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**INNOVATION ECOSYSTEMS IN MANAGEMENT:
AN ORGANIZING TYPOLOGY**

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SUMMARY (420 WORDS)

The concept of an ‘ecosystem’ is increasingly used in management and business to describe collectives of heterogeneous, yet complementary organizations who jointly create some kind of system-level output, analogous to an ‘ecosystem service’ delivered by natural ecosystems, and one that extends beyond the outputs and activities of any individual participant of the ecosystem. Due to its attractiveness and elasticity, the ecosystem concept has been applied to a wide range of phenomena by a variety of scholarly perspectives and under varying monikers such as ‘innovation ecosystems’, ‘business ecosystems’, ‘technology ecosystems’, ‘platform ecosystems’, ‘entrepreneurial ecosystems’, and ‘knowledge ecosystems’. This conceptual and application heterogeneity has contributed to conceptual and terminological confusion, which threatens to undermine the utility of the concept in supporting cumulative insight.

In this article we seek to re-introduce some order into this conceptual heterogeneity by reviewing how the ecosystem concept has been applied to variably overlapping phenomena and by highlighting key terminological and conceptual inconsistencies and their sources. We find that conceptual inconsistency in the ecosystem terminology relates to two key dimensions: the ‘unit’ of analysis and the type of ‘ecosystem service’ – i.e., the ecosystem output collectively generated. We then argue that although there is considerable heterogeneity in application, the concept nevertheless offers promise to support insights that are distinctive relative to other concepts that describe collectives of organizations, such as those of ‘industry’, ‘supply chain’, ‘cluster’, and ‘network’. We also find that despite extant proliferation, the concept nevertheless describes collectives that are distinctive in that they uniquely combine participant heterogeneity, coherence of ecosystem outputs, participant interdependence, and non-hierarchical governance.

Based on our identified dimensions of conceptual heterogeneity, we offer a typology of the different ecosystem concepts, thereby helping re-organize this proliferating domain. The typology is based upon three distinct ecosystem outputs—ecosystem-level value offering to a defined audience, collective generation of business model innovation, and collective generation of research-based knowledge—and three research emphases that resonate with alternative ‘units’ of analysis—community dynamics, output co-generation, and interdependence management. Together, these allow us to

clearly differentiate between the concepts of innovation ecosystems, business ecosystems, platform ecosystems, technology ecosystems, entrepreneurial ecosystems, and knowledge ecosystems. Based on the three distinct types of ecosystem outputs, our typology identifies three major types of ecosystems: innovation ecosystems, entrepreneurial ecosystems, and knowledge ecosystems. Under the rubric of ‘innovation ecosystems’, we further distinguish between business ecosystems, modular ecosystems, and platform ecosystems. We conclude by considering innovation ecosystem dynamics, highlighting the important role of digitalization, and reviewing the implications of our model for ecosystem emergence, competition, coevolution, and resilience.

Key words: ecosystem; innovation ecosystem; business ecosystem; platform ecosystem; technology ecosystem; entrepreneurial ecosystem; knowledge ecosystem

INTRODUCTION

In management, the concept of an ‘ecosystem’ provides an attractive metaphor to describe collectives of heterogeneous, yet complementary, organizational actors who collectively generate some kind of ecosystem-level output (Seppelt, Dormann, Eppink, Lautenbach, & Schmidt, 2011), and one that extends beyond the outputs and activities of any individual participant of the ecosystem (Adner, 2017; Autio, Nambisan, Thomas, & Wright, 2018; Järvi, Almpanopoulou, & Ritala, 2018). Ecosystems are distinguished from most other types of organizational collectives (e.g., supply chains, clusters, networks) by their governance systems and the nature of ecosystem outputs. Distinct from, e.g., conventional supply chains, ecosystems are not defined by contractual relationships alone (Jacobides, Cennamo, & Gawer, 2018). Distinguishing ecosystems from generic organizational networks, ecosystem roles and shared standards enable ecosystem constituents to engage in productive interactions that generate a coherent ecosystem-level output, often targeted at a defined audience (Shipilov & Gawer, 2019). The attractiveness of this rather elastic metaphor primarily rests on its ability to describe a fresh approach to ‘organically’ govern mutual organizational specialization, coevolution, and the collective generation of system-level outputs (Adner & Kapoor, 2010; Autio & Thomas, 2019).

Perhaps because of its elasticity, the ecosystem concept has been adopted by a wide variety of scholarly perspectives, with varied phenomenological and conceptual emphases. For instance, the strategy literature tends to emphasize the collective generation of outputs, defining ecosystems as “...the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner, 2017: 40). Economic geography scholars have emphasized the spatial dimension and defined ecosystems as “...institutional, geographic, economic, or industrial contexts [which] can be analysed at different levels of aggregation (e.g. firms, industries, universities, regions, and nations)” (Feldman, Siegel, & Wright, 2019: 1). Innovation scholars have emphasized the knowledge and learning dimensions, defining ecosystems as “...clusters (physical or virtual) of innovation activities around specific themes (e.g., biotechnology, electronics, pharmaceutical and software)” (Ritala, Agouridas, Assimakopoulos, & Gies, 2013: 248).

This heterogeneity is not confined to ‘units’ of analysis and scholarly perspectives alone. Scholars have also variably adopted related concepts such as ‘innovation ecosystems’, ‘business ecosystems’, ‘technology ecosystems’, ‘platform ecosystems’, ‘entrepreneurial ecosystems’, and ‘knowledge ecosystems’ – with significant overlap in their use. Confusing matters further, these concepts often conflate innovation processes and outputs.¹ As examples of the varying foci, flavours, and emphases of the broad ecosystem literature, Moore (1993:76) notes that in business ecosystems “...*companies coevolve capabilities around a new innovation*”, and that business ecosystems “...*condense out of the original swirl of capital, customer interest, and talent generated by a new innovation*”. In the early platform literature, Cusumano and Gawer (2002: 54) referred to a “*platform and its innovation ecosystem*”, and more recently, in an analysis of the downsides of collaborating with complementors in two-sided platform markets, Mantovani and Ruiz-Aliseda (2016) discuss ‘innovation ecosystems’. In their exposition on the genesis of entrepreneurial ecosystems, Autio et al. (2018) explicated how the concept of entrepreneurial ecosystems relates to a phenomenon that is similar but distinctive from those of ‘innovation ecosystems’, ‘regional systems of innovation’, and ‘innovative milieus’, and are distinguished by their focus on facilitating business model innovation by entrepreneurial new ventures. Järvi et al. (2018:1524), in their investigation of the organization of knowledge ecosystems, apply the concept to the “*very early phases of innovation—initial knowledge creation and search*”. Only recently have there been attempts to explore the theoretical contours of these concepts and to illuminate their shared theoretical and conceptual underpinnings (Adner, 2017; Autio & Thomas, 2019; Jacobides et al., 2018).

In one of the earliest reviews of the ecosystem literature (Autio & Thomas, 2014), we asked whether the ecosystem concept adds insight beyond existing constructs describing organizational collectives or whether we are simply dealing with yet another attractive catchphrase. We believe we can

¹ There are many examples of conflation of ecosystem concepts in the strategy literature. In our 2014 review we conflate business, innovation and platform ecosystems. Gawer and Cusumano (2014) in their review of industry platforms move interchangeably between “business ecosystems”, “innovation ecosystems” and “platform ecosystems”. Jacobides et al. (2018), while clearly differentiating between “business ecosystems”, “innovation ecosystems” and “platform ecosystems” in their initial conceptual review, title their main theoretical development section “business ecosystems”.

emphatically state that the ecosystem concept does indeed add insight beyond existing constructs.² In fact, we believe the proliferation of perspectives and applications of the different ecosystem concepts testifies of the salience of the underlying phenomenon (or set of related phenomena)—which is digitalization opening up new ways for companies to share ideas and knowledge and flexibly combine their outputs without contract-based coordination. But there is some distance still to cover for the ecosystem literature to reach theoretical maturity. Although there have been calls for greater definitional rigour in ecosystems research (Adner, 2017; Jacobides et al., 2018; Shipilov & Gawer, 2019), this rigor is still largely missing in the literature. In this article we seek to introduce some clarity to the conceptual proliferation that afflicts the ecosystem literature.

This article is structured as follows. We first detail the sources of the conceptual proliferation that characterizes the ecosystem literature, identifying two major dimensions of this proliferation: the nature of ecosystem outputs and the ‘unit’ of analysis (with associated thematic emphasis). We then detail four characteristics of ecosystems that are common across applications of the concept and which provide the baseline for our expansive definition. From this baseline we then propose a typology that positions different ecosystem concepts, drawing on the two major dimensions of conceptual proliferation. We conclude by discussing the important role digitalization in the popularity of the ecosystem concept, and the implications of our insights for ecosystem emergence, competition, coevolution, and resilience.

DIMENSIONS OF CONCEPTUAL PROLIFERATION

The notion of an ‘ecosystem’ was introduced into the management literature quite early, with Moore’s (1993) advocacy of an ‘ecological’ approach to understanding the contexts within which businesses compete and collaborate. In his seminal paper Moore never actually provided a clear definition for his term, merely noting that an ‘ecosystem’ is a structure where companies work ‘cooperatively and competitively’ across industries to satisfy customer needs. In addition to leaving the notion of the ‘ecosystem’ vague, Moore also never made it clear what exactly he meant with the notion of an

² We deliberately refer to the term ‘ecosystem’ as a concept to underline the as-yet early stage of theoretical development in this area. A ‘concept’ is a generally accepted term to refer to a phenomenon or instance that may or may not be well understood theoretically. A ‘construct’ is a statement of a concept that is useful for theorizing; a ‘construct’ lends itself for empirical operationalization, whereas a ‘concept’ may not (Suddaby, 2010).

‘ecological’ approach to strategy, beyond loose parallels to natural ecosystems and stating that this approach was ‘different’ from industry- or sector-specific analysis. While scholars subsequent to Moore, such as Iansiti and Levien (2004) and Peltoniemi (2006), began to develop these biology-inspired ideas further, they have not been systematically applied (see Gómez-Uranga, Miguel, & Zabala-Iturriagagoitia, 2014 for an exception). As a result, scholars have applied the ecosystem concept with varying prefixes such as ‘innovation ecosystem’ and ‘business ecosystem’ without enough specificity, which has given rise to the current conceptual proliferation we highlighted above. We suggest that this proliferation manifests itself along two key dimensions: the ‘unit’ of analysis (together with thematic emphasis) and the nature of ecosystem outputs.

Setting up the first dimension of conceptual proliferation is the fact that the ecosystem concept, broadly speaking, can be applied at many **levels, or ‘units’, of analysis**. This elasticity in terms of levels of analysis also characterizes the conception of biological ecosystems, which might consist of a patch of soil with plants and microorganisms, or an anthill, or the entire planet Earth (Pickett & Cadenasso, 2002; Willis, 1997). In management, similar elasticity can also be observed. For instance, innovation ecosystems have been considered at various spatial levels of analysis, ranging from suburban (Chesbrough, Kim, & Agogino, 2014), city (Claudel, 2018; Visnjic, Neely, Cennamo, & Visnjic, 2016), regional (Radziwon, Bogers, & Bilberg, 2017), to national (Carayannis & Campbell, 2009) and even global levels (Nambisan, Zahra, & Luo, 2019). Ecosystems have also been considered at non-spatial levels of analysis, and here the concept has been used to refer to the focal firm and its complementors and suppliers – which need not inhabit the same region, as long as they belong to the same sector (Adner, 2006, 2017; see Adner & Kapoor, 2010 for an operationalization), platforms and their complementors (Gawer & Cusumano, 2014; Mantovani & Ruiz-Aliseda, 2016), and entire industries (Ansari, Garud, & Kumaraswamy, 2016). Related to the ‘unit’ of analysis dimension, different levels also tend to be associated with different thematic emphases, in the sense of key challenges being addressed. Whereas spatial applications tend to focus on various ecosystem community dynamics (e.g., learning and knowledge spill-over processes), non-spatial dimensions tend to emphasize issues related to governance and coordination. This overlapping thematic emphasis will be adopted to inform our typology of ecosystem concepts.

A second dimension of conceptual proliferation arises from the nature of the ‘ecosystem service’ (for a review see Seppelt et al., 2011), or **ecosystem outputs collectively generated**. In ecosystem contexts, ecosystem outputs have been conceptualized as products and services (Adner, 2017), such as photolithography systems (Adner & Kapoor, 2010), mobile communications (Holgersson, Granstrand, & Bogers, 2017), software and apps (Boudreau, 2012), as well as new start-ups that instantiate business model innovations (Autio et al., 2018; Kanter, 2012), and new research-based knowledge (Alexy, George, & Salter, 2012; Almpanopoulou et al., 2017).

For the purposes of our organizing framework, we organize different types of ecosystems into three broad categories based on the nature of ecosystem outputs. The first category comprises innovation ecosystems. This category covers product and service innovation and describes situations where the generative outputs created by varied, non-hierarchically related (in terms of contractual relationships) ecosystem participants coalesce into a coherent, user-customizable offering at the ecosystem level, one that is aimed at a defined audience (e.g., photovoltaic solar energy systems). The second category covers entrepreneurial ecosystems, or regional communities who facilitate the creation of new start-up ventures. These communities operate collective discovery and instantiation of new, innovative ways of creating, delivering, and capturing value—i.e., business model innovation and new ventures that carry them as the ecosystem output. In contrast with the first category, the collective process of business model innovation usually does not target defined audiences at the ecosystem level, but rather, tends to be sector and technology agnostic. As the third category, we identify organizational collectives specializing in the production of new research-based knowledge, an ecosystem output that has previously been studied extensively under the rubrics of national, regional, and sector-specific systems of innovation. Although technology specific, the outputs of knowledge ecosystems comprise an important share of pre-commercialized knowledge and are usually not targeted at a defined audience.

In order to re-introduce coherence into the expanding literature on ecosystems in management, we use the two dimensions of ‘unit’ of analysis and the nature of the ecosystem output to create a con-

ceptual typology of different ecosystem concepts. Before doing so, however, we next discuss characteristics that are common to all ecosystem concepts and which help differentiate the ecosystem phenomenon from constructs that came before, such as supply chains and networks.

CHARACTERISTICS OF ECOSYSTEMS

The proliferation of the ecosystem literature has prompted several reviews (for recent reviews, see Aarikka-Stenroos & Ritala, 2017; Gomes, Facin, Salerno, & Ikenami, 2018; Oh, Phillips, Park, & Lee, 2016; Scaringella & Radziwon, 2018; Suominen, Seppänen, & Dedehayir, 2019). Drawing on these and our own reading of this burgeoning literature, we identify four distinguishing commonalities across different ecosystem concepts in management. The first characteristic is that of participant heterogeneity, in that ecosystems are composed of heterogeneous participants in various roles. Although participant heterogeneity characterizes also other concepts that describe collectives of organizations, the participant heterogeneity displayed by ecosystems is often broader and can span multiple industries and transcend the boundary between public and private sectors. The second distinguishing characteristic is that ecosystems facilitate an ecosystem output that is more encompassing than any single participant could deliver alone. Again, while a system-level output also characterizes supply chains, these are produced to a predefined design and therefore cannot match the generativity manifest in ecosystems, defined as their ‘...*overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences*’ (Zittrain, 2006: 1980). The third distinguishing characteristic is the nature of interdependence among ecosystem participants, which is distinctly different from that characterizing networks and supply chains. The fourth distinguishing characteristic is the nature of ecosystem governance, which relies primarily on non-contractual mechanisms such as role definitions, supermodular complementarity, and the co-alignment provided by the ecosystem platform to strike a balance between generativity and coherence in ecosystem outputs. Whilst none of the four characteristics alone uniquely distinguishes ecosystems from other organizational collectives, the combination of the four characteristics is unique to ecosystems, and individual characteristics also help distinguish

between innovation ecosystems, entrepreneurial ecosystems, and knowledge ecosystems. We next elaborate on each characteristic.

Participant heterogeneity

Ecosystem communities, regardless of level of analysis or type of innovation, tend to exhibit high levels of participant heterogeneity. Heterogeneity in ecosystems generally springs from the fact that their constituent participants may come from a variety of industries and sectors (Autio et al., 2018; Jacobides et al., 2018; Moore, 1993). This heterogeneity is further accentuated by the roles-based governance that characterizes ecosystems: instead of ecosystem roles being defined by formal supplier contracts on a bilateral basis, as is the case of supply chains, ecosystem roles are usually normatively defined and applicable to anyone who chooses to assume that role (Jacobides et al., 2018). Reflecting this looser regulation of ecosystem participation (relative to contractually defined supply chains), Iansiti and Levien (2004) described an ecosystem as including the loose networks of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and others. More recently, (Adner, 2017: 40) explicitly noted that ecosystems are composed of a “*multilateral set of partners*”. Others have specifically included customers in their ecosystem community (e.g., Autio and Thomas (2014) included customers as “use side participants”). Others have included competitors: for instance, Moore (1996) included competitors in his original definition, as has much of the “open innovation ecosystem” literature (Bogers et al., 2017; Frankort, 2013). Yet others have considered non-market participants, such as universities and public research institutions (Clarysse, Wright, Bruneel, & Mahajan, 2014; Järvi et al., 2018; van der Borgh, Cloudt, & Romme, 2012), and governmental organizations, such as regulatory authorities, standard-setting bodies, and the judiciary (Autio, Kenney, Mustar, Siegel, & Wright, 2014; Garnsey & Li, 2013; Teece, 2007). These inclusive definitions partly reflect the thematic foci of the respective ecosystem studies: for example, studies of ‘knowledge ecosystems’ are more likely to include also public-sector participants in the ecosystem,

making it challenging to distinguish this stream from the closely related and much more well established ‘systems of innovation’ stream of literature on public-private interaction – especially from the notion of sectoral systems of innovation (Malerba, 2002; Malerba & Breschi, 1997).

Ecosystem outputs

Ecosystems facilitate the collective generation of ecosystem outputs. One such output comprises products and services that are compatible with one another, often adhering to a modular product architecture that allows the user to assemble a customized composition of modules to suit individual preferences. A canonical example is the assembly, sometimes by users, of individualized PCs from components offered by the ‘Wintel’ ecosystem. In modularly structured ecosystems, participants “*interact in order for a focal value proposition to materialize*” (Adner, 2017: 40; Jacobides et al., 2018) and the specific products and services that they co-produce are abstracted into the more general notion of a coherent, yet customizable ecosystem value offering targeted at a defined set of users. Another ecosystem output comprises innovative business models—an output that characterizes entrepreneurial ecosystems in particular (Autio, Cao, Chumjit, Kaensup, & Temsiripoj, 2019; Autio et al., 2018). In entrepreneurial ecosystems, the participants “*facilitate entrepreneurial opportunity pursuit by new ventures through radical business model innovation*” (Autio et al., 2018: 74), and the innovative business models are operationalized by new ventures. However, this output of entrepreneurial ecosystems differs from product and service generating ecosystems in two important respects. First, business model innovations are not intended for consumption by a defined audience the same way as the outputs of product and service generating ecosystems are: business model innovations benefit entrepreneurial ventures who harness them for entrepreneurial competitive advantage. In this sense, entrepreneurial ecosystems do not facilitate an actual ecosystem value offering (i.e., help resolve the needs of a defined audience), only ecosystem outputs in a more general sense.

Yet another ecosystem output comprises generic knowledge production. In ‘knowledge ecosystems’, participants interact so that there is “*collaborative exploration of new knowledge as central activity and output*” (Järvi et al., 2018: 1524). In such situations, the knowledge may not yet be embodied in defined products, services, or even business models, but rather, capture the outputs of distributed innovative activities by ecosystem participants, making this concept virtually indistinguishable

from the concept of sector systems of innovation in the long-established ‘systems of innovation’ literature (Malerba, 2002). This ecosystem output also differs from those generated by product and service generating ecosystems, in that its audience is much more diffuse and comprises, e.g., the scientific and the industrial community (who may or may not be part of the knowledge ecosystem itself) and comprises both pre-commercialized and commercialized knowledge.

Participant interdependence

Probably the most widely referenced characteristic of ecosystems is participant interdependence. In biology, ecosystem interdependence is generally termed ‘mutual symbiosis’ and occurs when otherwise unrelated species exchange materials, energy, or information in a mutually beneficial manner (Miller, 1994). In management, while symbiosis has been occasionally referenced (Aarikka-Stenroos & Ritala, 2017; Autio & Thomas, 2014), interdependence between heterogeneous ecosystem participants has been mostly considered from technological, economic, and cognitive perspectives.

The first type of interdependence is *technological*, in that the heterogeneous actors within the ecosystem are co-specialized, often around a shared platform or a common modular architecture (Adner, 2012; Autio et al., 2018; Jacobides et al., 2018). Co-specialization occurs when there exists coevolved, idiosyncratic dependence between entities that emanates from the requirement to provide inputs into the ecosystem that are mutually compatible and so can support coherent, yet customizable ecosystem output (Jacobides et al., 2018; Teece, 1986). For example, in telecommunications ecosystems, different organizations are co-specialized when one organization supplies the technology, another customer relationship management, and a third infrastructure management, which together define the ecosystem output. Ecosystem outputs typified by technological interdependence tend to be composed of modular offerings available from a set of horizontally related suppliers, and where the final choice of which components to integrate may be left to the customer, as might the integration work itself (Autio, Dattée, & Thomas, 2019; Jacobides, Sundararajan, & Van Alstyne, 2019).

Compared to product and service generating ecosystems, entrepreneurial ecosystems do not exhibit as much technological interdependence as they do role dependence, where the roles are organized around the early life cycle of new ventures. In entrepreneurial ecosystems we observe different

ecosystem participants (e.g., new venture accelerators, funding and resource providers, advisors, trainers) each operating in a specialized role that requires specialized expertise, yet the roles are interdependent in the sense that none of the ecosystem participants alone is able to create the ecosystem output – i.e., business model innovation as carried by new ventures. In contrast, knowledge ecosystems exhibit specialization to a shared, specialized knowledge base, which may comprise both pre-commercialized and commercialized knowledge. In knowledge ecosystems interdependencies are exhibited along different stages of the knowledge maturity continuum.

A second type of ecosystem interdependence is *economic*, in that the value that each member receives from participating in the ecosystem is dependent on the simultaneous availability of compatible offerings by others. Economic interdependencies can occur when the ecosystem enables economies of scale and scope (Autio et al., 2018; Jacobides et al., 2018; Thomas, Autio, & Gann, 2014). Participants can also exhibit economic dependence when there are externalities, “*when the actions of one agent affect the interests of another agent other than by affecting prices*” (Davis & North, 1970: 134). In ecosystem contexts, many externalities are driven by the size of the network, where the utility from participating in the network is dependent on the numbers of others in the network, either through production or consumption economies (Katz & Shapiro, 1986). Such network externalities can be direct, linked to the physical network and its size, where increases in network size creates increases in the quality (Katz & Shapiro, 1985) and utility of output (Gupta, Jain, & Sawhney, 1999). They can also be indirect and emerge through the provision of complementary products and services (Gupta et al., 1999). Economic interdependencies can also arise from technological interdependencies, where supermodular complementarities in consumption occur across the different components. Supermodularity occurs when the presence of complementary modules makes the modules more valuable to the user, as is the case of, say, the Android platform and Android-compatible applications (Jacobides et al., 2018). In entrepreneurial and knowledge ecosystems, economic interdependencies arise from knowledge sharing and knowledge spill-overs concerning either ‘what works’ in business model innovation or specialized knowledge. Knowledge sharing and spill-overs drive the growth and maturation of the ecosystem’s shared knowledge base, and therefore increase its value for the ecosystem participants.

A third type of interdependence is *cognitive*, in the sense that ecosystem participants have a set of “*socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules ... which provide the formal and informal rules of action, interaction, and interpretation that guide and constrain decision makers*” (Thornton & Ocasio, 1999: 804). Cognitive interdependence is an important aspect of a functioning ecosystem, as participants can represent many different specializations, with differences in knowledge and skills and cognitive frames (Weick, 1995). Cognitive interdependence is particularly important in promoting ecosystem cohesion when the ecosystem participants are heterogeneous, and each participant may adhere to specific world and economic views that are not necessarily widely shared with others within the ecosystem. Cognitive interdependence is also important because the self-interests and expertise of ecosystem participants may differ, increasing cognitive distance among these (Wareham, Fox, & Cano Giner, 2014). Cognitive interdependence is often expressed through an ecosystem collective identity (Gawer & Phillips, 2013; Thomas & Ritala, 2019), that consists “*the shared meaning that an organizational entity is understood to have that arises from its members’ (and others’) awareness that they belong to it*” (Cornelissen, Haslam, & Balmer, 2007: S3). The ecosystem collective identity helps bind the ecosystem participants together by attenuating the negative effect of cognitive distance and by encouraging commonality in perspectives towards the ecosystem and coherence in responses to systemic and environmental changes (Friedland & Alford, 1991).

Non-contractual governance

The final characteristic that distinguishes ecosystems from value and supply chains, national and regional systems of innovation, and R&D consortia is their relatively strong reliance on non-contractual governance (Gulati, Puranam, & Tushman, 2012; Jacobides et al., 2019). On this basis, Jacobides et al. (2018) suggest that ecosystems should be seen as a distinctive solution to the distributed governance challenge characterized by co-specialization among hierarchically independent, yet interdependent ecosystem constituents. Instead of formal, relationship-specific contracts that uniquely define each relationship within, say, a supply chain, interactions among ecosystem participants are coordinated by a co-alignment structure that enables ecosystem participants to specialize in specific roles that are not necessarily defined by formal contracts.

An ecosystem co-alignment structure reflects both the interdependencies that typify an innovation ecosystem, as well as power relations between its constituents. In particular, innovation ecosystems that feature strong technological interdependence often employ technological architectures and platforms as their co-alignment structure (Wareham et al., 2014), while other types of ecosystems (e.g., entrepreneurial, knowledge ecosystems) may emphasize economic or cognitive co-alignment structures (Autio & Thomas, 2018; Järvi et al., 2018). For instance, an ecosystem collective identity that epitomizes the participants' shared sense of identification with the ecosystem community (Cornelissen et al., 2007; Gawer & Phillips, 2013; Thomas & Ritala, 2019; Wareham et al., 2014) can give meaning to the questions “who we are” and “what we do” (Navis & Glynn, 2010). This shared ecosystem identification shifts the perspective of ecosystem participants from the individual to the collective, so that ecosystem participants jointly confront challenges that lie beyond their own immediate responsibilities and defines how they want to organize and address mutual interdependence (Adner, 2012).

Ecosystem co-alignment structures also reflect power relationships within the ecosystem, or its stratification (Gulati et al., 2012). Stratification naturally emerges in networks, regardless of the nature of the networked system, its constituents, or the specific nature of network connections (Barabási, 2002). Although the alignment structure assigns ecosystem participants specific roles that are not necessarily defined by formal contracts, the degree of stratification between these roles (and participants) can vary, reflecting power differentials between participants. Depending on the size of the ecosystem community, its degree of stratification and the roles defined by the co-alignment structure, ecosystem governance modes can range from top-down, hierarchical direction through established lines of command to lateral and informal coordination, for example, through the communication of knowledge and the propagation of social roles and behavioural norms (Gawer & Phillips, 2013; Järvi et al., 2018).

ORGANIZING TYPOLOGY OF ECOSYSTEM CONCEPTS

Given the many levels, or ‘units’, of analysis at which the ecosystem concept has been applied in management and business disciplines and the range of different ecosystem outputs (i.e. ‘innovation’) that can be collectively generated, any overall definition will necessarily be rather general. That

said, integrating the characteristics of participant heterogeneity, system-level outputs, participant interdependence, and distinctive governance, we define an ecosystem as: “*a community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output*”. Figure 1 presents our typology and Table 1 presents definitions for each of the ecosystem types as well as other important ecosystem concepts.

[Insert Figure 1 and Table 1 around here]

Based on this definition and addressing the challenges introduced by the dimensions of conceptual proliferation, we now provide an organizing typology of ecosystem concepts. The first dimension of the typology is the ecosystem-level output. This output takes three main forms, for innovation ecosystems, entrepreneurial ecosystems, and knowledge ecosystems, respectively: ecosystem value offering targeted at a defined audience (innovation ecosystems), business model innovation encapsulated in new start-up ventures (entrepreneurial ecosystems), and new research-based knowledge (knowledge ecosystems). The second dimension of our typology is the research emphasis of extant scholarship—namely community dynamics, output co-creation, and interdependence management. By research emphasis, we are not directly referring to the unit or level of analysis (although different research emphases tend to be associated with different ‘units’ of analysis as noted above), but instead to the focus of scholarly attention. We next discuss our organizing typology of ecosystem concepts.

Innovation Ecosystems

In our organizing typology, innovation ecosystems are those that exhibit a coherent ecosystem-level value offering targeted at a defined audience as their ecosystem-level output. This conceptualization has primarily arisen from the strategy literature, although it has also drawn from earlier work on modularity (e.g. Baldwin & Clark, 2000). Innovation ecosystems are multi-stakeholder venues for value co-production, which often have a platform, or a set of shared technological compatibility standards as a co-alignment mechanism (Adner, 2017; Autio & Thomas, 2014; Constantinides, Henfridsson, & Parker, 2018; Jacobides et al., 2018; Thomas et al., 2014; Yoo, Boland, Lyytinen, & Majchrzak, 2012). This supply-side emphasis on value co-production reflects the roots of much of the strategic management literature in industrial organization economics, where

firms are portrayed as operating in clearly delineated industries, subject to competitive forces determined by industry structural properties, and competing in an open market with their products and services (Porter, 1980; Porter, 1985). Innovation ecosystems differ from conventional supply chains in that not all supplier relationships are contractually governed, yet the value of the offerings of any given ecosystem participant for the customer may be boosted by concurrent availability of complementary products and services (Adner, 2017; Ceccagnoli, Forman, Huang, & Wu, 2012; Teece, 2018).

Following our typology (Figure 1) and echoing the typology of Jacobides et al. (2018), we suggest that there are three types of innovation ecosystems: ‘business ecosystems’, which emphasize the broader community within which a focal firm operates; ‘modular ecosystems,’ which emphasize the collective co-production of an ecosystem value offering directed at a defined audience, and ‘platform ecosystems’ which emphasize the coordination of technological interdependencies, generally through platforms. We now discuss each, reviewing how the four ecosystem characteristics have been considered in each context.

Business ecosystems. When the research emphasis is on the broader economic context which a focal firm must monitor and react to, an innovation ecosystem has generally been called a ‘business ecosystem’. Deriving from the initial formulations of Moore (1993) and Iansiti and Levien (2004), many writings on business ecosystems do not make the explicit assumptions that characterize the other types of innovation ecosystems (see below). Adner (2017) calls these ‘ecosystems-as-affiliation’, and he uses the label to broadly denote an ecosystem as a community of actors operating around a shared co-alignment structure, such as a shared set of standards or cognitive schemata. Such communities tend to be characterized by greater levels of fluidity, emergence, and co-creation in the form of co-created, yet emergent ecosystem value offerings composed of generative inputs by ecosystem participants. As actor roles in such communities often are less fixed than in the case of other innovation ecosystems, there is also more scope for innovation that potentially changes the roles and relationships among ecosystem actors. Business ecosystems can have quite a broad scope – for instance, Teece (2007:1325) considers them to include “*the community of organizations, institutions, and individuals that impact the enterprise and the enterprise’s customers and supplies ... including*

complementors, suppliers, regulatory authorities, standard-setting bodies, the judiciary, and educational and research institutions”.

Modular ecosystems. Modular ecosystems emphasize the collective generation of an ecosystem output targeted at a defined audience—a value offering—with the analytic interest on the focal firm and the set of components (upstream) and complements (downstream) that support it, and which have a clear supply-push and value production emphasis (Adner, 2017; Adner & Kapoor, 2010; Hannah & Eisenhardt, 2018; Jacobides et al., 2018). In his review of this “structural” stream, Adner (2017:40) defined modular ecosystems³ as: “...*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize.*” This alignment structure needs to be able to align unpredictable innovative inputs from hierarchically unrelated participants yet retain enough coherence such that the different outputs can work together and thus deliver the overarching ecosystem value offering. Modular ecosystems deliver their value proposition through a co-alignment structure expressed as a shared product or service architecture featuring architectural interfaces that allow the platform ecosystem to be partitioned into a relatively stable set of modules (Baldwin & Woodard, 2009; Tiwana, Konsynski, & Bush, 2010). Examples from literature include, e.g., the semiconductor lithography equipment industry and the photovoltaic solar panel industry (Adner & Kapoor, 2010; Hannah & Eisenhardt, 2018). We use the term modular ecosystems to distinguish these structures—which often represent evolution of supply chains—from platform ecosystems, which are underpinned by a digital platform that acts as the underpinning co-alignment structure. Modular ecosystems generally have (comparatively) a narrow scope—consisting of the focal firm(s) and immediately adjacent complementors and suppliers, with the customer represented in abstract through their adoption and or acceptance of the ecosystem output, in the sense that the ecosystem output would not be viable if it did not meet specific customer needs.

Platform Ecosystems. Platform ecosystems are innovation ecosystems that emphasize the role of technological dependencies in the ecosystem and mostly focuses on a specific class of technologies—namely, a shared connectivity interface broadly referred to as a ‘platform’. Particularly

³ Adner used the term ‘innovation ecosystems’ to refer to what we define as ‘modular ecosystems’.

when accessible through the Internet, this co-alignment structure ensures that a network of location-unbound complementors are able to create complements that enhance the ecosystem value offering of the platform – without the need to resort to formal contracts particularly where there is a platform owner who can also act as an adjudicator of platform interactions (Ceccagnoli et al., 2012; Gawer & Cusumano, 2008; McIntyre & Srinivasan, 2017). A key governance challenge for platform ecosystems is the coordination and maintenance of the necessary capabilities and standards for the alignment structure (McIntyre & Srinivasan, 2017; Tiwana et al., 2010; Wareham et al., 2014) that define the technical specifications (Suarez, 2005) and ensure compatibility among the ecosystem participants and components (Eisenmann, 2007). Platform ecosystem governance needs to address a fundamental tension—between the need for flexibility and variety versus the need for integrity and standardization. While flexibility allows ecosystem participants to generate variety within the ecosystem, integrity helps align them so as to maintain the coherence of ecosystem outputs (Wareham et al., 2014).

A related concept that sometimes pops up within the ecosystems literature is that of **‘technology ecosystems’** (also sometimes called ‘digital ecosystems’ and ‘software ecosystems’), which has been employed mainly in the information systems discipline. The usage of this concept overlaps with those of modular ecosystems and platform ecosystems (see for instance Tiwana et al., 2010; Wareham et al., 2014), and occasionally knowledge ecosystems. This concept mostly considers ecosystems in the context of digital infrastructures, which are shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities (Hanseth & Lyytinen, 2010). The architecture and functionalities of digital infrastructures allow multiple constituents to interact and co-create digital artefacts such as open source software and other digital artefacts, due to the opportunities for ‘constrained serendipity’ amongst distributed actors (see for instance Adomavicius, Bockstedt, Gupta, & Kauffman, 2007; Thomas & Tee, 2019; Yoo et al., 2012). Because this concept overlaps with others in our typology, we do not include it as a distinct ecosystem type.

Entrepreneurial Ecosystems

Entrepreneurial ecosystems differ from innovation ecosystems in important respects. First, there is no ecosystem value offering targeted at a defined audience. Although entrepreneurial

ecosystems facilitate an ecosystem output by cultivating a shared knowledge base regarding ‘what works’ in harnessing advances in digital technologies and infrastructures for novel ways of organizing for the creation, delivery, and capture of value (i.e., business model innovation), the resulting business models can be applicable in virtually any sector and be targeted at any audience (Acs, Autio, & Szerb, 2013; Auerswald, 2014; Isenberg, 2010; Spiegel, 2017). In the case of entrepreneurial ecosystems, this audience is largely internal – i.e., composed of new ventures who tap the experiences of others to discover new business model practices that might be put into profitable use (Autio et al., 2018). In entrepreneurial ecosystems, the ecosystem output consists of innovative business models and the new ventures that embody them, but this output is not targeted at a defined audience.

While entrepreneurial ecosystems resemble concepts previously explored by economic geographers and innovation researchers—such as ‘clusters’, ‘knowledge clusters’, ‘industrial districts’, ‘innovative milieus’, and ‘regional and national systems of innovation’ (Arikan & Schilling, 2011; Crevoisier, 2004; Delgado, Porter, & Stern, 2010; Freeman, 2004; Lundvall, 1992; Tallman, Jenkins, Henry, & Pinch, 2004)—they constitute a distinct type of cluster because of their emphasis on entrepreneurial agents and business model innovation, as opposed to product, service, or technological innovation co-created by a more diverse set of active ecosystem participants. This implies a distinctively different learning and opportunity dynamics in entrepreneurial ecosystems, as opposed to entrepreneurial regions and clusters previously documented in the literature. The process of discovering ‘what works’ in terms of digitally enhanced business model practices is driven by constant experimentation by new ventures, as well as the sharing of resulting insights within the regional entrepreneurial ecosystem. In classical entrepreneurial clusters, opportunities are driven by, e.g., the discovery of niches and the linear spill-over of research-based knowledge advances and their translation into specific products and services (Autio et al., 2018; Autio & Thomas, 2019; Kenney & Von Burg, 1999). This distinction is reflected in characteristic structural elements of entrepreneurial ecosystems such as new venture accelerators, coworking spaces, makerspaces, start-up academies, university entrepreneurship programs, crowdfunding, angel investors, business angels, venture capital, and mentors, all of which enable them to more effectively facilitate business model experimentation and associated horizontal knowledge spillovers (Autio et al., 2018; Goswami, Mitchell, & Bhagavatula, 2018).

Entrepreneurial ecosystems are predominantly a regional phenomenon. Experimentation-driven collective discovery and related knowledge exchange regarding effective business model recipes are facilitated by geographical proximity. Entrepreneurial ecosystems also attract specialized resources (e.g., venture funding, new venture accelerators, specialized advice) that derive economies of scope from spatial proximity. Harnessing spatial affordances, participants of entrepreneurial ecosystems explore and discover business model innovation opportunities opened by advances in digital technologies and infrastructures to support a distinctive cluster-level learning dynamic that is expressed through the creation and scale-up of new ventures (Autio et al., 2018). These innovation opportunities derive from the technical architecture of digital infrastructures, and, being industry and sector agnostic and challenging legacy business models optimized by established incumbents, they ultimately support an economy-wide redesign of value creation, delivery, and capture processes (Autio & Levie, 2017). Entrepreneurial ecosystems support the cultivation and dissemination of cluster-level architectural knowledge on a generic business process (as opposed to product-or technology-specific innovation): effective business model innovation and entrepreneurial start-up and scale-up (Tallman et al., 2004).

The co-alignment structure of entrepreneurial ecosystems is mostly cognitive and economic, and they do not exhibit a high level of stratification due to their sector-agnostic nature (Colombelli, Paolucci, & Ughetto, 2019). A limitation of received research on entrepreneurial ecosystems is that most of this research has overlooked the core knowledge dynamic of entrepreneurial ecosystems and has instead focused on exploring how individual actors can influence their role within the entrepreneurial ecosystem. For instance, scholars have considered the governance of research joint ventures (Audretsch & Link, 2019), venture capital and technology parks (Cumming, Werth, & Zhang, 2019), individual researchers (Cunningham, Menter, & Wirsching, 2019), and universities (Meoli, Paleari, & Vismara, 2019). Given their importance to regional economic development, there are significant policy efforts being undertaken to manage their interdependencies (Autio & Levie, 2017; Spiegel, 2017) and understand the dynamics of digital technologies in this context (von Briel, Davidsson, & Recker, 2018).

Knowledge Ecosystems

The concept of ‘knowledge ecosystems’ features generic research-based knowledge and associated applications as their system-level output. This concept has primarily been employed in the innovation literature, reflecting the increasingly open processes of R&D and innovation (Bogers et al., 2017; Von Hippel, 2007). Distinctive underlying theoretical logics do not yet appear to be fully developed, however, and most of the themes explored under this rubric echo those extensively explored within the ‘systems of innovation’ tradition over the past four decades (Lundvall, Johnson, Andersen, & Dalum, 2002; Lundvall, 2007; Malerba, 2002; Malerba & Orsenigo, 1997; Nelson & Winter, 1982). Given this overlap, the insights from the ‘knowledge ecosystems’ appear difficult to distinguish from those in the extensive literature on systems of innovation. For instance, it is not clear how a ‘partial’ knowledge ecosystem differs from an R&D consortium (Doz, Olk, & Ring, 2000), given the dependence of both on formal forms of governance (Järvi et al., 2018). Similarly, it is challenging to see how a ‘pre-figurative’ knowledge ecosystem is distinguished from regional systems of innovation (Freeman, 2004), or a ‘knowledge cluster’ (Tallman et al., 2004), or even triple and quadruple helix processes (Etzkowitz & Leydesdorff, 2000), given that their coordination is “*informal, with no formal or determinate structures*” (Järvi et al., 2018: 1530). In addition to the indeterminacy of their co-alignment structure, it is also not particularly clear how ‘knowledge’ is embodied as an ecosystem-level output (although see Leten, Vanhaverbeke, Roijakkers, Clerix, & Van Helleputte, 2013 for an exception).

Because of the emphasis of collective learning and knowledge exchange processes, knowledge ecosystems have been primarily described at a regional level of analysis and in pre-competitive settings (Clarysse et al., 2014; Järvi et al., 2018). With collaborative exploration of new knowledge as their central activity and output (Järvi et al., 2018; van der Borgh et al., 2012), the goal of knowledge ecosystem participants—whose commercial interests may diverge—is to engage in joint creation of new pre-commercial knowledge to create a shared resource that no single participant would be able to create independently (Järvi et al., 2018; Leten et al., 2013). Given the focus of research under this label on knowledge as a system-level output, knowledge ecosystems have been described as consisting of universities, public research institutions, bridging and brokering organizations, and for-profit firms

collaborating to create new knowledge in a pre-competitive setting (Clarysse et al., 2014; Järvi et al., 2018; Valkokari, 2015; van der Borgh et al., 2012).

To summarize and recap, the conceptual proliferation of the ecosystem literature can be largely attributed to the elasticity of the concept in terms of ‘units’ of analysis, associated thematic foci, as well as the variety of ‘ecosystem services’, or outputs they facilitate. This elasticity partly reflects the ambiguity of the underlying phenomenon: organizations and individuals can coordinate their actions for many different purposes, and they can cohabit different spaces (physical and virtual) in different formations. Ultimately, however, the different manifestations of ecosystems all share two salient features: they facilitate the co-generation of ecosystem outputs, and they do this without resorting to formal supplier contracts. We next discuss implications of our model for ecosystems literature and research.

ECOSYSTEM DYNAMICS

When considering our organizing conceptual typology, it is useful to remind ourselves what ultimately drives the ecosystem phenomenon and why the literature has expanded so dramatically over the past decade. Ultimately, the trends of open innovation and business model innovation are enabled by digitalization—the application of digital technologies by business and society such that these become infrastructural. Being generic-purpose communication and coordination technologies, digital technologies and infrastructures enable organizations to radically re-think and re-design their interactions for value creation, delivery, and capture, and for the co-generation of compatible outputs. Digital technologies do not allow this solely by virtue of their coordination-enabling potency, but also because they can dramatically reduce asset specificity that constrains interactions among businesses that predominantly rely on physical assets (e.g., production machinery) for the creation of valuable outputs. Physical assets exhibiting low degree of asset specificity (i.e., they cannot be easily allocated to an alternative use without significant loss of value), the consequences of co-specialized investment tend to be more durable and therefore require long-term relationships underpinned by formal contracts. By alleviating this key constraint that regulates conventional relationships between business firms that predominantly exploit physical assets for value creation, digitalization has enabled much

more organic, emergent, and coevolving interactions within organizational communities for the purpose of co-generating valued ecosystem-level offerings and outputs. Digital technologies being general-purpose technologies, these effects are seen in virtually any sector – and Moore’s law ensures that this transformation is not likely to go away any time soon.

We believe the recent popularity of the ecosystem concept in management and business literatures is largely because digitalization enables flexible, organic, coevolving, and emergent evolution of collaborations within spatial and virtual communities of organizations in ways that rigidly asset-specific arrangements of inter-organizational collaborations do not. It is also notable how the ecosystem concept is demarcated by previous biology-inspired in organizational research – notably, the population ecological perspective to populations of organizations (Hannan & Freeman, 1977). Whereas the population ecological perspective focused on the effect of environmental effects on firm-level outcomes, notably, entry and survival (e.g., effect of environmental resource munificence and population density on organizational survival), the focus of the work on innovation ecosystems has been focusing on the collective generation of *outputs*, again reflecting the enabling impact of digitalization on interaction and collaboration among heterogeneous, hierarchically independent ecosystem participants (Autio et al., 2018).

If we accept that ecosystems in management are organic, coevolving phenomena, what do we know about their dynamics? In this final section of our discussion, we comment on four dynamic aspects of innovation ecosystems as coevolving organizational communities. Our focus is on ecosystem emergence, competition, coevolution, and resilience.

Emergence

How do ecosystems emerge? Although we know what drives the ecosystem phenomenon (i.e., digitalization), there have been few studies that explore specific processes of innovation ecosystem emergence (for exceptions, see Autio & Thomas, 2018; Dattée, Alexy, & Autio, 2018; Hannah & Eisenhardt, 2018; Snihur, Thomas, & Burgelman, 2018).

A distinction needs to be made between spatially confined ecosystems (e.g., entrepreneurial ecosystems) and those that are not spatially confined. This is because spatially confined ecosystems (e.g., entrepreneurial ecosystems, knowledge ecosystems) typically build on what existed before. For

example, the current incarnation of entrepreneurial ecosystems, with their emphasis on digitally enhanced business model innovation, exhibit very different dynamics than do ‘clusters of entrepreneurship’ or similar regional agglomerations of entrepreneurial activity of the pre-digitalization era (Delgado et al., 2010; Feldman, 2001). The classic 1990’s era entrepreneurial cluster at the core of many regional systems of innovation tended to emphasize linear, technology-push innovation, in which entrepreneurial agents translated advances in research into commercial application. The support structures of entrepreneurial clusters (e.g., science parks) were optimized to support such knowledge translation. In the digital era, many such structures have been co-opted to support the digitally enhanced process of business model experimentation and discovery, and many science parks currently house or have been transformed into new venture accelerators that subscribe to the ‘lean entrepreneurship’ heuristic. Whereas the dominant entrepreneur-driven innovation processes in regional systems of innovation were science and research centric or occurred within the confines of asset-specific supply chains, the 2010s era entrepreneurial ecosystems exhibit much more user-centric business model discovery processes that harness digitalization to sidestep and undermine established incumbents’ legacy business models. This means that in entrepreneurial and knowledge ecosystems, the emergence processes do not necessarily represent greenfield-type construction of a *de novo* ecosystem from scratch, as might have been the case of many a classic entrepreneurial cluster (Feldman & Francis, 2006), but rather, represent instances of gradual transformation of an existing cluster into a new *modus operandi* through the establishment of, e.g., new venture accelerators in the region.

The emergence of other types of ecosystems (business ecosystems, modular ecosystems, platform ecosystems) appears to follow a different pattern. While spatially confined ecosystems can come to being through a gradual transformation (while retaining structures and processes that dominated an earlier era), spatially unbound ecosystems are often *de novo* creations and therefore might require active agency in order to be set in motion. Along these lines, the seminal article of Moore (1993) proposed a four-stage evolutionary model of ecosystem creation—birth, expansion, leadership, and self-renewal—where an ecosystem progresses from a random collection of ad-hoc stakeholders to a more structured and coherent community driven by a lead firm who balances cooperative and competitive

processes (cf. Hannah & Eisenhardt, 2018). In the platform ecosystem literature, Gawer (2009) suggested a three-stage model, where the platform ecosystem evolves under the direction of a platform leader from a closed system towards greater openness. This view has been further developed by Thomas et al. (2014), who suggested that in addition to developing along a predefined openness trajectory, platform ecosystems can also evolve along three distinct leverage trajectories. More recently Teece (2017) analyzed the requirements at each stage of this evolutionary lifecycle in terms of the innovation ecosystem leader's dependence on the high-level dynamic capability categories of sensing, seizing, and transforming. Recent empirical scholarship has begun to provide empirical evidence of these stages (see, for instance Jha, Pinsonneault, & Dube, 2016; Leong, Pan, Newell, & Cui, 2016). On a related view of ecosystem emergence, Dattée et al. (2018) showed how active agency is required in the early stages of innovation ecosystem creation, and how it is critical for the ecosystem promoter to exercise dynamic control of the visioning process (cf. Ansari et al., 2016; Snihur et al., 2018) in order to encourage sign-up and early commitments to the emergent ecosystem—as opposed to static control of predefined ecosystem assets, as maintained by the ‘ecosystem blueprint’ view (Adner & Kapoor, 2016).

Competition

Do ecosystems compete? Although we have a good understanding of what makes an ecosystem unique as a venue for collaborative creation of ecosystem-level outputs, we know surprisingly little about how ecosystems compete. Like the case of ecosystem emergence, a distinction needs to be made between spatially confined innovation ecosystems and those that are not spatially confined. This is because spatially confined innovation ecosystems are not exposed to specific market conditions determined by user choice as are innovation ecosystems, whose value offerings are more directly targeted at defined audiences. For this reason, the literature on competition in entrepreneurial and knowledge ecosystems is sparse, although their properties may be systematically measured (Stam, 2018) and ranked (Szerb, Ács, Komlósi, & Ortega-Argilés, 2015).⁴ As entrepreneurial and knowledge ecosystems do not address defined audiences to the extent that market choice would be relevant for

⁴ See also: <https://ecosystembuilderhub.com/ranking-the-startup-ecosystems-of-1000-cities-and-100-countries/>; retrieved 14/10/2019.

their survival, such ecosystem rankings are more likely to cater to the needs of policy-makers. In the case of spatially confined ecosystems, the competition that does occur tends to be on the supply side rather than the demand side, in that entrepreneurial ecosystems compete for venture capital, angel investors, mentors and entrepreneurs. However, there is little research to date to explore this dynamic.

Spatially unbound ecosystems operate in a market context as their ecosystem-level outputs are subject to competing value offerings. The notion of ecosystem competition was present in the earliest of ecosystem literatures, with Moore (1993) subtitling his seminal HBR article “a new ecology of competition” and titling his 1996 book “The Death of Competition”, referring to the end of traditional competition between individual products or services (cf. Chen, 1996). Rather than occurring at the level of products, competition plays out instead between ecosystems that span multiple (traditionally defined) product markets (Cennamo, 2019; Rochet & Tirole, 2003). Similarly, ecosystem competition is not a zero-sum game where competitors compete for a market of a given size (Priem, 2007) but is instead focused on how the ecosystem can meet as many customer needs as possible (Cennamo & Santalo, 2013). As a consequence, competitive behaviours in ecosystem settings are different (Cennamo, 2019), consisting of, for instance: subsidization of one set of customers to support others (Rochet & Tirole, 2003); varying the openness of the ecosystem to participants (Boudreau, 2010); varying level of exclusivity (Cennamo & Santalo, 2013); as well as specific strategic moves such as platform envelopment (Eisenmann, Parker, & Van Alstyne, 2011). Interestingly, while there has been substantive research into competition in platform ecosystems, there is much less substantive research that considers competition in business or modular ecosystems which have been seen more as venues to understand interdependencies and governance (for an exception, see Hannah & Eisenhardt, 2018).

Coevolution

How do ecosystems change? We know that ecosystems are not static, in that they change over time. In biology, ecosystems exhibit a “*mutual adjustment of their components*” that tends towards the “*perfect dynamic equilibrium that can be attained in a system developed under given conditions and with the available components*” (Tansley, 1935: 300). In the language of management, ecosystems ‘coevolve’ (Basole, 2009; Moore, 1993) through a process where environmental changes and changes

in the ecosystem participants mutually influence each other, prompting mutual adjustments (Lewin & Volberda, 1999; Merry, 1999; Van De Ven & Garud, 1994).

The notion of coevolution was initially suggested in the earliest innovation ecosystem literature. For instance Moore (1993) stated that ecosystems “...*coevolve capabilities around a new innovation*”, suggesting that ecosystem participants need to adjust their investments and choices over time to maintain their complementarity with other participants, technologies and institutions. Others have noted how ecosystem output coevolves with the business models of the ecosystem participants, explaining why certain participants join, stay in, or leave the ecosystem at specific points in time (van der Borgh et al., 2012). The platform ecosystem literature has also considered how competition between ecosystem participants can lead to changes in the ecosystem itself (Mäkinen, Kanninen, & Peltola, 2014; Tiwana, 2015). More broadly, others have considered how external environmental factors can lead to ecosystem coevolution. For instance, Tiwana et al. (2010) argued that ecosystem governance and participant interactions need to coevolve with changes to the environment, and others have indicated that competition between challengers and incumbents can drive coevolution of an ecosystem (Ansari et al., 2016; Snihur et al., 2018). Still others have looked at how ecosystem participants can collectively evolve so as to ensure that the standards of legitimacy that define success for an ecosystem are appropriate (Autio & Thomas, 2018).

The study of evolutionary processes within ecosystems thus seems to offer a trove of opportunities. Yet there has been little research that has substantively investigated coevolution, as most of the papers mentioned refer to coevolution as a supporting dynamic. We believe this is an important research gap, as coevolutionary processes within ecosystems represent an important dynamic regulating their growth and stability. Given that ecosystems are open systems, we suggest there might be merit in heeding the view of Rosenkopf and Nerkar (1999), who pointed out that coevolution is driven by both internal factors (within-level coevolution) or was well as external factors (cross-level coevolution).

Resilience

Finally, how to ecosystems remain healthy? In biology, an ecosystem is considered resilient when it persists in the face of environmental changes and continues to provide ecosystem services to

the species that depend on it (Willis, 1997). In ecosystems literature, the concept of resilience was introduced by Iansiti and Levien (2004: 72), who argued that ecosystems need to be *robust*, i.e., capable of absorbing external shocks and maintaining the potential for productive innovation: “*the benefits are obvious: A company that is part of a robust ecosystem enjoys relative predictability, and the relationships among members of the ecosystem are buffered against external shocks.*” By virtue of their relative absence of asset specificity and contractual relationships, innovation ecosystems are naturally better positioned to exhibit resilience in the face of environmental change than are contractually underpinned, asset-specific supply chains. Interestingly, Adner and Kapoor (2010) arguably serves as an illustration of the implications of a lack of resilience and the inability of innovation ecosystem participants to coevolve.

Ecosystem resilience has generally been considered along two dimensions—response diversity (Krause, Razavi, Moschoyiannis, & Marinos, 2009) and governance (Wareham et al., 2014). Response diversity is the ecosystem’s ability to generate a broad variety of offerings to meet customer requirements (Cennamo & Santalo, 2013; Zhu & Iansiti, 2012), thereby enhancing the ecosystem’s ability to adjust to changes in demand. For instance, Leong et al. (2016) considered how the adaptation of product offerings within an ecosystem could also eventually enhance the ecosystem resilience. Response resilience is regulated by ecosystem governance (Wareham et al., 2014), particularly when it comes to the ability of the ecosystem to resolve the fundamental tension between the need for flexibility and variety versus the need for coherence and standardization. Here the emphasis is on understanding how the ecosystem’s interdependent participants interact to continue to produce the ecosystem output—with the corollary that if coordination within the ecosystem is inadequate, the ecosystem will fail (e.g., Adner, 2012; Adner & Kapoor, 2010; Kapoor & Lee, 2013). With reference to governance, emerging work in platform contexts is also investigating the implications platform characteristics (e.g., Penttinen, Halme, Lyytinen, & Myllynen, 2018) and the dynamics of generativity (Cennamo & Santaló, 2019) may have for resilience. In the context of entrepreneurial and knowledge ecosystems, there is little that we are aware of that has substantively considered ecosystem resilience (for an exception, see Roundy, Brockman, & Bradshaw, 2017).

CONCLUSION

In this article we have outlined the dimensions of conceptual proliferation that afflict the ecosystem concept in management, highlighting how this proliferation operates along two main dimensions: ‘unit’ of analysis and the nature of ecosystem outputs collectively generated. This proliferation has resulted in conceptual heterogeneity, which hampers cumulative insight. We identified four characteristics of ecosystems—community heterogeneity, ecosystem outputs, participant interdependence, and distinctive governance—and how these distinguish the various ecosystem concepts from other concepts and constructs used to theorize about organizational collectives. From this baseline we proposed a general definition of an ecosystem—*a community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output*—and an organizing conceptual typology that positions the different concepts used in ecosystem research and can be used to delineate different streams of ecosystem research. We concluded by discussing the important role digitalization has for the popularity of the ecosystem concept, and four dynamic aspects of innovation ecosystems: emergence, competition, coevolution and resilience.

The concept of ecosystems in management describes a real phenomenon of high practical relevance, yet one that can assume a broad range of manifestations. In order to coherently address this important phenomenon, researchers are challenged to adopt a coherent vocabulary to ensure cumulative insight. We hope that the organizing conceptual framework suggested in this article will help the mushrooming community of ecosystem researchers progress towards this goal.

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FIGURE 1 – Ecosystem Typology

		Research Emphasis		
		Community Dynamics	Output Co-creation	Interdependence Management
Ecosystem Output	Ecosystem value offering targeted at a defined audience	← ----- Business Ecosystem <i>(Moore, 1996; Iansiti & Levien, 2004)</i>	Innovation Ecosystem Modular Ecosystem <i>(Adner & Kapoor, 2010; Adner, 2017)</i>	----- → Platform Ecosystem <i>(Wareham et al 2014; Gawer & Cusumano, 2014)</i>
	Business model innovation instantiated in new start-up ventures	<i>(Autio et al, 2018)</i>	Entrepreneurial Ecosystem <i>(Klofsten et al, 2018)</i>	<i>(von Briel et al 2017)</i>
	New research-based knowledge	<i>(Järvi et al 2018; van der Borgh et al 2012)</i>	Knowledge Ecosystem <i>(Clarysse et al, 2014)</i>	<i>(Leten et al 2013; Dougherty & Dunne, 2011)</i>

TABLE 1 – Ecosystem Vocabulary

Term	Definition
Ecosystem	A community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output.
Innovation Ecosystem	A community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output and related value offering targeted at a defined audience.
Entrepreneurial Ecosystem	A regional community of hierarchically independent, yet interdependent heterogeneous participants who facilitate the start-up and scale-up of entrepreneurial new ventures who compete with innovative business models.
Knowledge Ecosystem	A regional community of hierarchically independent, yet interdependent heterogeneous participants who advance the translation of advances in research knowledge into products and services.
Ecosystem Output	An system-level output that has been collectively generated by heterogeneous ecosystem participants.
Ecosystem Value Offering	An ecosystem output that is targeted at a defined audience whose needs it helps address.

