Review of Managerial Science (2022) 16:249–282
https://doi.org/10.1007/s11846-020-00439-4

REVIEW PAPER

Species in the wild: a typology of innovation ecosystems

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Received: 24 March 2020 / Accepted: 29 December 2020 / Published online: 20 January 2021

Abstract
The purpose of this paper is to offer a comprehensive and useful typology of innovation ecosystems. While recent conceptual efforts have been allocated to delineating innovation ecosystems from other phenomena, much less systematic attention has been given to the diversity found within the innovation ecosystem realm. We run a thematic analysis of systematic literature reviews and collect 34 specific types of innovation ecosystems. We expand this list with criteria-derived complementary types and propose a set of 50 distinct innovation ecosystem varieties. Next, we identify the 14 typology criteria used so far in the literature, thematically analyse them and aggregate them into a set useful for further rigorous scrutiny and for the incremental collection of empirical findings. Innovation ecosystems can thus be categorized into (1) life cycle, (2) structure, (3) innovation focus, (4) scope of activities, and (5) performance.

Keywords Innovation ecosystems · Co-innovation · Co-creation · Typology · Open innovations

JEL Classification L20 · L25 · L26 · O36

1 Introduction

J.F. Moore was the first to use the concept of a business ecosystem, wherein organizations "*coevolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually*

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incorporate the next round of innovations" (Moore 1993, p. 76). Moore's seminal paper triggered a whole new way of perceiving the business environment, which, in contrast to the traditional industry organization framework developed by M.E. Porter, considers the environment as a system not limited to one single industry, not limited only to organizations, and mutually interdependent (Teece 2007).

Prior literature reviews have identified several different varieties of ecosystems, such as industrial, innovation, business, digital and entrepreneurial ecosystems (Pilinkiene and Maciulis 2014); business, knowledge and innovation ecosystems (Valkokari 2015); business, innovation, entrepreneurial & start-up, platform and service ecosystems (Aarikka-Stenroos and Ritala 2017); and business, innovation, entrepreneurial (entrepreneurship) and knowledge ecosystems (Scaringella and Radziwon 2018). This paper focuses on innovation ecosystems (IE) as they are gaining in importance and popularity in both innovation and strategic management. Furthermore, as they are crucial for development of new or young ventures and increase in the likelihood of firm survival, therefore for entrepreneurship at individual, organizational, and regional levels (Kraus et al. 2020b).

After two decades of fruitful application of the innovation ecosystem concept in a variety of contexts and ways, there are presently a wide array of definitions for the term (Wei et al. 2020), with only very recent efforts aimed at forging a consensual definition (Granstrand and Holgersson 2020; Rabelo and Bernus 2015; Valkokari 2015). Variations in definitions hamper dialogue across streams of research, disconnect conversations, confuse (Maitlis and Christianson 2014), impede the accumulation of coherent empirical evidence and the development of measurement, and hinder research progress in general (Venkatraman 1989). It is therefore critically important to rigorously define concepts and look for consensus in emerging fields of research (Kang et al. 2019). Consensual definitions are essential in academic disciplines in order to maintain their distinctiveness and collective identity (Nag et al. 2007). This process is challenging due to ecosystems' substantially polymorphic nature (Aarikka-Stenroos and Ritala 2017; Scaringella and Radziwon 2018; Tsujimoto et al. 2018; Valkokari 2015), which results in overlaps among different types of ecosystems (Aarikka-Stenroos and Ritala 2017), and partial overlaps with similar concepts such as networks, chains or clusters (Carayannis and Campbell 2009). Two conceptual challenges are related to defining innovation ecosystems: delineation and typology. While delineation has recently received rigorous attention (Granstrand and Holgersson 2020), typology has not. Our study aims to fill this gap and thus contribute to the advancement of innovation ecosystem research.

Therefore, this paper aims to offer a synthesis of innovation ecosystem delineation and to develop a typology useful in further empirical research. Using a critical analysis of systematic literature reviews and a thematic analysis, our study provides 5 generic typology criteria, encapsulating 14 literature-derived typology criteria, and identifies 50 different types of innovation ecosystems.

The remainder of this paper is divided into four sections. The following section focuses on delineating innovation ecosystems. The third section explains our methodological approach. In the fourth section we outline the typology emerging from our thematic analysis and the developmental process. Conventionally, the last part

of the paper points to the theoretical contributions, outlines the main limitations and identifies directions for further research.

2 Understanding of innovation ecosystems

The last decade has witnessed dynamic growth in the popularity of innovation ecosystems research among scholars (Beliaeva et al. 2019; Kang et al. 2019; Liguori et al. 2019; Su et al. 2018; Xu et al. 2018; Bacon et al. 2020) accompanied by a "*burgeoning interest*" among practitioners and policymakers (Dedehayir et al. 2016, p. 9). Innovation ecosystems are depicted as a dominant concept in innovation management (Jucevicius et al. 2016), allowing research in the field of innovation management to be carried out in a particularly timely and accurate manner. The ecosystem concept takes into account the progressive externalization, systemic coimplementation and networking of innovation (Ritala and Almpanopoulou 2017, p. 39) typical for the current business environment. Innovation ecosystems are attributed with exerting a multilevel impact on innovation: they enhance innovation capability (Pellikka and Ali-Vehmas 2018) and the innovation performance of actors (Song 2016), as well as increasing the innovation performance of the entire ecosystem (Talmar et al. 2018). Innovation ecosystems correspond perfectly with the recent interest in various forms of customer engagement in new product development processes. What is more, communities of interest and communities of users are also viewed as a meaningful component of innovation ecosystems (Autio and Thomas 2014; Russell and Smorodinskaya 2018). All in all, the involvement of additional actors such as customers and communities in innovation ecosystems is a distinctive feature when compared to other types of ecosystems (Gomes et al. 2018; Oh et al. 2016; Valkokari 2015).

Innovation ecosystems have also become a relevant research stream in strategic management as they impact a firm's strategy and performance (Luo 2018) through an increase in firms' profitability, shorter time-to-market, enhanced market access (Pellikka and Ali-Vehmas 2018) and improved new product development (Bouncken et al. 2018). From a more longitudinal perspective, engagement in an innovation ecosystem brings strategic advantages stemming from relationships with other actors through competition, cooperation or coopetition. Competitive advantages accrue on the part of those involved in innovation ecosystems as opposed to those outside of innovation ecosystems. Collaborative advantages are rooted in relational rents (Dyer and Singh 1998) as well as in social relationships of manegers (Glińska-Neweś et al. 2018), and are exploited under relational strategies (Zakrzewska-Bielawska 2019). It is emphasized that they encourage radical innovations (Bouncken et al. 2018) as well as innovations of business models (Bouncken and Fredrich 2016). At the same time, coopetition within the innovation ecosystem brings the advantages of both competition and cooperation (Bacon et al. 2020), and is usually at more beneficial levels than those based on being "*just competitive*" or "*just cooperative*" (Bouncken et al. 2015; Ritala et al. 2013, 2016; Gawer and Cusumano 2014). Finally, when compared to other types of ecosystems, innovation ecosystems seem to be the most strategically oriented (Beliaeva et al. 2019; Granstrand and Holgersson 2020). The

latest findings from a review of the literature suggest that four out of six IE contexts refer directly to strategy, i.e. ecosystem strategy, innovation strategy, management strategy and orchestration strategy (Yaghmaie and Vanhaverbeke 2019). The popularity of the innovation ecosystem in various research streams adds to the ambiguity of the concept. Below, we delineate innovation ecosystems from other ecosystems and offer a narrow definition focused on their key component, that is relationships (Granstrand and Holgersson 2020).

2.1 Delineating innovation ecosystems from other ecosystems

The use of ecosystem concepts and related approaches has spawned studies across the literature (Adner 2017; Tsujimoto et al. 2018; Liguori et al. 2019). This development induces an increase in knowledge, including the emergence and exploration of different types of ecosystems (Aarikka-Stenroos and Ritala 2017; Pilinkiene and Maciulis 2014; Scaringella and Radziwon 2018; Valkokari 2015), acknowledged as overlapping (Scaringella and Radziwon 2018), intertwined (Valkokari 2015) and interdependent (Xu et al. 2018). Some scholars propose viewing innovation ecosystems as a meta-ecosystem comprising of three mutually intertwined layers: a science ecosystem, a knowledge ecosystem and a business ecosystem (Xu et al. 2018). This view offers the benefit of complexity, and the prevalence of the innovation ecosystem over others qualifies it as a higher-order concept.

However, a sustained research stream identifies several delineation criteria that distinguish innovation ecosystems from other ecosystems (Aarikka-Stenroos and Ritala 2017; Pilinkiene and Maciulis 2014; Rohrbeck et al. 2009; Scaringella and Radziwon 2018; Valkokari 2015; Vasconcelos Gomes et al. 2018). Clarysse et al. (2014) differentiate knowledge and innovation ecosystems using several criteria, that is: aims, relationships and actors. Pilinkiene and Maciulis (2014) use type of environment, actors, micro and macro outputs, and key success indicators to differentiate industrial, innovation, business, digital and entrepreneurial ecosystems. Valkokari (2015) identifies three distinct types of ecosystems: business, innovation and knowledge, by analysing their aims, internal relationships, levels of interconnection of actors, roles adopted by actors, and the general logic of each ecosystem type. In a more territorial perspective, Scaringella and Radziwon (2018) clearly delineate innovation, business, knowledge and entrepreneurial ecosystems in terms of geographical scope, values, stakeholders, importance and types of economic and social issues, knowledge and outcomes. Finally, Aarikka-Stenroos and Ritala (2017) point to geographical scope, actors, and actor-related issues (e.g. particular goals, values and beliefs followed by them) as a reasoned approach for distinguishing between business, innovation, entrepreneurial, platform and service ecosystems. The pool of differentiation criteria is quite broad, which suggests that scholars see innovation ecosystems as different in many respects from other ecosystems.

Furthermore, value creation and value capture appear as key characteristics for delineating innovation ecosystems (Gomes et al. 2018). An important criterion that allows business, knowledge and innovation ecosystems to be distinguished is the type of actors' and ecosystem's orientation towards current and/or future customer

value creation (Valkokari 2015). We posit that the underlying basis of co-created value can also be used as a differentiation criterion. Different types of co-creation relationships constitute different ecosystems. Indeed, business ecosystems consist of co-creation relationships aimed at joint creation of up-to-date and competitive value propositions. In the case of knowledge ecosystems, new, original and jointly created knowledge is the root of the value co-created by actors. In turn, innovation ecosystems operating as co-innovation processes co-create value based on co-innovation. In this perspective, every ecosystem targets value co-creation and consists of co-creation relationships.

In innovation ecosystems, co-created value is based on innovations, specifically on co-innovations, which are reached through the exploitation of innovation co-creation relationships. Innovation co-creation relationships are a specific type of co-creation relationships (Klimas 2019; labelled also as ecosystem relationships—Vargo 2009), as one of the external, relational resources of an organization targeting value co-creation through the implementation of co-innovation processes. These relationships are instrumental in innovation processes with the support of external partners in delivering innovations to the market. We propose that innovation co-creation relationships are distinctive to the innovation ecosystem concept as they allow the actors and the entire ecosystem to co-create value resulting from co-innovation (Aarikka-Stenroos and Ritala 2017).

In innovation ecosystems, other types of co-creation relationships are also utilized, such as: knowledge co-creation relationships distinctive for knowledge ecosystems, business model co-creation relationships distinctive for business ecosystems, or venture co-creation relationships distinctive for entrepreneurial ecosystems (Beliaeva et al. 2019; Kang et al. 2019). Indeed, the various types of ecosystems are acknowledged as being highly interpenetrating (Scaringella and Radziwon 2018; Valkokari 2015; Xu et al. 2018). However, without innovation co-creation relationships, innovation ecosystems cannot be delineated from others.

2.2 Defining the innovation ecosystem concept

Innovation ecosystems differ significantly and multidimensionally from other types of ecosystems (Ferasso et al. 2018; Gomes et al. 2018), and are attracting a strong and rapidly growing interest among scholars, practitioners and policymakers (Tsujimoto et al. 2018; Yaghmaie and Vanhaverbeke 2019). This results in a rapidly growing stock of knowledge including theoretical propositions, conceptual considerations, analyses of practical examples and findings from explorative case studies. At the same time, the current knowledge on the innovation ecosystem lacks integration (Durst and Poutanen 2013; Gomes et al. 2018; Granstrand and Holgersson 2020; Bacon et al. 2020). Solid, coherent knowledge on innovation ecosystems is nascent and remains fragmentary (Russell and Smorodinskaya 2018). Indeed, it is still described as frugal and ambiguous when compared to business ecosystems literature (Oh et al. 2016). A major reason for this is the diversity of existing innovation ecosystems. Conceptual rigour and clarity call for its varied manifestations to

be delineated from related concepts, its key characteristics to be identified, and identification of classification criteria to be conducted.

Generally, innovation ecosystems are seen as the "*most prominent type of environment*" (Rabelo and Bernus 2015, p. 2250), crossing the borders of a single industry or sector (Autio and Thomas 2014) and giving a multidimensional, complex context for any entrepreneurial activities (Vasconcelos Gomes et al. 2018) that result in innovation (Beliaeva et al. 2019; Valkokari 2015). Nonetheless, as in the case of ecosystems, the literature does not provide one widely recognized definition of the innovation ecosystem. The diversity and abundance of conceptualizations, definitions, operationalizations, structural approaches or even terms and labels (Oh et al. 2016) is substantiated in available systematic literature reviews, including interpretative (Tsujimoto et al. 2018), hybrid (Gomes et al. 2018) and meta-analytical (Ferasso et al. 2018) ones. Nevertheless, prior conceptualizations are mostly compatible with one another (Gomes et al. 2018), and the adoption of a particular conceptualization depends on the reference theories underlying the particular aspects of innovation ecosystems explored in a particular study (Shaw and Allen 2018). Therefore, one can find the chaos (e.g. see different views presented in Table 2 in Wei et al. 2020, p. 5) that exists in the definitions and labels used (Gomes et al. 2018) as a rationale for paying greater attention to conceptual choices and requirements of methodological rigour (Ritala and Almpanopoulou 2017). Recent studies outline several flaws in the available conceptualisations, and from rigorous identification of the shortcomings of prior works, derive a definition that underscores the importance of relationships, actors and artifacts (Granstrand and Holgersson 2020).

Given the content of the existing definitions of innovation ecosystems, the similarities among them, and the main foci adopted by the authors (Table 1), we see the innovation ecosystem as a *cooperation environment surrounding the innovation activities of its co-evolving actors, organized across co-innovation processes, and resulting in co-creation of new value delivered through innovation*.

Innovation ecosystems are not restricted either to one co-innovation process or to innovation processes carried out by one focal actor. In our understanding, the innovation ecosystem encapsulates the innovation processes run by involved actors if these processes are deployed with external support from the innovation ecosystem. Therefore, we extend the construct beyond an ego-centric perspective, where innovation ecosystems are defined from the focal firm's perspective (Holgersson et al. 2018; Jucevičius and Grumadaitė 2014; Pombo-Juárez et al. 2017; Song 2016; Yaghmaie and Vanhaverbeke 2019). We incorporate parallel innovations within the boundaries of innovation ecosystems (Rubens et al. 2011, p. 1743).

The proposed way of understanding the innovation ecosystem corresponds to a recent ecosystem definition: *"the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize"* (Adner 2017, p. 40). Our definition focuses on the scope of interaction, which is the joint realization of innovation processes within innovation ecosystems. When engaging other actors, these activities become co-innovation processes. Secondly, within innovation ecosystems, the co-created and delivered value is based on

Table 1 Definitions of innovation ecosystems

Author(s) (year)	Definition	Main focus
Adner (2006, p. 98)	"The collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution"	Value co-creation
Rubens et al. (2011, p. 1743)	"The "creation nets" that provide a mechanism for "(a) goal-focused creation of new goods and services tailored to rapidly evolving market needs, (b) with multiple institutions and dispersed individuals, (c) for parallel innovation"	Co-innovation
Jucevičius and Grumadaitė (2014, p. 125)	"A smart system that is explained by the characteristics of complex adaptive systems (mutual adjustments and flexibility ensured by the possibility of exploitation of both bottom-up and top-down developmental initiatives and pro-innovative actions)"	Co-evolution
Autio and Thomas (2014, p. 3)	"A network of interconnected organizations, organized around a focal firm or a platform, and incorporating both production and use side participants, and focusing on the development of new value through innovation"	Value co-creation
Dedehayir et al. (2016, p. 2)	"A heterogeneous constellation of organizations, which co-evolve capabilities in the co-creation of value"	Co-evolution
Jucevicius et al. (2016, p. 430)	"A complex network of interactions between the actors from industry, government and academia that underlies the innovative activities and performance in the area"	Co-innovation
Mazzucato and Robinson (2018, s. 3)	"The network of interconnected actors, organized around a particular value chain/industry where the actors include public agencies, firms, intermediaries and any other actor that contributes to the production and use of a product or service stemming from that value chain/industry"	Co-innovation
Aarikka-Stenroos and Ritala (2017, s. 25)	A type of "ecosystem consisting of actors, technologies and institutions that enable innovation (…) characterized by innovation-driven goals and related uncertainties over value creation and capture"	Co-innovation
Schroth et al. (2018, p. 3)	"The dynamic and co-productive space in which industrial R&D&I takes place, highlighting both interdependencies between organisations and the co-evolution of value"	Co-evolution
Vasconcelos Gomes et al. (2018, p. 165)	"A theoretical perspective for investigating the phenomenon of managing uncertainties that affect external interdependent actors in a network of value co-creation. (…) A network of counterparties connected to jointly create value (…) fundamental to successful development and commercialization of a complex innovation"	Co-innovation
Shaw and Allen (2018: 88; 90)	"The pathways of interlinked business models; the flow of services to a customer and resources related to that customer, which are recycled by business models linked into pathways; powered by value co-creation for stakeholders; innovation in the form of new business models that reuse scarce customer-related resources in new ways or in ways that co-create value more directly, e.g. organising around a common customer journey"	Value co-creation

Table 1 (continued)

Author(s) (year)	Definition	Main focus
Dattee et al. (2018, p. 467)	"The collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution (Adner 2006, p. 98), usually based on a technology platform: a set of shared assets, standards and interfaces that underpins an activity system surrounding it (Gawer and Cusumano 2014; Thomas et al. 2014)."	Co-innovation
Yaghmaie and Vanhaverbeke (2019: 2)	"A group of organizations that aim to jointly create and capture value from joint innovation activities" (technical or business related innovations)	Co-innovation

Source: own elaboration based on Klimas (2019)

Table 2 Reviews of literature on ecosystems and innovation ecosystems

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
The scope: innovation ecosystems							
Durst and Poutanen (2013)[b]	Systematic	2006–2012	Web of Science, Proquest ABI, INFORM, EBSCO	Scientific articles including empirical findings	9	Success factors facilitating implementation of innovation ecosystems	Innovation (138); ecosystems (86); research (37); factors (26); review (22); different (19); study (17); success (17); systems (17); communities (14)
Oh et al. (2016)	Interpretative, critical	ND	ND	ND	ND	Applicability of the ecosystem concept in the field of economics and management. A critical view on types, opportunities, challenges, benefits, limitations, etc. within innovation ecosystems	Innovation (131); ecosystem (117); system (43); research (21); industry (18); government (16); development (16); natural (14); different (13); support (12); technology (12)
Dedehayir et al. (2016)	Systematic	2003–2015	ISI Web of Knowledge	Scientific articles and conference papers	60	The roles to be played by actors of innovation ecosystems in the birth phase of the IE life cycle	Ecosystem (337); roles (192); innovation (113); actors (89); value (79); activities (70); genesis (57); products (50); birth (46); leader (45)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
Ferasso et al. (2018)	Systematic, metasynthesis	2009–2014	Periodicals CAPES	Scientific articles including case study analysis	6	Analysis of conceptual frameworks adopted in prior case study-based studies aimed at determination of distinguishing features of innovation ecosystems. Additionally, identification of main contributions provided by qualitative works on IE	Innovation (210); ecosystem (164); organizations (105); research (105); papers (95); concept (80); case (61); contribution (41); resources (39); relationships (39)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
Gomes et al. (2018)	Systematic, hybrid	1993–2016	Web of Science	Scientific articles	125	Evolution and development of IE concept including differentiation of IE from business ecosystems. Identification of the leading theoretical lenses, seminal publications and the most influential authors. Identification of the leading and most promising research streams	Ecosystem (469); innovation (313); business (163); articles (119); value (95); network (87); research (85); management (74); firms (73); concept (71)
Yaghmaie and Vanhaverbeke (2019)	(grey) Systematic	2004–2018	Google Scholar	Articles and graduate theses	33	Analysis of application contexts used in prior works on IE, e.g. industries, the level of analysis, the main actors and success factors. Extensive, comparative summary of prior research	Ecosystem (273); innovation (237); orchestration (78); studies (69), value (67); actors (66); Adner (60); partners (52); management (50); firms (50)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
The scope: ecosystems							
Valkokari (2015)	Critical	ND	ND	ND	ND	Differentiation of business, knowledge and innovation ecosystems. Analysis of the main features and interlinks among them. Adopted typology of ecosystems: business, innovation and knowledge	Ecosystem (169); different (43); innovation (39); business (39), actors (36); knowledge (31); research (25); interaction (24); types (24); relationships (15); management (15)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
Aarikka-Stenroos and Ritala (2017)	Systematic	1999–2016	4 journals: JBR, JBIM, IMM, JBBM	Scientific articles	71	The main themes, conceptualisations and research approaches in prior works using "ecosystem" in B2B investigation. Implications of the ecosystem concept for strategic management and network management in particular. Adopted typology of ecosystems: business, innovation, entrepreneurial, platform and service	Ecosystem (370); business (166); network (152); actors (108); research (108); management (97); approach (83); studies (73); innovation (70); value (65)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
Tsujimoto et al. (2018)	Interpretative, *quasi*-systematic	1995–2014	Scimago Lab	Scientific articles	90	Identification of the main research streams within the concept of ecosystems. Adopted typology of ecosystems: none—ecosystems considered in general terms	Ecosystem (248); research (88); concept (75); management (72); papers (69); actors (63); innovation (59); network (47); studies (47); industrial (46)

Table 2 (continued)

Author(s) (year)	Methodological approach	Timespan of analysed works	Source of analysed works	Types of analysed works	Number of analysed works	Leading line of analysis	Most frequently used words within the text[a]
Scaringella and Radziwon (2018)	Systematic	2004–2015	Web of Science, and Scopus	Scientific articles and monographs	104	Ecosystem archetypes, the leading reference theories and types of ecosystems applicable in management studies. Discussion of ecosystems in the context of other regional and geography-related ways used in interorganisational cooperation, innovation, and regional development. Adopted typology of ecosystems: business, innovation, entrepreneurial/entrepreneurship and knowledge	Ecosystem (341); innovation (149); knowledge (148); territorial (117); approach (115); local (87); industrial (87); business (81); firms (71); research (70)

ND no data

[a]The content of the literature reviews (not including acknowledgments and references) was subject to frequency analysis with the use of tagcrowd.com. The analysis provided information about the 50 words that appeared most often within the papers. The column presents the 10 highest scores

[b]Note: some of the analysed papers refer to business (not innovation) ecosystems

co-innovations.[1] Finally, innovation ecosystem actors can engage in either cooperation or coopetition. Indeed, many actions undertaken within innovation ecosystems bring competitors (Holgersson et al. 2018; Talmar et al. 2018; Walrave et al. 2018; Bacon et al. 2020), even direct ones (Planko et al. 2017), to collaborate with one another because of the need for innovation.

Summing up, the literature published to date displays a broad variety in the way innovation ecosystems are understood (Durst and Poutanen 2013; Granstrand and Holgersson 2020). Given the wide range of terminological (Oh et al. 2016), definitional (Gomes et al. 2018; Granstrand and Holgersson 2020; Yaghmaie and Vanhaverbeke 2019), and methodological (Aarikka-Stenroos and Ritala 2017; Ritala and Almpanopoulou 2017) inconsistencies, it is important to critically analyse and synthesize the existing state of knowledge to pave the way for accumulation of effective empirical knowledge. In particular, we deem it relevant to pay attention to the types of innovation ecosystems, how they are understood and the criteria used to group them. Among the gaps and shortcomings discussed in the literature on innovation ecosystems, there is a clear indication that "*the literature does not yield a firm typology of innovation ecosystems"* even though *"the term is mentioned in several contexts*" (Oh et al. 2016, p. 3). Our study addresses this gap.

3 Methodology

Our study aims to develop a typology of innovation ecosystems useful in further empirical research. To this end, it is necessary to identify relevant differentiation criteria and corresponding types of innovation ecosystems. We start by identifying a literature-derived inventory of types and typology criteria. Next, we conduct a thematic analysis (Czakon and Czernek-Marszałek 2020) to aggregate typology criteria by similarity and relatedness. Finally, we extend the list of innovation ecosystem types with logically complementary types according to each of the typology criteria. Our approach to reviewing is qualitative as the field of interest in IE is too recent to carry out extensive literature reviews by applying bibliometric analyses or meta-synthesis to provide more quantified conclusions about the current stock of knowledge (King and He 2005). Differently from literature reviews on entrepreneurship (Ferreira et al. 2019; Kraus et al. 2020a), knowledge management (Pellegrini et al. 2020), or entrepreneurial ecosystems (Kang et al. 2019; Liguori et al. 2019), the field of innovation ecosystems requires integration (Granstrand and Holgersson 2020) as it is too early for systematization, cluster aggregation or citation mapping.

3.1 Literature review process

The primary source of the state-of-the-art knowledge used in our study were previously published literature reviews on innovation ecosystems. Prior literature reviews

[1] See the differences in the scope and meaning of open innovation, collaborative innovation and co-innovation (Lee et al. 2012).

have summarised and integrated the current stock of knowledge on innovation ecosystems in terms of adopted theoretical frameworks (e.g. Yaghmaie and Vanhaverbeke 2019), findings and contributions (Durst and Poutanen 2013; Ferasso et al. 2018; Gomes et al. 2018); relevant cognitive gaps (Gomes et al. 2018), types of published works (Dedehayir et al. 2016), applied research methods (Gomes et al. 2018), adopted conceptual and industry context (Yaghmaie and Vanhaverbeke 2019), and the most promising benefits and main limitations of the application of the innovation ecosystem approach within innovation and strategic management research (Oh et al. 2016). Furthermore, a review carried out by Gomes and colleagues (Gomes et al. 2018) provides insightful findings from bibliometric analyses, such as the identification of seminal papers and the most often cited authors, analysis of networks of references, co-citations, and cross-citations which might be useful when making any conceptual, methodological or research choices. Thus we were able to map how innovation ecosystem scholars view the concept, what is their shared understanding and how this understanding can feed further research (Roth et al. 2017).

We decided to start with a critical, thematic analysis focused on several available literature reviews that are rigorous in terms of applying a systematic approach or hybrid approach linking qualitative content analysis with quantitative bibliometric techniques. Such an approach is used in research domains that are similar by novelty, are rapidly growing and are conceptually diverse (Czakon et al. 2020). Typically, in the systematic approach (Ferreira et al. 2019; Pellegrini et al. 2020; Kraus et al. 2020a), two academic databases are used (Ebsco and Scopus) to gather relevant and reliable reviews covering works from the field of management. Nonetheless, to ensure broader coverage, two sources of grey literature were also used, namely Google Scholar.com and ResearchGate.net. During the literature collection process, we applied the following searching criteria: "*innovation*" AND "*ecosystem**" AND "*review*" in the title, "*innovation*" AND "*ecosystem**" in the title and "*review*" in the keywords, "*ecosystem**" AND "*review*" in the title, "*ecosystem**" in the title and "*review*" in the keywords. Our initial literature search identified 10 literature reviews published between 2013 and 2019, including 6 reviews specifically focused on innovation ecosystems (Table 2).

We used these prior reviews as our starting point. Next, for more granularity, we examined individual papers analysed in the identified literature reviews, and ran our own review process in order to supplement the literature database with original and as yet unprocessed findings on different types, forms or variations of IE.

3.2 Thematic analysis and aggregation

To grasp the comprehensive scope of the theoretical and conceptual aspects of innovation ecosystems, we examined the findings from both literature reviews on innovation ecosystems (the upper part of Table 2) as well as the latest literature reviews on ecosystems, as the latter might reveal the distinguishing features of IE and justify their importance in comparison to other types (the lower part of Table 2). Next, we ran a thematic analysis in view of identifying themes within the data (Braun and Clarke 2006; Dabić et al. 2020). By theme, we mean the type, characteristic or

criterion for typology used in prior literature reviews or individual articles. Characteristics help in grouping innovation ecosystems by similarity or relatedness, whereas types are labels used to refer to a set of similar innovation ecosystems. We therefore use a semantic level of analysis, that is we do not look for meanings that prior literature has not explicitly referred to. In line with the systematic approach to reviewing (Pellegrini et al. 2020), we performed our thematic analysis and aggregation without subjectively pre-determined differentiation criteria or innovation ecosystem types.

The literature analysis was run independently by two researchers, and the results were discussed in turn in view of extracting triangulated and congruent types of innovation ecosystems, as well as typology criteria. We also triangulated the typology criteria and changed the subsequent type lists, as well as agreed the final proposition by consensus.

4 The typology of innovation ecosystems

Interestingly, no previous literature review, be it focused on innovation ecosystems or on ecosystems in general, was specifically aimed at developing a typology of innovation ecosystems. Moreover, the need for granularity, segmentation and innovation ecosystem differentiation has been pointed out as a relevant research gap. For instance, the lack of research on the characteristics of innovation ecosystems (Gomes et al. 2018; Su et al. 2018), the lack of research on the distinguishing features of innovation ecosystems (Oh et al. 2016; Scaringella and Radziwon 2018; Valkokari 2015), or methodological shortcomings in conceptual papers resulting in a selective and too narrow approach to theoretical considerations (Aarikka-Stenroos and Ritala 2017; Dattee et al. 2018; Oh et al. 2016; Ritala and Almpanopoulou 2017). Furthermore, as shown by Oh et al. (2016), even though there are many blurry, fragmentarily recognized and proven aspects related to innovation ecosystems, these are complex phenomena that take many different forms in business practice. To the best of our knowledge, these forms, their characteristics and ways of aggregation have not as yet been addressed.

So far, studies that have considered types of innovation ecosystems have done it selectively and in isolation from the broader framework or previous recommendations. As a result, while various innovation ecosystems can be identified, this diversity does not meet the requirements of a logical division of theoretical constructs, and consequently does not help in cumulative knowledge creation. In particular, existing considerations on IE types are not comprehensive as only single characteristics were considered, while others were overlooked. Even complementary types to those under investigation are missing (e.g. addressing profitable IE while omitting unprofitable ones, addressing ego-centric IE while omitting eco-centric ones, or addressing intentional/deliberate/planned IE while omitting emergent/implicit ones). Furthermore, the prior literature does not offer sets of differentiation criteria or typology.

Table 3 Typology of innovation ecosystems

Criteria category	Typology criteria	Types of IE	Characteristics
Genesis and existence of innovation ecosystem	Ecosystem birth	Intentional (deliberate, planned)	Purposefully created by focal firms or market players with above-average market power. The moment of an ecosystem's birth depends on the focal firm's decision
		Emergent (implicit)	Emerging spontaneously. Non-intentional ecosystem emergence requires time counted in decades, thus it is hard to identify the moment of its birth
	Governance mechanism	Orchestration (hierarchy)	The ecosystem is orchestrated by the dominant actor, usually a producer. Such type of IE is usually tightly and autonomously managed by the hub firm
		Collectively coordinated (heterarchy)	Governance mechanisms are driven collectively by a set of actors—usually companies with access to strategic resources. Such a type of IE is usually loosely managed
		Self-coordination	The actors do not pay attention to ecosystem coordination. Such a type of IE is usually not managed but rather coordinated ad hoc
	Life cycle stage	Emerging	Ecosystems in the birth phase. In a more detailed view, this stage can be divided further into the preparation, formation and operation phases (Dedehayir et al. 2016)
		Developmental	Developing in terms of the number of actors engaged in co-realized innovation processes
		Mature	Both the innovation ecosystem activity and its structure are stabilised, thus the dominant actors' behaviours are rather co-adaptative and co-evolutionary

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
		Declining	The number of actors and innovation co-creation relationships decreases. The co-adaptative and co-evolutionary behaviours of actors get weaker. The focus of value creation is (if at all) paid rather to incremental innovations, while the co-innovation processes concentrate more on later stages
		Death	The innovation ecosystem does not exist—some of the actors are operating on the market as they are trying to take the final benefits from collectively implemented innovation processes under the historic innovation ecosystem (e.g. the case of the IE operating in the Detroit district—Arena et al. 2018)

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
Structure of innovation ecosystem	Actors	Symmetrical	Actors manifest a similar involvement in co-innovation processes
		Asymmetrical	Actors manifest a diversified involvement in co-innovation processes (e.g. corporate IE with the dominant engagement of private firms—Oh et al. 2016; university-based IE with the dominant engagement of universities— Wu et al. 2018)
		Centralized	There is a dominant actor (the focal firm) undertaking a leadership role, the essence of which is the orchestration of the innovation ecosystem
		Decentralized	There is no dominant/focal actor
	Innovation co-creation relationships	Ego-centric (firm-centric; hub-based)	IE considered from the perspective of the focal firm responsible for the product launch and its direct (one-way, bidirectional and multi-directional) innovation co-creation relationships maintained with other actors of IE
		Eco-centric	IE considered from the perspective of different actors and either their direct or indirect (one-way, bidirectional and multidirectional) innovation co-creative relationships with the companies responsible for the product launch

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
Leading innovation focus within innovation ecosystem	Innovation scope	Microscopic	The main focus is placed on the elements/implementation/outcomes of co-innovation, collaborative innovation or open innovation at the organisational level
		Middlescopic	The main focus is placed on the elements/implementation/outcomes of co-innovation, collaborative innovation or open innovation at the industry/regional level
		Macroscopic	The main focus is placed on the elements/implementation/outcomes of co-innovation, collaborative innovation or open innovation at the national/international level
	Innovation type	Focused on disruptive innovation	Targeting market-breaking innovations (e.g. IE related to NASA)
		Focused on radical innovation	Targeting pure innovations based usually on new technologies
		Focused on incremental innovation	Targeting innovations based on changes, adjustments or development of existing solutions
		Focused on social innovation	Targeting social innovations focused on meeting social needs in a better way than before
		Focused on path-breaking innovations	Targeting innovations breaking simultaneously current technology, market structure and the way of meeting social needs
	Intensity of co-innovation process	Narrowed to co-Discovery	A priority importance of cooperation, a domination of exploitation of innovation co-creation relationships and the highest impact on value co-creation at the Discovery stage of the innovation process

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
		Narrowed to co-Development	A priority importance of cooperation, a domination of exploitation of innovation co-creation relationships and the highest impact on value co-creation at the Development stage of the innovation process
		Narrowed to co-Deployment	A priority importance of cooperation, a domination of exploitation of innovation co-creation relationships and the highest impact on value co-creation at the Deployment stage of the innovation process
		Narrowed to co-Delivery	A priority importance of cooperation, a domination of exploitation of innovation co-creation relationships and the highest impact on value co-creation at the Delivery stage of the innovation process
		Narrowed to co-Dissemination	A priority importance of cooperation, a domination of exploitation of innovation co-creation relationships and the highest impact on value co-creation at the Dissemination stage of the innovation process
		Adopting a multi-stage co-innovation focus	Multi-stage cooperation across the innovation process, exploitation of innovation co-creation relationships at different stages of the innovation process, a dispersed process of value co-creation among different stages of the innovation process

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
Range of innovation ecosystem	Technological scope	High-tech	Operating around the industry (industries) classified as a high technology industry according to regulations developed by the OECD
		Medium-tech	Operating around the industry (industries) classified either as a medium–high or medium–low technology industry according to regulations developed by the OECD
		Low-tech	Operating around the industry (industries) classified as a low technology industry according to regulations developed by the OECD
		Mono-platform	Operating around one technological platform
		Multi-platform	Operating around more than one technological platform

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
	Spatial range	City-based/innovation districts	In the physical sense, the structure of IE does not extend beyond one city or industrial district. Usually, this type of ecosystem is led by municipal authorities
		Local	In the physical sense the structure of IE is local
		Regional	In the physical sense the structure of IE is regional
		National	In the physical sense the structure of IE is national
		International	In the physical sense the structure of IE is international but not global
		Global	In the physical sense the structure of IE is global
	Physical scope	Digital (clicks only)	Operating only in cyberspace (e.g. IE related to blockchain technology, IE related to InnoCentive.com or other crowdfunding platforms). Among the digital innovation ecosystems are mobile digital ecosystems operating through mobile applications
		Bricks & clicks	Operating in both virtual and non-virtual reality

Table 3 (continued)

Criteria category	Typology criteria	Types of IE	Characteristics
Performance of innovation ecosystem	Innovation performance	Successful (strong)	Capable of reaching goals
		Unsuccessful (weak)	Having problems with reaching the goals
		Promising	Forming/developing ecosystems with a high innovation potential as these cover actors with high innovation capabilities and organisational innovativeness, hence the value chain in the market is well integrated
	Economic performance	Profitable	Consistently transforms technology and other inputs into innovation competitive on the market. This type of IE is also labelled as healthy (Autio and Thomas 2014)
		Unprofitable	Having problems with delivering competitive innovations
	Strategic performance	Sustainable	The actors (organisational ones in particular) are characterized by an appropriate level of proximity, e.g. organisational proximity, cognitive proximity, social proximity, institutional proximity and geographical proximity
		Unsustainable	The actors are missing from the multidimensional fit, which leads to tensions, communication problems and an increase in the risk to co-innovation processes

Source: based on Klimas (2019) and inspired by the following works: Aarikka-Stenroos and Ritala (2017); Autio and Thomas (2014); Arena et al. (2018); Arora et al., (2019); Dattee et al. (2018); Dedehayir et al., (2016); Durst and Poutanen (2013); Ferasso et al. (2018); Iyer and Davenport (2008); Gomes et al. (2018); Jucevicius et al. (2016); Kapoor and Lee (2013); Luo (2018); Mazzucato and Robinson (2018); Oh et al. (2016); Phillips and Srai (2018); Planko et al. (2017); Pombo-Juárez et al. (2017); Rabelo and Bernus (2015); Radziwon (2018); Reynolds and Uygun (2018); Rocha et al. (2019); Russell and Smorodinskaya (2018); Schroth et al. (2018); Spelmeyer and Lingens (2018); Su et al. (2018); Sun et al. (2017); Walrave et al. (2018); Wu et al. (2018); Xu et al. (2018); Yaghmaie and Vanhaverbeke (2019)

4.1 Innovation ecosystem types

Our literature analysis reveals 34 different types of innovation ecosystems (see Table 3): intentional (deliberate, planned), emergent (implicit), orchestrated (hierarchy), collectively coordinated (heterarchy), emerging, developmental, mature, declining, death, corporate-dominated, university dominated, meta-organizational, centralized, decentralized, ego-centric (firm-centric; hub-based), microscopic, middlescopic, macroscopic, focused on radical innovation, focused on incremental innovation, focused on path-breaking innovations, high-tech, multi-platform, city-based/innovation districts, local, regional, national, international, global, digital (clicks only), successful (strong), promising, profitable and sustainable.

By logical extension of the innovation ecosystem types identified, we revealed several complementary types: self-coordinated, symmetrical, asymmetrical, eco-centric, focused on disruptive innovation, focused on social innovation, medium-tech, low-tech, mono-platform, bricks & clicks, unsuccessful (weak), unprofitable and unsustainable. Moreover, as innovation ecosystems are understood as operating around the co-innovation process, we decided to distinguish six other types dependent on the extent to which innovation co-creation relationships are exploited through innovation processes implemented by IE actors, and focused on: (1) co-discovery; (2) co-development; (3) co-deployment; (4) co-delivery; (5) co-dissemination; and (6) multi-stage co-innovation.

4.2 Innovation ecosystem typology criteria

All in all, we distinguish 50 types of innovation ecosystems (shown in Table 3), using fourteen typological criteria aggregated into five more general categories: (1) life cycle, (2) structure, (3) innovation focus within IE, (4) scope and (5) performance.

The first criterion focuses on how the innovation ecosystem comes into existence, and in what life-cycle phase it can be found. In this context, IE can be divided according to their origin (intentional versus emergent IE, as inspired especially by the works of Planko et al. 2017; Rabelo and Bernus 2015; and Russell and Smorodinskaya 2018), or the stage of the ecosystem life cycle (emerging, developmental, mature, declining or death, as inspired especially by the works of Dedehayir et al. 2016; Moore 1993; Ritala et al. 2013).

The second criterion adopts a structural perspective, suggested as useful for conceptualizations in the ecosystem approach (Adner 2017). Following the structural view narrowed down to the actors' perspective, innovation ecosystems can be divided into symmetrical and asymmetrical, or centralized and decentralized. However, if the focus is on innovation co-creation relationships, it is possible to distinguish ego- and eco-centric innovation ecosystems (as inspired by the findings from the literature review—Gomes et al. (2018). This also includes governance mechanisms (orchestration/hierarchy, collective coordination/heterarchy or self-coordination, as inspired especially by the works of Oh et al. 2016; Rabelo and Bernus 2015; and Russell and Smorodinskaya 2018).

The third criterion addresses the main aim of innovation ecosystems or its leading innovation focus. In a more detailed perspective, IEs can be categorized using three typological criteria: (1) the scope of innovation adopted within the ecosystem, that is microscopic, middlescopic or macroscopic, as suggested by Su et al. (2018); (2) the innovation type usually targeted by the actors of IE (i.e. focused especially on disruptive innovations, radical innovations, incremental innovations, social innovations or path-breaking innovations (Aarikka-Stenroos and Ritala 2017; Adner and Kapoor 2016; Walrave et al. 2018); and (3) the intensity of cooperation across the co-innovation process, that is innovation processes taking benefits only from co-discovery, only from co-development, only from co-deployment, only from co-delivery, only from dissemination, or benefiting from cooperation in a few or all stages of the innovation process (Autio and Thomas 2014; Klimas 2019; Song 2016).

The fourth typology criterion refers to the scope of innovation ecosystem activity, be it technological, spatial or physical. In terms of the technological scope, this is claimed to differentiate innovation ecosystems based on either the classification of the underlying industry using OECD recommendations, i.e. high-tech, medium-tech and low-tech innovation ecosystems (Ritala et al. 2013; Rocha et al. 2019), or the number of underlying technology platforms, i.e. mono- versus multi-platform innovation ecosystems (Gomes et al. 2018; Su et al. 2018; Vasconcelos Gomes et al. 2018). This is because IE can operate across one industry-wide platform or several company-specific platforms (Gawer and Cusumano 2014). Regarding the spatial scope, understood as the geographical range of both the activity and outputs of innovation ecosystems, it is possible to distinguish city-based/district-limited, local, regional, national, international and global innovation ecosystems (Mazzucato and Robinson 2018; Oh et al. 2016; Pombo-Juárez et al. 2017; Xu et al. 2018). The differences in geographical scope imply additional variations in terms of the level of horizontal, vertical, time-related and inter-systemic coordination within innovation ecosystems (Pombo-Juárez et al. 2017). Finally, regarding the physical scope, innovation ecosystems can be divided into those operating only in cyberspace (i.e. digital innovation ecosystems) and those operating in both the virtual and the real world, commonly known as bricks & clicks (Gomes et al. 2018; Rocha et al. 2019). In both cases, innovation ecosystems are shown as leveraging the dynamics of digital entrepreneurship (Beliaeva et al. 2019).

The last typology criterion addresses the performance of innovation ecosystems. Considering the type of performance, it is possible to differentiate innovation ecosystems based on the level of (1) innovation performance, i.e. successful/strong, unsuccessful/weak and promising (Mercan and Göktaş 2016; Sun et al. 2017; Xu et al. 2018); (2) economic performance reflected as profitable/healthy versus unprofitable/unhealthy innovation ecosystems (Autio and Thomas 2014); and (3) strategic performance, i.e. sustainable versus unsustainable innovation ecosystems (Wu et al. 2018).

In summarising considerations about the differentiation of innovation ecosystems, it is important to underline that the types identified within each criterion are not alternatives. On the contrary, it is possible and useful to categorize a given innovation ecosystem using several criteria at the same time. For instance, a given innovation ecosystem can be explored as ego-centric when considering innovation

co-creation relationships, as centralized when considering the strategic dominance of a single actor, as deliberate when discussing the emergence of the innovation ecosystem, or as regional when considering the spatial scope. Therefore, we recommend adopting all categories of typology criteria as well as their specific types as this allows the researcher, practitioner or policymaker to form a vivid and comprehensive picture of the considered innovation ecosystem.

5 Conclusions

Our study addresses the conceptual challenge of a definition for the innovation ecosystem by offering a synthesis of delineation efforts and developing a useful typology within these frames. A recent study offers a consensual definition of innovation ecosystems by identifying three critical components, that is actors, relationships and artifacts (Granstrand and Holgersson 2020). We follow the same consensual perspective and systematically study the literature collected in view of identifying typology criteria and corresponding innovation ecosystem types. Thus, we map the intellectual structure of research, categorize the diversity of innovation ecosystems studied so far, identify types missing from the literature and offer a coherent typology of 50 innovation ecosystems across 5 key criteria.

Our study advances knowledge about innovation ecosystems in several ways. Firstly, we extend and complement recent efforts aimed at increasing the conceptual rigour and clarity of innovation ecosystems research. It is equally important to delineate such concepts from others and to identify attributes relevant for capturing the variety of phenomena at hand (Nag et al. 2007; Venkatraman 1989). Typologies help systematize this diversity by grouping according to certain attributes or criteria. They are acknowledged as the next step along the operationalization path for any conceptual constructs, and are the step made between definition and measurement (Ahlquist and Breunig 2012). While recent studies focus on delineating the concept by defining and identifying features that differentiate innovation ecosystems from other concepts, we tackle the diversity issue and systematize innovation ecosystems using a typical categorization-based approach. We identify 14 criteria used in prior literature, and through thematic analysis aggregate them into just 5, useful for identifying research gaps, helpful in focusing further empirical work, and crucial for the systematic accumulation of knowledge on innovation ecosystems. Secondly, by applying the typology to existing literature, we identify 16 innovation ecosystem types that have as yet received no research attention. Therefore, we advance research by rigorously identifying a comprehensive set of innovation ecosystems, and at the same time substantiating a research gap in extant literature. Thirdly, we contribute to recent streams of thought that acknowledge innovation ecosystems as complex and multidimensional (Vasconcelos Gomes et al. 2018; Bacon et al. 2020; Wei et al. 2020). At the same time, our typology helps locate relevant attributes that characterize a particular ecosystem.

We are aware of limitations that help outline promising directions for further research. Firstly, our study follows the fundamental assumption that a consensual typology is needed. Therefore, we used the available literature and are similarly

skewed towards high–technology industries at the national level and from the perspective of focal firms (Lechman 2017). We suggest carrying out further research in other contexts such as medium- and low-tech industries instead of high-tech ones (Kapoor and Furr 2015; Oh et al. 2016; Song 2016), global markets instead of national ones (Arora et al. 2019; Yaghmaie and Vanhaverbeke 2019), and eco-centric innovation ecosystems instead of firm-centric ones (Holgersson et al. 2018; Jucevicius et al. 2016; Song 2016; Yaghmaie and Vanhaverbeke 2019).

Furthermore, our typology was developed using a cumulative approach as it builds on prior studies. While we were able to add 16 complementary types of innovation ecosystems and aggregate typology criteria, we are equally bound by prior literature foci. Other criteria may be developed, and we see qualitative in-depth studies as a particularly promising perspective for identifying such criteria. In the same vein, we believe that taxonomies may be developed as a bottom-up complementary procedure to our top-down typology**.** Therefore, we consider it worthwhile undertaking empirical research targeting the recognition of additional attributes that significantly differentiate innovation ecosystems.

Acknowledgments We thank the Editors and Reviewers from Review of Managerial Science for their insightful and constructive comments improving the manuscript.

Funding This paper was supported by a research grant from the National Science Centre under the project titled: Co-creative relationships and innovativeness—the perspective of the video game industry (UMO-2013/11/D/HS4/04045). Moreover, publication was supported by the Ministry of Science and Higher Education in Poland under the programme "Regional Initiative of Excellence" 2019–2022 project number 015/RID/2018/19 total funding amount 10 721 040,00 PLN".

Compliance with ethical standards

Conflicts of interest The authors have no conflict of interest to declare.

Declaration of the exclusivity of submission The manuscript has not been published previously, it is not under consideration for publication elsewhere, and if accepted, it will not be published elsewhere in the same form, in English or any other language.

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