends in Digital Innovation, Sustainability, and Governance; Project Collaboration, Culture, and Communication; and Project Digital Transformation and Sustainable Innovation. Firstly, Figure 1 displays the word cloud of Innovation Ecosystems, generated with Voyant Tools (Sinclair & Rockwell, 2026).

Figure 1: Conceptual Word Cloud: Innovation Ecosystems



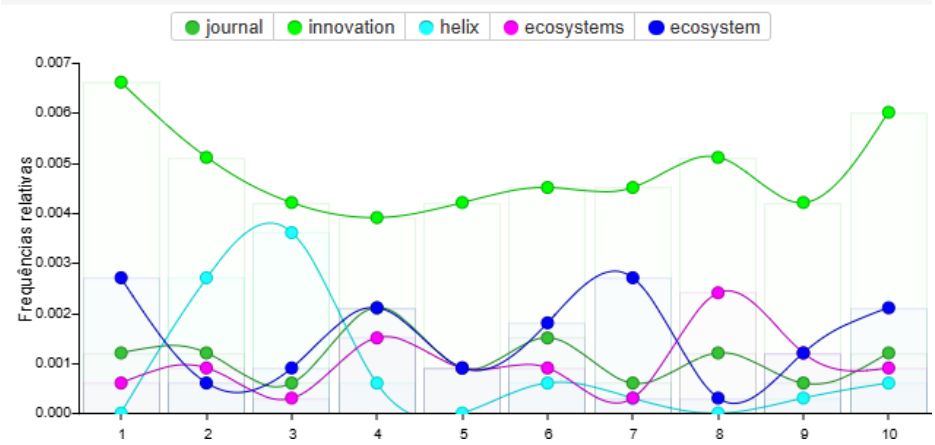
Source: Voyant 2.0. (Sinclair & Rockwell, 2026)

Figure 1 also presents major topics and terms within the field of innovation ecosystems. In the center of the word cloud, the term “innovation” is dominant because it lies at the core of “innovation ecosystems”. A closer inspection of the surrounding terms reveals that the word cloud includes all the major dimensions of innovation ecosystems. Thus, the term “ecosystem” primarily refers to the context in which an organization’s innovation processes take place. Other terms such as “management”, “technology,” and “development” can be seen as being part of the innovation process. Moreover, the word cloud includes terms that describe several theoretical frameworks of innovation ecosystems and the societal challenges they face. Additionally, the word cloud includes terms that represent current innovation practices and newly emerging approaches. The terms were selected based on frequency and emphasis. The varying sizes of the terms correspond to their frequency, whereas the colors of the terms were distributed based on both of these criteria. The word cloud therefore presents the relationships among the various conceptual foundations, several empirical cases, and different methodological approaches to innovation ecosystems. In summary, the provided word cloud graph first visually confirms the results of the thematic analysis. It visualizes the central role of the term “innovation” and presents the many

associations among its dimensions, which are studied from different angles, i.e., theoretical, practical, and governance perspectives.

Figure 2 displays the relative frequencies of the term “innovation”, “ecosystem”, “ecosystems”, “helix”, and “journal” within ten intervals. The most frequently used term “innovation” is displayed in bright green. The terms “ecosystem” and “ecosystems” show relatively stable frequencies; their use increases as innovation develops. The line graph also displays “helix” within all of the intervals. This shows the impact of the triple, quadruple, and quintuple helix approaches on various concepts for promoting innovation.

Figure 2: Frequency distribution: Innovation Ecosystems



Source: Voyant 2.0. (Sinclair & Rockwell, 2026)

Figure 3 presents the term ‘innovation ecosystem’ as the core of the visualization. It is the largest node and the network's root. Other terms in the network are centered on this term and are thus clustered together under the term ‘innovation ecosystem’. This indicates the central position that the term ' innovation ecosystem' holds in the current literature and how it connects with many other themes discussed in the academic environment. Furthermore, there are several secondary nodes, mainly of a thematic nature, connected to the central innovation ecosystem node. These secondary nodes

form several clusters, or groups of nodes, distinguished by different colors and representing thematic communities. There is, for example, a community consisting of nodes for the empirical validation of effects and the academic work of innovation ecosystems (impact, evidence, research). Further communities are distinguished by their geographical scope of application, such as the regional innovation ecosystem, or by different regional contexts, such as China. Further clusters of nodes symbolize the concerns of sustainability and the dynamics of various developments. Other clusters symbolize the process of evolution and the acquisition of new knowledge and insights. Between the core and the peripheral concepts, there are also secondary concepts, and these form connections between the different thematic areas, such as the connection between the themes of impact, evidence, and research and the themes of application in China, as well as in other regional settings around the world, and the themes of sustainability and dynamic development and the required insights for development of these areas.

Figure 3: Network map

Source: VOSviewer (version 1.6.20). Adapted from van Eck and Waltman (2010)

Finally, the next sections provide a comprehensive examination of the emerging themes from the analysis.

4.1. Theme One: Definitional Ambiguity And Conceptual Frameworks

As mentioned above, a major problem with research on innovation ecosystems is the lack of a definition of what constitutes an innovation ecosystem and its components. There is a plethora of frameworks developed by individual researchers to describe the components of an innovation ecosystem. Some of the more notable frameworks for describing innovation ecosystems as networks of firms and other actors include those of Adner (2006) and Autio and Thomas (2014). Other frameworks have been developed to describe innovation ecosystems as socio-technical systems, for example the work of Oh et al. (2016). There are also many frameworks that describe specific aspects of innovation ecosystems. The work of Carayannis and Campbell (2009, 2018, 2022) describes, for example, the role of universities in regional innovation systems, while that of Leydesdorff and Etzkowitz (1998) describes university-industry-government interactions in the Triple Helix model of innovation. The work of Carayannis and Campbell (2012, 2018, 2022) goes on to describe the Quadruple and Quintuple Helix models of innovation, which, in addition to the three HELIXes of the Triple Helix, also include civil society and environmental sustainability.

4.2. Theme Two: Empirical Fragmentation And Sectoral Focus

There is considerable empirical evidence from within single industries or even single companies, but that is not sufficient to allow for generalization. There are few studies that compare across different sectors, even if they use similar methods to analyze the same types of issues. An exception is provided by studies that focus

on sustainability challenges in regional development and on environmental and social innovation through ecosystem approaches. For instance, the I-Reef initiative has been studied by Asefi et al. (2020) and by Lima et al. (2024). Although these studies can highlight key drivers of resilience and scalability within innovation ecosystems, more varied perspectives and a greater use of comparable studies are required.

4.3. Theme Three: Methodological Diversity And Lack Of Convergence

Most of the qualitative studies are based on case studies using grounded theory (Saunders et al., 2009; Strauss & Corbin, 1998). Some studies have used qualitative text analysis and others quantitative content analysis (Van Eck & Waltman, 2010; Sinclair et al., 2026). To synthesize the results of studies on innovation ecosystems, the authors of this thesis have conducted a thematic analysis. In addition, the authors have used a range of bibliometric methods to map the results of studies across bibliographic databases and to analyze large amounts of text (Xu & Li, 2025; Yoon, 2026). For instance, VOSviewer (Xu & Li, 2025) has been used for mapping, and Voyant Tools (Yoon, 2026) for analyzing large amounts of text.

4.4. Theme Four: Emerging Trends In Digital Innovation, Sustainability, And Governance

The fourth group of themes consists of emerging trends in research on innovation ecosystems. The first group of trends consists of research on digital innovation ecosystems, typical for Industry 4.0, artificial intelligence, and the platform economy. Benitez et al. (2020)

study the business models of platform ecosystems. The second group of trends consists of research on sustainability transitions, circular innovation ecosystems, and green technology. Battistella and Attanasio (2026), Bojovic et al. (2025) and Su et al. Su (2025) study the mentioned themes. The third group of trends consists of research on the governance structures of innovation ecosystems. Within this group of trends, Attarpour et al. (2025), Cobben et al. (2026), and Koch et al. (2026) study orchestration and the related institutional settings. The sum of these trends in research on innovation ecosystems will shape the future of this field.

4.5. Theme Five: Project Collaboration, Culture, And Communication

Innovations often occur within the context of projects. A theme that must therefore not be neglected in this connection is how people interact in projects and how they manage differences in their teams. Many case studies of projects from around the world have been written in great detail (Ochieng & Price, 2010–2016). There are also numerous in-depth studies of teams of project managers from around the world working on global projects (Anbari et al., 2010). There are also many studies that, in general terms, examine how communication is planned and managed by project managers. In these studies, solutions are also presented for managing teams and projects to fully leverage differences among team members (Cramton, 2001; Henderson & Louhkiarung, 2010; Love, 2002). Studies on organizations and how they deal with workplace diversity, with a view to gaining a competitive edge, are also highly relevant in this connection (Thomas & Inkson, 2004; Maznevski & Chudoba, 2000). Consequently, when managing projects in global environments, it is

not sufficient to rely solely on project management tools; an understanding of cultural issues and collaboration is also necessary.

4.6. Theme Six: Project Digital Transformation And Sustainable Innovation

This last theme concerns a current new perspective on projects. The perspective in question views projects as no longer being simple and isolated, self-contained events or interventions within organizations. As a rule, projects are the way in which an organization carries out its strategy. In addition to that, a number of new perspectives on projects are currently gaining attention, perspectives that view projects from the angles of digital transformation, of sustainable innovation, and of enhancing organizational capacity for resilience and innovation. In essence, from this new perspective, projects are viewed as being within a system of innovation and as being geared to put into practice a wide variety of sustainable practices and to make use of a wide variety of digital technologies. In summary, projects are now viewed as being strategic, and as being carried out within an organizational and even a societal context in order to achieve their objectives. Finally, the themes are summarized in Table 1, as follows:

Table 1 - Summary of Emerging Themes

Theme	Focus	Representative References	Key Insights
Definitional Ambiguity and Conceptual Frameworks	Lack of consensus on the definition and components of innovation ecosystems; evolution of helix models	(Adner, 2006; Autio & Thomas, 2014; Carayannis & Campbell, 2009, 2018, 2022; Leydesdorff & Etzkowitz, 1998; Oh et al., 2016)	Conceptual fragmentation persists; Triple, Quadruple, and Quintuple Helix models expand perspectives but also multiply interpretations.
Empirical Fragmentation and Sectoral Focus	Studies concentrated on specific industries or regions, with limited generalization	de Vasconcelos Gomes et al., 2018; Faissal Bassis & Armellini, 2018; Ferasso et al., 2018; Lima et al., 2024; Asefi et al., 2020; Xu & Li, 2025)	Localized case studies, including I-Reef models for sustainable regional development, provide contextual insights but fail to generate universal principles of resilience and scalability.
Methodological Diversity and Lack of Convergence	Use of multiple methodological approaches without systematic integration	(Xu & Li, 2025; Yoon, 2026)	Methodological diversity enriches analysis but hinders comparability; integration of thematic analysis with bibliometric and text analysis tools enhances rigor and replicability.
Emerging Trends in Digital Innovation, Sustainability, and Governance	New emphases on digital ecosystems, sustainability transitions, and governance structures	(Attarpour et al., 2025; Battistella & Attanasio, 2026; Benitez et al., 2020; Bojovic et al., 2025; Cobben et al., 2026; Koch et al., 2026; Marchese et al., 2026; Su et al., 2025)	Digital ecosystems drive collaboration and value creation; sustainability and governance are central to adaptability and long-term ecosystem viability.
Project Collaboration, Culture, and Communication	Cross-cultural dynamics and team collaboration.	Ochieng & Price (2010–2016); Love et al. (2008–2016); Cooke et al. (network studies); Hofstede (1991); Thomas & Inkson (2004); Maznevski & Chudoba (2000); Anbari et al. (2010); Cramton (2001); Henderson & Louhkiarung (2010)	Managing diversity and fostering collaboration are critical in global projects, directly influencing outcomes, communication effectiveness, and team cohesion.
Project Digital Transformation and Sustainable Innovation	Emerging perspectives such as digital transformation, sustainability, resilience, and innovation.	Love, Edwards & Irani (2016–2025); PMI Pulse Reports; Turner (2014–2016); Gareis et al. (2020); Carvalho & Rabechini (2017); Silvius & Schipper (2014); Hanelt et al. (2021); Dufresne & Martin (2020); Shenhar (2015)	Projects are evolving into vehicles for organizational and societal change, embedding digital transformation and sustainable innovation into governance, collaboration, and knowledge systems.

Source: Adapted from the authors

5. DISCUSSION

Researchers worldwide have studied a wide range of themes related to innovation ecosystems. The network visualization of themes (Figure 3) conveys the many different perspectives studied by researchers from around the world. There is a clear distinction between empirical research, regional implementations, sustainability-related issues, and conceptual developments. A central question within the scope of this research is the conceptual ambiguity of terms used in research on innovation ecosystems. Adner (2006, p. 78) already defined an ecosystem as a network of interdependent firms, such that their strategies must align with those of other firms and with external factors within the ecosystem. These firms are especially companies that manage their innovation within an ecosystem described by Autio and Thomas (2014, 2022). Until recently, innovation within a company was either managed as

a project or as part of the respective business units. A well-known concept to describe regional systems of innovation is the triple helix model developed by Leydesdorff and Etzkowitz (1998). The quadruple and quintuple helix models developed by Carayannis & Campbell (2009, 2018, 2022, 2026) extend the triple helix model by including civil society and the environmental helix, thereby widening the scope for analyzing ecosystems within this research framework. However, the greater complexity of these models leads to fragmentation in the definitions of terms used for ecosystems and their components, which, in turn, hampers the development of cumulative knowledge and rules to increase resilience and scale up.

There is significant fragmentation in studies of innovation ecosystems. First, many studies focus on specific industries, such as tourism (de Vasconcelos Gomes et al. 2018; Ferasso et al. 2018). Second, many studies focus on specific regional innovation ecosystems (Liu 2017). Recently, some studies have started to focus on the Chinese context. In these studies, local institutions and government policies within ecosystems are analyzed (Xu & Li 2025). However, to identify the principles of ecosystem resilience, more comparative studies across different industries and regions are needed (Chrisman & Carter 2017). The I-Reef initiative is an example of a sustainable innovation ecosystem that is fostering sustainability and resilience (Asefi et al. 2020; Lima et al. 2024). More perspectives are, however, needed to understand the degree to which this innovation ecosystem is scalable in other contexts. Beyond the general characteristics of innovation ecosystems, trends are currently shaping these systems to facilitate the generation of innovations that solve complex problems. With the increasing digitalization, especially in Industry 4.0, innovation ecosystems are influenced by digital processes. Therefore, the ecosystems are

determined by digital transformation processes (Benitez et al., 2020; Liu & Li, 2025; Marchese et al., 2026). As a consequence, especially small and medium-sized enterprises that lack the financial resources to implement digital technologies are facing marginalization. On the other hand, however, the digitalization of innovation ecosystems also leads to new forms of collaboration between companies as well as between companies and research and educational institutions by using digital platforms for communication in order to co-create innovative solutions (Anbari et al., 2010; Cramton, 2001; Love, 2002; Ochieng & Price, 2010–2016). Besides the above-mentioned effects of digitalization, sustainability transitions are also increasingly influencing innovation ecosystems. This is because companies, in the face of climate change and limited resources, have to transform into so-called green companies and introduce corresponding sustainable technologies to develop and implement competitive solutions for markets worldwide. To generate the knowledge needed for the development of such innovations, cooperation among companies, between companies and research and educational institutions, and across regions is needed (Battistella & Attanasio, 2026; Bojovic et al., 2025; Su et al., 2025). The corresponding sustainability transitions, however, require not only changes within companies but also within institutions.

The character of projects within innovation ecosystems and how they are managed are critical issues. Since most companies' innovation activities take place within an ecosystem, individual projects cannot be considered in isolation. Rather, they are a strategic means by which companies can put their innovation and sustainability strategies into practice. There are a number of current studies that deal with collaboration and communication within and between individual projects (Ochieng & Price 2010–2016; Anbari et al.

2010; Cramton 2001; Love 2002). Managing projects is always difficult, but in environments with very different cultures, it is even more complex. The ways in which cultural diversity affects collaboration have been dealt with from a variety of perspectives (Thomas & Inkson 2004). Managing cultural differences is critical in global collaboration.

This study analyzed the current state of knowledge about the innovation ecosystem concept. The core of the innovation ecosystem concept is a network of inter-organizational interactions and collaborations. The variety of topics linked by the innovation ecosystem concept is large and diverse. The major challenge for this field of research is to tackle several serious shortcomings. The lack of sufficient conceptual clarity is the most important of these shortcomings. Many studies and applications of the concept of innovation ecosystems lack definition. This lack of definition refers to both the boundaries of ecosystems and their constituent elements. Moreover, many studies on the innovation ecosystem concept lack sufficient empirical depth and breadth. This means that most studies focusing on the innovation ecosystems concept are restricted to single industries and geographic locations. Finally, there is a serious need for more integrative approaches to the study of innovation ecosystems. This is necessary to increase our understanding of the complex interactions that occur not only within individual ecosystems but also between ecosystems.

To summarize, research on innovation ecosystems can help managers and policymakers foster innovation across industries and regions. It can also help governments and business leaders better manage their ecosystems and make them more resilient. New digital platforms, AI, and other emerging technologies are

increasingly used to create new forms of collaboration and drive innovation. The sustainability transitions, however, require not only new technologies but also changes in institutions and management. The concept of innovation ecosystems can be very helpful for managers and for policymakers.

6. CONCLUSION

Within the framework of the triple helix model of innovation, this study examines innovation ecosystems from a perspective of governance, sustainability, and digitalization. Using thematic analysis and a large-scale bibliometric study, the existing knowledge on the subject is mapped, and the main research themes are connected and explained through the metaphor of an ecosystem. Although the metaphor of an innovation ecosystem has become very popular in both management practice and academic research, many challenges remain to be addressed. Although many studies examine innovation ecosystems and their roles in industries, a lack of a common definition of the term hampers the development of a substantial body of knowledge. The majority of studies so far are based on very limited data from single cases in specific industries and regions. However, due to the recent changes in digitalization, sustainability transitions and governance, new forms and functions of innovation ecosystems are emerging and therefore require new theoretical and practical approaches. For analyzing these transformations, organizations use projects as strategic means to implement their innovation and sustainability-related goals. Thus, studying such projects can reveal how collaboration, culture, and communication at the project level foster greater resilience in innovation ecosystems across global environments. This study is valuable to many studies that have addressed innovation

ecosystems by structuring the existing literature into several themes, which in turn can be of value to both theory and practice. The study can serve as a good point of departure for further developing existing concepts and developing new methodological approaches to the study of innovation ecosystems. For the manager and the policymaker, the study underscores the importance of establishing and orchestrating an effective innovation ecosystem that addresses the challenges of the 21st century while remaining resilient and sustainable. In the end, the study shows that the innovation ecosystems studied in this research are not mere abstractions but practical tools that can be applied by organizations and societies.

7. FUTURE RESEARCH

Future research on innovation ecosystems should attempt to establish a shared definition of the concept. Currently, there is a wide variety of Triple Helix models (including quintuple, quadruple, and other helix models), and there is no agreement on the boundaries or key elements of an innovation ecosystem. Therefore, future research on the topic should aim to produce a shared definition of innovation ecosystems (Adner, 2006; Autio & Thomas, 2014, 2022; Carayannis & Campbell, 2009, 2018, 2022, 2026). A considerable body of research addresses issues within individual industries, such as biotechnology (Chrisman & Carter, 2017; Ferasso et al., 2018), or even within single companies (Koch et al., 2016; de Vasconcelos Gomes et al., 2018) in specific regions. This study is one of the few attempts to look at projects and project-related innovation within and across industries. However, to deepen understanding of the resilience of innovation ecosystems at the cross-sectoral and cross-regional levels, more is needed. A more general understanding of the principles of resilience, scalability, and

the adaptability of ecosystems of all kinds increases the preparedness of companies and other actors to handle external shocks, such as a new pandemic, a financial crisis, or a technological revolution. Third, there is a need for future research on the interplay between digitalization, sustainability and governance within innovation ecosystems. Current and future digital technologies, such as digital platforms, artificial intelligence and Industry 4.0 technologies, will fundamentally change collaboration and value creation (Benitez et al., 2020; Liu & Li, 2025; Marchese et al., 2026). Sustainability transitions, however, require green and circular innovation ecosystems (Battistella & Attanasio, 2026; Bojovic et al., 2025; Su et al., 2025). Finally, the way governance is organized in ecosystems, i.e., how ecosystems are orchestrated, will also determine to what extent such sustainability transitions can be managed (Attarpour et al., 2025; Cobben et al., 2026; Koch et al., 2026). Thus, future research on innovation ecosystems should focus on the interplay among these three dimensions and on how to manage them to balance technological innovation and environmental responsibility with institutional resilience. A final key theme to be tackled in future research on innovation ecosystems is Projects as Strategic Vehicles for Ecosystem Transformation. Within organizations, more and more change and value is created by projects. Of course, not all projects are aimed at change, but for many organizations the value created by a project will not only be measured in financial terms. It also contributes to the organization's sustainability agenda. The key challenge here is creating the necessary collaboration, culture, and communication within and around a project. Here, various strategies organizations use to address diversity in projects can be identified (Thomas & Inkson, 2004). Future research will focus on the opportunities arising in

innovation ecosystems and on the different ways stakeholders can address them.

Competing Interests

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